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The economic burden of type 2 diabetes on the public healthcare system in Kenya: a cost of illness study

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Abstract

Background The burden of chronic non-communicable diseases (NCDs) is a growing public health concern. The availability of cost-of-illness data, particularly public healthcare costs for NCDs, is limited in Sub-Saharan Africa (SSA), yet such data evidence is needed for policy action.

Objective The objective of this study was to estimate the economic burden of type 2 diabetes (T2D) on Kenya's public healthcare system in 2021 and project costs for 2045.

Methods This was a cost-of-illness study using the prevalence-based bottom-up costing approach to estimate the economic burden of T2D in the year 2021. We further conducted projections on the estimated costs for the year 2045. The costs were estimated corresponding to the care, treatment, and management of diabetes and some diabetes complications based on the primary data collected from six healthcare facilities in Nairobi and secondary costing data from previous costing studies in low and middle-income countries (LMICs). The data capture and costing analysis were done in Microsoft Excel 16, and sensitivity analysis was conducted on all the parameters to estimate the cost changes.

Results The total cost of managing T2D for the healthcare system in Kenya was estimated to be US$ 635 million (KES 74,521 million) in 2021. This was an increase of US$ 2 million (KES 197 million) considering the screening costs of undiagnosed T2D in the country. The major cost driver representing 59% of the overall costs was attributed to T2D complications, with nephropathy having the highest estimated costs of care and management (US$ 332 million (KES 36, 457 million). The total cost for T2D was projected to rise to US$ 1.6 billion (KES 177 billion) in 2045.

Conclusion This study shows that T2D imposes a huge burden on Kenya's healthcare system. There is a need for government and societal action to develop and implement policies that prevent T2D, and appropriately plan care for those diagnosed with T2D.

Keywords Type 2 diabetes, Chronic diseases, Non-communicable diseases, Cost-of-illness, Bottom-up costing, Public healthcare system, Diabetes complications, Kenya

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Background

Diabetes mellitus (DM) is one of the nutrition-related non-communicable diseases (NR-NCDs), with overall prevalence estimated to be 8.8% globally in 2021 and predicted to rise significantly to 48.8% by 2045 [1]. Diabetes is ranked as the ninth cause of mortality globally, with over 1 million deaths per year, and it caused 416,000 deaths in Africa in 2021 [1, 2]. More than 90% of diabetes cases are mainly type 2 diabetes (T2D) [3]. Urbanization, propagated economic transitions, sociocultural diversities, and demographic characteristics such as age, and gender have been correlated with the rise in T2D in Sub-Saharan Africa (SSA) [4, 5]. Further, other risk factors such as overweight/obesity, genetic factors, and racial orientation have contributed to the increased incidence of diabetes in SSA [6–10].

In Kenya, there is an upsurge in DM prevalence, as observed in other low- and middle-income countries (LMICs). Approximately 1.8 million adults had diabetes in 2019, and this is projected to reach 2.2 million in 2030 [11]. The overall prevalence of pre-diabetes (glycated hemoglobin (HBA1c) of between 5.7% and 6.4%) and diabetes in Kenya is approximately 3.1% and 2.4%, respectively, with age, raised blood pressure, and increased body mass index (BMI) levels as the notable risk factors [12]. Poor glycemic control among diabetes patients is associated with the occurrence of diabetes complications, estimated to be approximately 34.6% among adults in Kenya [13]. A retrospective analysis of hospital data collected between 2012 and 2016 showed retinopathy, neuropathy, and cardiovascular diseases to be the most common diabetes complications among patients, with a prevalence of 12%, 11%, and 11%, respectively [14], among which diabetes nephropathy is the leading cause of death [15].

The management of T2D and related complications poses economic strain to both patients and the public healthcare system. Globally, the management of diabetes was estimated to cost US$ 966 billion in 2021 and this is expected to rise to US$ 1,054 billion by 2045 [3]. In Africa, this was approximately US$ 13 billion, accounting for 1% of the global expenditure [3], and is projected to double to US$ 59.3 billion per year by 2030 if no action is taken now [4]. Gaps have been identified in the readiness of the public healthcare systems to deliver NCD services in Kenya and other LMICs, and in the allocation of resources. There are notable challenges to the healthcare system in diabetes care and prevention in SSA, hence a need to incorporate policies to enhance continuity of care for chronic illnesses [16].

Most of the studies conducted in LMICs have mainly focused on the economic burden of diabetes on patients and their families [17, 18]. These costing studies, using the patient perspective, have reported medication costs and diabetes complications as the main driver of catastrophic expenditure among patients and caregivers in Kenya [17, 19], whereas studies from another study conducted in Kenya showed a significant burden of DM using the societal perspective found indirect costs such as productivity losses to major cost drivers [20]. A similar study conducted in a refugee hospital on the cost of managing uncomplicated DM to the healthcare system found diagnostics and outpatient consultation costs as the main cost drivers [18]. A study on public healthcare in the management of T2D in South Africa found that 49% and 33% of the overall expenditure were allocated to T2D complications and medications, respectively [21].

While there are studies on the economic burden of diabetes in Kenya, none of the studies has estimated the total burden of T2D on Kenya's public healthcare system including costs of T2D without complications and T2D with complications. Therefore, this study contributes to the literature by estimating the economic burden of T2D on Kenya's public healthcare system in the year 2021. Such analysis is useful to inform policy on the prevention, care and management of T2D in Kenya.

Methods

Setting

This study was conducted in Kenya, focusing on the overall cost implications of T2D to Kenya's public healthcare system. The prevalence and the related complications in the country were considered, while the unit costs were extracted from costing studies conducted in Kenya and comparable countries in the LMICs category. The majority of patients in Kenya utilize primary and secondary healthcare facilities, which are majorly supported and funded by the government. These facilities were included to give estimates of the costs incurred by the public healthcare system in Kenya for the care and management of T2D.

Costing approach and perspective

This study estimated the annual direct costs of managing T2D from the perspective of the Kenyan public healthcare system using a prevalence-based standard cost-of-illness (COI) approach [18, 20, 21]. The costs of the inputs used in managing T2D were estimated through the ingredient-based (bottom-up) costing technique that involved identifying the relevant inputs utilized in managing T2D, their quantities, and unit prices [22].

Data sources

Both primary and secondary data, all gathered retrospectively, were employed in the costing exercise. The secondary data originated from a variety of sources. After secondary data abstraction was completed, primary data

collecting was carried out to fill any gaps in the secondary data.

Primary data collection

Sampling for primary data collection

Primary data was collected from six public health facilities in Nairobi County. These public health facilities were purposely sampled to include facilities from various levels (level II, level III, and level IV facilities) as defined in Kenya's health pyramid [23]. The level II facilities offer primary healthcare services, and curative and preventive outpatient services to an average of 10,000 people [23]. Level III facilities offer outpatient services to approximately 30,000 people in their catchment areas, while Level IV facilities act as primary referral hospitals providing both outpatient and inpatient services [23]. The following were the inclusion and exclusion criteria for the facilities:

Inclusion criteria

1. Public health facilities that offer routine diabetes treatment and management services.
2. Facilities that were easily accessed/ mostly preferred by patients, and had a sufficient flow of patients in need of T2D services.

Exclusion criteria

1. Facilities that did not offer diabetes treatment and management.
2. Facilities whose administration did not permit the data collection activities.

The facilities included two level II facilities (Karen Health Center and Kibera District Office Health Center), two-level III facilities (Riruta Health Center and Mathare North Health Center), and one level IV facility (Mbagathi Hospital). Upon identification of the facilities, a purposive sampling approach was used to select the eligible study participants who were healthcare personnel at the facility. The following inclusion and exclusion criteria were utilized to select the healthcare staff in the facilities:

Inclusion criteria

1. Staff who routinely cared for offered T2D patients in the selected facilities
2. Staff from the selected facilities.

Exclusion criteria

1. Healthcare staff who did not consent to participate in the study.

The staff cadres included clinical nursing officers (15), community health volunteers (1), community nurse dieticians (2), nutritionists (4), medical officers (4), dispensing pharmacists (4), and lab technologists (5). We asked the healthcare personnel questions related to the last 30 patients they saw, either outpatient/ inpatient and the kind of services they received from the facility.

Data collection instruments

Both primary and secondary data were gathered using specifically designed quantitative instruments between April to September 2022 (Supplementary file 1). These instruments were designed following the clinical guidelines for T2D management in Kenya [24] and the WHO tools and guidelines for costing NCDs in LMICs [25, 26] (Supplementary file 1). The instruments were adapted after consultations with a wide range of experts including the African Population and Health Research Center (APHRC) costing experts, NCD coordinators, the research team at the Kenyan Ministry of Health (MOH), medical practitioners, and nurses. Pilot testing was done to ensure the appropriateness of the instrument for the study. The primary data were collected employing a survey conducted at a few Kenyan healthcare facilities, entailing direct interviews with health personnel regularly treating patients with T2D. The secondary data was collected, from July 2022 to December 2022, using a data abstraction form. Before the extraction of the secondary data, the data abstraction form was reviewed and validated by the research team.

Collected data and data collection procedures

The primary data collection aimed to capture the costs borne by the health facilities in treating T2D and related complications. The first questionnaire was administered to healthcare service providers, to collect data on the individual items used in treating patients. The items included drugs, lab supplies, and personnel costs. The second questionnaire also gathered the number of T2D by type of complication and frequency of health service use in a year, unit costs of seeking care, costs of healthcare resources used (e.g., consultation, testing, medication, etc.), and ambulatory services. Reviews of the relevant registers in selected facilities were also conducted to assess the throughput of patients treated in each health facility for T2D and its related complications. Quantities of drugs and medical supplies used in diagnoses, consultation, testing, and treatments were gathered through interviews with health personnel. The testing equipment cost included a blood lancet, disposable, blood taking set with needle, disposable, ethanol 70% denatured, 1-liter

gauze compresse 5*5 cm (per 5 pieces), HbA1c, renal function tests, and urine collecting container/bag. The drugs, which were routinely prescribed to T2D patients in these facilities included, glibenclamide, insulin premixed (ultra-short acting+intermediate-acting), insulin short-acting (soluble), insulin, ultra-short-acting rapid, and metformin. Health personnel wages attributed to diabetes were calculated based on the estimated time spent with T2D patients in diagnosis, treatment, and management of the condition.

Table 1 Unit costs and data collection sources

Data category	Parameter	Source of data	Source of unit costs
T2D without complications			
Staff time	Average cost of time spent with a patient(inpatient/outpatient)	Primary data collection	WHO, 2012 [25]
Drugs/ Medication	Average dosage to a patient (inpatient/outpatient)	Primary data collection	KEMSA Drug Price list (2016) [27]
Lab Requirements/ Equipment	Average units used	Primary data collection	KEMSA Drug Price list (2016) [27]
Screening	Average screening in 2021 by hospital level	Primary data collection	Subramanian et al. (2018) [19]
Overheads	Annual average overheads costs	Primary data collection	Masis et al. (2022) [18]
Hospital visits	Annual hospital visits	Bertran et al., (2021)	Subramanian et al. (2018) [19]
T2D with complications			
Foot Ulcer	Average annual costs Cost per inpatient/outpatient visit/ episode -$69.95	Subramanian et al. (2018)	Rigato et al., (2016) [29]
Retinopathy	Average annual costs Cost per inpatient/outpatient visit/ episode- $94.45	Subramanian et al. (2018)	Ochoki et al., (2020) [28]
Nephropathy- Dialysis	Average annual costs Dialysis (2 sessions per week per patient for one year) ($)5338	Subramanian et al. (2018)	Ochoki et al., (2020) [28]; Subramanian et al. (2018) [19]

Secondary data collection

Secondary data extraction was conducted to determine the T2D prevalence and the associated unit costs per patient for T2D. We recorded the date, specific population and age groups from previous studies and the year in which the respective unit costs were determined. The International Diabetes Federation Surveys [3], as well as the published studies on diabetes that are displayed in Table 1, were among the sources from which statistics and distribution of T2D were gathered. The retained studies were all conducted between 2012 and 2022. Unit costs of drugs and medical supplies were obtained from Kenya's Essential Drugs price list (KEMSA drug list) [27]. Due to the limited secondary data on T2D complications, only three T2D complications, including foot ulcer, nephropathy, and retinopathy, were analyzed.

The prevalence of T2D without complications was extracted from the international diabetes federation report 2023 for age groups between 20 and 79 years [3]. The IDF reports data from different sources including national health surveys such as the World Health Organization STEPS survey and peer-reviewed publications [3]. The data extracted from this source also included the prevalence of undiagnosed cases of T2D in Kenya [3]. Table 1 shows the prevalence of T2D with and without complications, with specification of the individual diabetes complications [14, 28, 29]. The individual diabetes complication prevalence was accrued from peer-reviewed articles from Kenya and comparable countries (LMICs). We further extracted the number of hospital visits for T2D without complications, diabetic foot ulcers, diabetic retinopathy, and diabetic nephropathy from a cost-effectiveness study conducted in SSA and South-East Asia, as indicated in Table 1 [26].

Cost analysis

Unit cost of screening and managing T2D

The unit cost of screening for T2D, and treating T2D with and without complication was obtained by estimating the average costs of screening for T2D, and treating a case of T2D with and without complication. The unit cost of screening for T2D was obtained from a previous study conducted in Kenya [19]. The unit cost of treating a case of T2D with complication was estimated as the average cost of managing T2D complications considering the prevalence of T2D complications included in the study. The unit cost of treating a case of T2D without

complication was estimated as the average cost of managing T2D considering the prevalence of T2D in Kenya.

Annual costs of managing T2D

The annual cost of the management of T2D to the healthcare system was calculated as the total of all the direct costs incurred in screening and treating T2D with and without complications using the following formulae:

$$Tc_y = \sum [(Us_y \times Pop_{sy}) + (Uw_y \times Pop_{wy}) + (Uc_y \times Pop_{cy})]$$

Where Tc_y refers to the total direct *medical* and non-medical cost to the healthcare system for screening and managing T2D in year y; Us_y, Uw_y and Uc_y refer to the unit costs of screening for T2D, treating a case of T2D without complication, and treating a case of T2D with complication, respectively. Pop_{sy}, Pop_{wy} *and* Pop_{cy} refer to the respective populations of individuals screened for T2D, without complications, and with complications treated in year y. y represents the year for which costs are estimated, with 2021 being the reference year. The direct medical costs further comprised the costs of healthcare seeking and healthcare utilization like consultation, testing, medication, and personnel. Non-medical costs included the overheads costs of the health facilities.

The annual costs for the treatment of T2D with complications were obtained as the total of the treatment costs of three complications of T2D including foot ulcers, nephropathy and retinopathy. Furthermore, the total number of cases of T2D by type of complication was obtained by multiplying the estimated total number of T2D with complications by the respective prevalence rates from different studies [30]. The annual costs of treating a given complication of T2D for the entire country were obtained by multiplying each unit cost by the total number of individuals presenting with the same complication. The annual costs of screening for T2D were obtained by multiplying this unit cost by the total population that suffered from T2D in 2021.

Because a significant proportion of diabetes cases are undiagnosed, we also estimated the total cost if those who are undiagnosed are taken into account [12]. Therefore, we added the costs that will accrue if undiagnosed people are diagnosed and put on treatment. Because of these, the findings disaggregate costs into those borne by the healthcare system T2D screened and treated in 2021, and also the costs to the system if those undiagnosed T2D cases are to be screened and treated. All the unit costs and total costs were appropriately adjusted for inflation and thereafter converted from Kenyan Shillings (KES) to US dollars (US $), using the average conversion rates from the central bank of Kenya for the year 2021 (KES109.67) [31]. We used the Consumer Price Index (CPI) to adjust the costs using the year 2017 as the base year in comparison to the year 2021 [21, 31]. Table 1 shows the source of the costs and individual indicators. Data capture and costing analysis were conducted using the Microsoft Excel 2016 software.

Sensitivity analysis and cost projections

Costing assessments are prone to errors, in part due to uncertainties surrounding some input parameters. Sensitivity analyses are common exercises undertaken by costing evaluators to take into account the uncertainties surrounding the cost parameters [32]. A sensitivity analysis was performed to understand the effects of the variation in selected model parameters and their subsequent impacts on the annual costs of T2D for the healthcare system. The sensitivity analysis focused only on cost parameters, and cost parameters were varied by ±20% from their central values [21, 32]. We also performed cost projections based on the predicted prevalence of T2D in Kenya in the year 2045 [3, 21].

Analysis of the burden of T2D

To assess the burden of the management of T2D in relation to Kenya's Ministry of Health (MOH) budget, an analysis of the burden of the costs associated with screening and treating T2D with and without complications was conducted. To do this, the estimated total cost managing T2D was expressed as a percentage of the MOH budget, which is estimated to be KES 130.4 billion equivalent to US$ 130,004 million in 2020/2021 [33].

Ethical consideration

The study protocol was approved by the AMREF-Health Ethics and Scientific Review Committee (ESRC) in Kenya (ESRC/P901/2020) and the National Commission for Science, Technology, and ss (NACOSTI) (NACOSTI-P/22/19104). Informed written consent was sought from the healthcare personnel recruited in the study. All analyses were performed in line with ethical guidelines and applicable regulations in Kenya.

Results

Prevalence of T2D and complications

Table 2 shows the calculated prevalence estimates. The total number of DM patients in Kenya was estimated to be 821,500 in 2021, with T2D accounting for 90% of these cases (N=739, 350) [3]. Of this, the number of T2D patients with complications was estimated at 289,990 with an overall prevalence of T2D complications of 35% [13]. The remaining i.e. 531,511 consisted of T2D patients without complications [3, 13]. The findings also show that 37,699; 134,845 and 20,299 patients were estimated to present with diabetic foot, diabetic retinopathy, and diabetic nephropathy, respectively.

Table 2 T2D and complication prevalence estimates

Description	Prevalence/ Number	Source
Total number of T2DM cases in Kenya	**821,500**	IDF 10th Edition-2021 [3]
Percentage of T2D patients with complications (%) **	35.30	Otieno et al., 2021 [13]
Percentage of T2D patients without complications (%) **	64.70	Calculated
Number of T2Dm patients with complications	289,990	Calculated
Number of T2Dm patients without complications	531,511	Calculated
Diabetes Complications prevalence in Kenya **		
Foot ulcers/ Diabetic foot (%)	13	Rigato et al., (2016) [29]
Number of patients with foot ulcers in Kenya	37,699	calculated
Diabetic retinopathy (%)	46.50	Ochoki et al., (2020) [28]
Number of patients with retinopathy in Kenya	134,845	Calculated
Diabetic nephropathy (%)	7	Ochoki et al., (2020) [28]
Number of patients with nephropathy in Kenya	20,299	Calculated
Undiagnosed T2DM estimates		
Number of patients with undiagnosed DM patients	358,700	IDF 10th Edition 2021 [3]
Proportion of T2DM patients in Kenya	90%	IDF 10th Edition 2021 [3]
Number of patients with undiagnosed T2DM	**322,830**	Calculated

** Based on the total number of T2DM patients in Kenya

Table 3 Total cost of the management of T2D for the healthcare system in 2021

	Unit Costs (KES)	Unit Costs (USD)	Total Cost (KES)	Total Costs (USD)	Percentage
	Investigation of suspect cases of T2D				
Screening	609.95	5.56	10,611.72	96.76	15.29
Total 1	***609.95***	***5.56***	***10,611.72***	***96.76***	15.29
	T2D without complication				
Staff time	129,907.26	1,184.53	8,630.88	78.7	12.44
Drugs/medication (total)	3,090.37	28.18	6,570.26	14.98	2.37
Glibenclamide	34.74	0.32	18.47	0.17	0.03
Insulin	3,044.98	27.76	1,618.44	14.76	2.33
Metformin	10.65	0.10	5.66	0.05	0.01
Lab requirements/ equipment	2,044.57	18.64	4,346.84	39.64	6.26
Overheads costs	273,380.23	2,492.75	57.02	0.52	0.08
Total 2			***21,247.57***	***148.82***	**23.52**
	Diabetes with complications				
Foot ulcer	8,619.39	72.04	1,299.76	11.85	1.87
Retinopathy	11,638.33	97.27	4,708.11	42.93	6.78
Nephropathy- Dialysis	657,759.58	5,497.36	13,352.04	121.75	19.24
Nephropathy-Transplant	1,138,202.56	9,512.77	23,104.68	210.67	33.29
Total 3			***42,464.59***	***387.2***	***61.19***
Grand total			**74,323.88**	**632.78**	**100.00**

All costs are in millions

Total costs for the management of T2D

Table 3 shows the total costs of managing T2D in the healthcare system in Kenya in 2021. The findings suggest that the total cost for screening and treating T2D with and without complications was equivalent to US$ 633 million (KES 74,324 million) in 2021. The total cost for the management of T2D with complications was US$ 387 million (KES 42,465 million), accounting for approximately 59% of the overall costs, while that for the management of T2D without complications was US$ 149 million (KES 21, 248 million). Among the T2D complications, the management of nephropathy had the highest burden on healthcare system resources, with an estimated cost of US$ 332 million (or KES 36, 457 million).

Looking at the distribution of the cost of T2D without complications by cost lines, the findings show that the personnel costs (i.e., staff time, salaries, and benefits) were the main cost drivers, accounting for 12% of the required resources. Costs of laboratory diagnostic tests and equipment appeared to be the second cost driver of the total costs required for the management of diabetes without complications (Total 2).

Total costs of T2D considering the screening of undiagnosed cases

Table 4 reports the total costs of the management of T2D to the healthcare system in Kenya considering that the unscreened cases of T2D are diagnosed and treated. The findings suggest that the total cost of the management of T2D for the healthcare system in Kenya would have been US$ 635 million (KES 74,521 million) in 2021. This suggests a potential increase of US$ 2 million (KES 197 million). Unit costs of the management of T2D by the healthcare system considering the unscreened cases was US$ 822 (KES 90,117) per year. Considering the cost breakdowns, the unit cost for T2D without complications was US$ 365 (KES 39, 976) while the unit cost of T2D with complications was US$ 1,335 (KES 146,435).

The burden of managing T2D

Table 4 shows that approximately 57% of the health sector budget would have been utilized to manage T2D

Table 4 Total cost of the management of T2D for the healthcare system in 2021 if unscreened cases are diagnosed (million US$)

	Unit Costs (KES)	Unit Costs (USD)	Total Cost (KES)	Total Costs (USD)	% Overall Costs	% of Kenya Health Sector Budget 2021
Investigation of suspect cases of T2D (actual cases)	609.95	5.56	10,611.72	96.76	15.25	8.16
T2D without complication	-	-	21,247.57	148.82	23.45	16.34
Diabetes with complication	-	-	42,464.59	387.2	61.02	32.67
Screening of undiagnosed cases	609.95	5.56	196.91	1.80	0.28	0.15
Grand total			**74,520.79**	**634.58**	**100.00**	**57.32%**

Table 5 Sensitivity analysis of T2D costs in Kenya shillings (million US $)

	Total Cost (KES)	Total Costs (USD)	-20% Costs (KES)	+20% Costs (KES)
Investigation of suspect cases of T2D (actual cases)	10,611.72	96.76	8,489.38	12,734.06
T2D without complication	21,247.57	148.82	16,998.06	25,497.08
Diabetes with complication	42,464.59	387.2	33,971.67	50,957.51
Screening of undiagnosed cases	196.91	1.80	157.53	236.29
Grand total	**74,520.79**	**634.58**	**59,616.63**	**89,424.95**

patients assuming all patients were treated, with complicated diabetes accounting for 32%.

Sensitivity analysis and cost projections to 2045

Table 5 shows the results of the sensitivity analysis. The findings show that the total costs of managing T2D are estimated to range from US$ 544 million (KES 59,617 million) to US$ 815 million (KES 89,424 million). The total costs of T2D with complications are expected to range from US$ 310 million (KES 33,972 million) to US$ 465 million (KES 50, 958 million). The cost of managing diabetes is estimated to be US$ 1.6 billion (KES177 billion) in the year 2045 considering the predicted 1,964,900 new diabetes cases in Kenya by 2045 [3].

Discussion

The burden of chronic NCDs such as T2D is a growing public health concern. We found that the total costs for managing T2D in Kenya were approximately US$ 632.78 million (KES.74, 324 million), equivalent to ~60% of the entire health budget in 2021/2022. This is a substantial economic burden to Kenya, just from one nutrition-related NCD. The major cost driver in this study was diabetes complications accounting for more than 60% of the overall costs incurred by the public healthcare system. Even if undiagnosed cases of T2D are not considered, the management of T2D complications would still represent the most burdening cost component of healthcare system costs of the management of T2D in Kenya, with diabetes nephropathy accounting approximately for half of the total cost of complications.

The overall estimates of the actual costs in our study are significantly higher compared to estimates from a previous study showing that the total direct cost of managing diabetes in Kenya was approximately USD 144,204,459 [20]. Our estimated costs are higher by 66% compared to findings from a study conducted in 2022 in Kenya that was reported at US$ 372,184,585, accounting for both direct and indirect costs [20]. This difference may be explained by differences in study designs and the fact that our study is a prevalence-based accounting for the treatment and management of T2D in Kenya. The unit cost per T2D patient estimate in our study is higher compared to the study by Ebrahim et al. [20]. This is because the cost inputs (e.g., personnel costs, undiagnosed T2D management costs, and facility overheads) capture the differences in service delivery in a diversified public health system [20]. These calculations also accounted for the average number of hospital visits per year depending on whether the diabetic patient has complications or not. The annual unit costs per patient considering the patient perspective have been reported to be US$ 528.5 in Kenya, which is more than 40% less than the costs of managing T2D per patient to the public healthcare system [17]. The changes in the costs may be due to the costing year, which may have changed due to inflation and adjustments from previous periods.

The key drivers for T2D without complications in this study were diabetes screening and staff labor costs, which contradicts previous studies where patient and public health facilities costs where the main drivers of costs were medications and transport [17, 20]. A patient perspective study on T2D without complications had one major cost driver as personnel costs, which is similar to this study despite the healthcare system perspective approach [18]. This shows that the cost drivers are similar, and both have a significant burden both to the patients and the government.

The diabetes complications were the major cost drivers in this study. A study conducted in Ethiopia on the assessment of direct costs of DM at a hospital level showed that there were significant expenditures on drugs, which accounted for ~70% of the overall costs,

where the costs accelerated by 1.6 times for diabetes complications [34]. In South Africa, the medication costs accounted for 33% of the direct cost breakdown, however, the retinopathy and renal disease complications had the largest cost implications on the total direct cost of managing T2D [21]. It is evident that in both LMICs and high-income countries diabetes complications take the largest chunk of the resources both to patients and the government [21, 35–37]. This is similar to Kenya where the major cost drivers for the overall direct costs to the public health system are the T2D complications such as management of retinopathy, foot ulcers, and nephropathy [21]. The high-cost implications of T2D complications are because the management of these complications consumes more healthcare system resources, including specialized human resource costs, medications costs, and advanced care such as dialysis. This study shows the high contribution of diabetes complications to overall economic expenditures to the public healthcare system.

The economic burden of T2D as observed in this study correlates with patients' perspective costing studies on other cardiometabolic diseases such as hypertension. Studies conducted in Kenya, and other countries in the LMICs showed substantial direct and indirect costs associated with the management of hypertension, with key cost drivers as medication and inpatient and outpatient care [38, 39]. Similarly, there are high-cost implications of other cardiovascular diseases such as stroke and coronary heart disease [40]. Infectious diseases such as COVID-19 among other respiratory infections have been attributed to increased burden to the patients and the public healthcare systems in LMICs [41–43]. This shows that there is a substantial economic burden of diseases affecting healthcare systems in LMICs, hence the need for increased funding to the healthcare sector.

Public health implications

The impact of the study is showing the significant burden of type 2 diabetes on the public healthcare system. The majority of the studies mainly show the patient costing perspective of diabetes and other cardiometabolic diseases. Besides the paucity of the availability of cost data in LMICs and neighboring countries, this study sets a blueprint for the formulation of health financing policies aimed at preventing, controlling, and managing diseases affecting the countries. These findings reveal a significant burden of T2D on the Kenyan public healthcare system. Ideally, 60% of the entire budget to the Kenya Ministry of Health in the fiscal year 2021, would only fund T2D. A huge proportion of the Ministry of Health in the year 2021/2022 was allocated to infectious diseases such as HIV/AIDS and tuberculosis, and tropical diseases such as malaria. Hence elucidating a considerable gap in catering for all diseases in the country, especially chronic diseases. Kenya's public healthcare system is complex, in terms of its dynamic nature due to the need to manage a wide range of healthcare constraints such as infectious diseases and unexpected pandemics. The budgetary reports stipulated a 95% gap in funding needed for the prevention, treatment, and management of diabetes in the country according to NCD strategic plans [33]. There needs to be optimization in health financing and equitable budgetary allocations in public healthcare facilities accessible to many patients in different parts of the country. This should take into consideration noncommunicable diseases and NCDS, and surplus budgetary allocations to cater for unanticipated epidemiological constraints such as pandemics.

The cost of screening was significantly lower compared to the cost of managing T2D in Kenya. This indicates the need for advocacy of early screening as a preventive mechanism to reduce the rate of complicated diabetes cases, which have higher cost implications for the healthcare system. There is a need to formulate fiscal policies to justify the cost-effectiveness accrued by the government funding screening services, which are cheaper than managing costs associated with diabetes complications. Further, there is a need for regulation of food environments in the country and heightened advocacy for nutrition policies to reduce the burden of lifestyle diseases such as T2D. Indeed, a recent simulation study on Kenya shows that prevention strategies for NCDs, including T2D will reduce the burden on the healthcare system, improve population health, and provide other economic benefits to the Kenyan population in the long term. As is evident from our analysis and a recent cost-effectiveness study conducted in Kenya it is more beneficial from an economic perspective to take action to prevent T2D [44]. In this regard, there needs to be improvement in the national food insecurity policies to account for the availability of healthy foods for Kenyans. Other policies that should be formulated and implemented include the front-of-pack labeling policies (FOPL) and restriction of marketing of unhealthy foods using the nutritional guidelines from the Kenya Nutrition Profile Model (KNPM).

Limitations and strengths

This study has several limitations, which need to be considered in interpreting the findings. Detailed data were only obtained from health facilities managing T2D with no complications. For T2D with complications we used parameters from published literature from countries comparable to Kenya, and there were limitations on the availability of unit costs for all the T2D complications. The use of secondary data from literature was a limitation as this data can cause bias and uncertainty in the interpretation and outcomes of the study. Very few studies have been conducted in LMICs, especially on the T2D

costs to the public healthcare system. It therefore limits the possibility of presenting detailed estimates by cost components and drivers, which, in turn, limits potential recommendations that could have been formulated. This study did not account for the costs of many complications that could be associated with T2D, including the most prevalent in Kenya such as neuropathy and sexual dysfunction. It is plausible that our cost estimates may likely be an underestimation of the true cost of T2D in Kenya. We observed a lack of medication/stockouts at the primary-level health facilities, which might have affected the overall medication costs since the prescription was affected by drug availability.

Despite these limitations, this study has some strengths. First, to our knowledge, it is the first study attempting to comprehensively estimate the healthcare system costs for the management of T2D and related complications in Kenya. The vast majority of the studies have looked at the costs either focusing on the patient's perspective or mixing the various types of diabetes and/or perspectives. Secondly, because this study focused solely on estimating the costs of T2D, one of the most prevalent forms of diabetes affecting the productive proportion of the Kenyan population, the implications may be larger than that concerning solely the healthcare sector and may be valuable as a starting point for cost minimization through prevention strategies. Finally, it could serve as a basis for designing a larger and more representative research project on the economic costs of T2D and its complications for the healthcare system and society. This work provides a basis for the adoption of strategies and policies that reduce the risks such as unhealthy diet consumption physical inactivity, and incidence of T2D as well as broader NCDs.

Conclusions

This study illustrates the huge economic burden of T2D in Kenya's healthcare system using the public healthcare system perspective. The identification of the individual drivers of the costs associated with the effective management of T2D in the country is vital in showing the financial gaps that should be considered in budget allocation to the Ministry of Health, and NCD departments. The management of T2D, among other NCDs, is essential to enable equity in resource allocation and prevent catastrophic expenditures for an improved standard of living. There is a need for multisector and multistakeholder action to advocate for the prevention of T2D, and the formulation and implementation of policies geared towards addressing the corresponding risk factors. The regulation of food environments by restricting the marketing of unhealthy foods and sensitization on the consumption of healthier food options will enhance the reduction of NR-NCDS in Kenya.

Abbreviations

NCDs	Non-communicable diseases
NR	NCDs-Nutrition related non-communicable diseases
SSA	Sub-Saharan Africa
T2D	Type 2 diabetes
LMICs	Low and middle-income countries
DM	Diabetes mellitus
HBA1C	Glycated hemoglobin
COI	Cost of illness
APHRC	African Population and Health Research Center
MOH	Ministry of Health
CPI	Consumer price index
KES	Kenya shillings
US$	US dollars
ERSC	Ethics and Scientific Review Committee
NACOSTI	The national commission for science, technology and innovation

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

G.A., P.I., C.A., and S.V. were involved in the conceptualization and design of the study. P.I., M.B., A.M., C.H.K., and G.A. developed the analysis plan. C.H.K. analyzed the costing data with support from P.I., A.M., L.M., and M.B. C.H.K., L.M., M.W., G.A., V.O., and R.S. supported project implementation, management, and data collection. G.A., C.A., S.V., A.M., M.B., P.I., and R.S. contributed to results synthesis and interpretation. C.H.K. developed the first manuscript draft. G.A., S.V., C.A., P.I., M.B., and R.S. supported further input and edits on the manuscript. All the authors contributed to the finalization of the manuscript. All authors approved the final manuscript.

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Availability of data and materials

Data and other materials from this study will be available upon request by other researchers. The primary author will be the contact person for the provision of data and other supporting documents related to the work.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the AMREF-Health Ethics and Scientific Review Committee (ESRC) in Kenya (ESRC/P901/2020) and the National Commission for Science, Technology, and Innovation (NACOSTI) (NACOSTI-P/22/19104). Informed written consent was sought from the healthcare personnel recruited in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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