Exploring cost drivers to improve disease management: the case of type 2 diabetes at a tertiary hospital in Burundi, Africa

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Abstract

Background. In Burundi, the International Diabetes Federation estimated the prevalence of diabetes mellitus (DM) as high as 2.4% in adults aged between 20 and 79 years old. Thus, the healthcare expenditure for the treatment of diabetic patients is considerably high.

Objective. This study explores the economic burden of type 2 DM and its cost drivers at a tertiary hospital in 2018. It included adult type 2 DM patients who received treatment from a tertiary hospital (Hospital Prince Regent Charles) in 2018. In this study, 81 patients were included.

Methods. Data on illness treatment and complications were collected through patient interviews and by reviewing patients' medical and financial records. A stepwise multiple linear regression model was used to explore factors affecting the cost of type 2 diabetes mellitus.

Results. The average total cost per patient per year was estimated at $2621.06. The fitted cost model had an adjusted R^2 of 0.427, which explained up to 43% of the variation in the total cost. The results suggest primary cost drivers such as treatment regimen, duration of the disease, payment method, and number of complications.

Conclusion. The findings confirm the profound economic burden of type 2 DM and the need to improve patient care and prevent disease progression. The establishment of a special clinic for patients with diabetes is recommended, as is financial support for underprivileged patients. A specific focus on cost drivers could help establish appropriate disease management programs to control the costs for type 2 diabetes patients.

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Introduction

Type 2 diabetes mellitus (DM) accounts for over 90% of all diabetes types, creating a heavy burden worldwide.[1] In Burundi and most African countries, epidemiological data on DM are rare. The International Diabetes Federation estimated a DM prevalence of 2.4% in adults aged between 20 and 79.[2] The demographic health survey conducted during 2016-2017 revealed that, out of 75,552 men between 15 and 59 years old and 17,269 women between 15 and 49 years, 0.5 and 0.3% respectively, had been diagnosed with DM by a health professional.[3] However, the undiagnosed cases of type 2 DM are significant.[4]

Alongside DM, endemic communicable diseases such as malaria, HIV/AIDS, and tuberculosis accentuate the health burden, especially in low-middle-income countries with fragile healthcare systems such as Burundi.[5] Similar to many other African countries, Burundi has a healthcare sector human resource problem. Most medical doctors (50.5%) and nurses (21%) practice in Bujumbura, the former capital city, and most Burundian households use out-of-pocket funds for their health expenses, which limits their healthcare access because of the low purchasing power. The government launched a health insurance card in 1984, but it is only accepted in specific public health facilities because of late reimbursement. Public insurance for government officers covers around 80% of healthcare expenditures. The remaining expense is paid either by the patients or the Ministry of Health for health workers. Children under 5 and pregnant women receive health services free of charge in public hospitals.[5] Glycemic control is challenging for diabetes patients because of the high costs of treatment and monitoring,

which increases the risk of developing microvascular and macrovascular complications.[6] The HbA_{1C} test is a useful tool for glycemic control and helps prevent DM complications;[7] however, it is expensive and only available in a few hospitals. Consequently, the prevention of DM complications is challenging.

A cost of illness (COI) study measures the economic burden of diseases on society and healthcare providers or payers as monetary value. COI analysis includes direct costs that represent all expenditures used in treatment and indirect costs that represent the productivity loss of both patients and informal caregivers due to morbidity and mortality.[8] The systematic review of the economic burden of DM conducted by Mutyambizi *et al*. assessed the costs associated with DM in different African countries,[9] showing the burden in Africa to be immense. In Nigeria, the DM national direct costs ranged from $3.5 to $4.5 billion *per annum*, while in Morocco, the DM national direct and indirect costs ranged from $5.9 to $8.2 billion *per annum*.

This study is the first to estimate the economic burden of type 2 DM and explore the cost drivers for its treatment in Burundi, Africa. The results help increase awareness among the public and policymakers regarding the economic impact of the disease on society and healthcare providers. Healthcare workers could use the results to improve disease management programs for DM patients, thereby preventing DM-related complications and increase in healthcare expenditure.

Materials and Methods

Study design

This is a prevalence-based COI study employing a bottom-up approach. The prevalence-based COI includes the costs of all patients and treatment during the study period. The bottom-up approach involves collecting the costs of medical services received by individual patients. The study was conducted from the societal perspective that costs cover direct medical, direct non-medical, and indirect costs. The scope includes the treatment of illness and its complications.[10]

Study site and population

This study was conducted at a 600-bed public tertiary hospital, Hospital Prince Regent Charles (HPRC), inaugurated in 1949 and situated in the Mukaza commune of Bujumbura Mairie, the former capital city. The HPRC has autonomy but receives subsidies from the government.[11] The patients were selected for the study if they: i) were identified to the International Classification of Diseases, tenth revision (ICD-10 codes: E11.0-E11.9);[12] ii) received type 2 DM treatment at HPRC from January 1 to December 31, 2018; iii) received treatment for type 2 DM for at least one year; iv) aged 18 or above; v) willing and able to provide written informed consent and complete the questionnaire interview.

Eligible patients included outpatients and inpatients, and patients with incomplete medical records were excluded from the study. The sample size for the cost function is determined as:

$$n \text{ (at least)} = 10 \times IV$$

where n is the sample size and IV is the number of potential predictor variables.[13] The number of potential predictor variables was based on the characteristics of the study sample: the COI of type 2 DM is associated with diabetes-related complications, insurance schemes, duration of disease, and treatment regimen. Therefore, 9 independent variables were included and the minimum sample size was 90.

Patient recruitment and data collection

Cost data were collected over 2 months (November and December 2019). The recruitment process was performed in 2 steps. The first was reviewing the medical records from the hospital's electronic database to collect direct medical records for the study year. The second was contacting the selected patients either during routine visits to the hospital or in a telephonic interview during November and December 2019.

For direct non-medical and indirect costs, the patients or their caregivers were interviewed face-to-face in the hospital using a questionnaire designed by the researchers. The questionnaire included questions concerning demographics, diabetes characteristics, existing type 2 DM complications, treatment history, and a self-estimation of the meal cost, transport fees, accommodation cost, and caregiver time loss while visiting the hospital. The data were recalled two months after the interview.

Cost calculation method

The total direct medical cost was the summation of the treatment costs of outpatients and inpatients. The treatment cost included the costs of medical services (outpatient visits, inpatient visits, emergency services, and laboratory tests), drugs, and other materials, obtained by multiplying the quantity of each utilized service by their unit costs. Due to the limitation in estimating the unit cost of the hospital's services, different references were used for each unit cost. Routine services such as outpatient department visits and hospitalization costs were obtained from WHO-CHOICE,[14] the unit cost of laboratory tests from the proxy unit costs of the private market, and the unit costs of drugs and medical supplies from the purchasing price of the hospital. Patients' payments for additional treatment, such as drugstore medications, were also included.

The total direct non-medical cost was the summation of the transportation cost, meal cost, accommodation fees, and informal caregiver productivity loss. The time spent by informal caregivers was provided by the study participants either in hours per day or in days per month, according to the services provided. The opportunity cost method was used to evaluate informal care.[15]

Regarding indirect costs, the cost of time loss of patients related to treatment and recovery period at home, a human capital approach was used. The mortality cost (cost of death cases) was estimated considering the number of deaths among participants during the study period. Permanent disability was estimated for patients who reported that they were unable to work due to their disability. The Barthel index (BI) score was used to assess the severity of disability and the cost of time loss was included in the working age of the patients. In Burundi, the official working age ranges from 18 to 60.

To convert the time loss of caregivers and patients into the cost of time loss or productivity, the human capital approach was used. The gross national income (GNI) *per capita* was used as the base for the calculations.[16] A constant 3.28% growth rate of the GNI *per capita* was utilized to calculate income in future years.[17] A 3% discount rate was used to convert future earnings to the current value.[18] All costs were assumed to be the same for each month and the obtained cost was multiplied by 12 to cover the past year.

One-way sensitivity analysis was performed to analyze the uncertainty of the results due to the wide variation in drug prices from brand-name to generic drugs. Therefore, the minimum and maximum prices of each drug were chosen to recalculate the cost. The estimate of the drug price range was obtained from a private drugstore near the hospital.

All costs are calculated in BIF (Burundian franc) prices for 2018 and then converted to international dollars (Int$1=651BIF).[19]

Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics version V21.0. Descriptive statistics were used to summarize data on demographic characteristics, clinical status, and costs. Stepwise multiple linear regression was used to explore the factors influencing cost.[20] As cost data were not normally distributed, the data were transformed using natural logarithms. Model diagnostics were applied to examine the quality of cost functions. The unstandardized coefficient was multiplied by the average value of each predictor to calculate the log cost. The log cost was retransformed using the exponential form and then adjusted by the smearing factor, which is the average of the exponential values of unstandardized residuals.[21] For all statistical significance tests, the P value was set below 0.05, for a confidence interval of 95%.

Ethical considerations

The study protocol was approved by the Institutional Review Board of the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University (COA.No.MU-DT/PY-IRB 2019/072.2210). Written consent was obtained from participants. The coded data collection method was applied to protect the personal data and confidentiality of participants. No photos or recordings were taken.

Results

Demographic and clinical characteristics of participants

A total of 99 patients were included in the review of medical records from HPRC. Of these, 81 were interviewed and included in the final analysis. The average age of the 81 included patients was 52.16 years [standard deviation (SD)=13.65], and women represented 54.3% of the sample population. Most patients had a primary level of education (32.8%). Unemployed patients and public employees had the same representation of 22.4%, and 20.9% were agriculturists. Most patients (43.2%) had no insurance. The Mutuelle de la Fonction Publique (MFP), an insurance scheme for public employees, covered 28.4%, while the Ministry of National Solidarity, Human Rights, and Gender provided financial assistance to 17.3% of patients.

Patients visited the outpatient department 3.78 times a year on average (SD=4.63). The number of hospitalized patients was 51 (62.9%). The yearly average number of hospital admissions per patient was 0.81 (SD=0.85), with an average length of stay of 17 days (SD=26.14). The average length of stay among the admitted patients (66 admissions) was 21 days (SD=28.5). Most patients had no complications (50.6%). Patients with type 2 DM for 1-10 years represented 59.7%. The disability measured by the BI showed that 83.6% were independent patients and 9.0% had a permanent disability. There were 14 deaths reported (17.3%) during the study and their direct costs were included.

The unit cost of major services and resource utilization

As per Table 1, Actrapid and Mixtard were the drugs of choice at the hospital, with usage percentages of 49.5 and 31.3%, respectively. Most patients (90.9%) had their glucose levels measured through fasting plasma glucose tests and only 36.4% used glycated hemoglobin HbA_{1C}. The serum creatinine, serum urea, and albuminuria tests were the most commonly used tests for the diagnosis and control of nephropathy. Inpatient services were provided for 80.9% of the patients and emergency services for 65.7%, and 20.2% of patients were referred to receive hospitalization services without routine outpatient follow-up services.

Description of cost from a societal perspective

Due to cost data skewness, the medians and quartiles were reported together with the means. The total cost per person per year for type 2 diabetes during 2018 was estimated at $2621.06. The direct medical cost (DMC) accounted for 39.3% of the total COI, with an average cost of $1029.47. Among the considered DMC components, drugstore medication had the highest percentage (17.8%), with an average cost of $465.53. The direct non-medical cost was 6.1% of COI. The average cost was $159.49. The meal cost was the highest compared to other components. The indirect cost was 54.6% of the COI, with a total cost of $116,000.23. The mortality cost represented the highest percentage of permanent disability and morbidity costs. All costs are listed in Table 2.

Cost function formulation

The impact of independent variables, namely demographic

Table 1. Unit cost of major services and resource utilization (2018 prices) (n=99).

Resource utilization	n (%)	Unit	Unit cost (Int$)
Hypoglycemic drugs			
Actrapid 100 UI/ML	49 (49.5)	1 vial-10 mL	22.16
Mixtard 30 HM 100 UI/ML	31 (31.3)	1 vial-10 mL	16.92
Insulatard 100 UI/ML	8 (8.1)	1 vial-10 mL	22.16
Medical materials			
Examination gloves	99 (100)	1 pair	0.65
Disposable needle	91 (91.9)	1 piece	0.11
Alcohol pads	91 (91.9)	1 piece	0.15
Insulin syringe	90 (90.9)	1 piece	0.34
Laboratory tests			
Fasting plasma glucose	90 (90.9)	1 test	7.68
Serum creatinine test	71 (71.7)	1 test	6.14
Serum urea test	70 (70.7)	1 test	6.14
Albuminuria test	45 (45.5)	1 test	4.61
Glycated hemoglobin HbA1C	36 (36.4)	1 test	49.15
Routine services			
Inpatient visits	80 (80.8)	1 bed day	5.28
Outpatient visits	79 (79.8)	1 visit	1.72
Emergency visits	65 (65.7)	1 visit	1.72

characteristics such as insurance schemes and clinical characteristics such as duration of disease and types of complications, on the dependent variable COI of type 2 diabetes patients was analyzed. The potential predictor variables are listed in Table 3.

The fitted cost model had an adjusted R^2 of 0.427 (crude R^2=0.462), meaning the model explained up to 43% of the variation in total COI (Table 4). The significant predictor variables were insulin therapy, duration of disease between 21 and 30 years, more than 2 complications, and insurance covered by the Ministry of National Solidarity, Human Rights, and Gender. To adjust the retransformation bias, the smearing factor was multiplied by the fitted value. The smearing factor is the average of the antilog forms of the unstandardized residuals.[21] The smearing was 1.0391 for the fitted model.

The analysis of the COI prediction model resulted in a scatter plot of residuals against predicted values and all independent variables showing no funnel shape. Therefore, the variance was homogeneous in the model. The Durbin-Watson value was 2.040, meaning the model met the assumption of independence of the residuals (criteria=1.5-2.5).[22] There was no multicollinearity because the condition index was below 15 (2.408) and no influential observations were found as Cook's distance ranged between 0.000 and 1.235 with a mean of 0.053 (criteria<1). The smearing factor (1.0391), the mean of the antilog of the residuals, was used to adjust the estimated expected response after the multiple linear regression.[20]

The predicted cost per person per year by demographic and clinical status is presented in Table 5. The model predicted a 43% increase in the COI for the patients on insulin therapy compared to the others. There was a 37% increase in the number of patients living with type 2 DM for more than 20 years. The number of patients covered by the Ministry of National Solidarity, Human Rights, and

Table 2. Cost of illness for diabetes ($ in 2018 prices) (n=81).

Type of costs	Cost (%)	Mean (SD)	Median	Percentile 25-75
Direct medical cost	83,386.84 (39.3)	1029.47 (932.29)	777.48	483.88-1,367.77
Drug and material supply cost	21,325.56 (10)	263.28 (638.42)	113.51	18.71-303.18
Investigation cost	16,515.38 (7.8)	203.89 (230.95)	161.28	50.69-272.64
Routine services cost	7,838.35 (3.7)	96.77 (137.99)	52.75	6.89-105.50
Drug purchased from the drugstore	37,707.55 (17.8)	465.53 (256.02)	477.38	243.30-758.16
Direct non-medical cost	12,918.90 (6.1)	159.49 (182.62)	107.36	44.24-196.85
Transport cost	1,324.32 (0.6)	16.35 (33.07)	4.92	2.46-9.83
Meal cost	8,663.54 (4.1)	106.96 (124.17)	70.96	26.11-132.71
Accommodation cost	0	0	0	0
Informal caregiver time loss	2,808.15 (1.3)	34.67 (53.92)	18.38	0-40.85
Cost of personal facilities	122.88 (0.1)	1.52 (13.65)	0	0
Indirect cost	116,000.23 (54.6)	1432.10 (4,863.39)	20.76	1.36-56.33
Morbidity cost	3026.42 (1.4)	37.36 (55.66)	20.42	1.36-40.85
Mortality cost	97,152.35 (45.8)	1199.41 (4,773.15)	0	0
Permanent disability cost	15,821.46 (7.4)	195.33 (1129.62)	0	0
Total cost of illness	212,305.97 (100)	2621.06 (5087.68)	955.77	603.26-1,844.78

SD, standard deviation.

Table 3. Potential predictor variables.

Code	Variable definition	Value and definition
Dependent variable		
LnCOI	Natural logarithm of the total cost of illness in case of type 2 diabetes	Continuous
Independent variables		
Insulin therapy	Treatment regimen	
Duration of illness		Up to 10 years=reference
11 to 20 years	Duration of the disease	1=11-20 years (28.4), 0=other
21 to 30 years	Duration of the disease	1=21-30 years (11.9%), 0=other
Complications		No complication=reference
One complication	Patient's complication	
Two complications	Patient's complication	
More than two complications	Patient's complication	
Insurance scheme		No insurance=reference
Mutuelle de Fonction Publique	Insurance scheme	
Ministry of National Solidarity, Human Rights, and Gender	Insurance scheme	Ministry of National Solidarity, Human Rights, and Gender (14.9%), 0=other

COI, cost of illness.

Gender had a 24% increase compared to the other patients. Patients with more than 2 complications had a 68% increase in total cost. According to the fitted model, the highest costs were for patients on insulin therapy, living with type 2 DM for more than 20 years, with more than 2 complications, and covered by the Ministry of National Solidarity, Human Rights, and Gender as they had a 230% increase in COI compared to the base case.

Discussion

This study is the first prevalence-based COI study aimed at estimating the economic burden of type 2 DM from a societal perspective and evaluating the demographic and clinical factors affecting cost at a tertiary hospital in Burundi. The average annual COI from the societal perspective was estimated at $2,621.06 as per 2018 prices, which is considerably higher than the Burundian GNI *per capita* in the same year ($750).[16] The study hospital is a tertiary one, to which most patients were referred from primary health centers and district hospitals in critical condition, thereby causing a longer treatment period and immense costs. The management of type 2 DM poses a real economic burden on Burundian households, especially for underprivileged patients, such as the unemployed and agriculturists. Agriculture is the principal source of employment (nearly 80% of the population) and it does not generate sufficient income.[23] Most patients (43%) were uninsured and used out-of-pocket money to pay for their health expenditures. The out-of-pocket expenditure was estimated at 28% of the total health expenditure in Burundi in 2012.[24] For some households, such catastrophic health expenditures will cause poverty and hinder healthcare access.

The comparison of costs among different studies considering various countries, methodologies, treatment practices, and healthcare systems is difficult. This explains the wide variation in DM costs in different studies. However, a study conducted in the WHO African region in 2009 used various secondary data, estimating a slightly lower average COI of diabetes from a societal perspective at $2144.3 for countries with a GNI *per capita* below $2000, among which Burundi was included.[25] The average annual COI was estimated to be 3 times higher than the GNI *per capita*. However, in other studies in Africa, the average COI was reported to be 45.5% of the GNI *per capita* in Ghana in 2016, 10.6% in South Africa in 2016,[26] 12.9% in Nigeria in 2012,[27] and 67.2% in Morocco in 2013.[28]

Indirect costs represented the highest proportion (54.6%) of the total COI, which was due to the mortality cost accounting for 46% of total costs. The study hospital registered 14 deaths (of 81 cases) from type 2 DM and its complications during the study period. The proportions of direct and indirect costs varied among studies. A study conducted in India reported a direct cost of 83.6% of the total cost.[29] Similarly, in Iran, Mali, and the WHO Africa region, direct costs represented 49.3, 38, and 31.8%, respectively. The drug and material supply costs were the highest components of the hospital treatment cost, in line with a study conducted in Iran.[30]

The results of the fitted model suggest that the treatment regimen, duration of the disease, payment method, and number of complications affected the total cost of type 2 DM significantly. Insulin therapy greatly increased patients' total COI. Similarly, in a study conducted in five European countries, costs were notably higher for patients on insulin therapy compared to those on non-insulin monotherapy and non-insulin combination therapy.[31] The high costs for patients on insulin therapy can be explained by the high cost of insulin, compared to oral hypoglycemic agents, and the mandatory use of syringes.[32] Although the costs were high for patients on insulin therapy, long-term treatment costs such as hospitalization, outpatient, and laboratory costs were lower.[33] However, insulin therapy is believed to increase the incidence of

Table 4. Fitted cost model (n=67).

Model	Unstandardized coefficients		t	Sig.	95.0% Confidence interval for B	
	B	SE			Lower bound	Upper bound
(Constant)	5.574	0.046	121.602	0.000	5.483	5.666
Insulin therapy	0.355	0.081	4.390	0.000	0.194	0.517
21 to 30 years	0.311	0.120	2.606	0.011	0.073	0.550
More than two complications	0.516	0.219	2.353	0.022	0.078	0.955
Ministry of National Solidarity, Human Rights, and Gender	0.212	0.106	2.002	0.050	0.000	0.424

Adjusted R^2=0.427; probability of F test=0.000; SE=standard error; Sig, significance.

Table 5. Predicted cost of various components (n=67).

Demographic and clinical status	Predicted cost per patient per year ($)	Cost increase ($)	Percentage increase
No insulin therapy	297.8	-	-
Insulin therapy	424.7	129.9	42.6
Duration of disease 20 years or less	322.4	-	-
Duration of disease above 20 years	440.0	117.6	36.5
Without complication	329.4	-	-
With more than two complications	551.9	222.5	67.5
No insurance	324.1	-	-
Covered by the Ministry of National Solidarity, Human Rights, and Gender	400.7	76.6	23.6
Base case	334.6	-	-
Worst case	1,103.6	769.0	229.9

hypoglycemic events, which leads to increased medical costs, especially physician visit costs.[34]

Patients whose medical expenses were covered by the Ministry of National Solidarity, Human Rights, and Gender had a 34.8% increase in predicted COI. The Ministry has an assistance program for those who are unable to afford their medical expenses that only covers medical expenses in public health institutions. The covered patients are usually referred to HPRC from their district hospitals or primary health centers when in critical condition and require long-term treatments that generate high costs, especially hospitalization costs. Similar results were found in China, where diabetic patients with medical insurance had higher hospitalization costs, mostly the costs for laboratory tests and medical services, than those without medical insurance.[35] Longer duration of diabetes increases the risk of developing peripheral arterial disease;[36] therefore, the COI may increase with the treatment of diabetes and peripheral arterial diseases.

These findings highlight the need for appropriate disease management to improve the care for type 2 diabetes patients. Disease management efforts should emphasize the reduction in the number of patients with insulin therapy and with severe complications and prevention of critical conditions when coming to the HPRC by establishing proper health education and health promotion campaigns for both the healthy population and diabetes patients.

Type 2 diabetes is a preventable disease and, to reduce its social and economic burden, interventions focusing on its prevention must be implemented, such as providing information on the prevention and treatment of type 2 diabetes to groups of people at high risk of developing it. The implementation of education programs at community health centers for patients with type 2 diabetes was found to be cost-effective in South Africa.[37] Additionally, the provision of financial aid for type 2 diabetes patients who cannot afford medication, especially insulin, is also needed. The predicted cost related to complications is useful for analyzing the feasibility of cost-benefit analysis of complication prevention programs.

Limitations

There are certain limitations to this study. First, during recruitment, not all patients who received treatment at HPRC in 2018 were successfully tracked down to be interviewed, mainly because of changed contact numbers. Second, the cost was underestimated due to the absence of information on expenditures at health facilities other than the selected hospital. Third, the cost was estimated retrospectively, and there was a lack of crucial information that led to a smaller sample size than expected. Fourth, the lack of specific data on hospital service unit costs resulted in the use of the WHO-CHOICE unit costs of tertiary hospitals in Burundi, which might not be specific to the selected hospital. Fifth, information on some cost items was excluded because of the recall after two months. Sixth, the prevalence of complications here might not represent the actual situation because data were collected by reviewing electronic medical records. As some health professionals did not complete patients' medical records correctly, there was missing information in some cases. Finally, as the study was confined to one hospital, the findings should be generalized with caution.

Conclusions

This study estimated the average COI per diabetic patient at HPRC at $2927.65 in 2018, which was significantly higher than the GNI of Burundi *per capita*. The morbidity, mortality, and permanent disability costs accounted for a significantly high cost and a high economic burden on society. The average treatment cost per patient at HPRC was $501.49, a cost that most Burundians are unable to afford. Therefore, policymakers and healthcare administrators should consider these numbers to tackle the vast healthcare expenditure of the treatment of type 2 DM. Policymakers should also focus on cost drivers to establish appropriate disease management programs for the prevention and improvement of care for type 2 diabetes patients.

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