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Patient-incurred cost of inpatient treatment for Tuberculosis in rural Malawi

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Abstract

Objectives: To mitigate the economic burden of tuberculosis (TB), it is important to fully understand the costs of TB treatment from the patient perspective. We therefore sought to quantify the patient-incurred cost of TB treatment in rural Malawi, with specific focus on costs borne by patients requiring inpatient hospitalization.

Methods: We conducted a cross-sectional survey of 197 inpatients and 156 outpatients being treated for TB in rural Malawi. We collected data on out-of-pocket costs and lost wages, including costs to guardians. Costs for inpatient TB treatment were estimated and compared to costs for outpatient TB treatment. We then explored the equity distribution of inpatient TB treatment cost using concentration curves.

Results: Despite free government services, inpatients were estimated to incur a mean of $137 (standard deviation: $147) per initial TB episode, corresponding to > 50% of annual household spending among patients in the lowest expenditure quintile. Non-medical hospitalization costs accounted for 88% of this total. Patients treated entirely as outpatients incurred estimated costs of $25 (standard deviation: $15) per episode. The concentration curves showed that, among individuals hospitalized for an initial TB episode, poorer patients shouldered a much greater proportion of inpatient TB treatment costs than wealthier ones (concentration index: −0.279).

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CONFLICT OF INTEREST

All authors have no potential conflicts of interest.

Conclusion: Patients hospitalized for TB in resource-limited rural Malawi experience devastating costs of TB treatment. Earlier diagnosis and treatment must be prioritized if we are to meet goals of effective TB control, avoidance of catastrophic costs, and provision of appropriate patient-centered care in such settings.

Keywords

Tuberculosis (TB); patient-incurred cost; inpatient; Malawi; rural

INTRODUCTION

Tuberculosis (TB) is the world's deadliest infectious disease, with an estimated 10 million people developing new active TB and more than 1.5 million dying from TB each year (1). Although TB treatment is provided free of charge in most high-burden countries, non-medical costs for such expenses as transport to health facilities, temporary accommodation, childcare and food are still shouldered by people being treated for TB and their households (4–5). This burden may be particularly severe for patients in rural settings with very few resources, especially those who require extended hospitalization after presenting with advanced disease. Indeed, a negative cycle often develops whereby high perceived costs cause individuals to delay seeking care, in turn resulting in more severe disease at presentation and the need for even costlier interventions such as hospitalization – with both the initial barriers to seeking care and the economic consequences of hospitalization disproportionately affecting the poor. This cycle is further exacerbated by the fact that TB often affects adults in their most productive years, resulting in loss of key household income (6).

In 2017, the World Health Organization (WHO) and World Bank reported that 10% of the world's population experience catastrophic health expenditures, and urged countries to implement universal health coverage (7). The End TB Strategy includes a target of zero catastrophic costs due to TB by 2020 (1). Eliminating barriers and expanding access to care can mitigate TB-related catastrophic costs (8), but costs of TB treatment are still incompletely defined from the patient perspective. While a number of studies have estimated patient costs of TB (9–14), most consider hospitalization in a proportional fashion (for example, calculating a single mean cost assuming a probability of hospitalization). This masks the tremendous costs that may be borne by those who require hospitalization, particularly in severely resource-constrained rural contexts, where these costs may be most devastating.

We therefore sought to quantify the cost of TB treatment from the patient perspective in rural Malawi, with explicit attention to the costs associated with hospitalization in this setting. We assessed hospital-related costs by surveying individuals undergoing inpatient treatment. We also surveyed individuals attending primary health clinics to infer the costs of outpatient treatment for comparison. We then used these data to estimate the total cost of TB treatment from the patient perspective, separately for individuals who are hospitalized versus treated entirely as outpatients.

METHODS

Study population

We enrolled randomly selected adult inpatients who were receiving inpatient treatment for TB at Thyolo District Hospital in Malawi between the dates of Aug. 2012 to Jan. 2017. Thyolo District Hospital is the only inpatient facility serving Thyolo District, a rural district located in the southern portion of Malawi (bordering Mozambique) with a population of over 720,000 (15). Contemporary Malawian guidelines recommended hospitalization for individuals with recurrent TB for two months of injectable ("category 2") treatment; otherwise, the decision to hospitalize was at the discretion of individual clinician with likely consideration of symptom severity and ability to mobilize the patient to Thyolo District Hospital. Following hospital discharge, patients were referred to their local clinics for completion of treatment as outpatients. Data collection was performed contemporaneously with the CHEPETSA study (16–17), a cluster-randomized trial of point-of-care TB screening among adults newly diagnosed with HIV in 12 primary health clinics in Thyolo District. In these clinics, due to severe resource constraints, medication for TB treatment is provided on a monthly basis and is not directly observed in clinic, though some community based directly observed therapy is provided.

For comparison of inpatient and outpatient costs, we also surveyed two additional populations. First, we assessed the cost of clinic visits among CHEPETSA participants (i.e., consecutive adults in 12 primary health clinics who were recently diagnosed with HIV and undergoing screening for active TB). Second, we obtained demographic and socioeconomic data from a consecutive cross-section of patients who were not CHEPETSA participants but who received outpatient treatment for TB in the 12 CHEPETSA clinics. The latter population was recruited by study staff who approached patients at the time of presentation for regularly scheduled monthly follow-up visits (for clinical evaluation and TB medication dispensation) and did not include participants diagnosed with TB through CHEPETSA screening activities.

Data collection

We asked inpatients to respond to a costing survey developed based on the Stop TB Partnership's Tool to Estimate Patients' Costs (18). We asked patients to estimate their total out-of-pocket (OOP) costs related to TB treatment, from the time of TB diagnosis to the time of interview. Costs assessed included costs for transportation, food, accommodation, clothing, consultation and diagnostic expenses, medicine, childcare, and other expenses. In a separate single item (analyzed as a secondary outcome), we asked respondents to estimate the total OOP cost incurred. We also elicited costs to guardians and caregivers (for example, those accompanying the patient during the inpatient stay). We estimated the opportunity cost of lost work while hospitalized as the patient's weekly pre-illness wage, multiplied by the expected total number of weeks hospitalized. When earnings were in-kind, patients were asked to estimate the market value of all in-kind payments or gifts received. In addition, we elicited guardians' lost income from time of TB diagnosis to the day of survey administration, in a single questionnaire item. In calculating the total cost of TB treatment, we assumed that additional childcare, food, and opportunity costs would be incurred during hospitalization (in prorated fashion based on the number of additional expected hospital days), that additional medical costs would not be incurred from the time of the survey to hospital discharge, and an equivalent cost of transportation would be incurred on discharge as on admission. We also assumed that, following discharge, hospitalized patients would visit an outpatient clinic on a monthly basis for the rest of the six-month standard treatment period. To estimate the costs of these outpatient clinic visits, we used the outpatient OOP cost per visit and time spent at the facility as reported by the outpatient population.

To compare the cost of inpatient and outpatient treatment, we administered the same costing survey to a consecutive sample of CHEPETSA participants (individuals recently diagnosed with HIV and screened for TB in the outpatient setting). This enabled us to estimate the cost of an outpatient clinic visit from the patient perspective. Since CHEPETSA participants could differ from individuals receiving treatment for TB in ways that might be important from a costing perspective (for example, having different levels of income), we used demographic and socioeconomic data from a sample of individuals receiving outpatient treatment for TB in the same clinics to estimate the likely cost per clinic visit among people being treated for TB in the outpatient setting. We assumed that the patient cost of outpatient TB treatment consisted of seven clinic visits (one for diagnosis and six monthly visits for treatment), according to the contemporary standard of care in this impoverished rural setting, that additional medical costs and guardian costs would not be incurred during outpatient TB treatment, and that reported patient OOP and opportunity costs were representative of a typical clinic visit.

All costs were measured in Malawian Kwacha at the time of the interview, inflated to 2017 values using the Malawian GDP deflator (19), and converted into US dollars using the average December 2017 exchange rate (1USD = 716.557MK) (20). We considered alternative methods of inflation given a spike in the exchange rate that occurred during study period (reflecting a 2012 fiscal policy decision to stop benchmarking the value of the kwacha to that of the US dollar), and found that this alternative valuation did not materially affect our results (defined as a >10% change in any of our primary estimates of cost; data not shown) (21).

Statistical analysis

Descriptive statistics were used to summarize data on mean costs as well as general characteristics for each study population group. To compare general characteristics and mean costs among the groups, univariate comparison analyses were done with chi-square tests for categorical variables and F-tests from analysis of variance (ANOVA) tests for continuous variables. We analyzed patients with recurrent TB separately from those who were hospitalized for an initial TB episode. In our primary analysis, we included all reasonable responses to the questionnaire, but in a sensitivity analysis, we excluded outlier responses (defined as the being more than twice as large as the next-largest value). This sensitivity analysis did not cause our estimates of mean per-person OOP costs or opportunity costs to vary by more than ten percent (data not shown).

We used multiple imputation with chained equations to estimate the mean costs associated with an outpatient clinic visit, extrapolated from costs reported by Chepetsa participants.

Imputation was based on log-linear regression models that regressed socio-economic data including weekly household consumption, occupation, education level, literacy, and household size on the components of mean OOP costs (travel, childcare, food, and accommodation) and wage estimates used to calculate the mean opportunity cost per clinic visit. In order to account for skewness in the data and ensure that the residuals were normally distributed, we performed a log transformation on the cost regressors in the model. The sum of each imputed mean cost estimate (using the characteristics of patients being treated for TB) was then compared to the mean cost estimate as directly imputed from the sum of each cost obtained in CHEPETSA (from patients newly diagnosed with HIV).

Finally, we used concentration curves to describe the equity distribution of inpatient TB treatment costs, according to two metrics: (a) total treatment costs and (b) treatment costs scaled as a proportion of annual household spending. To estimate annual household expenditure, participants were asked to estimate all household spending in a typical week; we multiplied this estimate by 52. Concentration curves provide magnitude of socio-economic inequality intuitively by plotting the cumulative proportion of health spending against the cumulative proportion of individuals ranked by income level (here measured by annual household expenditure) (22). The concentration index is defined as twice the area between the concentration curve and the 45-degree line of perfect equality and ranges from −1 to 1, with 0 indicating perfect equality. Positive values indicate inequality concentrated toward the wealthy, and negative values indicate inequality concentrated toward the poor. All analyses were performed using R version 3.5.3 (R Foundation for Statistical Computing, Vienna, Austria).

Ethical Considerations

The CHEPETSA trial is registered on ClinicalTrials.gov (NCT01450085). This trial was approved by the Institutional Review Boards of the Johns Hopkins Medical Institutions, the London School of Hygiene and Tropical Medicine, and the Malawi College of Medicine.

RESULTS

Study population

In all three populations, mean patient age ranged from 35 to 38 years, fewer than 15% reported completing secondary education, and mean annual household expenditure ranged from $346 to $595 with 70~90% of participants under the poverty line (Table 1). Outpatients receiving new HIV diagnoses had lower household expenditure and education than other groups. Twenty-eight percent of hospitalized individuals had previously been treated for TB.

Empiric data on Patient costs

The mean reported OOP expenditures per individual receiving inpatient treatment for an initial TB episode was $14.96 (standard deviation, SD: $19.52), versus $22.86 (SD: $27.46) for recurrent TB. When also considering guardian costs, mean total OOP costs rose to $28.66 (SD: $29.09) and $39.68 (SD: $46.04), respectively. Among the OOP expenditures, food costs accounted for 50% in both populations. Mean (SD) lost wages (for patients and guardians) from the time of TB diagnosis to the time of survey were $26.65 (SD: $39.75) per hospitalization for initial TB and $83.32 (SD: $132.40) per recurrent TB hospitalization. Combining lost wages and OOP costs for both patients and guardians, the mean total patient cost from TB diagnosis to the time of survey was $55.31 (SD: $58.50) per patient for an initial TB episode and $123.00 (SD: $153.79) per patient for a recurrent TB episode. Mean (SD) total OOP expenditures for outpatients receiving new HIV diagnoses were $3.25 (SD: $5.06) per clinic visit, and mean lost wages per visit were estimated at $1.57 (SD: $5.89). When asked to report total OOP costs as a single item (i.e., without enumerating each component individually), patients underestimated their itemized OOP costs by 53–74% (Table 2).

Cost per TB treatment

The last column of Table 2 shows the estimated patient-incurred costs per clinic visit among outpatients being treated for TB, based on extrapolation from reported costs among outpatients receiving new HIV diagnoses. Mean OOP costs per visit were estimated as $1.69 (SD: $1.41), assuming medical costs would not be incurred for TB outpatient treatment visits. Food costs accounted for the largest proportion of OOP costs (38%). Mean lost wages were estimated as $1.79 (SD: $1.40) per outpatient clinic visit with longer time spent at the facility for TB treatment than receiving HIV diagnoses. When data from patients receiving new HIV diagnoses were used to estimate total visit costs as a single item (rather than estimating each individual cost item separately), results were similar, though variance was larger: mean $3.29 (SD: $4.86) versus $3.52 (SD: $2.11) per visit.

Assuming standard six-month treatment for TB in this population with no documented cases of multidrug resistance, we estimated the total patient costs per TB treatment episode, for individuals who were hospitalized (separately for initial and recurrent episodes) and for individuals receiving treatment entirely as outpatients (Figure 1). The mean estimated total patient-incurred costs of TB treatment for initial and recurrent TB with hospitalization were $136.83 (SD: $147.49) and $286.01 (SD: $305.32), respectively, with most of those costs occurring during the inpatient period. Patient lost wages accounted for $42.47 (31%) and $163.82 (57%) of mean total treatment costs, guardian lost wages accounted for $23.59 (17%) and $29.30 (10%), and food costs accounted for $22.02 (16%) and $32.75 (11%), respectively. For patients treated entirely in the outpatient setting, the mean total TB treatment cost was estimated as $24.61 (SD: $14.77), of which $12.50 (51%) represented lost wages, and $4.47 (18%) represented OOP costs for food.

Concentration curves

We next examined the relationship between inpatient TB treatment costs (as an absolute cost and as a proportion of annual household spending) and annual household expenditures. As annual household expenditure increased, the OOP costs and total TB treatment costs also increased (Figure 2A). The corresponding concentration indices ranged from 0.122 (OOP costs, recurrent TB) to 0.330 (total costs, initial TB episode) (Figure 3A and 3B). However, inpatient TB treatment costs as a proportion of annual household spending were four to thirteen times higher for the poorest quintile relative to the wealthiest quintile (Figure 2B). When patient costs were scaled according to proportion of annual household expenditures, poorer patients were found to shoulder a much greater proportion of scaled costs than wealthier ones (concentration indices for OOP costs of −0.279 for initial TB and −0.430 for recurrent TB) (Figure 3C and 3D).

DISCUSSION

This cross-sectional survey of 197 inpatients and 156 outpatients being treated for TB in an impoverished rural area of Malawi illustrates the high cost of TB treatment shouldered by patients, particularly those who present with severe symptoms requiring hospitalization. The average patient who was hospitalized for TB in this setting was estimated to incur at least $137 (up to $ 286 for recurrent TB), which accounted for over half of annual household spending among patients in the poorest quintile. These estimates do not include pre-treatment costs of illness and care-seeking and assume very low mean wages of about $3 per day. Thus, among patients being hospitalized for TB in this setting, even for initial TB episodes, the costs of TB illness are likely to be catastrophic. Interventions to facilitate earlier care-seeking and diagnosis of TB, such as community mobilization and active case finding, might enable treatment to be initiated before hospitalization is required. Such interventions should therefore be urgently prioritized as a means to avert financial ruin among people living in poor rural sub-Saharan Africa.

While the costs of inpatient treatment in this setting were tremendous, the costs of outpatient TB treatment also should not be overlooked. Even though TB treatment is offered free of charge in Malawi and is often directly observed in the community (such that only monthly clinic visits are required), patients treated entirely as outpatients nonetheless incurred costs of $25 per treatment episode, of which one-third were transportation and food costs and half were lost wages. For example, each clinic visit in this rural setting resulted in costs to patients totaling more than the mean daily wage. These estimates of outpatient costs highlight the additional burden faced by patients in rural settings – who also often have the fewest available resources and highest barriers to seeking care. Innovative community-based approaches of case-finding, diagnosis, and treatment, especially prioritizing underserved populations, may be necessary in these contexts to make TB services more accessible, thereby facilitating appropriate patient-centered care and reducing TB transmission.

In absolute terms, the cost of TB treatment in Thyolo District is lower than in other settings. For example, estimated patient costs of TB treatment have ranged in other studies from $121 in Nigeria to $708 in South Africa (10–14, 23). Patient costs of TB treatment associated with hospitalization ranged from $327 in Ethiopia to $840 in Nigeria (24–26), and patient costs of entirely outpatient-based TB treatment ranged from $11 in Ethiopia to $287 in Nigeria (24–27). The lower costs measured in our study primary reflect the low daily wages of our population (i.e., lower cost of lost wages), the lack of directly-observed therapy, and the low cost of other goods and services (e.g., food and transportation) in rural Malawi. However, despite these low absolute costs, patient costs as a proportion of annual household income were very high – particularly for inpatients and the poor. In the studies cited above, TB treatment costs ranged from 4% to 71% of annual household income; in our population, inpatient costs alone accounted for more than 50% of annual household income for patients in the lowest quintile of household expenditure.

As with all research in resource-constrained settings, this study had a number of important limitations. First, our data relied on cross-sectional self-report; such data might be subject to recall bias (for example, recalling all costs since inpatient admission to the time of survey) and might not reflect full costs over the longitudinal course of treatment. Future studies using longitudinal data could further refine the estimates of patient costs presented here. Importantly, however, we did explicitly assess costs of inpatient and outpatient treatment, enabling us to highlight the disproportionate costs borne by individuals whose disease severity required hospitalization. Second, patients may have underestimated certain costs due to the format of the questionnaire. For example, we did not capture guardian costs for outpatient visits, we did not explicitly ask about dissavings and coping strategies, and we asked about lost wages for guardians as a single item. For those who reported zero weekly income, zero opportunity cost was applied. Such biases in estimated costs are more likely to be under- rather than overestimates; thus, our estimated costs are more likely to be conservative. Third, due to lack of complete data on treatment costs among individuals being treated in the outpatient setting (because of low patient volumes and time constraints in assessing these costs among patients in 12 different clinics), we had to extrapolate costs using data from a similar outpatient population. There may be unmeasured factors that result in different clinic costs for patients receiving outpatient TB treatment and individuals receiving initial HIV diagnoses that could therefore bias our estimates of outpatient treatment. Our finding of similar estimated costs regardless of whether imputation was carried out on individual cost components or the total visit cost may be somewhat reassuring in this regard, but better estimates could be obtained by future studies directly assessing treatment costs among people receiving outpatient TB treatment in similar poor rural settings. Lastly, we aimed to collect costs in a very poor rural sub-Saharan African setting, and our results may therefore not generalize to other settings including urban areas, other world regions, and less resource-constrained contexts.

CONCLUSION

In conclusion, our results show that patients who are hospitalized for TB in resource-limited rural Malawi experience truly devastating costs of TB treatment that account for at least half of annual household income among the poorest and are at least six times higher than outpatient treatment costs. The need for inpatient hospitalization is likely driven by poor access to care resulting in late presentation. Therefore, earlier diagnosis and treatment must be prioritized if we are to meet goals of effective TB control, avoidance of catastrophic costs, and provision of appropriate patient-centered care in such settings. Social protection and other schemes to mitigate the economic consequences of TB disease must also be implemented and evaluated. Only by enabling patients to receive diagnosis before they develop end-stage disease and by lowering of the financial burden of seeking care and receiving treatment can we achieve ambitious global targets to end TB in poor rural sub-Saharan Africa.

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REFERENCES

1. World Health Organization. Global Tuberculosis Report 2018. Geneva; 2018.
2. World Health Organization. Addressing Poverty in TB Control - Options for National TB Control Programmes [Internet]. WHO 2005 Available from: http://apps.who.int/iris/bitstream/10665/43256/1/WHO_HTM_TB_2005.352.pdf
3. Sullivan BJ, Esmaili BE, Cunningham CK. Barriers to initiating tuberculosis treatment in sub-Saharan Africa: A systematic review focused on children and youth. Vol. 10, Global Health Action. Taylor and Francis Ltd.; 2017.
4. Aspler A, Menzies D, Oxlade O, Banda J, Mwenge L, Ayles H. Cost of tuberculosis diagnosis and treatment from the patient perspective in Lusaka, Zambia 2008;12(July 2007):928–35.
5. World Health Organization. Tuberculosis patient cost surveys: a hand book [Internet]. Geneva: WHO; 2017 Available from: http://apps.who.int/bookorders.
6. Heemskerk D, Caws M, Marais B, Farrar J. Tuberculosis in Adults and Children Vol. 193, The Lancet. London: Springer; 2015.
7. World Health Organization and International Bank for Reconstruction and Development. Tracking Universal Health Coverage: 2017 Global Monitoring Report [Internet]. Geneva: WHO; 2017 Available from: http://apps.who.int/iris/bitstream/handle/10665/259817/9789241513555-eng.pdf;jsessionid=C29E21005A5692511BE2B70BD2D3C941?sequence=1
8. Verguet S, Riumallo-Herl C, Gomez GB, Menzies NA, Houben RMGJ, Sumner T, et al. Catastrophic costs potentially averted by tuberculosis control in India and South Africa: a modelling study. Lancet Glob Heal. 2017 11 1;5(11):e1123–32.
9. Stracker N, Hanrahan C, Mmolawa L, Nonyane B, Tampi R, Tucker A, et al. Risk factors for catastrophic costs associated with tuberculosis in rural South Africa. Int J Tuberc Lung Dis. 2019 7 18;23(6):756–63. [PubMed: 31315710]
10. Mudzengi D, Sweeney S, Hippner P, Kufa T, Fielding K, Grant AD, et al. The patient costs of care for those with TB and HIV: A cross-sectional study from South Africa. Health Policy Plan. 2017 11 1;32:iv48–56. [PubMed: 28204500]
11. Chimbindi N, Bor J, Newell ML, Tanser F, Baltussen R, Hontelez J, et al. Time and money: The true costs of health care utilization for patients receiving "free" HIV/tuberculosis care and treatment in rural KwaZulu-natal In: Journal of Acquired Immune Deficiency Syndromes. Lippincott Williams and Wilkins; 2015 p. e52–60.
12. Gospodarevskaya E, Tulloch O, Bunga C, Ferdous S, Jonas A, Islam S, et al. Patient costs during tuberculosis treatment in Bangladesh and Tanzania: The potential of shorter regimens. Int J Tuberc Lung Dis. 2014 7 1;18(7).
13. Mauch V, Bonsu F, Gyapong M, Awini E, Suarez P, Marcelino B, et al. Free tuberculosis diagnosis and treatment are not enough : 2013;17(May 2012):381–7. [PubMed: 23407227]
14. Ukwaja KN, Alobu I, lgwenyi C, Hopewell PC. The High Cost of Free Tuberculosis Services: Patient and Household Costs Associated with Tuberculosis Care in Ebonyi State, Nigeria. PLoS One. 2013 8 27;8(8).
15. National Statistical Office of Malawi. MALAWI POPULATION AND HOUSING CENSUS REPORT-2018 2018 Malawi Population and Housing Main Report. 2019.
16. Zwerling AA, Sahu M, Ngwira LG, Khundi M, Harawa T, Corbett EL, et al. Screening for tuberculosis among adults newly diagnosed with HIV in Sub-Saharan Africa: A cost-effectiveness analysis In: Journal of Acquired Immune Deficiency Syndromes. Lippincott Williams and Wilkins; 2015 p. 83–90.
17. Ngwira LG, Corbett EL, Khundi M, Barnes GL, Nkhoma A, Murowa M, et al. Screening for Tuberculosis With Xpert MTB/RIF Assay Versus Fluorescent Microscopy Among Adults Newly Diagnosed With Human Immunodeficiency Virus in Rural Malawi: A Cluster Randomized Trial (Chepetsa). Clin Infect Dis. 2019 3 19;68(7):1176–83. [PubMed: 30059995]
18. TB|CTA & USAID. The tool to estimate patients' costs. 2008.
19. World Bank. World Bank National Accounts data, and OECD National Accounts data files: GDP deflator (Malawi) [Internet]. [cited 2019 Jul 29]. Available from: https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS?locations=MW

20. Reserve bank of Malawi. Foreign Exchange Rates [Internet]. [cited 2019 Jul 29]. Available from: https://www.rbm.mw/Statistics/MajorRates/
21. Turner HC, Lauer JA, Tran BX, Teerawattananon Y, Jit M. Adjusting for Inflation and Currency Changes Within Health Economic Studies. Value Heal. 2019;
22. Khaled MA, Makdissi P, Tabri RV., Yazbeck M A framework for testing the equality between the health concentration curve and the 45-degree line. Heal Econ (United Kingdom). 2018;27(5):887–96.
23. Stracker N, Hanrahan C, Mmolawa L, Nonyane B, Tampi R, Tucker A, et al. Risk factors for catastrophic costs associated with tuberculosis in rural South Africa. 2019;23(November 2018):756–63.
24. Vassall A, Seme A, Compernolle P, Meheus F. Patient costs of accessing collaborative tuberculosis and human immunodefi ciency virus interventions in Ethiopia. Int J Tuberc Lung Dis. 2010 5;14(5):604–10. [PubMed: 20392354]
25. Umar NA, Abubakar I, Fordham R, Bachmann M. Direct costs of pulmonary tuberculosis among patients receiving treatment in Bauchi State, Nigeria. 2012;16(January):835–40.
26. Umar NA, Fordham R, Abubakar I, Bachmann M. The indirect cost due to pulmonary Tuberculosis in patients receiving treatment in Bauchi State — Nigeria 2012;1–8.
27. Datiko DG, Lindtjørn B. Cost and cost-effectiveness of treating smear-positive tuberculosis by health extension workers in Ethiopia: An ancillary cost-effectiveness analysis of community randomized trial. PLoS One. 2010 2 17;5(2).

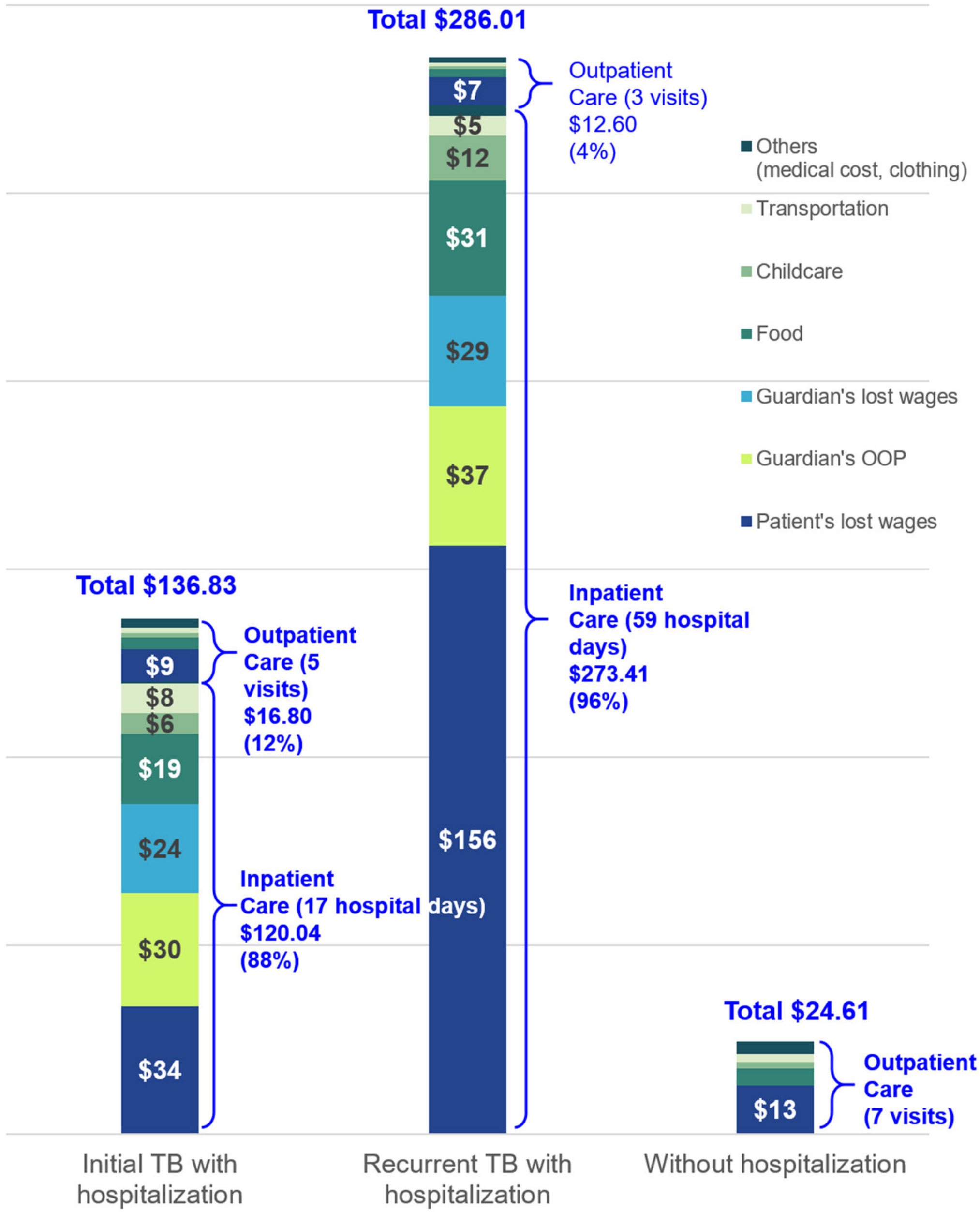

Figure 1. Patient incurred costs for TB treatment associated with and without hospitalization

Based on the assumption of a six-month duration of TB treatment with monthly outpatient visits, we estimated the mean total patient cost per TB treatment episode, separately for inpatients being treated TB for the first time (left column), inpatients being treated for recurrent TB (middle column), and individuals treated entirely as outpatients (right column). Further assumptions used to estimate per-treatment-episode costs on the basis of a single cross-sectional assessment are described in the text.

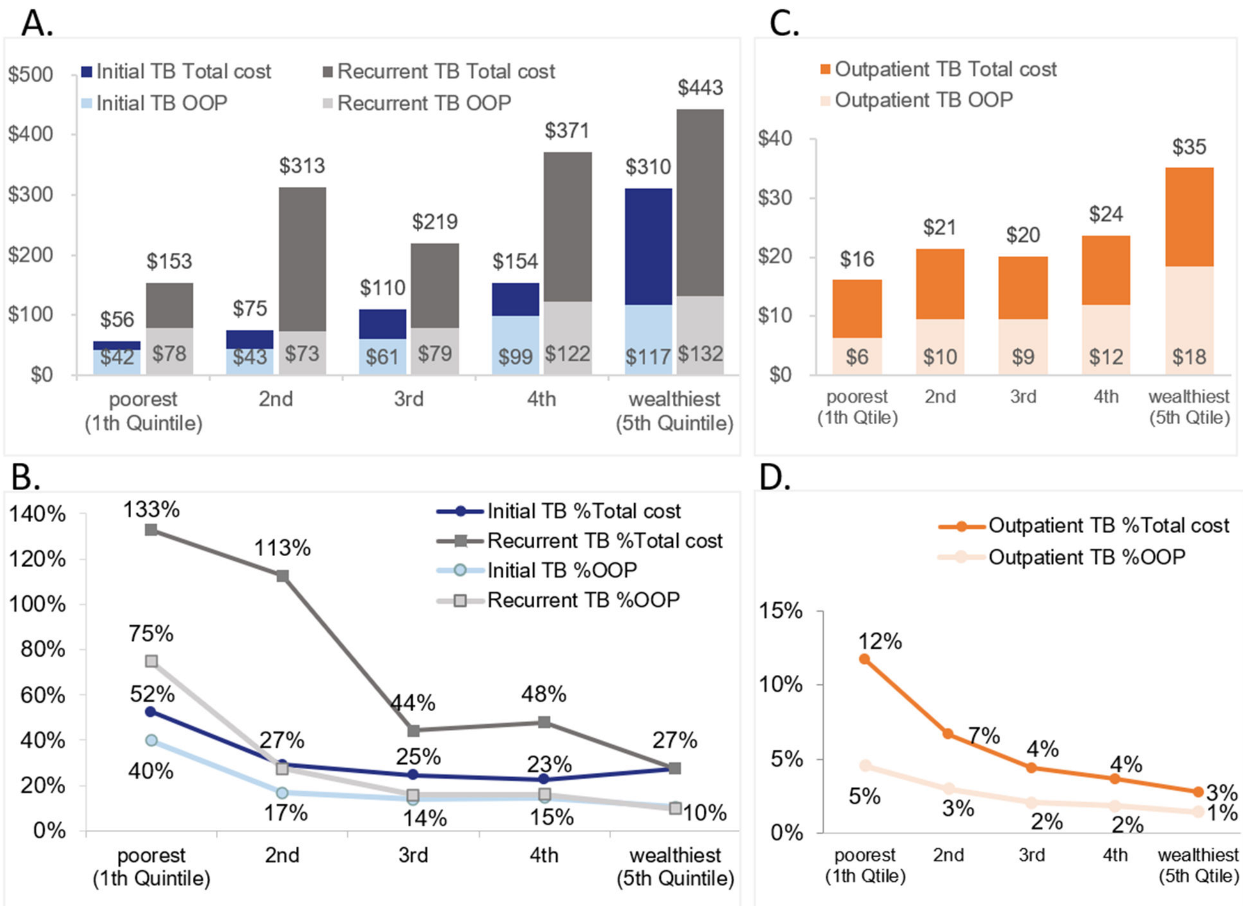

Figure 2. Inpatient TB treatment Costs by household spending quintile

Figure 2A represents the estimated mean out-of-pocket (OOP) costs and mean total patient-incurred costs for inpatient TB treatment, according to quintile of household expenditure, illustrating that absolute patient costs of treatment increased with increasing wealth. Blue bars represent patients being treated for initial TB episodes; grey bars represent patients being treated for recurrent TB.

Figure 2B depicts the estimated mean OOP cost and mean total cost of inpatient TB treatment, as a proportion of annual household spending. Dark and light blue lines indicate patients being treated for initial TB episodes; dark and light grey lines indicate patients being treated for recurrent TB. This panel illustrates that, as a proportion of total household expenditure, the patient-incurred cost of TB treatment declines with increasing wealth and is particularly catastrophic for those in the lowest income quintile.

Figure 2C and 2D show similar numbers but for outpatient-only TB treatment.

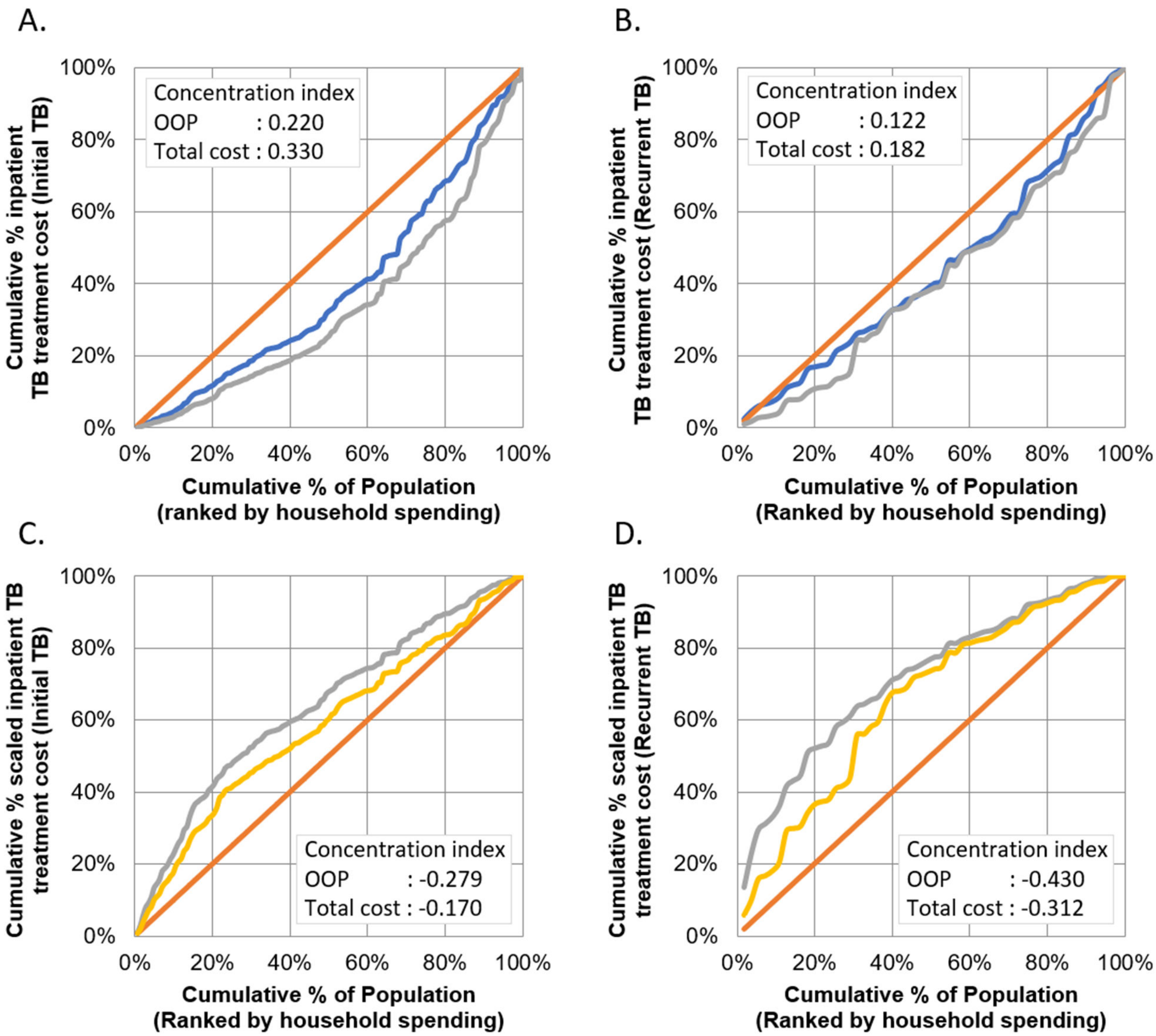

Figure 3. Concentration curves describing inpatient TB treatment costs

These four sets of concentration curves display the cumulative percentages of TB treatment costs against the cumulative percentage of the population ranked by household spending level from the poorest to the richest (x-axis). The two upper curves show the unequal distribution of out-of-pocket (OOP) costs (blue line) and total patient costs (grey line) for inpatient treatment of initial TB episodes (Panel A) and recurrent TB episodes (Panel B), in which patients with higher self-reported household expenditures also have higher costs of TB treatment. The two lower curves show TB treatment costs scaled as a fraction of household expenditure, revealing that – as a proportion of total household expenditure – the poorest individuals experienced the greatest scaled costs of TB treatment for both initial TB episodes (Panel C) and recurrent TB (Panel D).

Table 1.

Population characteristics

Characteristics	Primary population		Comparison population			
	Inpatients being treated for TB		Outpatients being treated for TB		Outpatients receiving new HIV diagnoses	
	(N=197)		(N=156)		(N=1,530)	
Sex						
Male	93	(47%)	82	(53%)	615	(40%)
Age (years)	38	(12)	37	(12)	35	(11)
Literate						
Yes	138	(72%)	97	(64%)	960	(63%)
Educational level, head of household						
None	85	(43%)	61	(39%)	617	(41%)
Primary	82	(42%)	79	(51%)	738	(49%)
Secondary+	30	(15%)	16	(10%)	148	(10%)
Pre-illness occupation						
Farmer	53	(27%)	58	(37%)	497	(33%)
Employed worker	56	(29%)	37	(24%)	302	(20%)
Self-employed	58	(30%)	35	(23%)	320	(21%)
Unemployed	21	(11%)	15	(10%)	188	(12%)
Annual household expenditure (2017 US $)	595	(676)	573	(442)	346	(395)
Under poverty line ($1.9/day)						
Yes	136	(69%)	111	(71%)	1,357	(89%)
First location to seek care						
Health center	90	(46%)	67	(44%)	486	(66%)
Hospital	96	(49%)	77	(51%)	214	(29%)
Traditional healer/Pharmacist/Other	11	(6%)	7	(5%)	37	(5%)
Mode of transportation to the facility						
Walk	20	(10%)	100	(64%)	1,116	(73%)
Bike	28	(14%)	43	(28%)	285	(19%)
Vehicle	148	(75%)	13	(8%)	126	(8%)
Transportation time to the facility (min)	207	(364)	105	(94)	91	(80)
Estimated walking time to the facility (min)	715	(1,187)	199	(501)	110	(105)
Previously treated for TB						
Yes	55	(28%)	20	(13%)	34	(2%)
Days since starting TB treatment (days)	13	(14)	101	(58)	-	
Days in hospital (days)	15	(15)	-		-	

*Each categorical value and parenthesis indicate n (%), and continuous value and parenthesis indicate mean (SD).

Table 2.

Reported and estimated out-of-pocket and opportunity costs per clinic visit in rural Thyolo, Malawi (in 2017 US dollars)

Cost component	Reported cost from admission to time of survey among inpatients being treated for TB				Reported cost per clinic visit among outpatients receiving new HIV diagnoses		Estimated cost per clinic visit among outpatients being treated for TB	
	Initial TB episode (mean 10 days)		Recurrent TB (mean 28 days)					
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Medical cost								
Consult & diagnosis	$0.09	($0.76)	$0.34	($2.48)	$1.12	($2.61)	-	
Medicines	$0.004	($0.03)	$0.39	($2.49)	$0.18	($0.75)	-	
Non-medical cost								
Transportation *	$3.98	($12.74)	$2.57	($3.24)	$0.31	($0.52)	$0.32	($0.30)
Childcare	$2.53	($5.52)	$4.60	($9.29)	$0.36	($0.85)	$0.23	($0.19)
Food	$8.18	($11.85)	$12.72	($12.78)	$0.50	($1.01)	$0.64	($0.61)
Accommodation	-		-		$0.76	($1.72)	$0.49	($0.54)
Clothing	$0.18	($0.64)	$2.26	($13.87)	-		-	
Patient total OOP cost (sum of itemized costs)	$14.96	($19.52)	$22.86	($27.46)	$3.25	($5.06)	$1.69	($1.41)
Self-reported total OOP cost (reported as a single item)	$5.72	($13.04)	$10.81	($27.61)	$0.84	($1.93)	-	
Guardian total OOP cost *	$13.70	($16.62)	$16.82	($27.00)	-		-	
Total OOP cost	$28.66	($29.09)	$39.68	($46.04)	$3.25	($5.06)	$1.69	($1.41)
Patient Opportunity cost	$18.06	($35.14)	$70.81	($129.63)	$1.57	($5.89)	$1.79	($1.40)
Time spent at facility (hrs)	*240.68***	*(215.5)*	*674.62***	*(457.07)*	*3.92*	*(2.34)*	4.96	(2.63)
Patient's Wage (per day)	*$2.84*	*($5.65)*	*$3.84*	*($6.21)*	*$3.23*	*($8.97)*	$2.99	($1.76)
Guardian opportunity cost	$8.65	($12.69)	$12.73	($26.55)	-			
Total Opportunity cost	$26.65	($39.75)	$83.32	($132.40)	$1.57	($5.89)	$1.79	($1.40)
Total Cost per episode	$55.31	($58.50)	$123.00	($153.79)	$4.89	($8.60) ***	$3.52	($2.11) ****

SD, standard deviation; OOP, out-of-pocket

* Guardian expenses included the same cost components with patient expenses.

** This is the number of hospital days (converted to hours) until the time of survey administration. Lost wages for hospitalization were calculated as the weekly wage (5days per week)* number of weeks hospitalized; for clinic visits, these were calculated as the hourly wage (daily wage / 8 hrs per work day) * number of hours spent on the visit.

*** Total patient incurred cost does not necessarily match the sum of 'Total OOP cost' and 'Total Opportunity cost' due to missing values for opportunity costs. (There were fifty missing values).

**** Total cost per episode as a single item, which was extrapolated from patients newly diagnosed with HIV, was $3.29 ($4.86) (see methods for description of imputation procedures).