Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Economic burden of severe non-communicable diseases by level of care to inform priority-setting in Tanzania

Ritha A. Willilo

Ritha.Willilo@uib.no

University of Bergen

Ole F. Norheim

Harvard T.H. Chan School of Public Health

Mary Mayige

National Institute for Medical Research (NIMR)

Melf-Jakob Kühl

University of Bergen

Alemayehu Hailu

Western Norway University of Applied Sciences

Research Article

Keywords: Non-communicable diseases, Cost of illness, Economic burden, PEN-Plus, Health equity, Tanzania.

Posted Date: November 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11473598/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Manuscript Type: Original Article

Title: Economic burden of severe non-communicable diseases by level of care to inform priority-setting in Tanzania

1. **Ritha A. Willilo *** (corresponding author)

Affiliation: [1]Bergen Centre of Ethics and Priority Setting (BCEPS), Department of Global Public Health and Primary Care, Faculty of Medicine, University of Bergen (UiB), Bergen, Norway

Postal address: P.O. Box 7804, NO-5020 Bergen, Norway

Email: Ritha.Willilo@uib.no

ORCID: https://orcid.org/0000-0002-4576-7964

2. **Ole F. Norheim**

Affiliation: [1]Bergen Centre of Ethics and Priority Setting (BCEPS), Department of Global Public Health and Primary Care, Faculty of Medicine, University of Bergen (UiB), Bergen, Norway.

[2]Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, USA.

Postal address: Harvard T.H. Chan School of Public Health, Department of Global Health and Population, 665 Huntington Avenue, Boston, MA 02115

USA

Email: onorheim@hsph.harvard.edu

ORCID: https://orcid.org/0000-0003-4872-8036.

3. **Mary Mayige**

Affiliation: National Institute for Medical Research (NIMR)

Postal Address: P.O. Box 2016, 41119 Dodoma, Tanzania

Email: mmayige@nimr.or.tz

ORCID: https://orcid.org/0000-0003-4861-7870

4. **Melf-Jakob Kühl****

Affiliation: [1]Department of Global Public Health and Primary Care, Faculty of Medicine, University of Bergen (UiB), Bergen, Norway

Postal address: P.O. Box 7804, NO-5020 Bergen, Norway

Email: melf-jakob.kuhl@uib.no

ORCID: https://orcid.org/0000-0003-3039-8606.

5. **Alemayehu Hailu****

Affiliation: Section for Global Health and Rehabilitation, Western Norway University of Applied Sciences, Bergen, Norway

Email: alemayehu.hailu@hvl.no

Postal address: P.O. Box 7030, NO-5020 Bergen, Norway

ORCID: https://orcid.org/0000-0003-4872-8036.

** **Shared senior authors**

Abstract

Background

Noncommunicable diseases (NCDs) account for nearly half of all deaths in Tanzania. To improve access to care for severe NCDs, Tanzania has introduced the PEN-Plus model at primary hospitals. However, evidence on the patient-level economic burden of severe NCD care across diseases and levels of care remains limited. This study estimated patient-level costs for rheumatic heart disease, sickle cell disease, type 1 diabetes mellitus, and type 2 diabetes mellitus and identified key drivers of cost variation.

Methods

A cross-sectional, prevalence-based cost-of-illness study was conducted among patients receiving outpatient care for type 1 diabetes, type 2 diabetes, rheumatic heart disease, and sickle cell disease at primary and tertiary hospitals in Tanzania. A bottom-up costing approach was used to estimate direct and indirect costs of outpatient care from the patients' perspective. Indirect costs were valued using the human capital approach. Socioeconomic inequality was assessed using concentration indices and generalised linear models with a log link; key drivers of cost variation were identified.

Results

We included 1,037 participants. The mean annual outpatient cost per patient was USD 255 (95% CI: 242–270). Direct non-medical and indirect costs accounted for most of the economic burden, with transport as the largest cost component (USD 87 per year). Costs varied by disease and level of care. Patients with sickle cell disease incurred the highest direct costs (USD 238 per year). For rheumatic heart disease, mean drug costs increased from USD

3 at primary hospitals to USD 65 per year at tertiary hospitals. Costs were lower at primary hospitals (CR 0.80; 95% CI: 0.72–0.90) and increased with distance travelled. Socioeconomic inequality was minimal at primary hospitals. In contrast, low-income groups had a statistically significantly higher share of patient costs among patients with type 2 diabetes and sickle cell disease attending tertiary hospitals.

Conclusion

The economic burden of severe NCD care in Tanzania is driven as much by access barriers as by medical costs. Expanding PEN-Plus, reducing transport-related costs, and aligning insurance benefits with long-term care needs could improve financial protection and equity.

Key words

Non-communicable diseases; Cost of illness; Economic burden; PEN-Plus; Health equity; Tanzania.

Introduction

Noncommunicable diseases (NCDs) are a leading cause of death worldwide, accounting for nearly 41 million deaths each year, or about 74% of global mortality [1]. The burden of NCDs is rising rapidly in Sub-Saharan Africa, while many countries are still grappling with infectious diseases, creating a double burden [2]. In Tanzania, NCDs contributed to disability-adjusted life years (DALYs) increased from 19% in 1990 to 36% in 2019. NCDs now account for almost half of all deaths in the country [3, 4]. In response, Tanzania adopted decentralised models of care to strengthen management of severe and chronic NCDs. One such approach is the PEN-Plus model, which aims to deliver specialised services for severe NCDs at first-level referral hospitals, depending on the context, including [5, 6]. Conditions primarily targeted by the PEN-Plus model include type 1 diabetes (T1D), type 2 diabetes, sickle cell disease (SCD), rheumatic and congenital heart disease, hemoglobinopathies, and

epilepsy [7]. These conditions are often diagnosed late or inadequately managed. Late diagnosis contributes to poor health outcomes, disability, and premature mortality, while also increasing economic burden on households and health systems [8, 9].

Recent policy reforms have also sought to improve financial protection. The Universal Health Insurance Act of 2023 aims to expand coverage through a national prepayment system and reduce reliance on out-of-pocket payments at the point of care [10]. A national health-insurance benefit package is under development to define covered services and guide implementation [11]. Despite these reforms, severe and chronic NCDs continue to strain health system capacity and household financial protection [12, 13]. NCDs require lifelong treatment and regular follow-up, including medication refills, clinical reviews, monitoring, and sustained access to laboratory and diagnostic equipment [12]. As a result, patients incur not only direct medical costs but also direct non-medical costs, such as transport, and indirect costs from productivity losses associated with routine monitoring visits [14, 15]. In rural Tanzania, even routine outpatient care generates substantial non-medical expenses and lost productivity. Average non-medical costs are estimated at US$2.79 per visit, while productivity losses total about US$10.19 per month due to missed workdays. Such costs may discourage care-seeking and exacerbate inequities in access to essential health services [16, 17]

Studies from sub-Saharan Africa suggest that these costs vary across disease groups and reflect differences in age profiles, comorbidity burden, and opportunity costs [18, 19]. For example, patients with type 2 diabetes are of working age and often experience productivity losses due to frequent clinic visits and work absences. Many also have comorbid conditions, such as hypertension and cardiovascular disease, which increase healthcare utilisation and costs. Unlike patients with type 1 diabetes, those with type 2 diabetes are usually younger and

have fewer comorbidities, resulting in lower economic costs [18, 19]. The economic burden on patients also varies across disease-specific care pathways. Limited access to early diagnosis and long-term management of rheumatic heart disease and sickle cell disease may increase reliance on secondary and tertiary-level care [20-22]. Care at these levels often involves higher costs, longer travel distances, and more time away from productive activities, increasing access-related opportunity costs [20-22].

However, empirical evidence on the patient-level economic burden of severe NCDs in Tanzania remains limited, particularly regarding how costs vary across diseases, cost components, and levels of care. Understanding these patterns is important for informing priority setting under Universal Health Coverage and for designing health insurance benefits that better reflect patient needs [23]. This study estimated the patient-level economic burden of selected severe NCDs, namely rheumatic heart disease, sickle cell disease, type 1 diabetes mellitus, and type 2 diabetes mellitus, in Tanzania. Direct medical, direct non-medical, and indirect costs attributable to productivity losses were quantified across selected severe NCDs and levels of care. We also identified key drivers of patient-side costs and examined socioeconomic inequalities in the distribution of the economic burden

Methods

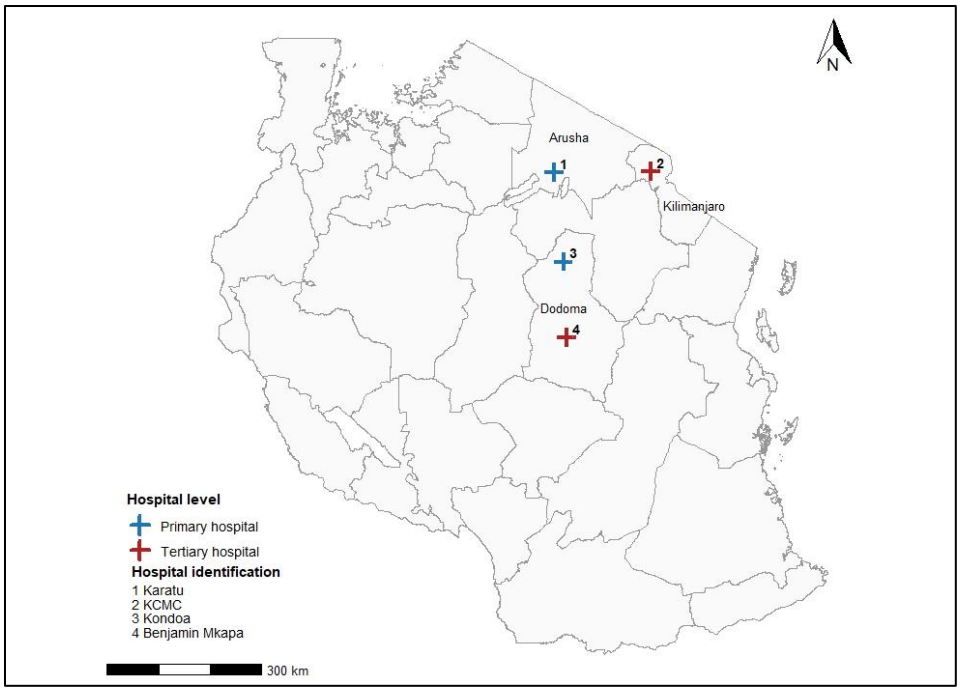
Study Design

This study used a cross-sectional, prevalence-based cost-of-illness (COI) study design to estimate the economic burden of severe NCDs in Tanzania. The study included patients with rheumatic heart disease (RHD), sickle cell disease (SCD), type 1 diabetes mellitus (T1DM), and type 2 diabetes mellitus (T2DM). Participants received routine outpatient care at primary and tertiary hospitals in Tanzania [24].

Study Setting

Tanzania has a decentralised health system with three levels of care. Primary care includes community services, dispensaries, health centres, and district hospitals. Secondary care is provided at regional referral hospitals. Tertiary care includes zonal referral hospitals, specialised hospitals, and national hospitals. The study was conducted in four hospitals across three regions: Dodoma, Arusha and Kilimanjaro (Figure 1). Two facilities were district hospitals, Kondoa Town Council Hospital and Karatu Lutheran Hospital, both of which have operated PEN-Plus clinics since April 2023. The National Institute for Medical Research (NIMR) selected these hospitals as initial pilot sites, in collaboration with the Ministry of Health, to support pilot and the national scale-up of decentralised services for severe non-communicable diseases [9]. The other two sites were zonal referral hospitals: Benjamin Mkapa Hospital (BMH) and Kilimanjaro Christian Medical Centre (KCMC). These hospitals provide specialised services, support referral pathways, and offer clinical mentorship for district-level PEN Plus facilities [9]. These facilities represent key levels of the Tanzanian referral system. Including them enabled comparisons between decentralised and specialised service delivery settings and enhanced the transferability of findings to similar hospital settings in Tanzania. Figure 1 shows the locations of the four hospitals included in the study.

Figure 1. Study Hospital locations, Tanzania



Sampling and Data Collection

Eligible individuals attending routine outpatient follow-up visits at the selected facilities were consecutively recruited throughout the study period. Individuals who were critically ill, clinically unstable, admitted as inpatients, or not enrolled in PEN Plus clinics at district hospitals were excluded. Trained nurses staff collected data using a structured questionnaire. The data collection tool was adapted from the WHO tuberculosis patient cost survey and USAID patient cost survey tools [25, 26]. The questionnaire was programmed in Open Data Kit (ODK), an open-source electronic data collection platform. The questionnaire was initially developed in English, translated into Swahili, and back-translated into English to ensure consistency. Data collection was conducted from February to April 2024 and from December 2024 to January 2025. Face-to-face interviews were conducted during routine clinic visits.

Cost Estimation

The analysis was conducted from a patient perspective and estimated direct medical, direct non-medical, and indirect costs associated with outpatient care. Direct medical costs included consultation fees, medicines, laboratory tests, diagnostic procedures, and imaging. Direct non-medical costs comprised transportation, food, and accommodation expenses incurred during healthcare visits. Indirect costs reflected productivity losses resulting from time spent seeking healthcare.

Cost Measurement

Patient-level costs were measured using a prevalence-based, prospective cost-of-illness approach [24]. Costs were collected prospectively during routine outpatient follow-up visits using an ingredient-based, bottom-up costing approach. The primary outcome was total cost, defined as the sum of direct costs and indirect costs incurred during outpatient care. To estimate annual outpatient costs, visit-level costs were annualised assuming monthly follow-up (12 visits per year), reflecting the standard follow-up schedule in PEN-Plus clinics and providing a standardised basis for comparison across diseases and levels of care.

Cost Valuation

Direct costs were valued using reported non-reimbursed out-of-pocket expenditures incurred by patients during outpatient care. Indirect costs were estimated using the human capital approach and valued using national data from the 2024 Integrated Labour Force Survey [27, 28]. The average monthly wage among paid employees in Tanzania was TZS 477,241 (USD 188.11). This corresponds to a daily wage of TZS 23,862 (USD 9.41), based on 20 working days per month. Productivity losses among children aged 7–14 years were valued at half the adult daily wage. Productivity losses among children younger than seven years were assumed to be negligible [29]. All costs were collected in Tanzanian Shillings (TZS). Costs were converted to 2025 United States Dollars (USD) using the annual average Bank of Tanzania

mean exchange rate (USD 1 = TZS 2,537) [30]. Costs were adjusted for inflation using the Consumer Price Index, with 2025 USD as the reference year.

Data analysis

Data were analysed using R software (version 4.5.2). Categorical variables were summarised using frequencies and percentages. Continuous variables were summarised using means with standard deviations or medians with interquartile ranges, as appropriate. Mean cost estimates were reported with bootstrapped 95% confidence intervals based on 1,000 replications to account for the right-skewed distribution of cost data.

Socioeconomic status was measured using per capita household consumption expenditure, a commonly used proxy for income in low-income settings [31]. Consumption expenditure was adjusted using an equivalence scale with an elasticity parameter of 0.56, consistent with WHO recommendations [32]. Individuals were ranked into socioeconomic quintiles from the poorest (Q1) to the richest (Q5). Concentration indices were used to assess socioeconomic inequality in cost distributions.

Generalised linear models (GLMs) with a Gamma distribution and a log link were used to identify drivers of patient-born costs. This model suits positive, right-skewed healthcare cost data and estimates relative differences in mean costs multiplicatively. We selected covariates a priori based on patient characteristics, disease type, socioeconomic position, and health-system factors. We estimated unadjusted and fully adjusted models. Results are reported as cost ratios with bootstrapped 95% confidence intervals based on 1,000 replications.

Sensitivity analyses assessed the robustness of annual direct cost estimates under alternative annualisation assumptions. Costs were recalculated assuming four or six clinic visits per year, based on reported attendance frequencies, while participants attending their first clinic visit

were assumed to follow the predominant attendance pattern of 12 visits per year. Sensitivity analyses also assessed the robustness of the primary model to alternative modelling assumptions and the influence of extreme observations. Second, we compared estimates from the Gamma GLM with those from lognormal models using log-transformed costs, and re-estimated models using costs winsorised at the 99th percentile. Multicollinearity was assessed using variance inflation factors (VIFs) for continuous variables and generalised variance inflation factors (GVIFs) for categorical variables.GVIFs were transformed using the transformation $GVIF^{1/(2\cdot df)}$ to allow comparability with standard VIFs.

Ethical Consideration

The study received ethical approval from the National Health Research Ethics Committee (NatHREC) at the National Institute for Medical Research (NIMR), Tanzania (Ref. Vol. IX/4533). We also obtained approval from the Regional Committee for Medical and Health Research Ethics in Norway (Ref. 611486). We obtained written informed consent from participants before data collection. For participants younger than 18 years, we obtained consent from a parent or legal guardian. Participants were informed about study procedures, confidentiality safeguards, and their right to withdraw at any time. We anonymised all data before analysis to protect participant confidentiality.

Results

Participants characteristics

A total of 1, 037 participants were enrolled; 317 (30.6%) received care at primary hospitals and 720 (69.4%) at tertiary hospitals (Table 1). Participants were evenly distributed by sex, with 534 (51.5% female) and had a mean age of 37.0 years (SD 24.7). Educational attainment varied by facility level. College education was higher among patients attending tertiary

hospitals (28.9% vs 5.0%). Primary-level education was higher in primary hospitals (62.1% vs 33.8%). Patients attending tertiary hospitals often resided in urban areas (63.8% vs 46.1%), travelled farther to access care (median: 27.0 km vs 10.0 km), and had higher health insurance coverage (77.4% vs 49.8%) than those attending primary hospitals.

Household characteristics were broadly similar across facility levels. The mean household size was 4.9 members, and about 71% of households included at least one child under 18 years. Participants identified as household heads accounted for 34.6% of the study population, and almost half (49.2%) attended visits with a family member or guardian.

Table 1: Socio-demographic characteristics of the study participants by level of care

Variable	Primary hospital N=317	Tertiary hospital N=720	Overall N=1037
Age			
Mean (SD)	37.1 (22.3)	36.9 (25.7)	37.0 (24.7)
Median (Q1, Q3)	34.0 (18.0, 55.0)	40.0 (10.0, 60.5)	36.0 (12.0, 60.0)
Gender (%)			
Female	167 (52.7)	367 (51.0)	534 (51.5)
Male	150 (47.3)	353 (49.0)	503 (48.5)
Marital status (%)			
Married	169 (53.3)	313 (43.5)	482 (46.5)
Unmarried	110 (34.7)	195 (27.1)	305 (29.4)
Not applicable*	38 (12.0)	212 (29,4%)	250 (24.1)
Education level (%)			
College (diploma, university)	16 (5.0)	208 (28.9)	224 (21.6)
Secondary school education	65 (20.5)	148 (20.6)	213 (20.5)
Primary school education	197 (62.1)	243 (33.8)	440 (42.4)
No formal education	23 (7.3)	9 (1.3)	32 (3.1)
Not applicable*	16 (5.0%)	112(15.6%)	128 (12.3%)
Residence (%)			

Variable	Primary hospital N=317	Tertiary hospital N=720	Overall N=1037
Rural	171 (53.9)	261 (36.3)	432 (41.7)
Urban	146 (46.1)	459 (63.8)	605 (58.3)
Distance to facility (km)			
Mean (SD)	15.4 (17.8)	79.6 (126.2)	62.9 (112.4)
Median (Q1, Q3)	10.0 (5.0, 20.0)	27.0 (14.0, 75.0)	20.0 (10.0, 50.0)
Missing**	82	54	136
Accompanied during care-seeking (%)			
Yes	141 (44.5)	369 (51.3)	510 (49.2)
No	176 (55.5)	351 (48.8)	527 (50.8)
Has insurance (%)			
Yes	158 (49.8)	557 (77.4)	715 (68.9)
No	159 (50.2)	163 (22.6)	322 (31.1)
Insurance covers today's condition (%) * **			
Yes	76 (48.1)	446 (80.1)	522 (73.0)
No	82 (51.9)	111 (19.9)	193 (27.0)
Co-existing with other chronic illnesses			
Yes	36 (11.4)	147 (20.4)	183 (17.6)
No	281 (88.6)	573 (79.6)	854 (82.4)
Household size			
Mean (SD)	4.9 (1.8)	4.9 (2.1)	4.9 (2.0)
Median (IQR)	5.0 (3.0, 6.0)	5.0 (3.0, 6.0)	5.0 (3.0, 6.0)
Number of children under 18 years (%)			
Yes	231 (72.9)	502 (69.7)	733 (70.7)
No	86 (27.1)	218 (30.3)	304 (29.3)

N denotes the total number of participants in the study or a specific facility category.

n (\%) represents the absolute frequency and the corresponding column percentage

Mean (SD): SD = standard deviation.

Median (IQR): IQR = interquartile range, denoting the 25th and 75th percentiles.

Not applicable * denotes children for whom marital status and educational attainment were not applicable because of age.

Variable	Primary hospital N=317	Tertiary hospital N=720	Overall N=1037

** Distance to facility was summarised using available observations; participants with missing distance data were excluded from these calculations and reported separately.

*** Percentages for insurance coverage of today's condition were calculated among insured participants only (n = 715).

Disease profiles differed markedly by level of care (Figure 2). Rheumatic heart disease was the most common condition among patients attending primary hospitals (37.5%), whereas type 2 diabetes (48.3%) and sickle cell disease (32.4%) predominated at tertiary hospitals. Type 1 diabetes accounted for 25.9% of patients at primary hospitals and 15.7% at tertiary hospitals (Figure 2).

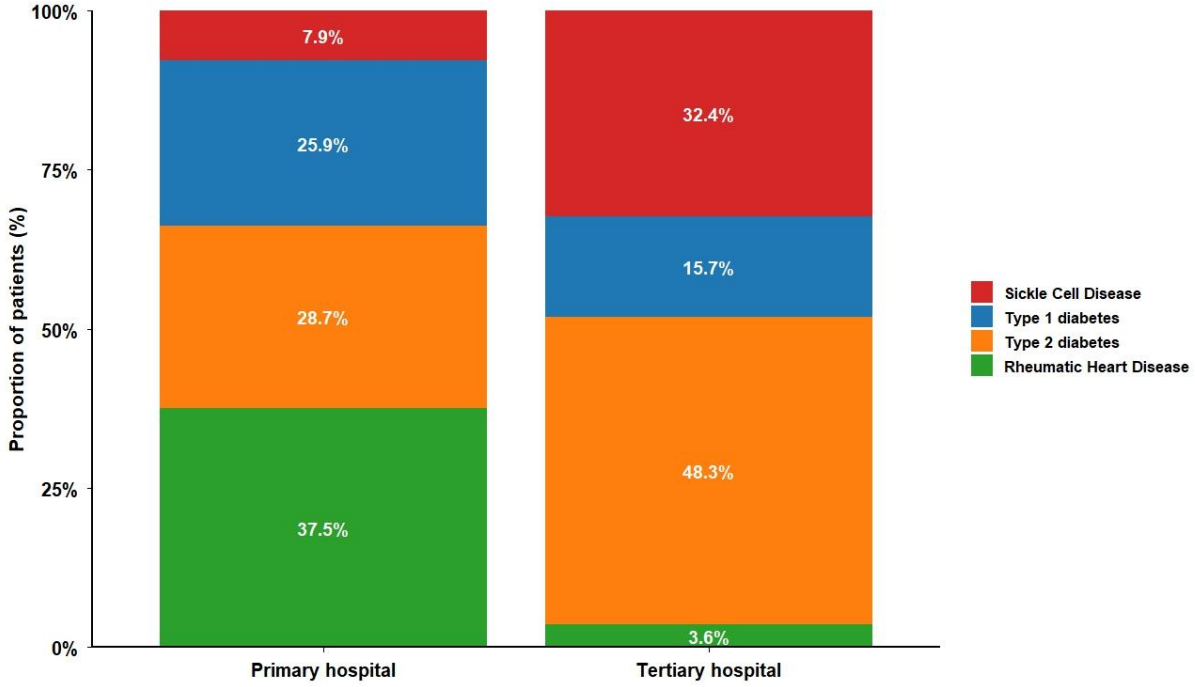


Figure 2. Distribution of severe non-communicable diseases by health facility levels.

Overall direct, indirect and total costs

Across all diseases and facilities, the annual mean total cost per patient was USD 255 (95% CI: 242–270), and the direct cost was 161 (95% CI: 148-175) (Table 2a). Annual Mean total costs were higher at tertiary hospitals (USD 276) (Table 2c) than at primary hospitals (USD 207) (Table 2a) than at primary hospitals (USD 207) (Table 2b). Overall, mean direct medical costs were USD 48, compared with USD 113 for direct non-medical costs. Direct non-medical and indirect costs accounted for the largest share of the economic burden. Transport was the largest cost component (USD 87). Mean direct medical costs increased from USD 23 at primary hospitals to USD 59 at tertiary hospitals. Mean indirect costs averaged USD 94, accounting for approximately 37% of total patient costs.

In sensitivity analyses exploring alternative annualisation assumptions, 843 (81.3%) of participants reported monthly clinic attendance, 115 (11.1%) every three months, 11 (1.1%) every two months, 7 (0.7%) weekly, and 6 (0.6%) twice weekly. Fifty-three participants (5.1%) were attending clinic for the first time and were assumed to follow the predominant monthly attendance pattern. Recalculating annual direct costs using participants' reported attendance frequencies yielded a mean estimate of USD 160.6 (95% CI: 145-180). This represented a reduction of only 0.23% compared with the base-case assumption of 12 visits per year (Figure 3). Similar patterns were observed across disease groups and facility levels (Supplementary Figures S1-S2).

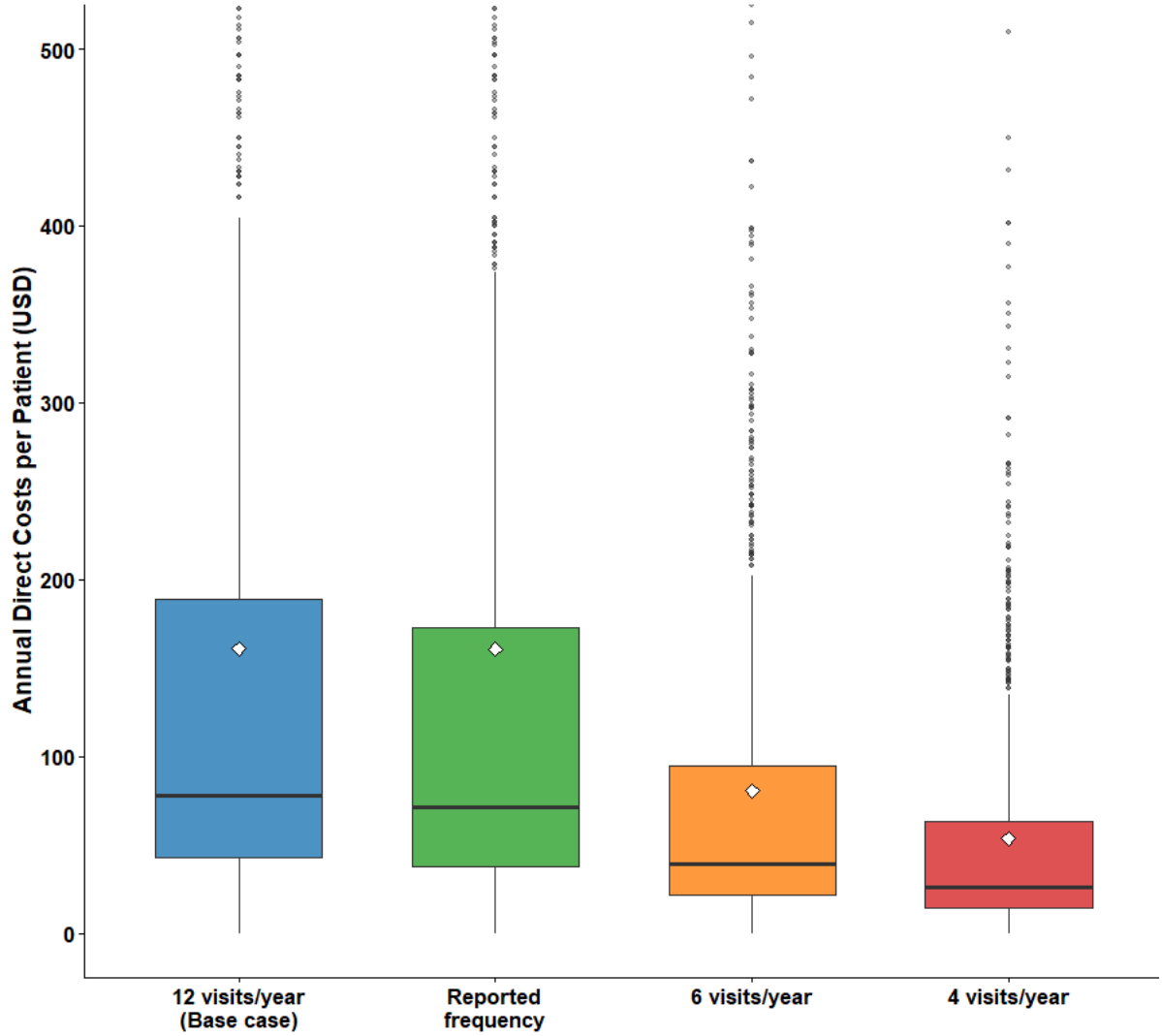


Figure 3. Sensitivity Analysis of Annual Direct Patient Costs: Alternative annualisation assumptions

Note: For visual clarity, the y-axis is truncated at USD 500; all observations were retained in the analysis. Diamonds indicate mean costs, boxes represent interquartile ranges (IQRs), and whiskers extend to 1.5 times the IQR.

Disease-specific cost

Total costs varied considerably by disease type (Table 2). Patients with type 2 diabetes incurred the highest indirect costs, with a mean indirect cost of USD 121, followed by patients with type 1 diabetes (USD 103). Patients with sickle cell disease incurred the highest direct costs (USD 253), driven largely by transport (USD 146) and drug expenditure. Among

patients with rheumatic heart disease, mean drug costs increased from USD 3 at primary hospitals to USD 65 at tertiary hospitals.

Insurance

Mean annual direct costs were USD 118 (95% CI: 105.6, 132.4) among insured participants compared with USD 257 (95% CI: 228-289) among uninsured participants. Median annual direct costs were USD 66 and USD 134 among insured and uninsured participants, respectively (Figure 4). Similar patterns were observed across all disease groups (Supplementary Figure S3).

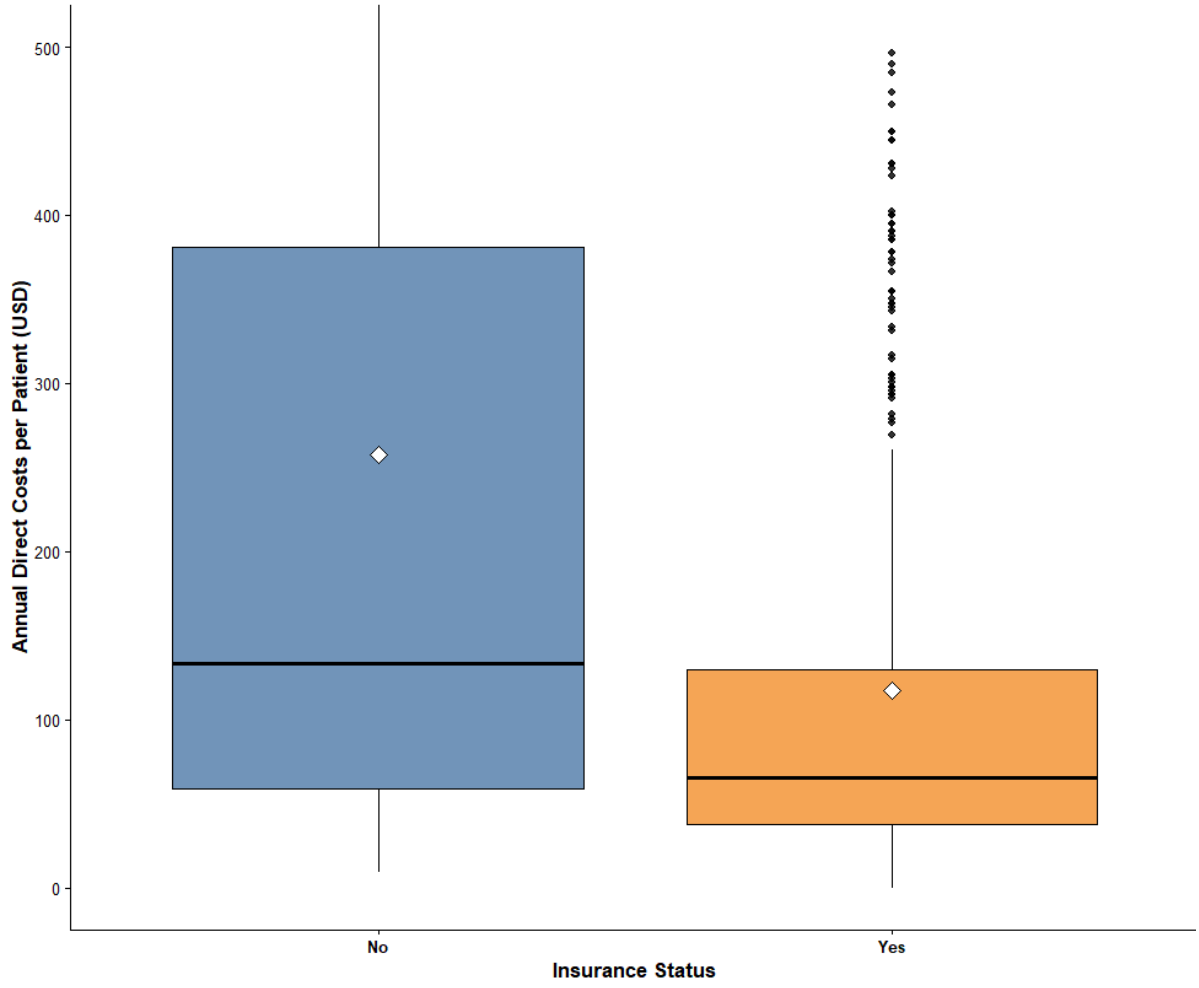


Figure 4: Distribution of Annual Direct Patient Costs by Insurance Status

Note: For visual clarity, the y-axis is truncated at USD 500; all observations were retained in the analysis. Diamonds indicate mean costs, boxes represent interquartile ranges (IQRs), and whiskers extend to 1.5 times the IQR.

Table 2a-c: Annual patient costs of severe NCD care in Tanzania (2025 USD)

2a: Annual patient costs of severe NCD care, overall

Characteristic	Diabetes type 1 (N = 195)	Diabetes type 2 (N = 439)	Rheumatic Heart Disease (N = 145)	Sickle Cell Disease (N = 258)	Overall (N = 1037)
Direct medical cost	**34 (20, 51)**	**50 (34, 71)**	**27 (11, 48)**	**68 (49, 86)**	**48 (39, 58)**
Consultation cost	8 (6, 11)	8 (6, 10)	5 (2, 8)	19 (14, 23)	10 (9, 12)
Diagnostic cost	8 (3, 15)	13 (5, 28)	7 (2, 12)	24 (14, 33)	14 (9, 21)
Drug costs	15 (7, 24)	20 (15, 26)	14 (5, 25)	24 (18, 32)	19 (15, 23)
Other chronic disease costs	2 (0, 6)	9 (2, 18)	2 (0, 5)	1 (0, 3)	5 (2, 8)
Direct non-medical cost	**72 (64, 81)**	**96 (87, 104)**	**118 (95, 147)**	**170 (149, 194)**	**113 (105, 121)**
Transport costs	55 (48, 64)	70 (63, 78)	89 (70, 115)	137 (120, 155)	87 (80, 93)
Food costs	15 (14, 17)	16 (15, 19)	21 (18, 25)	15 (13, 17)	16 (15, 17)
Accommodation costs	0 (0, 0)	7 (4, 9)	7 (3, 12)	18 (13, 24)	8 (6, 10)
Total direct cost	**106 (89, 125)**	**146 (126, 170)**	**145 (111, 182)**	**238 (207, 268)**	**161 (148, 175)**
Indirect cost	**100 (95, 104)**	**119 (117, 122)**	**105 (98, 111)**	**40 (35, 46)**	**94 (91, 97)**

Total cost (direct and indirect)	**206 (189, 226)**	**265 (246, 290)**	**249 (213, 290)**	**278 (246, 309)**	**255 (242, 270)**

Table 2b: Annual patient costs of severe NCD care at primary hospitals

Characteristic	Diabetes type 1 (N = 82)	Diabetes type 2 (N = 91)	Rheumatic Heart Disease (N = 119)	Sickle Cell Disease (N = 25)	Overall (N = 317)
Direct medical cost	37 (12, 70)	32 (13, 53)	7 (1, 14)	25 (0, 65)	23 (13, 34)
Consultation cost	2 (1, 4)	3 (1, 5)	1 (0, 2)	3 (0, 6)	2 (1, 3)
Diagnostic cost	14 (3, 29)	11 (4, 20)	2 (0, 4)	10 (0, 28)	8 (4, 13)
Drug costs	15 (3, 30)	15 (4, 30)	3 (0, 6)	11 (0, 28)	10 (5, 16)
Other chronic disease costs	5 (0, 13)	3 (0, 9)	2 (0, 8)	0 (0, 0)	3 (1, 6)
Direct non-medical cost	**73 (59, 91)**	**88 (71, 106)**	**95 (74, 125)**	**74 (49, 105)**	**85 (74, 97)**
Transport costs	54 (41, 70)	68 (53, 87)	73 (53, 100)	49 (30, 71)	65 (55, 77)
Food costs	17 (15, 20)	16 (14, 18)	21 (17, 26)	25 (13, 45)	19 (17, 21)
Accommodation costs	0 (0, 0)	1 (0, 4)	0 (0, 0)	0 (0, 0)	0 (0, 1)
Total direct cost	**110 (80, 147)**	**120 (94, 148)**	**102 (79, 132)**	**98 (60, 147)**	**109 (94, 124)**
Indirect cost	**96 (88, 104)**	**111 (107, 115)**	**98 (92, 103)**	**59 (43, 74)**	**98 (95, 102)**
Total cost	**206 (173, 244)**	**231 (208, 260)**	**200 (177, 231)**	**157 (116, 209)**	**207 (192, 223)**

Table 2c. Annual patient costs of severe NCD care at tertiary hospitals

Characteristic	Diabetes type 1 (N = 113)	Diabetes type 2 (N = 348)	Rheumatic Heart Disease (N =26)	Sickle Cell Disease (N = 233)	Overall (N = 720)
Direct medical cost	32 (17, 51)	55 (35, 79)	116 (41, 215)	72 (53, 93)	59 (47, 73)
Consultation cost	13 (10, 17)	9 (7, 13)	22 (7, 36)	20 (16, 25)	14 (12, 16)
Diagnostic cost	4 (1, 8)	14 (5, 32)	28 (6, 61)	25 (16, 36)	17 (10, 25)
Drug costs	15 (5, 27)	21 (15, 27)	65 (21, 118)	26 (18, 34)	23 (19, 28)
Other chronic disease costs	0 (0, 0)	10 (2, 22)	0 (0, 0)	1 (0, 3)	5 (2, 11)
Direct non-medical cost	71 (61, 81)	98 (88, 109)	223 (164, 293)	181 (158, 206)	125 (115, 136)
Transport costs	56 (47, 65)	70 (63, 78)	164 (119, 217)	146 (127, 167)	96 (88, 104)
Food costs	14 (12, 16)	17 (15, 19)	20 (15, 26)	14 (12, 15)	15 (14, 17)
Accommodation costs	0 (0, 0)	8 (5, 11)	37 (18, 59)	20 (14, 26)	12 (9, 14)
Total direct cost	**103 (83, 126)**	**152 (130, 181)**	**339 (221, 505)**	**253 (220, 290)**	**184 (166, 204)**
Indirect cost	**103 (98, 107)**	**121 (118, 125)**	**137 (115, 158)**	**38 (32, 44)**	**92 (88, 96)**

Characteristic	Diabetes type 1 (N = 113)	Diabetes type 2 (N = 348)	Rheumatic Heart Disease (N =26)	Sickle Cell Disease (N = 233)	Overall (N = 720)
Total cost (direct and indirect)	**206 (185, 228)**	**274 (249, 304)**	**476 (341, 639)**	**291 (257, 325)**	**276 (259, 294)**

Note:
Severe NCDs include type 1 diabetes, type 2 diabetes, rheumatic heart disease, and sickle cell disease. Costs are reported in 2025 USD.
Indirect costs are estimated for ages greater than 7
Values are mean costs in USD with 95% confidence intervals (CI) estimated via bootstrap (R = 1000). All values are displayed as: Mean (Lower CI - Upper CI).
Sample sizes (N) refer to the number of participants in each disease group at the health facility level and overall, across hospitals

Inequality in total costs

Figures 5a and 5b show concentration curves for total outpatient costs across socioeconomic groups for patients with type 1 diabetes, type 2 diabetes, rheumatic heart disease, and sickle cell disease at primary and tertiary hospitals, respectively. At primary hospitals, concentration curves lie close to the line of equality, indicating little socioeconomic inequality in total costs. The corresponding concentration indices were small and not statistically significant (Supplemental material, Table S1). At tertiary hospitals, concentration curves for Type 2 Diabetes and Sickle Cell Disease lay predominantly above the line of equality for most diseases, indicating a greater concentration of total outpatient costs among lower-income socioeconomic groups. This observation was supported by statistically significant pro-poor inequality observed for type 2 diabetes (CI = −0.099, 95% CI: −0.169 to −0.047, $p < 0.001$) and Sickle Cell Disease (CI = −0.101, 95% CI: −0.165 to −0.040, $p = 0.004$).

Figure 5. Concentration curves of total outpatient costs by level of care

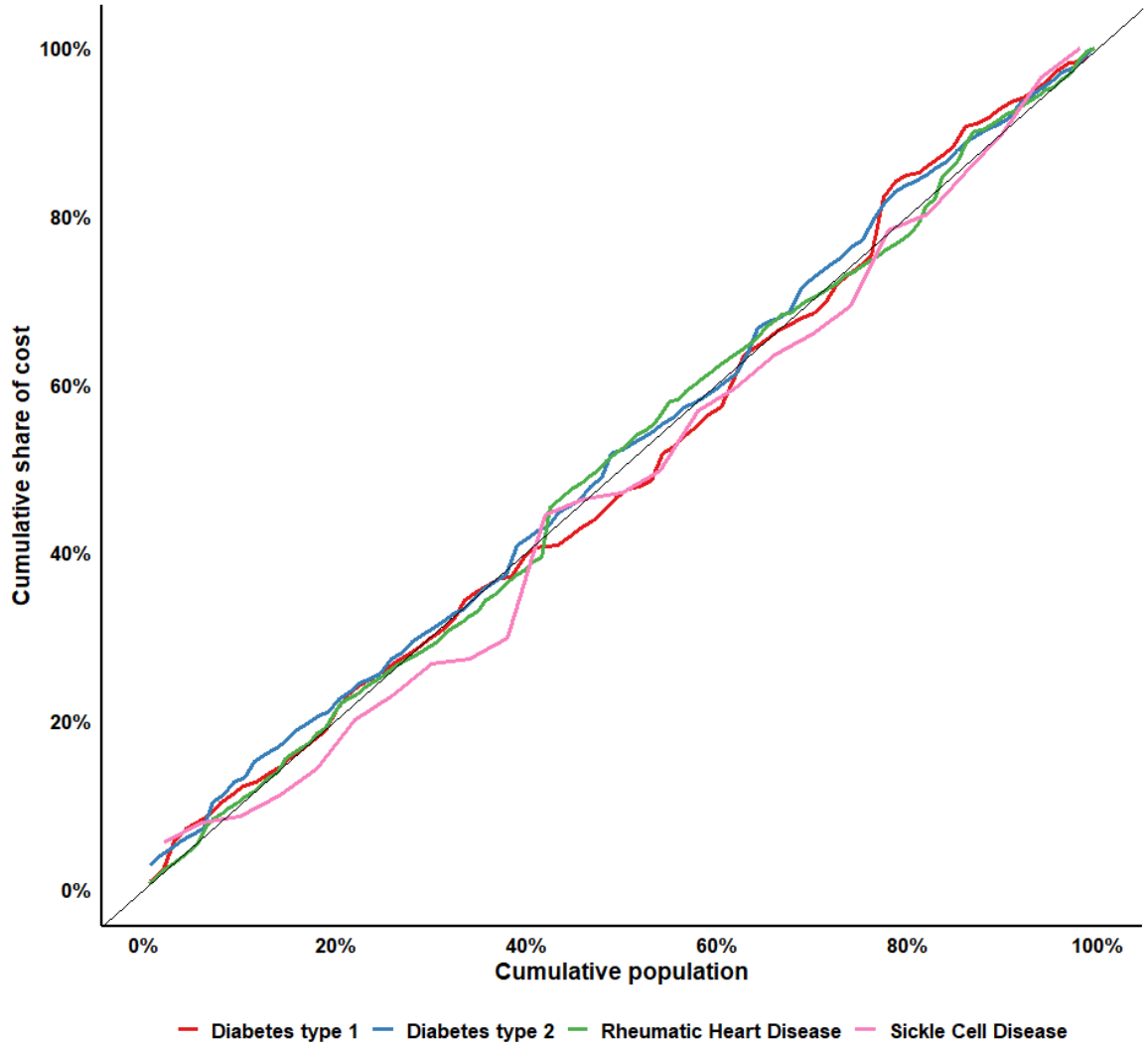


Figure 5a: Concentration curves of total outpatient costs by socioeconomic status in primary hospitals.

Note: The 45° diagonal line represents perfect equality in the distribution of outpatient costs across socioeconomic groups. Curves above the line indicate a disproportionate concentration of costs among lower-income groups (pro-poor distribution), whereas curves below the line indicate a disproportionate concentration among higher-income groups (pro-rich distribution).

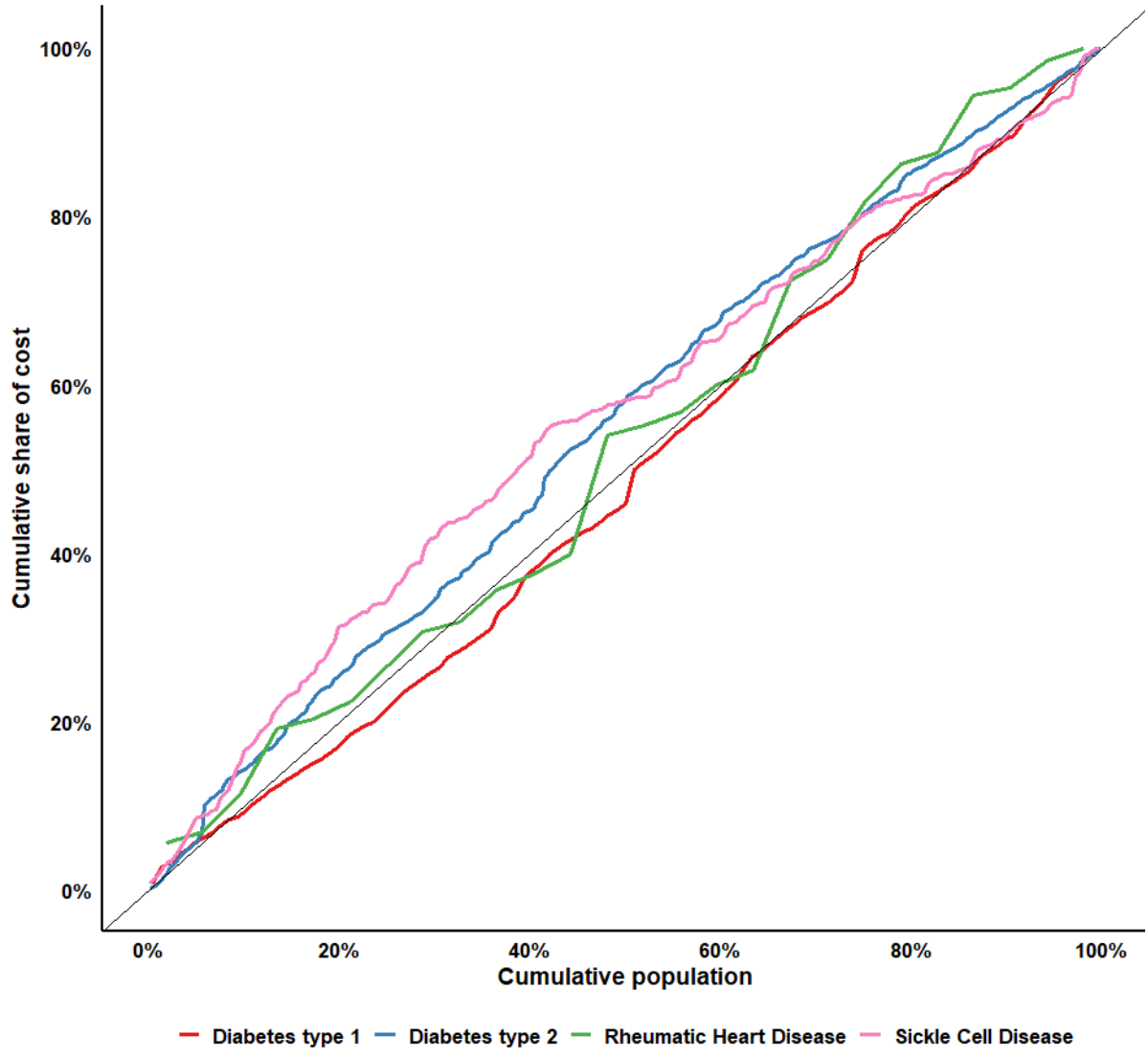


Figure 5b: Concentration curves of total outpatient costs by socioeconomic status in tertiary hospitals

Note: The 45° diagonal line represents perfect equality in the distribution of outpatient costs across socioeconomic groups. Curves above the line indicate a disproportionate concentration of costs among lower-income groups (pro-poor distribution), whereas curves below the line indicate a disproportionate concentration among higher-income groups (pro-rich distribution).

Drivers of costs

Table 3 presents adjusted associations between patient characteristics and costs.

Receiving care at primary hospitals was associated with lower total costs than receiving care at tertiary hospitals (CR 0.80; 95% CI: 0.72–0.90). Total costs increased with greater distance to the health facility (CR 1.002 per kilometre; 95% CI: 1.002–1.003). Participants who were accompanied during care-seeking incurred higher total costs than those attending alone (CR 1.41; 95% CI: 1.28–1.55). Unmarried participants incurred lower total costs than married participants (CR 0.87; 95% CI: 0.78–0.96). Compared with participants without formal education, those with primary education (CR 0.78; 95% CI: 0.61–0.97) and college education (CR 0.68; 95% CI: 0.53–0.87) incurred lower total costs. Results were robust to alternative model specifications, including log-normal models and winsorised cost values. Multicollinearity diagnostics indicated no evidence of model instability. Detailed results are presented in Supplemental material, Tables S2–S4.

Table 3: Adjusted regression models using Gamma GLM (log link)

Variables	Adjusted cost ratio (95% CI)			
	Direct medical cost	Direct non-medical cost	Indirect Cost	Total cost
Age	1.011 (1.000–1.022)	0.998 (0.995–1.002)	1.002 (1.001–1.003)*	0.999 (0.996–1.001)
Gender				
Female	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Male	1.048 (0.743–1.482)	1.039 (0.923–1.169)	1.025 (0.993–1.057)	1.064 (0.976–1.160)
Marital status				
Married	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Unmarried	0.466 (0.314–0.694)*	0.778 (0.679–0.894)*	0.973 (0.938–1.009)	0.865 (0.783–0.956)*
Education level				
Not formal	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Primary school	0.616 (0.206–1.502)	0.658 (0.474–0.893)*	0.945 (0.869–1.026)	0.776 (0.613–0.971)*
Secondary school	0.434 (0.144–1.079)	0.654 (0.463–0.903)*	1.016 (0.930–1.108)	0.790 (0.616–1.002)
College	0.464 (0.146–1.247)	0.621 (0.437–0.866)*	1.002 (0.916–1.095)	0.682 (0.529–0.870)*

Variables	Adjusted cost ratio (95% CI)			
	Direct medical cost	Direct non-medical cost	Indirect Cost	Total cost
Socioeconomic status (quintile)				
Poorest	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Poor	1.529 (0.935–2.504)	0.977 (0.811–1.178)	0.973 (0.927–1.023)	0.983 (0.859–1.126)
Middle	1.959 (1.180–3.278)*	1.149 (0.938–1.409)	0.969 (0.918–1.022)	1.152 (0.994–1.336)
Rich	1.899 (1.127–3.221)*	1.274 (1.041–1.562)*	0.977 (0.926–1.031)	1.102 (0.951–1.277)
Richest	1.416 (0.799–2.560)	1.404 (1.152–1.709)*	0.914 (0.867–0.963)*	0.934 (0.810–1.077)
Residence				
Rural	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Urban	1.569 (1.084–2.280)*	0.830 (0.732–0.941)*	0.999 (0.967–1.032)	0.916 (0.837–1.003)
Household size	1.046 (0.681–1.711)	0.924 (0.775–1.115)	1.032 (0.984–1.084)	0.950 (0.843–1.077)
Other chronic disease				
No	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Yes	0.936 (0.573–1.567)	0.944 (0.814–1.099)	1.005 (0.966–1.047)	1.046 (0.937–1.169)
Health facility level				
Tertiary hospital	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Primary hospital	1.637 (0.992–2.788)	0.979 (0.836–1.149)	0.972 (0.933–1.013)	0.801 (0.717–0.896)*
Distance to facility (km)	1.002 (1.000–1.005)*	1.004 (1.003–1.005)*	1.001 (1.001–1.001)*	1.002 (1.002–1.003)*
Accompanied during care-seeking				
No	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)	1.000 (Ref)
Yes	1.450 (0.985–2.150)	2.082 (1.823–2.382)*	0.973 (0.939–1.007)	1.405 (1.275–1.550)*

exp(β) is the exponentiated regression coefficient, representing a multiplicative change relative to the reference category for categorical variables or a per-unit increase for continuous variables.

(*) $p < 0.05$.

(Ref) reference category.

Discussion

This study highlights the importance of understanding the patient-level economic burden of severe NCDs to inform priority-setting and to create fair financing mechanisms for chronic conditions. It provides empirical evidence from Tanzania on how outpatient expenditures vary across disease categories, cost components, and health facility tiers. Our analysis of direct and indirect costs across primary and tertiary care platforms in Tanzania shows that health system access pathways, not just user fees, drive the economic impact of severe NCD care.

Our findings show that direct non-medical and indirect costs drove the economic burden of severe NCD care, not direct medical payments alone. While consultation fees, medicines, and diagnostic services remain important contributors to patient expenditure, patients also incurred substantial costs for transport, accommodation, and lost wages associated with obtaining care. Similar patterns have been reported in other LMIC settings [18, 33, 34]. For severe NCDs, these access-related expenses are particularly pronounced. Their chronic nature requires lifelong management, repeated follow-up visits, and sustained engagement with the health system[1, 7].

Our study showed that these costs were not distributed equally across patients and households. Household heads and patients requiring accompanying caregivers incurred higher total costs; this increase was driven largely by higher indirect costs and additional transport expenses. These findings align with earlier work from similar settings [15, 18, 35]. Chronic illness affects not only patients but also household economic functioning by disrupting income-generating activities and increasing caregiving demands. This is particularly relevant in Tanzania, where most employment (94.6%) occurs in the informal sector and income losses can arise rapidly when work is interrupted [28]. The burden of severe NCD care therefore extends beyond direct medical costs and may adversely affect household livelihoods and economic security.

Socioeconomic differences influenced how these costs were experienced. Patients in the middle-income quintiles reported higher total costs than those in the poorest quintile. Financial barriers may lead poorer individuals to delay, ration, or forgo necessary care; their expenditure can therefore appear lower despite greater healthcare needs. Lower observed expenditure among poorer patients should not be interpreted as greater affordability: financial barriers may cause some individuals to delay, ration, or forgo care despite greater healthcare needs. Although this study did not directly measure unmet need or foregone care, this interpretation is consistent with evidence from other LMIC settings [35, 36].

Together, these findings show that affordability of severe NCD care depends on more than direct medical costs alone. Direct medical costs are also influenced by direct non-medical costs and indirect costs incurred when accessing and sustaining care over time. Consequently, assessments of financial protection based solely on out-of-pocket direct medical costs may underestimate the economic burden patients and households experience. Policies that focus only on reducing direct medical costs are therefore unlikely to eliminate financial hardship unless they are accompanied by interventions that reduce transport costs, minimise productivity losses, and address barriers to accessing care.

Our study further showed that patients' expenditure varied considerably by disease type and level of care, with patients attending tertiary hospitals generally incurring higher total costs than those receiving care at primary hospitals. This finding is consistent with evidence from other LMICs showing that decentralised service delivery models, such as PEN Plus, can reduce patient expenditure by bringing services closer to communities [5, 37]. Although direct medical costs may vary across facility levels, lower non-medical and indirect costs at primary hospitals more than offset these differences. In contrast, patients receiving care at tertiary facilities faced substantially higher transport, accommodation, and productivity-related costs. Geographic access appears to drive these differences. Greater travel distance was associated

with higher total costs, reflecting the cumulative burden of repeated journeys for chronic disease care. Similar findings have been reported across sub-Saharan Africa, where geographic barriers remain important drivers of out-of-pocket spending for chronic disease management [18, 34]. Differences across disease groups likely reflect variation in treatment complexity and referral pathways, with conditions requiring specialised services often necessitating care at higher-level facilities and, consequently, greater travel-related expenditure. These findings suggest that decentralisation should be viewed not only as a service-delivery strategy but also as a financial protection intervention. By bringing services closer to communities, decentralised models can reduce direct non-medical costs and indirect costs associated with repeated healthcare visits. Strengthening severe NCD services at primary hospitals, expanding PEN Plus implementation, supporting multi-month medication dispensing, and reducing unnecessary referrals may therefore improve both access to care and financial protection for affected households.

Descriptive analyses showed substantial cost differences between insured and uninsured participants. Almost all insured participants (96.5%) reported no direct medical expenditure, compared with 46.0% of uninsured participants. This finding suggests that health insurance primarily protects households by preventing direct medical payments rather than reducing expenditure among those who incur medical costs. Similar findings have been reported in several LMICs, where insurance coverage is associated with lower direct medical costs and improved financial protection for households [5, 38]. However, insurance did not eliminate the economic burden of chronic disease care in this study. Uninsured participants incurred more than twice the mean annual direct costs of insured participants, indicating that substantial financial barriers remain for individuals without coverage. The persistence of out-of-pocket spending among insured patients may reflect limitations in benefit packages, service coverage, or access to covered services. Consistent with this explanation, fewer than

half of insured patients attending district hospitals reported comprehensive insurance coverage, compared with approximately 80% of those attending tertiary hospitals. These findings suggest that variations in insurance benefits and incomplete coverage may reduce the effectiveness of insurance schemes in providing full financial risk protection for patients with chronic diseases. They also indicate that insurance is most effective when the benefit package aligns with patients' healthcare needs. The implementation of Tanzania's Universal Health Insurance Act of 2023 may therefore provide an important opportunity to strengthen financial protection through more comprehensive and equitable coverage of essential NCD services.

Overall, this study highlights how health-system organisation and access pathways shape the economic burden of severe NCDs. These findings suggest that reducing medical fees alone is unlikely to eliminate the economic burden of chronic disease. Effective financial protection, therefore, requires addressing the full costs of accessing services.

Strengths and limitations

This study has notable strengths, including being among the first to comprehensively evaluate the economic burden of severe NCDs selected for the PEN-Plus programme in Tanzania. It examined multiple NCDs within a single health system framework. By focusing on the patient perspective, it captured direct medical, non-medical, and indirect costs, providing a more comprehensive picture of the household economic impact. Additionally, incorporating health facilities across care levels enabled cost comparisons within the context of ongoing decentralisation reforms. Some limitations should be considered in interpreting these findings. First, annual costs were estimated assuming 12 follow-up visits per year. This assumption may have slightly overestimated costs, as some clinically stable patients at BMC and KCMC may be scheduled for follow-up visits every two to three months rather than monthly. Second, productivity losses were valued using a national average wage. Participants represented

diverse occupations, skill levels, and earning capacities, which may not accurately reflect individual productivity losses [28]. This approach may underestimate productivity losses under PEN Plus conditions, particularly for higher-income or skilled workers. Nevertheless, applying a national average wage for non-skilled workers provides a conservative estimate when occupation-specific wage data are unavailable and enhances comparability with similar economic evaluations. The indirect-cost estimate was limited to patient productivity losses and did not account for productivity losses incurred by accompanying persons or caregivers, which may have underestimated the overall economic burden of illness.

Third, the findings from the Gamma regression models should be interpreted with caution. Gamma GLMs exclude observations with zero costs and therefore estimate cost intensity among participants who incurred costs rather than the likelihood of incurring costs. This included direct medical costs: 96.5% of insured participants reported zero expenditure and were excluded from the regression analysis, whereas almost all participants had positive total costs. Consequently, the models assessed differences in spending among participants with non-zero costs and may thus have reduced the analysis's ability to detect associations between insurance status and direct medical expenditure, despite the substantial reduction in overall costs observed among insured participants.

Fourth, some cost components, particularly direct costs, were based on self-reported information and may therefore be subject to recall bias. The analysis only included outpatient visits, excluding costs related to inpatient care or long-term complications, which could underestimate the overall economic impact. Finally, the study was conducted in selected district hospitals implementing the PEN-Plus programme and in zonal referral hospitals that provide technical support and capacity building for these district hospitals. As a result, the findings may not be fully generalizable to all health-system settings.

Conclusion

This study shows that the economic burden of severe NCDs remains substantial for patients and households in Tanzania. A large share of this burden stems from access barriers, including long travel distances and productivity losses incurred while seeking care. Although health insurance reduces point-of-service costs, financial protection remains incomplete. Strengthening district-level capacity to deliver specialised NCD services will be critical to reducing the household economic burden of disease. Addressing the factors identified in this study is essential to advancing equitable access to chronic disease care and achieving UHC's financial protection goals.

Acknowledgements

We thank the National Institute for Medical Research (NIMR) and the PEN-Plus Tanzania team for their valuable feedback on the study design and the development of the data collection tools. We are particularly grateful to Peter Kalori, Kelvin Madyo, Elizabeth Malya, and Alphoncina Kagaigai for their important contributions to this work. We are also grateful to the management and healthcare providers at the four study hospitals for their collaboration and support. These include Kondoa Town Council Hospital (Dodoma Region), Karatu Lutheran Hospital (Manyara Region), Benjamin Mkapa Hospital (Dodoma Region), and Kilimanjaro Christian Medical Centre (Kilimanjaro Region).

Authors' contributions

The contribution of each author according to the CRediT (Contributor Roles Taxonomy) author statement. All authors contributed to the study conception and interpretation of findings, critically reviewed the manuscript, and approved the final version.

RW: Conceptualisation, Methodology, Investigation, Data Curation, Formal Analysis, Visualisation, Project Administration, Writing - Original Draft.

AH: Conceptualisation, Methodology, Formal Analysis, Visualisation, Supervision, Validation, Writing - Review & Editing.

MK: Conceptualisation, Methodology, Validation, Interpretation of Results, Supervision, Writing - Review & Editing.

MM: Investigation, Validation, Review & Editing.

OFN: Investigation, Project Administration, Validation, Review & Editing.

Funding information
This study was jointly funded by the Norwegian Agency for Development Cooperation (NORAD) under Project RAF20/0032 and by the Research Council of Norway through its Centres of Excellence scheme, project number 332673. The funders had no role in study design, data collection, analysis, interpretation, manuscript preparation, or the decision to publish.

Data availability statement
The corresponding author may make de-identified data available upon reasonable request, subject to approval by the relevant ethics committees and to compliance with applicable data protection and confidentiality requirements.

Declarations

Generative AI use
The authors used Grammarly to assist with language editing and improvement of manuscript readability. The authors reviewed, verified, and revised all content and take full responsibility for the final manuscript.

Ethics and consent

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and applicable national regulations. Ethical approval was obtained from the National Health Research Ethics Committee (NatHREC) at the National Institute for Medical Research (NIMR), Dar es Salaam, Tanzania (Ref. Vol IX/4533), and the Regional Committee for Medical and Health Research Ethics in Norway (Ref. 611486). Written informed consent was obtained from all adult participants prior to enrollment. For participants younger than 18 years, a parent or legal guardian provided written informed consent before participation.

Disclosure statement

The authors declare no competing interests.

References

1. World Health Organisation. Noncommunicable diseases. 2025 [cited 2026 04/05]. Available from: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

2. Gouda HN, Charlson F, Sorsdahl K, Ahmadzada S, Ferrari AJ, Erskine H, et al. Burden of non-communicable diseases in sub-Saharan Africa, 1990-2017: results from the Global Burden of Disease Study 2017. Lancet Glob Health. 2019;7(10):e1375-e87.

3. Ministry of Health, United Republic of Tanzania. Health Sector Strategic Plan July 2021 – June 2026 (HSSP V). 2021.

4. Institute for Health Metrics and Evaluation (IHME). Global Burden of Disease Study 2019 (GBD 2019) Disability Weights. 2023 [cited 2023 Available from: https://ghdx.healthdata.org/record/ihme-data/gbd-2019-disability-weights

5. Drown L, Adler AJ, Salvi D, Boudreaux C, Gupta N, Ali Z, et al. Facility readiness for decentralized Package of Essential Noncommunicable Disease Interventions-Plus (PEN-Plus) care in nine lower-income countries. PLOS Glob Public Health. 2025;5(4):e0004398.

6. NCDI Poverty. WHO/AFRO Member States Adopt Regional Strategy to Implement PEN-Plus. 2022 [cited 2022 23-12-22]. Available from: https://www.ncdipoverty.org/blog/2022/8/23/whoafro-member-states-adopt-regional-strategy-to-implement-pen-plus

7. NCDI Poverty Network. PEN-Plus Clinical Tools and Programmatic Standards. 2024.

8. Bukhman G, Mocumbi A, Wroe E, Gupta N, Pearson L, Bermejo R, et al. The PEN-Plus Partnership: addressing severe chronic non-communicable diseases among the poorest billion. Lancet Diabetes Endocrinol. 2023;11(6):384-6.

9. NIMR. Protocol-Improving access to Package of Essential services for severe Non-communicable Diseases in Tanzania- PEN PLUS PROJECT. 2022.

10. Otieno Osoro BM, Lizah Nyawira, Joseph Githinji, Shadrack Gikonyo. Policy Brief:Tanzania's Universal Health Insurance Act 2023: Implications on Health Financing. 2024 [cited 11/08/2025]. Available from: https://sparc.africa/resource/tanzanias-universal-health-insurance-act-2023-implications-on-health-financing/

11. Willilo RA, Hailu A, Melberg A, Norheim O.F, Kagaigai A, Kühl MJ. Procedural fairness in health priority-setting in Tanzania: The institutionalisation gap in revising the health benefits package.[Draft manuscript], University of Bergen. 2026;

12. Ndumwa HP, Amani DE, Ngowi JE, Njiro BJ, Munishi C, Mboya EA, et al. Mitigating the Rising Burden of Non-Communicable Diseases through Locally Generated Evidence-Lessons from Tanzania. Ann Glob Health. 2023;89(1):77.

13. Ministry of Health, United Republic of Tanzania. Tanzania National Health Accounts year 2023. 2023.

14. Bintabara D, Ngajilo D. Readiness of health facilities for the outpatient management of non-communicable diseases in a low-resource setting: an example from a facility-based cross-sectional survey in Tanzania. BMJ Open. 2020;10(11):e040908.

15. Butt MD, Ong SC, Wahab MU, Rasool MF, Saleem F, Hashmi A, et al. Cost of Illness Analysis of Type 2 Diabetes Mellitus: The Findings from a Lower-Middle Income Country. Int J Environ Res Public Health. 2022;19(19):

16. Broekhuizen H, Fehr A, Nieto-Sanchez C, Muela J, Peeters-Grietens K, Smekens T, et al. Costs and barriers faced by households seeking malaria treatment in the Upper River Region, The Gambia. Malar J. 2021;20(1):368.

17. Teni FS, Gebresillassie BM, Birru EM, Belachew SA, Tefera YG, Wubishet BL, et al. Costs incurred by outpatients at a university hospital in northwestern Ethiopia: a cross-sectional study. BMC Health Services Research. 2018;18(1):842.

18. Bommer C, Sagalova V, Heesemann E, Manne-Goehler J, Atun R, Bärnighausen T, et al. Global Economic Burden of Diabetes in Adults: Projections From 2015 to 2030. Diabetes Care. 2018;41(5):963-70.

19. Pastakia SD, Pekny CR, Manyara SM, Fischer L. Diabetes in sub-Saharan Africa - from policy to practice to progress: targeting the existing gaps for future care for diabetes. Diabetes Metab Syndr Obes. 2017;10(247-63.

20. Opara CC, Aghassibake N, Watkins DA. Economic consequences of rheumatic heart disease: A scoping review. Int J Cardiol. 2021;323(235-41.

21. Rwebembera J, Beaton AZ, de Loizaga SR, Rocha RTL, Doreen N, Ssinabulya I, et al. The Global Impact of Rheumatic Heart Disease. Curr Cardiol Rep. 2021;23(11):160.

22. Drown L, Osei M, Thapa A, Boudreaux C, Archer N, Bukhman G, et al. Models of care for sickle cell disease in low-income and lower-middle-income countries: a scoping review. Lancet Haematol. 2024;11(4):e299-e308.

23. Voorhoeve A, Edejer TTT, Kapiriri L, Norheim OF, Snowden J, Basenya O, et al. Three Case Studies in Making Fair Choices on the Path to Universal Health Coverage. Health Hum Rights. 2016;18(2):11-22.

24. Schnitzler L, Roberts TE, Jackson LJ, Paulus ATG, Evers S. A consensus-based checklist for the critical appraisal of cost-of-illness (COI) studies. Int J Technol Assess Health Care. 2023;39(1):e34.

25. World Health Organisation. Nationwide generic TB patient cost survey. 2017 [cited Available from: https://cdn.who.int/media/docs/default-source/hq-tuberculosis/patient-cost-survey/nationwide-generic-tb-patient-cost-survey-__-tool_2017.pdf?sfvrsn=b7c28af4_5

26. USAID. Tool to estimate patients' costs. [cited Available from: https://stoptb.org/wg/dots_expansion/tbandpoverty/assets/documents/Tool%20to%20estimate%20Patients%27%20Costs.pdf

27. Drummond M. Methods for the economic evaluation of health care programmes. Fourth edition. ed. Oxford, United Kingdom ; New York, NY, USA: Oxford University Press; 2015. xiii, 445 pages p.

28. National Bureau of Statistics (NBS) OotCGSO-Z. The Labour Market: Key Findings from Integrated Labour Force Survey 2024. Dodoma, Tanzania: 2025.

29. Cropper ML, Haile M, Lampietti JA, Poulos C, Whittington D. The Value of Preventing Malaria in Tembien, Ethiopia. Washington, DC: 2000.

30. Bank of Tanzania. Bank of Tanzania, Exchange Rates. 2025 [cited 10/01/2026]. Available from: https://www.bot.go.tz/exchangerate/excrates

31. Zaidi ADaS. Guidelines for Constructing Consumption Aggregates for Welfare Analysis. 2002 [cited 11/02/2026]. Available from: https://documents1.worldbank.org/curated/en/206561468781153320/pdf/Guidelines-for-constructing-consumption-aggregates-for-welfare-analysis.pdf

32. Xu K, Evans DB, Kawabata K, Zeramdini R, Klavus J, Murray CJ. Household catastrophic health expenditure: a multicountry analysis. Lancet. 2003;362(9378):111-7.

33. Lozano A, Gutiérrez-Clavijo JC, Pineda-Lozano JC, Cárdenas-Robledo S, Casallas-Vanegas A, Alvis-Zakzuk NJ. Economic and Disease Burden of Multiple Sclerosis in Colombia. Value in Health Regional Issues. 2025;47(101096.

34. Verjans A, Hooley B, Tani K, Mhalu G, Tediosi F. Cross-sectional study of the burden and determinants of non-medical and opportunity costs of accessing chronic disease care in rural Tanzania. BMJ Open. 2024;14(3):e080466.

35. Oyando R, Njoroge M, Nguhiu P, Kirui F, Mbui J, Sigilai A, et al. Patient costs of hypertension care in public health care facilities in Kenya. Int J Health Plann Manage. 2019;34(2):e1166-e78.

36. Barasa E, Kazungu J, Nguhiu P, Ravishankar N. Examining the level and inequality in health insurance coverage in 36 sub-Saharan African countries. BMJ Glob Health. 2021;6(4):

37. Karoli P, Mayige M, Kagaruki G, Mori A, Macha E, Mutagaywa R, et al. Mid-level healthcare workers knowledge on non-communicable diseases in Tanzania: a district-level pre-and post-training assessment. BMC Health Serv Res. 2024;24(1):612.

38. Watkins DA, Jamison DT, Mills T, Atun T, Danforth K, Glassman A, et al. Universal Health Coverage and Essential Packages of Care. In: Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, Mock CN, et al., editors. Disease Control Priorities: Improving Health and Reducing Poverty. Washington (DC): The International Bank for Reconstruction and Development / The World Bank © 2018 International Bank for Reconstruction and Development / The World Bank.; 2017.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplimentalmaterials.docx