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Costs and economic impacts of type-1 diabetes from the dominican patient perspective

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Abstract:

Objective: *Estimate the economic burden of type 1 diabetes (T1D) in the Dominican Republic and its impact on treatment adherence and patients' quality of life (QoL).*

Materials and Methods: *Cross-sectional observational study about T1D treatment cost and adherence plus patients QoL. The total monthly cost of treatment regimes was calculated through microcosting analysis and correlated with a national minimum wage (NMW) and average household income. Sociodemographic, clinical, treatment adherence and QoL data were obtained through an online questionnaire. In an exploratory approach, all variables were compared with the categorization of household income.*

Results: *Fixed doses (FD) regime has the lowest cost (46% of the NMW) and continuous subcutaneous insulin infusion (CSII) the highest (540% of the NMW). The lower household income group had less insurance coverage (P= 0.034), purchased fewer diabetes management supplies for cost-related reasons (P= 0.014), performed less glycemic monitoring (P= 0.016), and had more cost-related factors limiting appropriate treatment and follow-up (P= 0.030). Also, the FD treatment modality predominated in this group, while Multiple Daily Injections and constant subcutaneous insulin injection prevailed on the higher income group (P= 0.005). The QoL mean scores were 31.63 (SD 8.02) in the lower-income group and 32.52 (SD 8.81) in the higher-income one.*

Conclusions: *T1D has a high monthly economic impact, potentially worsening treatment adherence and QoL, especially in the lower socioeconomic status population. Efforts must be made by the healthcare system to enhance the economic support and management of this disease.*

Keywords: *Type 1 diabetes, Microcosting, Dominican Republic, Public Health, Treatment adherence.*

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INTRODUCTION

Type 1 diabetes (T1D) is an autoimmune disease that destroys the pancreatic β cells, resulting in insulin deficiency and predisposing to acute and chronic complications (Marathe et al., 2017). Based on its need for a multidisciplinary approach, intensive management, and insulin administration along with glycemic and glycated hemoglobin (HbA1c) monitoring, it is considered a high-cost disease. (Cobas et al., 2013). Despite being well-known among the Latin American (LATAM) community, epidemiological data about T1D is insufficient in most of the region. The scarce information available is reduced to reports by specialized centers, limiting its external validity (Rathe et al., 2011; Gomez et al., 2014). Furthermore, since the 1990s, there has been no published data on T1D incidence in the Dominican Republic (DR). At that time, it was 0.5 per 100,000 <15 years of age; but it has likely increased since then (Rathe et al., 2011; Gomez et al., 2014).

LATAM health systems face a sharp increase in life expectancy accompanied by a rise in chronic diseases, including T1D. The need to manage all health needs with limited resources (Gomez et al., 2014) has become a challenge, especially in developing countries where access to adequate clinical management and treatment is difficult due to budgetary constraints (Gomez et al., 2014; Mobasseri et al., 2020). Therefore, it is essential to consider economic parameters in local decision-making. This can be done by making use of health economics and outcomes research (HEOR), which is focused on describing and evaluating healthcare technologies, strategies, and disease management through analytical tools, such as cost-effectiveness and budget impact, to determine if the benefits of these compensate for their cost. HEOR takes into account different types of disease-related costs, including direct medical costs, associated with diagnosis, medication, follow-up, hospitalization, and emergency services, etc (Drummond et al., 2015; Rascati et al., 2015). In T1D these types of expenses represent more than 6,288 USD per capita per year in the United States and a high percentage of this figure is due to recurrent costs related to medications (Tao et al., 2010).

There is very limited data about the costs of chronic diseases, T1D included, in the DR. However, it is known that healthcare investment in this country is low when compared to others in its vicinity (World Bank, 2020). World Bank data shows that total the DR investment in healthcare represents 6.1% of its gross domestic product (GDP) (Digepres, 2020), less than the average amount in LATAM countries (8.0%) and globally (9.9%) (World Bank, 2020; Rathe et al., 2011). Similarly, the average health investment per inhabitant is also low. In consequence, the out-of-pocket spending percentage is one of the highest in the region (World Bank, 2020). This leaves DR in a critical scenario, considering that countries that cover the health expenditures of chronic conditions like T1D, benefit from those investments. Better quality of life, treatment adherence, and clinical outcomes are the results of this, according to literature from countries like Brazil (Ministério de Saúde, 2019), Argentina (PRODIABA, 2020), Colombia (Ministerio de Salud de Colombia, 2020), Mexico (Instituto de Seguridad y Servicios Sociales, 2016) and the United States (Chernew et al., 2008). Furthermore, high out-of-pocket expenditure rates can be linked to inadequate disease management and worsened long-term outcomes (Chernew et al., 2008; Paez et al., 2009).

Due to the lack of information related to the economic burden of diabetes in the DR and the evidence of the low health investment in the country, this study aimed to estimate the impact of T1D on Dominican patients regarding direct treatment costs and its representativity when compared to the national minimum wage income (NMW) and average household budgets. Also, it intended to explore the implications of this impact on treatment adherence and quality of life in relationship with their economic status.

MATERIALS AND METHODS

Study Design

This is a cross-sectional observational study about T1D direct costs, treatment adherence, and quality of life (QoL). Data collection was performed between July and August 2020 and was classified as Non-economic and Economic. Economic data was assessed through prospective micro costing analysis and consisted of total monthly costs of treatments and consumables of all available and validated therapy regimens. Since no sample size calculation was done due to lack of proper previous data or expert consensus, the non-economic data is exploratory. The variables measured include sociodemographic characteristics, clinical information, treatment adherence, and QoL collected from a methodologically validated online self-answered questionnaire which was available for 14 consecutive days. Social media was the recruitment tool, with invitations sent to T1D virtual support groups.

The study was approved by an Institutional Review Board (Approval number 003-2020) and consent was obtained from all the participants at the start of the survey. Those included in the non-economic analysis consisted of T1D patients, or their caregivers, who reside in the DR and completed the questionnaire. Non-consenting subjects partially answered questionnaires or those who self-specified as other than a person with diabetes type-1 or a caregiver of one were excluded from the analysis. CHEERS and STROBE guidelines checklists were applied to validate the economic and clinical evaluation respectively.

Economic data

Treatment regimens and disease management components and/or consumables were defined according to T1D ADA clinical protocols (American Diabetes Association, 2020), which include three insulin regimens: fixed doses (FD), multiple daily injections

(MDI), and continuous subcutaneous insulin infusion (CSII) as detailed in **Table 1**.

Through micro costing analysis, the total monthly cost (TMC) of each treatment regime was obtained by summing the prices of each treatment component taking a 70kg adult as a reference, as a conservative approach from a type 1 diabetes cohort (DCCT, 2016). The price of products with single use per month was multiplied by factor 1; the price of products with daily use was multiplied by the number of product units used per day, then multiplied by factor 30 (equivalent to thirty days) to reach the product final cost per month. Costs of devices obtained through a single purchase process, such as insulin pump and sensor transmission, were classified as "fixed costs", summed as "total fixed costs" and added to total monthly costs. Products with different prices depending on different commercial approaches—public and private drugstores—have been analyzed separately and prices from both perspectives have been reported. However, only the lowest commercial option price has been considered for the TMC. Afterward, the potential economic impacts of each regimen were contrasted with the NMW as of August 15 of 2020, and the self-reported average household income to establish the potential treatment impacts in budgets from the Dominican perspective. Prices were attained in Dominican pesos (DOP) and then converted to United States dollars (USD) (exchange rate: 1 USD= 58.04 DOP as of January 27, 2021). The discount rate has not been considered due to this being a preliminary and situational analysis of costs and their current impacts within the Dominican context.

Non-economic data

Data collection: The self-answered questionnaire included a variety of items related to sociodemographic data, glycemic control, insulin treatment and adherence, and cost-related limitations for adequate disease management. These items were based on a prior review of the literature of validated instruments (Alberts et al. 2010; DCCT, 1995; Herkert et al., 2018; Moffet et al., 2009).

QoL was assessed using the revised simplified Spanish version of the Diabetes QoL questionnaire. It is widely used in diabet es research and was created for the Diabetes Control and Complications Trial (DCCT Research Group, 1988) in 1998 to evaluate health-related QoL in T1D patients. It was validated in Spanish in 2002 (Millán et al., 2002) and revised in 2018 (Bujang et al., 2018). This instrument features 13 items divided into three dimensions: satisfaction, impact, and worry. Each item has a score, ranging from 1 to 5. The sum of each item results in a minimum of 13 points and a maximum of 65. A lower total score is related to better QoL and vice versa.

Statistical analysis: All variables were compared with the categorization of household income (< 40,000 DOP and > 40,000 DOP) according to the self-reported average household income in the questionnaire and contrasted with the NMW (Hidalgo et al., 2017).

For the descriptive analysis, the mean and standard deviation were used for normally distributed continuous variables; for non-normal continuous variables, median with interquartile range and categorical variables operated on frequency and percentage were used. Mean household income categorization is used as a group-defining variable, being excluded from the analysis of all patients who did not disclose their approximated household income. This inferential exploratory analysis sample (n= 100) used an unpaired t-student test for continuous normal variables; Wilcoxon rank-sum test for continuous non-normal and chi-square for categorical variables. Statistical significance was assumed with a P-value ≤ of 0.05, data normality was assessed with skewness and/or kurtosis and the approach for missing data was complete cases only. The software chosen for data analysis was STATA/IC 15.1.

Treatment	Components
FD	Regular insulin, NPH insulin, Syringes, Lancets, Test strips
MDI	Basal insulin, Rapid insulin, Syringes, Lancets, Test strips
CSII	Pump, Sensors, Sensor transmitter, Reservoirs, Insulin, Lancets, Test strips

FD: Fixed doses; **MDI**: Multiple daily injections; **CSII:** Continuous Subcutaneous Insulin Infusion
Syringes and lancets may be reused based on the patient individual decision.

Table 1. Treatment regimens components

Healthcare sector	Treatment regimen	DOP	USD*	Percent of NMW[b]	Percent of M
Public	**FD**	$4,222.00	$72.74	39.46%	10.48%
	MDI [a]	N/A	N/A	N/A	N/A
	CSII [a]	N/A	N/A	N/A	N/A
Private	**FD**	$4,882.00	$84.11	45.63%	12.11%
	MDI	$15,829.50	$271.05	147.94%	39.28%
	CSII	$57,812.00	$996.07	540.30%	143.45%

DOP: Dominican pesos; **USD:** United States dollars; **FD:** fixed dose; **MDI:** multiple daily injections; **CSII:** contin subcutaneous insulin infusion; **NMW:** national minimum wage, **MHI**: mean household income
The average minimum prices for each product were utilized
[a] Not commercially available at public sources
[b] NMW= 10,700 DOP
[c] MHI= 40,300 DOP
* USD= 58.04 DOP as of January 27, 2021

Table 2. Total monthly cost of treatment

RESULTS

Economic: total monthly cost of treatment

The micro costing analysis results are contained in **Table 2**, comparing the output of the total monthly cost of treatment of each regimen with individual economic indicators NMW and mean household income. The analysis can be visualized in detail in the supplemental material.

The FD regimen treatment was the only one estimated in the public sector, due to the limitation of the products offered. It costs 4,222 DOP (72.74 USD) per month, representing 39.46% of the NMW. All treatment modalities are available in the private sector, including the MDI regimen, with a cost of 15,829.50 DOP (272.73 USD) per month or 147% of the NMW.

Non-economic: population, sociodemographic data, clinical information, treatment adherence, and QoL

All non-economic descriptive data of the sample are contained in **Table 3**. The majority of answers were from T1D patients (73.5%), most of them being females (61.9%). The median age of the population was 23 years with an average of 10 years since T1D diagnosis. The glycemic control, measured as HbA1c, had a mean of 7.8% [9.8 mmol/l] (SD 1.8).

Information about the average household income was gathered, with 5.7% of patients reporting it at less than 10,000 DOP and 24.7% at more than 55,000 DOP; the rest of the sample was between these numbers. The majority of the subjects were students (47.9%), the most common insurance type was private (83.4%), and nearly all of them reported that their insurance does not cover all disease management expenditures (90%). Less than 25% of the coverage was frequent (56.2%).

When asked how they acquire their diabetic supplies, almost all patients reported using their income (93.3%) and at least one-third of the patients did not buy them due to their cost at a certain point in life (31.4%). Fewer blood glucose check reports were high (72.7%) with more than half attributing the cost of supplies as the cause for this (59.50%). Furthermore, treatment modalities MDI and FD were the most and least used (56.2% and 17.3%, respectively). For cost-related factors, they had stretched out insulin (63.6%), administered a dose lower than the recommended (38.8%), purchased less insulin than prescribed (37.1%), or skipped insulin doses (35.5%). Of those suggested by their doctor to initiate the CSII modality but who were not using it (46.2%), 45.4% attributed its cost as the reason for this.

Data from the inferential analysis, contained in **Table 4**, describes how the composed variable of mean household income was distributed. The lower household income group (< 40,000 DOP) had a lower percentage of insurance coverage (P= 0.034, Chi2),

Variable	**Aggrupation and dispersion**
Age[a]	23 (18-32)
Years since type-1 diabetes diagnosis [b]	10 (5-15)
HbA1c[a] (%)	7.3 (6.5-8.4)
HbA1c[a] (mmol/L)	9.0 (7.8-10.8)

Sociodemographic		
Variable	**Category**	**N (%)**
Participant	T1D caregiver	32 (26.45%)
	T1D	89 (73.55%)
Sex	Female	75 (61.98%)
	Male	46 (38.02%)
Occupation	Unemployed	16 (13.22%)
	Student	58 (47.93%)
	Employee	6 (4.96%)
	Retired	41 (33.88%)
Family Income	< 10,000 DOP	7 (5.79%)
	10,000 DOP – 25,000 DOP	33 (27.27%)
	25,000 DOP – 40,000 DOP	25 (20.66%)
	40,000 DOP – 55,000 DOP	5 (4.13%)
	> 55,000 DOP	30 (24.79%)
	Prefer not to say	21 (17.36%)
Health insurance	Public	8 (6.61%)
	Private	101 (83.47%)
	Public-private	4 (3.31%)
	Uninsured	8 (6.61%)
Insurance coverage: 100%	Yes	3 (2.48%)
	No	110 (90.91)
	Uninsured	8 (6.61%)
Percent of insurance coverage	< 25%	68 (56.20%)

	25-75%	34 (28.10%)
	75-100%	6 (4.96%)
	Does not apply	13 (10.74%)

Diabetic supplies and glycemic control		
Variable	**Category**	**N (%)**
Acquisition of supplies	Personal income	113 (93.39%)
	Sent from another country	25 (20.66%)
	Donations	14 (11.57%)
Ever stopped buying supplies due to their cost	Yes	38 (31.40%)
	No	76 (62.81%)
	I do not acquire supplies with my income	7 (5.79%)
Less blood glucose checks due to the cost of supplies	Yes	88 (72.73%)
	No	27 (22.31%)
	I do not monitor my glucose	3 (2.48%)
	Does not apply	3 (2.48%)
Inadequate glucose monitoring due to the cost of supplies	Yes	72 (59.50%)
	No	19 (15.70%)
	Maybe	19 (15.70%)
	Does not apply	9 (7.44%)
	I do not monitor my glucose	2 (1.65%)
Not using a flash glucose monitor due to its cost	Yes	92 (76.03%)
	No	4 (3.31%)
	Maybe	10 (8.26%)
	I use a flash glucose monitor	15 (12.40%)

Insulin treatment		
Variable	**Category**	**N (%)**
Insulin treatment regimen	FD	21 (17.36%)
	MDI	68 (56.20%)

	CSII	31 (25,62%)
	I'm currently not treating my diabetes	1 (0.83%)
Injections/day	0	28 (23.14%)
	1	5 (4.13%)
	2	17 (14.05%)
	3	22 (18.18%)
	4	22 (18.18%)
	> 4	27 (22.31%)
Type(s) of insulin used	Aspart	54 (44.63%)
	Glargine	40 (33.06%)
	Glulisine	30 (24.79%)
	Regular	18 (14.88%)
	NPH	13 (10.74%)
	Degludec	19 (15.70%)
	70/30	8 (6.61%)
Attempt to stretch out insulin due to its cost	Yes	77 (63.64%)
	No	44 (36.36%)
Administration of lower than prescribed insulin doses	Yes	47 (38.84%)
	No	74 (61.16%)
Less or no insulin bought due to its cost	Yes	45 (37.19%)
	No	76 (62.81%)
Skipped insulin doses due to its cost	Yes	43 (35.54%)
	No	78 (64.46%)
Doctor recommended an insulin pump	Yes, I already use it	33 (27.27%)
	Yes, but I do not use it	56 (46.28%)
	No	32 (26.45%)
Not using an insulin pump due to its cost	Yes	55 (45.45%)
	No	13 (10.74%)
	I use an insulin pump	22 (18.18%)

	Does not apply	31 (25.62%)

Complications & extra spending		
Variable	**Category**	**N (%)**
Sought less medical attention due to its cost	Yes	39 (32.23%)
	No	82 (67.77%)
Out-of-pocket spending (for a fee not covered by insurance)	Yes	100 (82.64%)
	No	21 (17.36%)
Less medical testing due to its cost	Yes	42 (34.71%)
	No	79 (65.29%)
Cost-related difficulties in acquiring diabetic supplies affecting your well-being	Always	44 (36.36%)
	Usually	24 (19.83%)
	Sometimes	30 (24.79%)
	Rarely	9 (7.44%)
	Never	3 (2.48%)
	It's not difficult to acquire my supplies	11 (9.09)

Quality of life					
Variable	**N%**				
Satisfaction domain					
	1.Very satisfied	**2.Moderately satisfied**	**3.Neither satisfied nor dissatisfied**	**4.Moderately dissatisfied**	**5.Very dissatisfied**
Time spent managing diabetes	39 (32.23%)	26 (21.49%)	32 (26.45%)	19 (15.70%)	5 (4.13%)
Time spent getting checkups	27 (22.31%)	36 (29.75%)	32 (26.45%)	20 (16.53%)	6 (4.96%)
Time it takes to monitor glucose	42 (34.71%)	33 (27.27%)	34 (28.10%)	5 (4.13%)	7 (5.79%)
Current treatment	44 (36.36%)	31 (25.62%)	37 (30.58%)	4 (3.31%)	5 (4.13%)
Knowledge about diabetes	52 (42.98%)	32 (26.45%)	33 (27.27%)	3 (2.48%)	1 (0.83%)
Life in general	40 (33.06%)	41 (33.88%)	28 (23.14%)	7 (5.79%)	5 (4.13 %)
Impact domain					
	1. Never	**2.Sometimes**	**3. Often**	**4.Frequently**	**5.Always**
Pain associated with treatment	19 (15.70%)	32 (26.45%)	57 (47.11%)	11 (9.09%)	2 (1.65%)

Feeling physically ill	30 (24.79%)	45 (37.19%)	34 (28.10%)	10 (8.26%)	2 (1.65%)
Diabetes interfering with family life	35 (28.93%)	36 (29.75%)	30 (24.79%)	12 (9.92%)	8 (6.61%)
Diabetes limiting social relationships and friendships	43 (35.54%)	23 (19.01%)	41 (33.88%)	8 (6.61%)	6 (4.96%)
Worry domain					
	1. Never	**2.Sometimes**	**3. Often**	**4.Frequently**	**5.Always**
Worried about passing out	25 (20.66%)	23 (19.01%)	51 (42.15%)	12 (9.92%)	10 (8.26%)
Worried that body looks different due to diabetes	22 (18.18%)	14 (11.57%)	46 (38.02%)	18 (14.88%)	21 (17.36%)
Worried about complications	5 (4.13%)	7 (5.79%)	42 (34.71%)	31 (25.62%)	36 (29.75%)

HbA1c: glycated haemoglobin; **T1D:** type-1 diabetes; **DOP:** Dominican pesos; **FD:** Fixed doses; **MDI:** Multiple daily injections; **CSII:** Continuous Subcutaneous Insulin Infusion
[a] mean with standard deviation [b] median with IQR

Table 3. Sociodemographic and clinical description of the sample

Variable		< 40,000 DOP (x, %)	> 40,000 DOP (x, %)	Total (n)	P value
Sociodemographic					
Participant	T1D· caregiver	21 (32.31%)	10 (28.57%)	31	0.700
	T1D	44 (67.69%)	25 (71.43%)	69	
Sex	Female	38 (58.46%)	21 (60.00%)	59	0.881
	Male	27 (41.54%)	14 (40.00%)	41	
Occupation	Unemployed	9 (13.85%)	3 (8.57%)	12	0.497
	Student	31 (47.69%)	16 (45.71%)	47	
	Employee	20 (30.77%)	15 (42.86%)	35	
	Retired	5 (7.69%)	1 (2.86%)	6	
Health insurance	Public	5 (7.69%)	1 (2.86%)	6	0.241
	Private	51 (78.46%)	33 (94.29%)	84	
	Public-private	2 (3.08%)	1 (2.86%)	3	
	Uninsured	7 (10.77%)	0 (0.00%)	7	

Insurance coverage: 100%	Yes	1 (1.54%)	1 (2.86%)	2	0.123
	No	57 (87.69%)	34 (97.14%)	91	
	Uninsured	7 (10.77%)	0 (0.00%)	7	
Percent of insurance coverage	< 25%	35 (53.85%)	19 (54.29%)	54	**0.034**
	25-75%	15 (23.08%)	13 (37.14%)	28	
	75-100%	3 (4.62%)	3 (8.57%)	6	
	Does not apply*	12 (18.46)	0 (0.00%)	12	
Diabetic supplies and glycemic control					
Acquisition of supplies	Personal income	63 (96.92%)	33 (94.29%)	96	0.521
	Sent from another country	11 (16.92%)	7 (20.00%)	18	0.702
	Donations	10 (15.38%)	3 (13.00%)	13	0.334
Not buying supplies due to their cost	Yes	26 (40%)	6 (17.14%)	32	**0.016**
	No	33 (50.77%)	28 (80.00%)	61	
	I do not acquire supplies with my income	6 (9.23%)	1 (2.86%)	7	
Less blood glucose checks due to the cost of supplies	Yes	55 (84.62%)	22 (62.86%)	77	**0.025**
	No	8 (12.31%)	9 (25.71%)	17	
	I do not monitor my glucose	2 (3.08%)	1 (2.86%)	3	
	Does not apply	0 (0.00%)	3 (8.57%)	3	
Inadequate glucose monitoring due to the cost of supplies	Yes	43 (66.15%)	20 (57.14%)	63	**0.030**
	No	5 (7.69%)	6 (17.14%)	11	
	Maybe	12 (20.00%)	3 (8.57%)	16	
	Does not apply	2 (3.08%)	6 (17.14%)	8	
	I do not monitor my glucose	2 (3.08%)	0 (0.00%)	2	
Not using a flash glucose monitor due to its cost	Yes	55 (84.62%)	25 (71.43%)	80	**0.012**
	No	0 (0.00%)	1 (2.86%)	1	
	Maybe	7 (10.77%)	1 (2.86%)	8	
	I use a flash glucose monitor	3 (4.62%)	8 (22.86%)	11	

Insulin treatment					
Insulin treatment regimen	FD	18 (27.69%)	0 (0.00%)	18	**0.005**
	MDI	35 (53.85%)	25 (71.43%)	60	
	CSII	11 (16.92%)	10 (28.57%)	21	
	I'm currently not treating my diabetes	1 (1.54%)	0 (0.00%)	1	
Type(s) of insulin used	Aspart	22 (33.85%)	18 (51.43%)	40	0.087
	Glargine	22 (33.85%)	15 (42.86%)	37	0.373
	Glulisine	12 (18.46%)	13 (37.14%)	25	**0.040**
	Regular	15 (23.08%)	2 (5.71%)	17	**0.027**
	NPH	11 (16.92%)	1 (2.86%)	12	**0.039**
	Degludec	7 (10.77%)	9 (25.71%)	16	0.052
	70/30	8 (12.31%)	0 (0.00%)	8	**0.030**
Injections/day	0	10 (15.38%)	8 (22.86%)	18	**0.018**
	1	5 (7.69%)	0 (0.00%)	5	
	2	10 (15.38%)	6 (17.14%)	16	
	3	18 (27.69%)	2 (5.71%)	20	
	4	12 (18.46%)	6 (17.14%)	18	
	> 4	10 (15.38%)	13 (37.14%)	23	
Attempt to stretch out insulin due to its cost		45 (69.23%)	19 (54.29%)	64	0.110
Administration of lower than prescribed insulin doses		27 (41.54%)	13 (37.14%)	40	0.669
Less or no insulin bought due to its cost		27 (41.54%)	10 (28.57%)	37	0.200
Skipped insulin doses due to its cost		29 (44.62%)	10 (28.57%)	39	0.117
Doctor recommended an insulin pump	Yes, I already use it	12 (18.46%)	10 (28.57%)	22	0.415
	Yes, but I don't use it	32 (49.23%)	17 (48.57%)	49	
	No	21 (32.31%)	8 (22.86%)	29	
Not using an insulin pump due to its cost	Yes	33 (50.77%)	16 (45.71%)	49	0.656
	No	6 (9.23%)	4 (11.43%)	10	
	I use an insulin pump	6 (9.23%)	6 (17.14%)	12	
	Does not apply	20 (30.77%)	9 (25.71%)	29	

Complications & extra spending					
Sought less medical attention due to its cost		27 (41.54%)	6 (17.14%)	33	**0.013**
Out-of-pocket spending (for a fee not covered by insurance)		57 (87.69%)	30 (85.71%)	87	0.779
Less medical testing due to its cost		31 (47.69%)	4 (11.43%)	35	**0.000**
Cost-related difficulties in acquiring diabetic supplies affecting your well-being	Always	26 (40.00%)	12 (34.29%)	38	**0.037**
	Usually	16 (24.62%)	5 (14.29%)	21	
	Sometimes	11 (16.92%)	11 (31.43%)	22	
	Rarely	8 (12.31%)	0 (0.00%)	8	
	Never	1 (1.54%)	2 (5.71%)	3	
	It's not difficult to acquire my supplies	3 (4.62%)	5 (14.29%)	8	

T1D: type-1 diabetes; **DOP:** Dominican pesos; **FD:** Fixed doses; **MDI:** Multiple daily injections; **CSII:** Continuous Subcutaneous Insulin Infusion

Table 4. Inferential analysis by mean household income

	DQoL Results					Distribution by mean household income			
	Mean	**SD**	**Lowest**	**Highest**	**Scale**	**MHI**	**Mean**	**SD**	**P value**
Satisfaction	13.28	4.87	6	27	6-30	< 40,000 DOP	13.01	4.51	0.3
						> 40,000 DOP	14.02	5.11	
Impact	9.41	3.22	4	18	4-20	< 40,000 DOP	9.1	3.09	0.55
						> 40,000 DOP	9.48	2.99	
Worries	9.38	2.86	3	15	3-15	< 40,000 DOP	9.5	2.65	0.38
						> 40,000 DOP	9	2.99	
Total	32.08	8.79	15	55	13-65	< 40,000 DOP	31.63	8.02	0.61
						> 40,000 DOP	32.51	8.81	

DQoL: diabetes quality of life; **SD:** standard deviation; **MHI:** mean household income; **DOP:** Dominican pesos.

Table 5. Diabetes quality of life scores and analysis by mean household income

purchased fewer diabetes management supplies for cost-related reasons (P= 0.014, Chi2), performed less glycemic monitoring (P= 0.016, Chi2), and had more cost-related factors limiting appropriate follow-ups (P= 0.030, Chi2). Also, the FD treatment modality predominated in this group, while MDI and CSII prevailed on the higher mean income group (P= 0.005, Chi2). As a result of an exploratory analysis, FD patients had a mean HbA1c higher than the non-FD group (8.3% [10.6 mmol/l] vs 7.7% [9.7 mmol/l] respectively) but this result was not significant (P = 0.163, Wilcoxon test).

The results of the DQoL questionnaire are shown in **Table 5**. The lower-income group score mean was 31.63 (SD 8.02), while the mean higher-income one was 32.52 (SD 8.81) (P= 0.61, t-test).

DISCUSSION

This is the first regional analysis that evaluates T1D patients from a clinical and economic perspective in addition to their adherence to treatment and QoL according to our literature review. Our findings suggest that the continuous care of T1D represents a high economic impact on households' budgets, even in its cheapest modality (FD). A high percentage of the NMW in 2020 (10,700 DOP) (Hidalgo et al., 2017) is needed for the management of the disease. The total monthly cost of MDI, the most clinically efficient treatment for T1D, represents 147% (15,829.50 DOP) of the NMW. Nonetheless, this modality of treatment is not available at the public level. FD, the only regimen covered by the local public healthcare system, represents 39% of the NMW and is associated with worse clinical outcomes (Alberts et al., 2010; DCCT, 2016). The appraisal of each treatment modality available in the DR, through a micro costing analysis, could identify the economic impact of this disease. It may guide governmental decision-making and contribute to the improvement of national budget management, access to treatment, and quality of life. An economic analysis from the Brazilian public health perspective evaluated the relationship between public investments in health and its benefits in chronic kidney patients' clinical outcomes. Their findings showed an inversely proportional relationship between mortality rate and budgetary investment per patient, suggesting that public investment in health leads to potential benefits over chronic patient's life indicators (Loesch et al., 2020).

Available health insurance packages for the Dominican T1D population are insufficient, which might increase out-of-pocket spending rates. This was evidenced by 56% of the sample reporting less than 25% of expenses coverage and 93% of acquiring supplies by their means (funds/resources). This fact may affect treatment adherence and disease management. When comparing the family income of < 40,000 DOP versus > 40,000 DOP, the former showed less supply acquisition (P= 0.016), administration of lower than recommended doses of insulin (P= 0.025), less use of flash glucose monitoring (P= 0.012), and more cost-related factors limiting adequate follow-up of the disease, like diminished seeking of medical attention (P= 0.013). A meta-analysis about pediatric T1D patients showed that treatment adherence is a determining factor in glycemic variability (Hood et al., 2009) associated with higher mortality (Lind et al., 2014). Meanwhile, the mean HbA1c of the lower-income group is 8.1% [10.3 mmol/l] versus 7.3% [9.0 mmol/l] (P= 0.059) in the higher-income one, showing a non-significant but numerical difference. These findings support the association of better glycemic control with a higher socioeconomic level (Hassan et al., 2006).

Limitations in treatment options were also evident. The readily available FD, more commonly used by the lower-income population, has a poor efficacy (DCCT, 2016), constituting a considerable reason to be proscribed. On the other hand, MDI is the most cost-efficient alternative (Wan et al., 2018) and it prevailed in the higher-income group (P= 0.018). It suggests unequal access to treatment, a phenomenon associated with worse outcomes on this disease (Nielsen et al., 2019). Uninterrupted treatment is the key to an efficient therapy in T1D preventing acute and life-threatening complications like ketoacidosis and hypoglycemia. Moreover, a cost-related diminished use of insulin is related to suboptimal glycemic control. Likewise, patients with limited income do not usually discuss issues related to pricing with their doctors, predisposing those with low socioeconomic status to worse clinical management (Herkert et al., 2019).

Average household income and treatment modality were not strong predictors of differences in QoL. Other studies have shown an association between a lower QoL and factors like poor glycemic control, fear of hypoglycemia and complications, and lack of confidence in self-management (Alvarado-Martel et al., 2015; Liu et al., 2020) being higher in FD users. This suggests that a subsidized alternative of MDI could improve QoL, decreasing cardiovascular disease probability by 30% and acute cardiovascular events by 32% (DCCT, 2016). Another study about T1D did not report differences in QoL associated with glycemic

variability, even though this study has only evaluated CSII users with optimal management, which represents a significant selection bias (Hoey et al., 2001).

Among the strengths of the study, we include the multidisciplinary approach based on costs and relating it to treatment and QoL. Being the first local analysis of its kind to our knowledge, we propose its use as a model to study other chronic diseases due to its simplicity. Furthermore, it can serve as a guide to similar studies in other countries in the region and promote awareness on the importance of health economics to the Dominican healthcare system. On the other hand, the absence of standardized epidemiological data on the disease makes it difficult to accurately estimate the national impacts and to determine the correct sample size. Similarly, our conclusions were restricted by multiple factors, such as limited internet access of the very-low socioeconomic patients, the subject being unwilling to invest their time with the instrument, social media access, and heterogeneous distribution of the questionnaire. Also, limiting the study to direct costs could underestimate the economic impact, and therefore we recommend further studies to include indirect costs. It is fundamental to consider that this analysis has been designed and performed during the COVID-19 pandemics, which in fact has led to several limitations, including the data collection strategy and recruitment.

It is common for LATAM countries to guarantee free diabetes treatment in their respective public health systems, such as Brazil (Ministério de Saúde, 2019), Argentina (PRODIABA, 2020), Colombia (Ministerio de Salud de Colombia, 2020), and Mexico (excluding blood glucose test strips) (Instituto de Seguridad y Sevicios Sociales, 2016). These countries have limited healthcare budgets but incorporate technologies and treatments to their public health system under both clinical and economic effectiveness criteria, providing full treatment coverage to their citizens. As previously described, DR's government contribution to the health sector is lower when compared to other countries with similar macro and socioeconomic realities (Digepres, 2020; Rathe et al., 2011). Investment in programs that aid patients is directly associated with better clinical indicators, fewer complications, and lower out-of-pocket spending, while less public support is related to more complications and more costs to the system (Musich et al., 2001). Furthermore, an analysis by the International Monetary Fund showed that investment in health programs has a potential positive impact in other sectors, such as education and the economy (Clift et al., 1998). Our preliminary findings suggest that treatment adherence of T1D may be affected by economic factors and increased public coverage of treatments and/or diagnostic would improve the quality of life of type 1 diabetes patients in the Dominican Republic.

CONCLUSION

T1D patients are a population exposed to a high monthly economic impact. This limits treatment efficacy, worsens adherence, and potentially decreases the quality of life, especially in the lower socioeconomic status population, with potential direct consequences in morbidity and mortality. The Dominican healthcare system has poor indicators concerning the attention and support to chronic diseases, being below the regional standards. The potential accumulated negative impacts over time can result in a greater expense for the state. Measures are needed to mitigate the human and economic impacts of these consequences.

We, therefore, propose that an effort to enhance economic support, along with diabetes education, clinical management, and treatment adherence must be made as a starting point to decrease direct and indirect costs, and consequently increase treatment efficacy and decrease morbidity and mortality.

This type of analysis can be used to monitor progress in the DR in the future and is also useful as a methodology to guide other countries to public health decisions informed by cost-efficiency and clinical outcomes.

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Conflict of Interests

One of the authors is part of the Baxter Hospitalar LTDA, a hospital products industry based in São Paulo, Brazil. We hereby declare that the company did not finance this study, is not involved in the worldwide diabetes market, and has authorized its employee participation as an independent author according to Baxter's Ethics and Compliance rules. Two of the authors are type 1 diabetes patients while the rest of the authors declare no conflict of interest.

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