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Institut der Ludwig-Maximilians-Universität München

Dissertation
zum Erwerb des Doctor of Philosophy (Ph.D.)
an der Medizinischen Fakultät der
Ludwig-Maximilians-Universität zu München

Socio-economic Burden of Tuberculosis and its Impact on Child Contacts in The Gambia

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Jahr
2024

Mit Genehmigung der Medizinischen Fakultät der
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I hereby declare, that the submitted thesis entitled:

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is my own work. I have only used the sources indicated and have not made unauthorized use of the services of a third party. Where the work of others has been quoted or reproduced, the source is always given.

I further declare that the dissertation presented here has not been submitted in the same or similar form to any other institution for the purpose of obtaining an academic degree.

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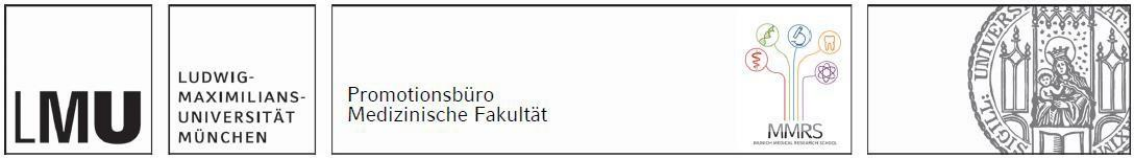
Confirmation of congruency



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Key words: tuberculosis; socio-economic impact, household contacts, The Gambia

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List of abbreviations

BAA	Brikama administrative area
CCM	Country Coordinating Mechanism
CRFs	Case Report Forms
ECG	Electrocardiogram
EIDs	Eid al-Adha and Eid al-Fitr
GBA	Greater Banjul area
GMD	Gambian Dalasis
GAMSTEP	Gambia Survey for Tuberculosis Prevalence
HIV	Human immunodeficiency virus (HIV)
KM	Kanifing Municipality
LMICs	Low-and middle-income countries
LMU	Ludwig Maximilian University of Munich
MDR-TB	Multi-Drug Resistance/ Rifampicin Resistance Tuberculosis
MRCG	Medical Research Council Unit The Gambia
MRCG at LSHTM	Medical Research Council Unit The Gambia at London School of Hygiene and Tropical Medicine
NGO	Non-Governmental Organizations
NLTP	National Leprosy Tuberculosis Control Program
WHO	World Health Organization
TB	Tuberculosis

List of publications

Main publications included in this thesis:

1. Denise Evans, Craig van Rensburg, Caroline Govathson, Olena Ivanova, Friedrich Rieß, Andrew Siroka, **Abdou K. Sillah**, Nyanda Elias Ntinginya, Ilesh Jani, Farzana Sathar, Sydney Rosen, Ian Sanne, Andrea Rachow & Knut Lönnroth on behalf of the TB Sequel Consortium (2021) Adaptation of WHO's generic tuberculosis patient cost instrument for a longitudinal study in Africa, Global Health Action, 14:1, 1865625.

2. Devoid I, **Sillah AK**, Sutherland J, Owolabi O, Ivanova O, Govathson C, et al. The household economic burden of drug-susceptible TB diagnosis and treatment in The Gambia. INT J TUBERC LUNG DIS [Internet]. 2022 [cited 2023 Jan 29];26(12):1162–Available from: http://dx.doi.org/10.5588/ijtld.22.0091

3. **Abdou K. Sillah,** Isaac Devoid, Jackson Jr Ndenkeh, Given Moonga, Isatou Loum, Awa Touray, Olumuyiwa Owolabi, Jayne Sutherland, Andrea Rachow, Olena Ivanova, Denise Evans, Beate Kampmann. Socio-economic Burden of Tuberculosis and its Impact on Child Contacts in The Gambia. (submitted to PHA-05-23-0025 on 03/05/2023)

1. Contribution to the publications

1.1 Contribution to Publication I

For the first manuscript, the candidate served as the research clinician overseeing patient recruitment and follow-ups. The candidate was also responsible for local adaptation and refinement of the tools. He was also responsible to assessing the completeness of data collected by the field workers at The Gambian site.

1.2 Contribution to Publication II

The dataset for this manuscript, in which the candidate shared first authorship working as a research clinician in TB Sequel Consortium and overseeing this sub-study at the MRCG at LSHTM. The candidate participated in the training and oversight over the data collection, supervised the data cleaning and verification, and oversaw the patients' recruitment and data collection through administration of questionnaires. The candidate later worked with an MSc student (Isaac Devoid) to clean the dataset, interpret the results, and draft the manuscript. He compiled the manuscript together with Isaac Devoid and presented it for review to the supervisory team. The candidate then shared the first authorship of the paper with Isaac Devoid.

1.3 Contribution to Publication III

The PhD candidate created the initial study concept and research proposal. The proposal was sent to the rest of the supervisory team for review. After collecting all necessary data, the candidate oversaw data cleaning, and analysis. The candidate was responsible for drafting the manuscript and presented the draft to the supervisory team. The candidate led this process and served as the corresponding author and oversaw managing the submission.

2. Introduction

2.1 Background

Infectious diseases contribute a substantial portion to the global burden of disease, and tuberculosis (TB) remains a main cause of mortality across the globe (1). While the COVID-19 pandemic has strained health systems across the world, TB has contributed substantially to the global burden of disease (2) with significant impact on childhood TB management (3). Adults have the highest TB incidence with an estimated 10.6 and 10.1 million people falling ill with TB in 2021 and 2020, respectively (1).

A large proportion of patients suffer long-term consequences due to post-TB sequalae (4), and households face economic and social effects that can have consequences on their households, including children (5). The heavy burden of tuberculosis could lead to the broader economic burden of illness for households in low-resource settings (6).

Governments, researchers, and non-governmental organizations (NGOs) are starting to focus efforts to control TB in low- and middle-income countries (LMICs) on not just strengthening of TB control programs, but also on the social determinants of TB (7,8).

The literature has clearly documented the association between poor TB treatment outcomes and high TB patient costs (8). Such literature has influenced a variety of social protection schemes across LMICs to enable patients to complete treatment and limit the likelihood of financial catastrophe for their households (9). Using existing biomedical interventions to support TB patients with financial support is a core pillar of the World Health Organization's (WHO) End TB strategy (10).

The WHO End TB strategy has also furthered the development and use of tools like the generic TB patient cost instrument to assess the socio-economic impact of TB. While this tool includes questions on household food security, it fails to record social and economic effects that children face when an adult household member has TB (11). Research on the social and economic consequence of adult TB in children remains very limited, but a study in India from Geetha Ramani, et al, showed that TB infection in caregivers can result in declining school performance in children, and some children leaving school entirely to support their households financially (12).

Economic shocks for TB patients are difficult to recover both socially and financially. However, social consequences for children such as declining school performance, dropout, and food insecurity can potentially follow them into adulthood (13, 14).

Patient costing studies have been vital to develop policy that reduces financial hardship patients with TB face; however, these studies rarely include the impact on children. Nonetheless, it is paramount that research assesses how children are impacted by TB so that future reforms can protect such a vulnerable population. Hence, this study seeks to address

a research gap by examining the societal and economic impacts of household tuberculosis on children in The Gambia. Despite The Gambia having a relatively low tuberculosis rate, it remains one of the world's poorest nations.

2.2 Tuberculosis in The Gambia

Tuberculosis still substantially contributes to the burden of disease in The Gambia. According to the Global TB Report (2021), the incidence rate of TB is 149/100,000 population with a corresponding treatment coverage rate of 57% (WHO GTB Report 2021) (15). The estimated Multi-Drug Resistance/ Rifampicin Resistance Tuberculosis (MDR/RR-TB) among new and previously treated TB cases is 2.4% and 15% respectively. The advent of COVID-19 pandemic significantly impacted TB notification in 2020 with 8% reduction in the number of TB cases notified from 2,635 TB cases in 2019 to 2,418 TB cases in 2020. The MDR/RR-TB notification also decreased by 13% within the same period (Regional Green Light Committee (rGLC) Monitoring mission to The Gambia, 2021).

TB treatment and diagnosis is offered for free across governmental facilities in The Gambia; however, patients can still incur substantial non-medical and indirect costs in accessing treatment (16).

The Gambia conducted its first-ever nationwide population-based multistage cluster survey where screening was conducted for active pulmonary tuberculosis with chest radiography and for tuberculosis symptoms. The survey which was called Gambia Survey for Tuberculosis Prevalence (GAMSTEP) showed a TB prevalence of 128/100.000 population (17).

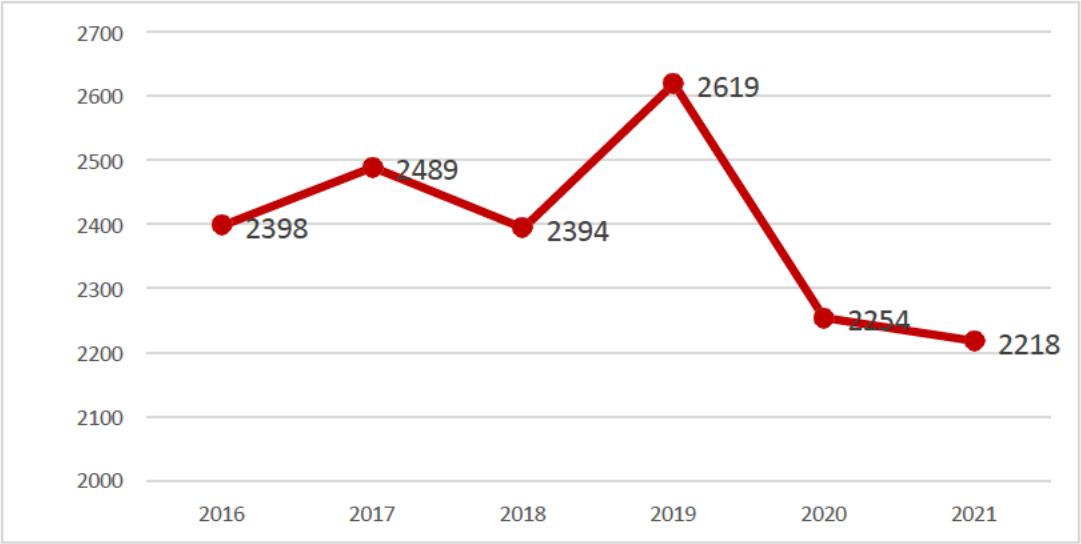


Figure 1: Trend in number of people with new and relapsed TB 2016-2021 according to The Gambia TB National Strategic Plan (NSP) 2023-2027

3. Rationale and Objectives

3.1 Rationale

During the entire period from pre-diagnosis to post-treatment, TB patients face significant financial burdens, both in terms of medical expenses and non-medical costs. Furthermore, the morbidity and disability associated with TB can result in decreased productivity, further exacerbating the economic impact during this period (18).

As at now no data exist to assess the challenges and the socio-economic burden of TB on adults as well as on child contacts in the settings such as The Gambia. There is a lack of available data to evaluate these challenges. Additionally, it is also essential to consider the contextual factors, such as the support provided by the extended family system within households, to estimate the true extent of the problem and allocate appropriate resources to address it.

3.2 General Objective

The project aims to demonstrate the socio-economic impact of TB disease on adults and child contacts, and the costs patients incur on the pathway to accessing care in The Gambia.

Specific Objectives

1. To adapt the existing WHO costs instrument for a longitudinal study design and for the Gambian context (11).
2. To assess costs and catastrophic costs incurred by drug-sensitive (DS) pulmonary TB patients in The Gambia (16).
3. To determine the social and economic impact of adult TB on child household contacts living in The Gambia.

4. Methods

Below we briefly introduce the study setting and methods used in each manuscript. More details can be found in the attached publications.

4.1 Study setting

The study was conducted in the Greater Banjul Area in The Gambia, where nearly two-thirds of TB patients are diagnosed (19). It is a mixed urban-rural setting of approximately 700,000 inhabitants with TB incidence of 174 cases per 100,000 population (20, 21). The study was part of the larger TB Sequel Project, which enrolled and followed-up TB patients during and after TB in four African countries (4) (Rachow A et al, BMC PubMed. 2019)

4.2 Publication I

For the first paper, we utilized the WHO generic TB patient cost survey instrument to collect information on the current TB treatment and associated costs. The instrument gathered data on demographics, economic position, direct medical and non-medical payments, indirect costs, and guardian costs (11). (Evans D et al, 2021)

For the longitudinal study design of TB Sequel, this instrument was adapted to capture costs at different time points throughout the TB treatment phases. Local adaptations were made to ensure the instrument's relevance to each setting, including modifications to TB services, healthcare fees, social protection mechanisms, socio-economic status, and socio-demographic information. Income adjustments were implemented to estimate individual and household monthly income, allowing for the calculation of changes in costs and income during the TB episode (11). (Evans D et al, 2021)

Study staff received comprehensive training, and refinements were made based on the pilot phase feedback to ensure standardized implementation of the instrument (11). (Evans D et al, 2021)

4.3 Publication II

For this paper, we collected data on the costs incurred by drug-susceptible TB patients from TB Sequel cohort on the pathway to diagnosis, during TB treatment and after completion of treatment using the WHO generic patient cost instrument adapted for use in a longitudinal study, see above (11) (Devoid I, et al 2022)

We analyzed the data using the micro-costing approach (22). We categorized costs into direct and indirect (23) and patients were asked to recall or where available provide the receipts of costs during the different phases of the illness. We assumed zero cost for

those not reporting no cost during their visits as the interviewers were leaving blank for such costs (24). We estimated catastrophic costs by summing total direct and indirect costs throughout the TB episode divided by annual household income (25). (Devoid I, et al 2022)

The study was approved by The Gambia Government/MRC Joint Ethics Committee and collected data from adults 18 years diagnosed with pulmonary TB as part of TB Sequel Project (16) (Devoid I, et al 2022)

4.4 Publication III

For this paper, TB Sequel participants who reported having child contact(s) were identified, consented, and enrolled between 06/2019 and 07/2021. We developed our questionnaire adopting the WHO patient cost survey tool (11) and the Household Food Insecurity for Access Scale (26). Trained field workers collected paper-based data which was later captured in the electronic database REDCap. We collected information on educational, nutritional, and social needs of the child contacts. We also collected information on the sick parents' ability to meet those needs of the child contacts during their TB illness (28). (Abdou K. Sillah et al, Unpublished: PHA-05-23-0025, Date 03-May-2023)

Table 1: Data collection timeline for TB Sequel and child contacts study

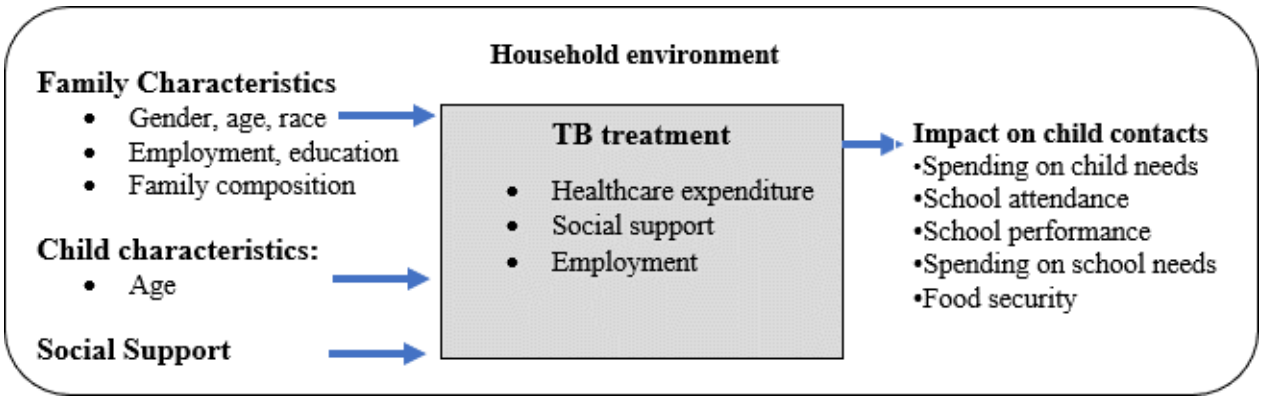
Study	TB Sequel main socio-economic study		Child contacts study
Study visits	Baseline (before TB treatment), months 2, 6, 12. 24, 36 and 48		Baseline (Before TB treatment) 6 months after the start of TB treatment
Tools used	Questionnaire		Questionnaire
Data variables	Patient demographics: Age, gender, HIV status, marital status, education, site of disease	Household composition, WHO National Patient cost survey (X),	School attendance, school expenditure, social functions, nutritional impact, family support
Data collection	OpenClinica	OpenClinica	REDCAP
Enrolment period	09/2017 – 02/2019		07/2019-06/2021

We assessed school attendances and performances by categorizing them into grades of the adopted school report forms. We also assessed the costs incurred by sick parents in providing

social and nutritional needs of the child contacts pre-TB illness and during TB illness. Cost is reported in 2021 Gambian dalasi (100 GMD) (approximately $1.64 USD) (27). (Abdou K. Sillah et al, Unpublished: PHA-05-23-0025, Date 03-May-2023)

We characterized our data based on the information collected at baseline and 6-month and described the demographic characteristics of participants using SPSS software and Microsoft Excel. We assessed the socio-economic impact of adult TB on their child contacts, the impact of the parent's illness on the contacts education, the nutritional impact as well as the family social supports. We compared the baseline data with that of the 6-month using different approaches including Wilcoxon sign rank test, test for symmetry, McNamar test and means to complete our analysis (28). (Abdou K. Sillah et al, Unpublished: PHA-05-23-0025, Date 03-May-2023)

Figure 2: Graphical depiction to show the relationship between the various characteristics, TB treatment and impact on household child contacts.



We gained Local ethics approval from The Gambia Government/MRCG at LSHTM Joint Ethics Committee (SCC1636). The study also received ethics approval from Ludwig Maximilian University of Munich (LMU) Ethics Commission (Project Nr: 19-481). Informed consent was obtained from all participants (28) (Abdou K. Sillah et al, Unpublished: PHA-05-23-0025, Date 03-May-2023)

5. Results

5.1 Publication I

Denise Evans, Craig van Rensburg, Caroline Govathson, Olena Ivanova, Friedrich Rieß, Andrew Siroka, **Abdou K. Sillah**, Nyanda Elias Ntinginya, Ilesh Jani, Farzana Sathar, Sydney Rosen, Ian Sanne, Andrea Rachow & Knut Lönnroth on behalf of the TB Sequel Consortium (2021) Adaptation of WHO's generic tuberculosis patient cost instrument for a longitudinal study in Africa, Global Health Action, 14:1, 1865625.

The main outcome of this work was the adaptation of the cross-sectional WHO generic TB patient cost survey tool. This helped us to assess the costs incurred by patients longitudinally, well after treatment completion and follow them through the sequelae of TB disease (11). (Evans D. et al 2021)

More details on results provided in the attached Publication I.

5.2 Publication II

Devoid I, **Sillah AK**, Sutherland J, Owolabi O, Ivanova O, Govathson C, et al. The household economic burden of drug-susceptible TB diagnosis and treatment in The Gambia. INT J TUBERC LUNG DIS [Internet]. 2022 [cited 2023 Jan 29];26(12):1162–Available from: http://dx.doi.org/10.5588/ijtld.22.0091

We set out to determine the costs incurred by 244 adult TB patients on their pathway to accessing care in The Gambia using longitudinal instrument from the Publication I.

We found that the mean total cost of TB care in The Gambia was $104.11 (2018 USD), which was mainly the results of out-of-pocket expenditure for accessing care before the start of TB treatment, as patients had to visit on average four providers before TB diagnosis. We also showed that the TB patients in our cohort encountered catastrophic costs (0.4-75% of participants) (16). (Devoid I et al, 2022)

We concluded that, despite TB treatment being free in The Gambia, TB patients experienced substantial costs on their pathway to diagnosis and through treatment. Hence, there is a need to design ways of supporting patients to reduce the burden of the disease on them and their families (16) (Devoid I. et al, 2022)

More details on results provided in the attached Publication II.

5.3 Publication III

Abdou K. Sillah, Isaac Devoid, Jackson Jr Ndenkeh, Given Moonga, Isatou Loum, Awa Touray, Olumuyiwa Owolabi, Jayne Sutherland, Andrea Rachow, Olena Ivanova, Denise Evans, Beate Kampmann. Socio-economic Burden of Tuberculosis and its Impact on Child Contacts in The Gambia. (Submitted to PHA-05-23-0025 on 03/05/2023)

For this study, we enrolled 51 TB Sequel participants with child contacts. We assessed data from 180 child contacts with an average of 3.5 child contacts per participant. We found that school performance was significantly impacted during TB compared to the start of TB treatment but there was no significant impact on the school attendances. There was a significant drop in household spending on child contacts including spending on educational needs, nutritional needs as well as the social needs of the children. We established that there was a significant food insecurity affecting child contacts (28). (Abdou K. Sillah et al: Unpublished: PHA-05-23-0025, Date 03-May-2023).

More details on results provided in the attached Publication III.

6. Discussion

Overall, this study makes a significant contribution to the body of evidence on socio-economic impact of TB on adults and child contacts in The Gambia.

In the first paper, we showed that adapted WHO generic tuberculosis patient cost tool has its advantages over the cross-sectional approach, which was adapted by the WHO (11). We collected repeated costs incurred by each patient's over different time points from pre-TB diagnosis and through TB treatment and post-TB treatment (29). With this longitudinal tool of assessing patients' cost, measurements could be assessed over time and changes noted (29). The tools could be used in assessing the costs incurred by TB patients during different phases of TB treatment and in describing the economic burden of the TB disease (11). (Evans D et al, 2021)

Our findings in second paper on the household economic burden of drug-susceptible TB diagnosis and treatment in The Gambia demonstrated that the TB patients incurred substantial costs on their pathway to pre-TB diagnosis, during treatment and post-TB treatment. We have shown that despite TB treatment being free in The Gambia, the mean cost of TB in our cohort exceeded $100 mainly before establishing the diagnosis (16). Similar findings were demonstrated in a systematic review of patients' cost studies across LMICs (30). Based on this, there is a need for early diagnosis and reduction of the time spent visiting different providers, which will indirectly reduce the costs incurred by TB patients and their families (16). (Devoid I et al, 2022)

In The Gambia there is still economic and social consequences for both adults with TB, and their child contacts. We hypothesized that TB in adults is associated with different social and educational consequences for their childhood contacts. There was strong evidence of households reporting food insecurity, which included the child contacts having unwanted foods, a limited variety of foods, and small portions of food. Additionally, there was evidence of a decline in spending on child contacts including on items like school fees, stationery, and school shoes. While many studies have descriptively assessed social factors of TB illness in children such as school dropout and food insecurity, this is the first study to our knowledge that collected school performance and direct costs from adults with TB concerning their child contacts (28). (Abdou K. Sillah et al: Unpublished: PHA-05-23-0025, Date 03-May-2023)

In three Indian studies, 11%, 12%, and 8% of child contacts dropped out of school. In our study, no child dropped out of school, which is potentially due to the difference in study setting (12,31,13). Similarly in our study, children could potentially remain in school due to high levels of caring and financial support from impacted families. The drop in school

performance could be associated with the increase in household food insecurity (28). (Abdou K. Sillah et al: Unpublished: PHA-05-23-0025, Date 03-May-2023)

We have also shown that child contacts in our cohort have experienced food insecurity ranging from the sick parents' inability to provide quality, insufficient or quantity foods. Similar findings from Geetharamani et al, have shown that adult TB cases were not able to provide adequate food for their children (12). Although, we did not assess the link between food insecurity among our child contacts to negative health impact, findings from other studies (32, 33, 34, 35) have shown food insecurity can have negative health impact among children (28). (Abdou K. Sillah et al: Unpublished: PHA-05-23-0025, Date 03-May-2023)

We also show that the ability of the TB patients to provide social needs of their children has been affected as results of their TB disease. Feasts being well celebrated in The Gambia with parents providing shoes, clothing and presents to their children. Our TB cohort has experienced significant decline in meeting those needs of their child contacts during their TB illness compared with when they were not sick. This impact might be mitigated with cash transfers as it was done in some studies where cash transfer improved the conditions of patients and their families and as well as school attendances (36,37,38,39). (Abdou K. Sillah et al: Unpublished: PHA-05-23-0025, Date 03-May-2023)

All three studies have their limitations. For example, the child contacts study's (Publication III) limitations are: 1) we did not disaggregate our child contacts by gender; 2) and the study was conducted in the semi-urban settings which might missed out the communities in the rural settings. (28). (Abdou K. Sillah et al: Unpublished: PHA-05-23-0025, Date 03-May-2023)

7. Conclusion

In conclusion, the adapted WHO generic TB patient cost survey helped us to show that TB patients in The Gambia incurred substantial costs on their pathway to accessing care pre-TB diagnosis and during TB treatment. Moreover, we also demonstrated that TB patients encountered socio-economic impact which affected their child contacts school performances as well as led to food insecurity for the household contacts.

There is a need for further research to establish the impact of TB on wider population in The Gambia. This could lead to policy changes to ameliorate the impact of TB on adults and their child contacts.

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9. Publications

9.1 Publication I

Denise Evans, Craig van Rensburg , Caroline Govathson , Olena Ivanova, Friedrich Rieß, Andrew Siroka , **Abdou K. Sillah** , Nyanda Elias Ntinginya , Ilesh Jani , Farzana Sathar , Sydney Rosen , Ian Sanne , Andrea Rachow & Knut Lönnroth on behalf of the TB Sequel Consortium (2021) Adaptation of WHO's generic tuberculosis patient cost instrument for a longitudinal study in Africa, Global Health Action, 14:1, 1865625

GLOBAL HEALTH ACTION
2021, VOL. 14, 1865625
https://doi.org/10.1080/16549716.2020.1865625

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Adaptation of WHO's generic tuberculosis patient cost instrument for a longitudinal study in Africa

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ABSTRACT

The WHO developed a generic 'TB patient cost survey' tool and a standardized approach to assess the direct and indirect costs of TB incurred by patients and their households, estimate the proportion of patients experiencing catastrophic costs, and measure the impact of interventions to reduce patient costs. While the generic tool is a facility-based cross-sectional survey, this standardized approach needs to be adapted for longitudinal studies. A longitudinal approach may overcome some of the limitations of a cross-sectional design and estimate the economic burden of TB more precisely. We describe the process of creating a longitudinal instrument and its application to the TB Sequel study, an ongoing multi-country, multi-center observational cohort study. We adapted the cross-sectional WHO generic TB patient cost survey instrument for the longitudinal study design of TB Sequel and the local context in each study country (South Africa, Mozambique, Tanzania, and The Gambia). The generic instrument was adapted for use at enrollment (start of TB treatment; Day 0) and at 2, 6, 12 and 24 months after enrollment, time points intended to capture costs incurred for diagnosis, during treatment, at the end of treatment, and during long-term follow-up once treatment has been completed. These time points make the adapted version suitable for use in patients with either drug-sensitive or drug-resistant TB. Using the adapted tool provides the opportunity to repeat measures and make comparisons over time, describe changes that extend beyond treatment completion, and link cost survey data to treatment outcomes and post-TB sequelae.

Trial registration: ClinicalTrials.gov: NCT032516 August 1196, 2017.

Abbreviations: DOTS: Directly observed treatment, short-course; DR-TB: Drug-resistant tuberculosis; MDR-TB: Multi-drug resistant tuberculosis; NTP: National Tuberculosis Programme; TB: Tuberculosis; USD: United States Dollar; WHO: World Health Organization.

ARTICLE HISTORY
Received 2 July 2020
Accepted 14 December 2020

RESPONSIBLE EDITOR
Jennifer Stewart Williams, Umeå University, Sweden

KEYWORDS
Catastrophic total costs; income; pre-treatment; out-of-pocket; TB sequelae

Background

The economic burden on households and individuals of illness due to TB can be devastating. Costs borne by patients can have catastrophic consequences, potentially entrenching individuals and households in a vicious poverty-disease cycle [1,2]. One of the three targets of the WHO End TB Strategy is that no TB patients or their households should face catastrophic total costs due to TB disease [3]. Catastrophic total costs is defined as costs (including direct medical expenditures, non-medical expenditures and overall indirect costs – which includes loss of paid work and/or time off work necessitated by symptoms and treatment seeking) that account for 20% or more of the patient's annual household income [4,5].

To reduce the risk of TB-related impoverishment, it is therefore important to document the types, magnitude, and drivers of TB-related costs for patients and their households so that appropriate policies and interventions, such as health financing, patient-centered delivery models, and social protection mechanisms (e.g. job protection, paid sick leave, social assistance, cash transfers, etc.) can be developed [2,6]. In 2015, WHO established a standardized protocol for conducting nationally representative TB patient cost surveys that assess the direct and indirect costs incurred by TB patients and their households to

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determine the proportion of TB patients who experience catastrophic total costs due to TB disease. In 2017, based on field-testing of the generic TB patient cost tool in nine countries and after consultation with a WHO-led TB Patient Cost Task force, the protocol was revised and expanded into a handbook [2]. By March 2020, 17 countries have completed the survey and an additional 30 were planning one in 2020 [7]. Countries that have completed analyses estimate that 27% to 83% of patients with any form of TB experience catastrophic costs. This number is much higher, at 67% to 100%, among those with drug-resistant TB [4].

The WHO instrument was designed for a cross-sectional, national, facility-based survey of patients registered for TB treatment in a country's National Tuberculosis Programme (NTP) who are attending a sampled facility for a visit during the survey period. Patients are interviewed only once, during either the intensive or the continuation phase of treatment [2]. Data collected in either the intensive or continuation phase are extrapolated to estimate the total costs for the entire TB episode.

While previous surveys have provided valuable information [2], the cross-sectional design has several limitations beyond those that are common to any survey. In particular, costs incurred before treatment are ascertained through recall interview, and only for those patients interviewed in the intensive phase of treatment. Costs incurred after treatment completion are missed, and costs cannot be related to treatment outcomes, which are usually not available at the time of survey implementation. The analysis is complex and involves extrapolations and imputations to calculate the total costs incurred for the entire duration of TB. As a result, several TB patient cost studies have highlighted the need for longitudinal studies [6,8]. There are a few longitudinal studies underway; however, none of these are collecting patient costs after TB treatment completion. This is likely to underestimate the economic burden of TB as costs incurred after the completion of treatment, due to TB sequelae or loss of productivity due to disability, would be ignored [9]. Similarly, economic recovery (e.g. ability to pay back loans or regain productivity) and the ability to build resilience to future shocks after completing TB treatment are essential consequences that should be measured to understand TB's full economic impact.

TB Sequel (NCT03251196) is a multi-country, multi-center, observational cohort study designed to understand the pathogenesis and risk factors of long-term sequelae of pulmonary TB in South Africa, Mozambique, Tanzania, and The Gambia [10]. The primary outcome is the proportion of TB patients with severe lung impairment measured by spirometry at 24 months after TB treatment initiation. There are four sub-studies nested within the main cohort study, and one of these is the 'Socio-economic costs and Impact of TB' sub-study, which aims to determine the occurrence of reversible and irreversible socio-economic consequences of TB on patients and their households before, during, and after TB treatment [10]. For this sub-study, patient interviews are conducted at study enrollment (Day 0 ± 14 days) and 2, 6, 12, and 24 months after enrollment. Further details about data collection and tools are available elsewhere [10]. To overcome some of the limitations of the existing WHO generic TB patient cost survey, we took advantage of TB Sequel to adapt the existing cross-sectional instrument for a longitudinal study design and tailored it for each of TB Sequel's study countries. Here we describe the process of creating a longitudinal instrument and its application in the study.

Methods

Original instrument

The WHO generic TB patient cost survey instrument collects information from patients on current TB treatment and costs incurred during the TB treatment phase the patient is interviewed in [2]. Costs are then calculated for the assumed total treatment duration through extrapolations and imputations (Table 1). Patients in the intensive phase of treatment are asked also about costs incurred before treatment. The survey instrument collects data on the patient's demographic (e.g. age, gender, employment status, household composition, etc.) and economic position (e.g. individual and household income, household assets, household food security, etc.), direct out-of-pocket medical (e.g. consultation fee, laboratory tests, medication, etc.) and non-medical (e.g. food, accommodation, transport) payments, indirect costs (i.e. income loss or time cost as a result of TB), and guardian costs. Patients' estimates of expenses for nutritional/food supplements, health insurance reimbursements, social assistance/protection (i.e. welfare, disability grants, cash transfers, etc.) and social con- sequences of TB are also collected. The patient is also asked about the financial consequences of TB and how they cope with these (i.e. dissaving, borrowing funds, selling assets to cover the costs of health-care expenditure). This instrument is designed to be administered only once per patient over the course of treatment. Before the interview, patient information is obtained from the TB treatment card and participants provide informed consent.

Longitudinal adaptation

We first adapted the generic instrument for the longitudinal study design of TB Sequel. We reviewed

Table 1. Characteristics and limitation of the WHO TB patient cost survey and the adapted version for longitudinal studies in Africa.

	Generic WHO TB patient cost survey	Adapted patient cost survey – for TB Sequel
Design	Cross-sectional facility-based	Longitudinal facility-based
Geographic location	National survey	Five African study clinics located in The Gambia, Mozambique, South Africa and Tanzania.
Population	All patients (adults and children) registered for TB (drug-susceptible or drug-resistant) treatment in the National Treatment Programme (NTP).	Adult patients (≥18 years) registered for TB (drug-susceptible or drug-resistant) treatment in the National Treatment Programme (NTP) in the study sites
Sampling	Random cluster sampling or a national simple random sampling where electronic registers are available.	Consecutive sampling – as eligible participants present at the facility [10]
	Sample size based on assumed prevalence of catastrophic costs.	Sample size based on prevalence (>20%) of the outcome of interest which is severe pulmonary function impairment, measured by spirometry at least 2 years after treatment initiation
Enrolment	Consecutive patients registered for TB treatment who are attending a sampled facility and are a minimum of 14 days into either the intensive or continuation phase.	Starting (+/- 14 days) TB treatment after TB diagnosis.
Interview schedule	Each patient is interviewed only once	Patients are interviewed multiple times at defined study visits (M0, M2, M6, M12 and M24).
Resources and time	The survey team is typically comprised of a principal investigator, a survey coordinator, a data manager and interviewers – these are temporary or short-term positions.	The team composition includes data capturers, quality control manager, and a statistician. Permanent or long-term positions are needed for continuity and retention of experienced staff.
requirements	Once off interview and consent (±45 minutes), either paper-based or electronic survey. Qualitative interviews can be performed both with patients and household members, as well as health and social service staff and policy-makers [2].	Multiple interviews (±45 minutes), only paper-based survey with data entry into an electronic database. No qualitative component but includes additional component to study social consequences (e.g. quality of life, pain, disability and stigma related to TB) [10].
Interviewers	Facility-based	Facility- and community-based
Calculating total costs	Requires some retrospective data collection, forward projections and imputations to calculate the total costs. Only patients in the intensive phase receive questions on the costs incurred prior to diagnosis.	Total costs available for each phase of TB treatment (i.e., pre-treatment, intensive phase of treatment, continuation phase of treatment and post-TB treatment). All patients receive questions on the costs incurred prior to diagnosis at the enrolment/M0 visit.
Outcomes	Treatment outcomes are typically not available Estimate the cost per patient treated for TB	Treatment outcomes are available Can estimate the cost per patient treated for TB by outcome Repeated measures of health-related quality of life, pain, depression or anxiety and disability related to TB is collected at M2, M6, M12 and M24. May contribute to better estimates of disability-adjusted life years (DALYs).
Limitations	Survey findings can only be generalized to a subset of people with TB who receive care in the NTP. Conclusions cannot be drawn about all people with TB in the country.	Survey findings can only be generalized to a subset of people with TB who receive care in the NTP in the study sites. Conclusions cannot be drawn about all people with TB in the country. The study site may not necessarily be where the patient goes for routine TB care or to collect medication. This may result in issues with recall as participants try to distinguish between routine treatment versus study related visits. Direct costs, income loss or coping costs may be underestimated as study sites reimburse patients for travel and time at each visit or may provide support (e.g. food parcels, supplements, travel vouchers) to promote retention.
	Recall bias – a major challenge for the estimation of total patient costs incurred. This mainly affects cost estimates for the pre-treatment period.	To minimize recall bias, patients receive questions on the costs incurred prior to diagnosis at the first visit (M0). During subsequent visits, patients are asked to recall since the date of their last interview. Interviewers are also trained to make it easier for the patient to recall by using local methods of time structuring.

Costs after treatment completion are not included.

Costs after treatment completion are included. Patients are followed for a minimum of 24 months after TB treatment initiation.

The current methodology only includes TB patients enrolled and retained in care.

A longitudinal design can only consider earlier aspects of the cascade of care, prior to when a patient becomes lost to follow up.

treatment guidelines for drug-sensitive and drug-resistant TB from the different countries [11–14] and adapted the generic instrument for use at enrollment (Day 0) and at Month 2, Month 6, Month 12 and Month 24, time points intended to capture costs incurred for different phases of TB. These time points make the adapted version suitable for use in patients with either drug-sensitive or drug-resistant TB. It should be noted that these time points were guided by standard treatment durations and do make provision for instances when the treatment duration may be extended (e.g. absence of smear conversion, severe or complicated disease or a treatment interruption lasting less than 2 months) [15].

Treatment phases for drug-susceptible TB: The preferred regimen for treating adults with TB remains a regimen consisting of an intensive phase of 2 months of isoniazid (INH), rifampin (RIF), pyrazinamide (PZA), and ethambutol (EMB) followed by a continuation phase of 4 months of INH and RIF. Using the time points described above, pre-treatment costs (Figure 1(a)) are estimated by asking patients to recall any out-of-pocket payments or indirect costs that they may have incurred from the onset of TB symptoms to the start of TB treatment (Day 0). Similarly, on-treatment (Figure 1(b)) costs for the intensive and continuation phase of TB treatment are estimated by asking patients to recall any out- of-pocket payments or indirect costs that they may have incurred from the start of TB treatment (Day 0) until Month 2, or from Month 2 to Month 6, respectively. The total on-treatment costs are estimated by combining costs incurred during these two time- points (Month 2 and Month 6). Post-treatment costs are estimated by asking patients to recall any out-of-pocket payments or indirect costs that they may have incurred from the end of TB treatment until the end of long-term follow-up (i.e. Month 12 to capture costs incurred in the first 6 months after treatment completion or Month 24 to capture costs incurred in the year after TB treatment completion) (Figure 1(c)).

Treatment phases for drug-resistant TB: The guidelines for drug-resistant TB were updated by the WHO in 2016 and 2019 to include the use of the shorter multi-drug resistant TB (MDR-TB) regimen (4–6 months intensive phase and 5 months continuation phase) [16,17]. Because the duration of treatment is longer for drug-resistant TB, the Month 2 and Month 6 instruments capture costs for the intensive phase of TB treatment. Then at 12 months, instead of administering the Month 12 instrument to capture post-treatment costs (as we would do for drug-susceptible TB patients), the Month 6 instrument is repeated in drug-resistant TB patients to capture on-treatment costs for the continuation phase. By combining costs incurred during these time-points (Month 2, Month 6 and Month 12), the total on-treatment costs can be estimated (Figure 1 (d)). Post-treatment costs incurred in the year after

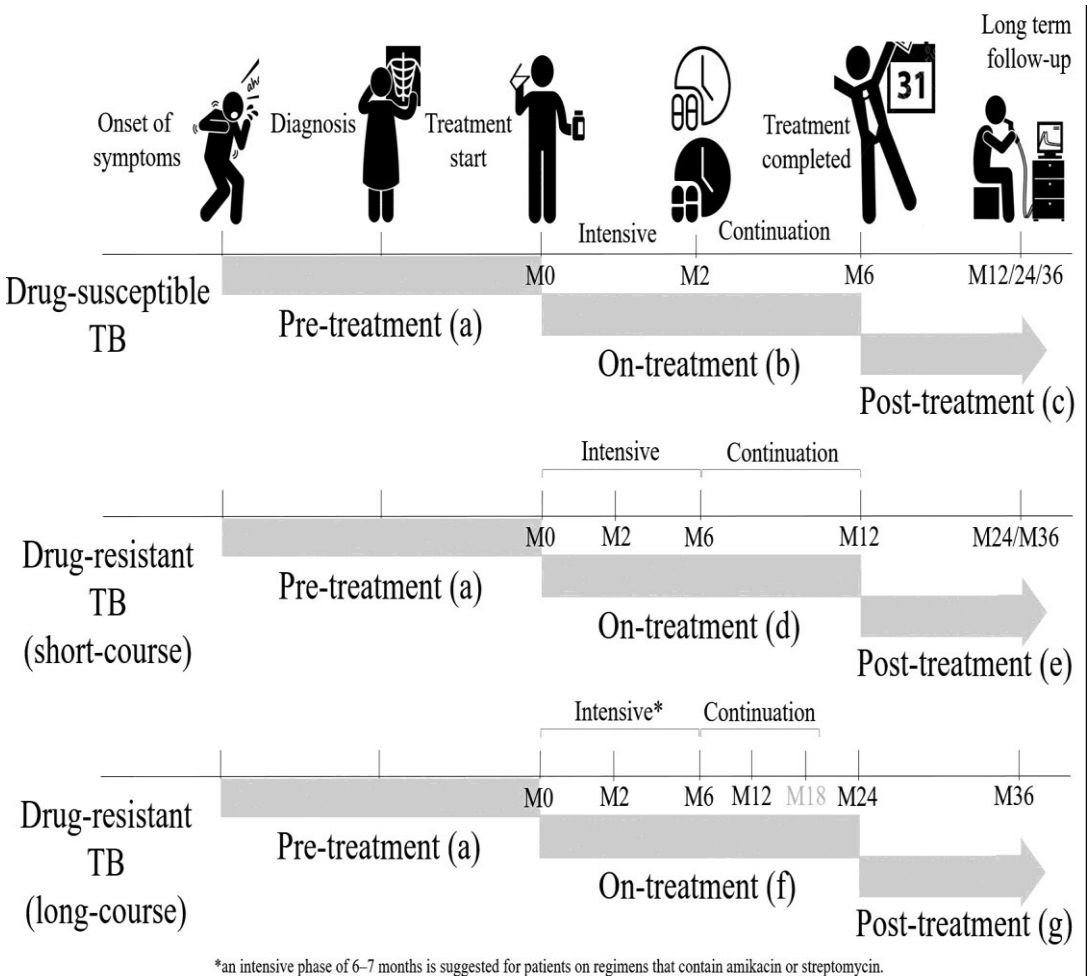

Figure 1. The WHO generic TB patient cost survey instrument was adapted for use at use at enrollment/start of TB treatment (Day 0) and at Month 2, Month 6, Month 12 and Month 24; time points intended to capture costs incurred for different phases of TB disease (e.g. pre-treatment, on-treatment and post-treatment).

TB treatment completion are collected using the Month 12 instrument (that was used at Month 12 for drug-susceptible TB patients) but administered at Month 24 (Figure 1(e)). The Month 12 instrument (for drug-susceptible TB patients) is administered once patients have completed TB treatment, and can be repeated at multiple time points after TB treatment completion (e.g. 12, 18, 24, 36 months, etc.). The adapted version for these pre-defined time points can be downloaded for use at www.tbsequel.org.

For drug-resistant TB treatment, countries can also opt for an individualized longer (18–20 months or 15–17 months after culture conversion) MDR-TB regimen [17], and preferably an all-oral regimen. In this case, countries can still use the adapted instruments to evaluate and monitor TB's economic burden on patients and their households. Total on-treatment costs are estimated from costs reported at Month 2, Month 6, Month 12, and Month 24 time-points (Figure 1(f)), however an additional visit is required at Month 18 to minimize recall bias. The Month 6 instrument is repeated until TB treatment has been completed, and then as described above once treatment has been completed, the Month 12 instrument can be administered to collect post-treatment costs. In this instance, it would be important to record the treatment completion date so that the overlap between on-treatment (12–20 months) and post- treatment periods (20–24 months) can be estimated during the analysis phase.

Each time point contains questions for the key data elements described above. While many of the data elements are repeated at the different time points (e.g. employment, numbers of hours worked, use of dissaving strategies, social assistance/protection, guardian costs, etc.), certain sections, specifically the direct out-of-pocket medical and non-medical payments, were adapted for the phase of treatment. For example, the pre- and post-treatment phases do not require data on direct medical (e.g. X-ray, laboratory tests or medication) or non-medical (e.g. transport to collect TB Medication) expenditures related to TB treatment and these questions are therefore omitted. Recall data on direct out-of-pocket payments are collected for all the time points of any visit to a health-care provider (whether scheduled or unscheduled, and including outpatient and inpatient care). For on-treatment and post-treatment direct medical and non-medical costs, participants are asked to recall since the date of the last interview. For pre-treatment costs, participants are asked to recall since the date when they first experienced symptoms. Pre-treatment costs (Day 0) are only collected for new TB cases as health-seeking behavior and duration of illness prior to TB treatment, and therefore the pre-treatment costs, are likely to be different for those previously treated (i.e. those with relapse, reinfection or retreatment after treatment failure).

Local adaptation

Next, we adapted the longitudinal instrument for each setting, to ensure that questions on TB services (e.g. type of provider), health-care fees for TB-specific tests and treatments, health insurance schemes, social protection mechanisms (disability grant, social welfare for the poor, travel vouchers, food assistance), socio-economic status (household assets), and socio-demographic information (education, employment and occupations) are locally appropriate. Discussions were held with local teams to determine the best way to adapt the instruments in terms of language to ensure that words in the target language conveyed the same or similar meaning as the source language (i.e. with an emphasis on thematic translation in local languages rather than literal translation of questions). Adjustments were made by modifying the list of options available for certain questions based on input from local clinicians, counsellors, and researchers. For example, in South Africa and The Gambia, we adapted the list of providers to reflect those commonly used while seeking care (e.g. pharmacy, traditional healer/practitioner, primary care clinic, private practitioner, public hospital, private hospital and herbalist). We also adapted the instrument to include the local currency unit.

As recommended by the WHO Task Force [2], instrument questions on self-reported income and household assets were adapted for each country, where possible using the same wording as in the standardized and validated demographic, expenditure or social survey instruments available for that country (e.g. Demographic or Health Survey or the Household Income and Expenditure Survey).

An interviewer aid with pictograms (e.g. for rating scales), definitions and/or synonyms for certain words or terms and other useful information was developed to supplement the training material and help guide interviewers during the patient interview. A sheet with country-specific prompted income ranges, as described below, was also included in the interviewer aid. The adapted instrument was available in English and was verbally translated into local languages by local study staff, who administer the questionnaire to the study participants. The study team agreed on appropriate wording for the translations during the training and piloting phase (see below), and a summary of this was also included in the interviewer aid. The interviewer aid was also designed to help interviewers with time structuring (e.g. help patients correctly recall costs they incurred since the last interview) and accurate reporting (e.g. help patients accurately recall changes in income since the last interview).

Table 2. Approaches to estimating annual household income using the TB patient cost instrument adapted for longitudinal studies*.

Catastrophic total costs[&] = Episode direct costs[a] ± Episode indirect cost[b] > threshold value (e.g. 20% base case) Household capacity to pay[c,d]	
Direct medical and non-medical costs[a]	Total indirect (productivity) loss[b]
These are payments made directly by the patient or their household member. Direct medical payments include payments for formal medical professionals, informal traditional or alternative practitioners, clinics, health centers, pharmacies, and hospitals – for medical services and products (e.g. medicines, consultation fee, payment to DOTS provider/supporter, day charges for hospitalization, diagnostics, lab tests and procedures). This excludes prepayment for health services – for example health insurance premiums – and where relevant, net of any reimbursements to the individual who made the payments. Non-medical direct costs include travel, accommodation, food or other non-medical payments incurred by the patient, their household member or caregiver/guardian while picking up medication or during the visit/hospital stay for TB care (e.g. nutritional or food supplements, interest on loans taken out to meet the costs of TB, day charges for time in hospital etc.). The sum of the direct medical and non-medical costs for the different phases/entire episode is used as the numerator.	Indirect costs can be estimated using two alternative methods; (i) Self-reported household income loss net of welfare or social assistance payments. This includes the cost that the caregivers bear by contributing their time and in-kind services. Any gain or loss of income reported during each phase or for the entire episode is considered the total indirect cost [18]. (i) Opportunity cost of time spent away from the daily productive routine. Participants are asked to self-report time spent seeking and receiving care as well as the average number of hours they work each day, if this changed since the last interview, and if so, by how much. The time total period of absence (in hours) is multiplied by the hourly wage rate of the absent worker. The hourly wage can be estimated from directly reported data, household asset ownership, or national statistics. Indirect costs for the different phase/entire episode is used as the numerator in the catastrophic total cost equation.
Household capacity to pay[c,d]	
Self-reported current income (detail or prompted ranges)[c] Participants are asked to self-report their monthly individual and household income, which is then used to calculate the annual income. If participants don't know or refuse to answer they are asked to identify their individual and household income from a list of prompted ranges. Detailed questions are used to solicit information about income (e.g. employment, property income, income from household production of services or goods) and non-salary income (e.g. travel voucher, food vouchers, disability grant, in-kind or cash transfers, public assistance, donations etc.) Annual household income before the onset of symptoms is typically used for the denominator.	Estimated income based on asset scoring[d] Annual household income can be estimated using asset ownership or dwelling characteristics (e.g. number of rooms, type of toilet facility, electricity supply, source of drinking water). A standard asset index can be used to divide households into five socio-economic quintiles. For each income quintile, mean household permanent income can be extrapolated from the National Income Dynamics Survey. This estimate usually represents income before TB. Estimating income based on assets is a suitable alternative if income is hard to report accurately or is subject to great variability over time (e.g. casual or seasonal work, large informal sector work etc.).
Alternative indicator of catastrophic costs – Coping strategies	
Coping strategies can be used as an indicator of economic catastrophe. Participants are asked if the individual or their household used savings, borrowed money, sold property or took out a loan to cover the cover of TB, and if so, how much. Participants are also asked about the economic consequences experienced (e.g. pulling children out of school, household food security etc.)	

*Adapted from [2] and [18].

Abbreviations: TB tuberculosis; DOTS Directly Observed Treatment Short-course & Participants are interviewed at time points intended to capture costs incurred for different phases of TB disease (e.g. pre-treatment, on-treatment and post-treatment). Catastrophic total costs can be calculated for the entire TB episode or for each phase of TB.

a = Direct medical and non-medical costs; b = Total indirect (productivity) loss; c = Self-reported current income (detail or prompted ranges); d = Estimated income based on asset scoring.

Income adjustments

Using the longitudinal instrument, participants are interviewed at selected time points to capture costs incurred for different phases of TB disease. Changes in costs and income can then be calculated for the entire TB episode or for each phase of TB (e.g. pre-treatment, on-treatment and post-treatment). The adapted tool allows for multiple methods for income estimation, as recommended by the WHO Task Force, and for alternative measures of income impact, such as the adoption of coping strategies. Measures of annual household income, which is used as the denominator (equivalent to household capacity to pay) when calculating the percentage for which the defined threshold for catastrophic total costs due to TB disease (>20%) is applied [4], can incorporate multiple direct and indirect measures, as described by Sweeney and colleagues and detailed in Table 2 [18].

To estimate individual and household monthly income, we first asked patients to report their current individual and household monthly income at each time point (e.g. Day 0, Month 2, Month 6, Month 12 and Month 24). At Day 0 patients were also asked to report their individual and household monthly income before the onset of symptoms (6 months ago). At each time point, if patients could not recall their individual or household monthly income or refused to answer, they were asked to identify their individual or household monthly income from country-specific income ranges. Pre-determined weekly, monthly, and annual income bands were included on a sheet, from which study participants could select the most appropriate response. Additional options for 'none', 'don't know' and 'refuse to answer' were again included to understand missing data. The self- reported mid-point income for the prompted range was used as the current monthly income. The monthly household income reported was then used to calculate the total income for the period (e.g. 2 months, 4 months, or 6 months since the last inter- view). Similarly, household income was annualized by multiplying the total income for the period by the ratio of the number of months in a year (12)

over the number of months in the period. For example, if a patient reported income at two or three time points (e.g. United States Dollar (USD) 2 USD 000 per month at Month 2 and USD 2 USD 200 per month at Month 6), we multiplied the total income for the period (e.g. USD 4 USD 200 for two months) by a ratio (number of months in a year divided by the number of months of income was reported; 12 ÷ 2 = 6) to estimate the amount of income in a year (e.g. USD 25 USD 200 per year). When calculating the proportion of TB patients and their house- holds facing catastrophic total costs, defined as total direct and indirect medical costs exceeding 20% of annual household income, household income prior to symptom onset (6 months prior to treatment initiation) is used as the denominator for catastrophic total costs [18,19].

Staff training and local refinement

Study staff were trained according to the recommendations outlined in the WHO Task Force and the TB patient cost surveys handbook [2]. Training consisted of an initial two-day introductory session, followed by a second two-day training on interviewing techniques, infection control, ethical considerations, understanding the indicators used in the instrument, and quality assurance (see below). Investigators then conducted an extensive three to five-day training session, either in-country or via interactive virtual training, to ensure that inter- viewers understood the questions and that the instrument would be implemented in a standardized way. The study team worked with the local study staff to identify potential sources of information (e. g. patient TB card, TB treatment register, etc.), so that clinic record information, such as the date of diagnosis and treatment regimen, could be extracted before the interview.

The study team also worked with local study staff to; (i) list types of health-care providers so that options in the instrument reflected the local typology/categories, (ii) identify country-specific prompted ranges for income, (iii) adapt some of the socio-demographic questions such as education, employment, occupation, so that options reflected the local standard categories, (iv) identify and include types of health insurance and social protection schemes that are available, and (v) adapt questions on income and assets using standardized/validated categories used in the country. Training material and a training guide documenting these adaptions and recommendations were distributed to study staff. Follow-up sessions were scheduled throughout the study period to provide feedback, resolve uncertainties or concerns, and repeat data collection procedures.

We considered the four months between the first introductory training session (May 2017) and the start of enrollment (September 2017) as the pilot phase. During this period, interviewers practiced administering the questionnaires, familiarized themselves with the online data collection tool (OpenClinica®), and provided extensive feedback to the study team, which was then incorporated in the adapted instrument. Countries continued to refine questions to ensure that options were appropriate for their setting (e.g. type of health insurance or social assistance available) and that different context-specific scenarios had been considered in the wording and subsequent options for the questions. For example, for The Gambia, the question on household assets was adapted from 'Do you own any of the following' to 'Does your household/dwelling have or do you own any of the following?' to reflect local living conditions (e.g. large families living in compounds). Similarly, in instances where patients were not formally employed but traded goods, interviewers were asked to obtain the value of goods, as a proxy for individual monthly income.

Discussion

The adapted, longitudinal TB cost instrument described above offers several advantages over the original, cross-sectional instrument. Collecting repeated measurements from each subject over time can simultaneously increase statistical power for detecting changes while reducing the costs of conducting a study [20]. Using the adapted tool provides the opportunity to repeat measures and make comparisons over time, describe changes that extend beyond treatment completion, and even link cost survey data to treatment outcomes. These adapted tools are particularly valuable when describing the economic burden of TB during different phases of TB treatment or determining whether economic consequences diminish or reverse when patients recover from TB. The longitudinal adaptation also allows for more in-depth information than does WHO's generic cross-sectional instrument. For instance, collecting repeated measurements of key variables can provide a more definitive evaluation of within-person change across time [20]. The longitudinal design can be used to further validate the cross-sectional approach and highlight dimensions which are particularly difficult to capture valid data for through extrapolations and imputations. In addition, the adapted tool can be used for either drug-susceptible or drug-resistant TB, making it particularly valuable in view of the scarcity of evidence available on the costs of drug-resistant TB to patients [21].

Additional time and resources, increased risk of attrition, and more complex sample size selection are some of the disadvantages of a longitudinal over a cross-sectional design. While longitudinal studies typically have higher statistical power and require fewer subjects than cross-sectional designs, repeated measurements taken from the same participant are correlated. Therefore, the sample size needs to account for special statistical methods required to analyze correlated data (e.g. multilevel models) [20]. In terms of capturing costs incurred for TB, these two instruments have different purposes. The WHO cross-sectional approach is driven by feasibility and the need to enable as many countries as possible to generate data to monitor the End TB indicator, for which the first milestone year is 2020. Whereas the longitudinal approach was adopted to suit the study design objectives of the research study (e.g. make comparisons over time and capture costs for each phase of treatment spanning from the onset of symptoms until at least 24 months after the completion of treatment). Therefore, it is essential to note that the longitudinal design is preferable for research purposes, while the cross-sectional approach is a more feasible option for national surveillance.

We conclude by noting that both instruments have some limitations (Table 1). It should be noted that the WHO generic TB patient cost survey was adapted for a longitudinal study design and tailored for the TB Sequel study. Therefore, there may be a need to further adapt the instruments for other settings or patient populations (e.g. children or those with extra-pulmonary TB).

The instruments do not capture the impact of mortality associated with TB on the household, nor do they capture the impact of multiple episodes of TB in the same individual or of multiple concurrent illnesses in the same household. Self-reported income can be challenging to assess in settings with informal economies [6,18,22–24]. For example, it is not possible to distinguish lost income due to illness from lost wages while seeking care for patients who report a zero income. Neither instrument measures household consumption or expenditure (i.e. the sum of the monetary values of all items consumed by the house- hold) to estimate annual household income, though questions could be added for settings in which short- form consumption questionnaires have been vali- dated. While the generic and adapted tools can be administered as paper-based surveys with subsequent data entry into an electronic database, the generic instrument has the added advantage that it can be administered as an electronic (E-survey) survey, offering secure management of electronic forms and data in real-time [2]. For those whose research questions are not hampered by these limitations; however, the longitudinal instrument provides a valuable addition to the toolkit for understanding the economic impact of tuberculosis.

Availability of data and materials

Templates for the adapted instruments (e.g. Day 0, Month 2, Month 6, Month 12 and Month 24) can be freely downloaded from the TB Sequel website (www.tbsequel.org) along with examples of the manual/guide and the interviewer aid which can be adapted. Templates are free to use provided users agree to the following terms and conditions.

TB Sequel hereby grants permission to use the adapted patient cost instruments under the following conditions, which shall be assumed by all to have been agreed to as a consequence of accepting and using the documents:

- Changes can be made to the instruments; however, all such changes shall be identified as having been made by the user.
- The user accepts full responsibility, and agrees to indemnify and hold TB Sequel harmless, for the accuracy of any translations into another language and any errors, omissions, misinterpretations, or consequences thereof, and any consequences resulting from the use of the instrument.
- The user will provide a credit line when printing and distributing the instruments acknowledging that it was developed as part of the TB Sequel study and acknowledging this and the sources; the WHO's generic TB patient cost instrument and the TB patient cost surveys handbook.

Acknowledgments

We would like to recognize the hard work and valuable contributions of all colleagues and partners in this project. We are also thankful to representatives of NTPs and representatives of other national health authorities for their support from early stages of the project.

Author contributions

AR, IS, SR, KL conceptualized and designed the work. DE, KL, AS and OI developed the different versions of the instrument. AS and KL provided input regarding analytical considerations. CvR and CG provided training and together with CG, AKS, IJ, NN and IS input for local adaptation and refinement. FB provided input into data collection and management. DE wrote the manuscript. All authors critically reviewed and approved the final version of the manuscript.

Disclosure statement

Authors do not have any competing interests to declare.

Ethics and consent

This study has been reviewed and approved by all respective Ethics Committees at each study site and also for coordinating institutions [2]. All participants enrolled in the TB Sequel study provide written informed consent before enrollment in the study. Participants are assigned a unique study identification number for identification purposes, and all electronic data extracted from the clinical data management system is de-identified.

Funding information

This project was funded by the German Ministry for Education and Research (BMBF) and is a part of the Research Networks for Health Innovations in Sub-Saharan Africa.

Paper context

The WHO cross-sectional TB patient cost tool was developed to enable countries to monitor the End TB indicator, namely, to eliminate the number of TB-affected households facing catastrophic costs by 2035. We adapted the generic tool, typically designed for national surveillance studies, for longitudinal studies. The adapted tool can now be used to make comparisons over time, describe changes that extend beyond treatment completion, and link cost survey data to treatment outcomes and post-TB sequelae.

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9.2 Publication II

Devoid I, **Sillah AK**, Sutherland J, Owolabi O, Ivanova O, Govathson C, et al. The household economic burden of drug-susceptible TB diagnosis and treatment in The Gambia. INT J TUBERC LUNG DIS [Internet]. 2022 [cited 2023 Jan 29];26(12):1162–Available from: http://dx.doi.org/10.5588/ijtld.22.0091

INT J TUBERC LUNG DIS 26(12):1162–1169

Q 2022 The Union
http://dx.doi.org/10.5588/ijtld.22.0091

The household economic burden of drug-susceptible TB diagnosis and treatment in The Gambia

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SUMMARY

OBJECTIVE: To determine the costs and catastrophic costs incurred by drug-susceptible (DS) pulmonary TB patients in The Gambia.

METHODS: This observational study collected cost and socio-economic data using a micro-costing approach from the household perspective from 244 adult DS-TB patients with pulmonary TB receiving treatment through the national treatment programme in The Gambia. We used data collected between 2017 and 2020 using an adapted version of the WHO generic patient cost survey instrument to estimate costs and the proportion of patients experiencing catastrophic costs (**2**:20% of household income).

RESULTS: The mean total cost of the TB episode was $104.11 (2018 USD). Direct costs were highest before treatment ($22.93). Indirect costs accounted for over 50% of the entire episode costs. Using different income estimation approaches and catastrophic cost thresholds, 0.4–75% of participants encountered catastrophic costs, showing the variability of results given the different assumptions we utilised.

CONCLUSIONS: We show that despite the benefits of free TB care and treatment, DS-TB patients still incur substantial direct and indirect costs, and cases of impoverishing expenditure varied vastly depending on the income estimation approaches used.

KEY WORDS: tuberculosis; patient costs; catastrophic costs; The Gambia

Until the COVID-19 era, TB disease was the leading cause of death from a single infectious agent worldwide, and nearly half of patients living with TB in low- and middle-income countries (LMICs) reported financial difficulties due to the disease.[1] TB patients encounter sizeable medical and non-medical costs from before diagnosis until after treatment, but also due to morbidity and disability that can lead to lost productivity during this time.[2]

The WHO End TB Strategy aims to eliminate TB-related catastrophic costs that patients and their families experience by 2030 and defines TB costs as ''catastrophic' when they exceed 20% of annual pre-TB household income.[3] Despite efforts from policy-makers and health systems to alleviate patient costs, many households still face catastrophic costs due to TB.[1,4] TB treatment is often provided free at the point of access in many settings. While there is information regarding catastrophic costs for high TB burden countries, there is limited information for The Gambia, which has a relatively low incidence of TB, but ranks among the poorest in the world with a gross national income per capita of less than $1,500.[5]

The majority of patients initiate care at government (public) health facilities in The Gambia, incur no charges for diagnostic GeneXpert testing and are then treated at governmental facilities, where they incur no cost. However, patients who require additional tests such as X-rays or other imaging must pay out-of-pocket expenses at private pharmacies, clinics or hospitals. Patients also incur non-medical costs through expenditure on transport, food, accommodation and indirect costs due to an inability to work or perform daily activities.[6]

Substantial patient costs can impede those most

ID and AKS are joint first authors; DE and MQ are joint last authors.

vulnerable from accessing essential care and treatment services due to an inability to pay, and ultimately, exacerbate TB transmission.[3] Information on costs and the proportion facing catastrophic costs are vital to inform social protection programmes to ensure that patients receive appropriate care and treatment, and are supported without the risk of financial catastrophe.

The WHO acknowledges several methods of estimating household capacity to pay.[3] A study from Sweeney et al. showed that catastrophic cost estimates varied vastly using different income estimation approaches, which displayed the diverse results and policy implications that can occur from use of distinct methodologies from the TB patient costing literature.[7]

This study has both empirical and methodological contributions. First, while many studies have estimated the proportion of those who experience catastrophic costs due to TB in LMICs,[1,4,] there is a lack of information regarding patient costs and catastrophic costs suffered due to the use of TB care in The Gambia.[4] Second, few studies explore the impact of different assumptions of household capacity to pay on catastrophic cost estimates. In the present study, we estimate the direct, indirect and catastrophic costs incurred by DS-TB patients in The Gambia, exploring the impact of different methodological assumptions on these estimates.

METHODS

Setting, sites, and study participants

Data were collected at the Medical Research Council Unit The Gambia of the London School of Hygiene & Tropical Medicine (MRCG@LSHTM) in the Greater Banjul Area (GBA), where nearly two-thirds of TB patients in The Gambia are diagnosed.[8] The GBA is a mixed urban and rural setting of approximately 700,000 inhabitants.[8] In 2019, the incidence rate of TB in The Gambia was 174 cases per 100,000 population.[9]

Ethics approval was obtained from The Gambia Government/MRC Joint Ethics Committee on 17 January 2018 (Ethical approval number for TB Sequel: SCC1523).

This study used longitudinal data that were collected as part of the TB Sequel study (NCT03251196).[10] One of this study's aims is to describe the economic costs of pulmonary TB to patients and their households. Adults (**2:**18 years) seeking care through the national TB programme in The Gambia who provided written informed consent, living within the study area, willing to be tested for HIV, with available collected and stored bodily fluids, and willing to start anti-TB treatment after diagnosis were eligible to participate. Patients were recruited from government health facilities or referred to the MRCG@LSHTM. Eligible participants were enrolled at TB treatment initiation between 2017 and 2020. Direct (medical and non-medical) and indirect costs data were collected using the WHO generic patient cost instrument adapted for use in a longitudinal study.[11] The surveys were administered by trained members of the TB Sequel study. Patients were surveyed at enrolment into the study and at the end of the intensive and continuation phases of treatment. The surveys comprised of questions on socio-economic and household information such as healthcare-seeking behaviours, costs of care, income, asset ownership and financial coping mechanisms.[10] Responses were entered on paper forms and later captured into an online data collection tool in OpenClinica[w] (https://www.openclinica.com/). We restricted the analysis to patients enrolled with DS-TB and used a micro-costing approach from the household perspective to estimate patient costs incurred before treatment starts and while on TB treatment. Micro-costing is a method to capture all cost components of healthcare services or interventions more precisely.[12] Participants who did not attend at all three visits or tested positive for rifampicin- resistant TB were excluded from the analysis.

Data analysis

Costs incurred by drug-susceptible TB patients

Total direct costs were summed and disaggregated by costing category and treatment phase. Direct costs were categorised as medical (consultation, imaging, medication, hospitalisation), non-medical (transport, food [including the cost of nutritional supplements], accommodation), associated with seeking TB care.[3] At enrolment, patients recalled the total costs incurred before treatment at each provider by cost category. In the pre-treatment phase, we assessed the frequency, duration and costs incurred by different provider types. In the intensive and continuation treatment stages, the same costing categories were used for TB-related follow-up visits, hospitalisation or DOTS visits.

Indirect costs were calculated using the human-capital approach, where the total time participants spent seeking care and treatment for TB was estimated and classified as travel, waiting, consultation and hospitalised time or guardian costs (costs or time incurred by family). The average number of visits per participant was multiplied by the mean visit length per participant within the respective treatment phase. An hourly wage was estimated by dividing monthly individual income by reported monthly working hours, and the total time lost was multiplied by the hourly wage per participant to calculate the total indirect cost (WHO method).[3]

Direct costs and income reported before 2018 were inflated to 2018, using the 2018 World Bank GDP deflator, and converted to USD using the conversion rate in January 2018 (Gambian dalasi [GMD] 47.31 ¼ 1USD).[13,14] Costs incurred after 2018 were not

inflated. Analyses were performed using Stata v16.1 (StataCorp, College Station, TX, USA) and MS Excel (MicroSoft, Redmond, WA, USA).[15,16]

Missing cost or income data

Missing cost data were replaced with zero for patients who attended the survey visit, assuming no cost was incurred,[17] as the study team noted that when patients incurred no cost at a provider or category, the interviewers left it blank instead of denoting a value of zero (Supplementary Data).

Calculation of catastrophic costs

Catastrophic costs were estimated by summing total direct and indirect costs throughout the TB episode divided by annual household income (Pre-TB). Predicted household income based on asset ownership and housing characteristics was used to serve as the default approach of catastrophic cost estimation. Participants were asked about asset ownership, and the same asset and housing characteristics as the 2010 World Bank Integrated Household Survey (IHS) were used to perform a principal components analysis (PCA) to calculate factor weights for each asset or housing characteristic in the IHS,[18] including washing machine, landline phone, cellphone, car, motorcycle, bicycle, refrigerator, television, DVD player, radio, horse/donkey, computer and housing characteristics, which included water source, electricity and toilet type. The factor weights from the first dimension of the PCA in the 2010 IHS dataset were applied to the study dataset to construct nationally representative wealth quintiles, to explore the socio-economic status of the patients in this dataset. The mean permanent household income from each quintile of the IHS was computed and applied to the corresponding quintile within the TB Sequel data to predict household income for each participant (Approach #1).[7,19] A catastrophic cost threshold of 20% was used, and varied between 5% and 30%.[3]

Sensitivity analyses

The indirect costing methods were assessed for variation in results using an approach from Sweeney et al., according to which monthly household income (for each of the three different income estimation approaches we use) was divided by the total number of reported adults in the household, which was divided by self-reported monthly working hours to estimate the hourly wage. The estimated hourly wage was then multiplied by the total lost time to calculate the total indirect cost.[7]

To enumerate household income, we assumed each household earns the national mean monthly income from the 2010 IHS. Second, we utilised a method in the patient costing literature where the catastrophic costs threshold was defined when total costs exceeded 10% of individual annual income, and income was imputed as $1 when zero or missing.[20–23] We also calculated the proportion of patients who used coping methods, including taking loans, selling assets or borrowing money to cover out-of-pocket costs related to TB care, which assumes any household using a coping mechanism has experienced catastrophic cost in line with the 2019 WHO Handbook.[3] Finally, sensitivity analyses were performed by adjusting the catastrophic cost threshold between 5% and 30%.[7]

Table 1 Participant characteristics (*n* ¼ 244).

	Included individuals (*n* ¼ 244)
Factor	*n* (%)
Age group, years	
18–29	115 (48)
30–40	67 (28)
2:41	59 (24)
Sex	
Female	71 (29)
Male	173 (71)
Education	
No formal schooling	83 (34)
Primary school	34 (14)
Secondary school	59 (24)
High school	68 (28)
HIV status	
HIV-positive	20 (8)
HIV-negative	221 (92)
Employment at enrolment	
Self-employed	38 (16)
Formally employed	22 (9)
Informally employed	28 (11)
Unemployed	83 (34)
On sick leave	51 (21)
Student	21 (9)
Household primary income earner at enrolment	
Patient	79 (33)
Immediate family member	63 (26)
Extended family member	36 (15)
Other	64 (26)
Job loss at study enrolment	
No	218 (89)
Yes, lost job	26 (11)
Working less than normal at enrolment	
No	41 (17)
Yes, less work	203 (83)
Socio-economic status	
1 – poorest	18 (7)
2	32 (13)
3	11 (5)
4	109 (45)
5 – richest	74 (30)
Number of weeks from symptom onset to seeking care, mean 6 SD	6.2 6 5.12

SD ¼ standard deviation.

RESULTS

Baseline characteristics

Table 1 displays the characteristics of the 244 DS-TB patients who were included for analysis in the study (Supplementary Data). The mean age of the included

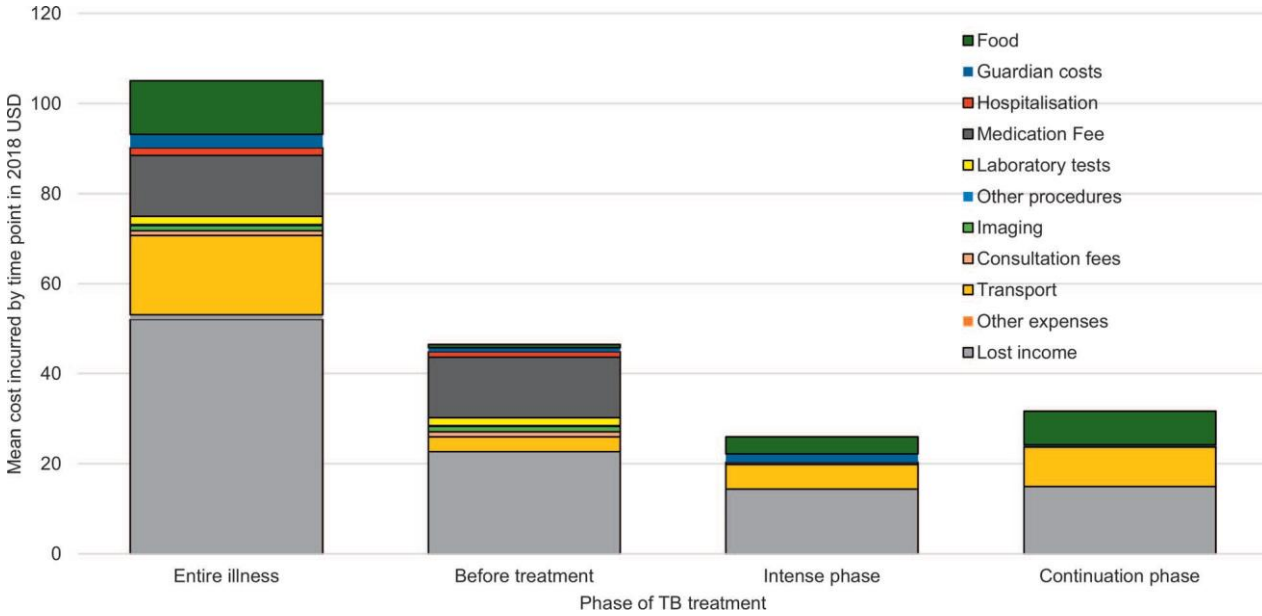

Figure 1 Mean direct and indirect cost per category and time-period in 2018 USD (*n* ¼ 244). Lost income calculated using the permanent income estimation approach and the WHO method of hourly wage valuation. The intensive treatment phase was 8 weeks, and the continuation phase was 16 weeks. USD ¼ US dollar.

participants was 33 years; 71% of participants were adult men, roughly in line with the proportion of TB cases in The Gambia (57%).[9] The proportion of HIV-TB co-infected participants (8%) was lower than the HIV-TB co-infection rate in The Gambia (16%).[24] The reported unemployment rate for study participants (34%) was approximately three-fold the national unemployment rate in The Gambia (9%).[25] Respectively 11% and 83% of participants had either lost their jobs or were working less at study enrolment. Based on results from the PCA, respectively 45% and 30% of included study participants fell into the richest/wealthiest quintiles 4 and 5.

Direct and indirect costs

Overall, mean direct costs before treatment accounted for the highest proportion of direct costs throughout the TB episode (47%). 59% ($13.49) of the mean direct costs before treatment comprised of medication fees. In the intensive phase, the mean direct cost was $9.77, and patients incurred little to no direct medical costs due to existing TB treatment coverage.[6] Furthermore, the mean direct cost in the continuation phase was $16.30. Figure 1 exhibits the mean direct and indirect costs for the entire TB episode. The mean total cost for the TB episode was $104.11. The mean direct cost for the entire TB episode was $49.00, and the costliest component was transport ($17.62).

Using the WHO approach of hourly wage valuation and permanent income, the mean indirect cost throughout the TB episode was $52.06. Figure 2 displays the average indirect costs incurred by time point and use of sensitivity analyses surrounding income and methodology of hourly wage valuation. Total mean indirect costs were lowest using mean national income and the approach from Sweeney et al. ($37.14).[7] Table 2 gives the total mean and median direct costs, provider visits and total time spent seeking care by provider type before treatment. The most substantial mean direct costs and total time lost was incurred at the traditional practitioners where patients spent $30.80 and exhausted 50 h seeking care on average, followed by private practitioners where patients sustained $14.84 and expended 5 h seeking care on average.

Catastrophic costs

Figure 3 illustrates the proportion of catastrophic costs experienced using different income estimation approaches and catastrophic cost thresholds. Participants experienced catastrophic costs ranging from 0.4% to 75%, using the aforementioned approaches; this highlights the substantial variability in cata- strophic cost estimates depending on the assumptions used. At the 20% standard catastrophic cost thresh- old, approximately 3% of participants experienced catastrophic costs using both permanent income and mean national income. Participants experienced the highest proportion of catastrophic costs when using self-reported individual income (35–75%).

Figure 4 displays the proportion of patients utilising coping strategies by time-period and strategy type. Nearly 70% of participants used any method of dissaving during the episode, and were most prevalent before treatment, where participants incurred the highest direct costs.

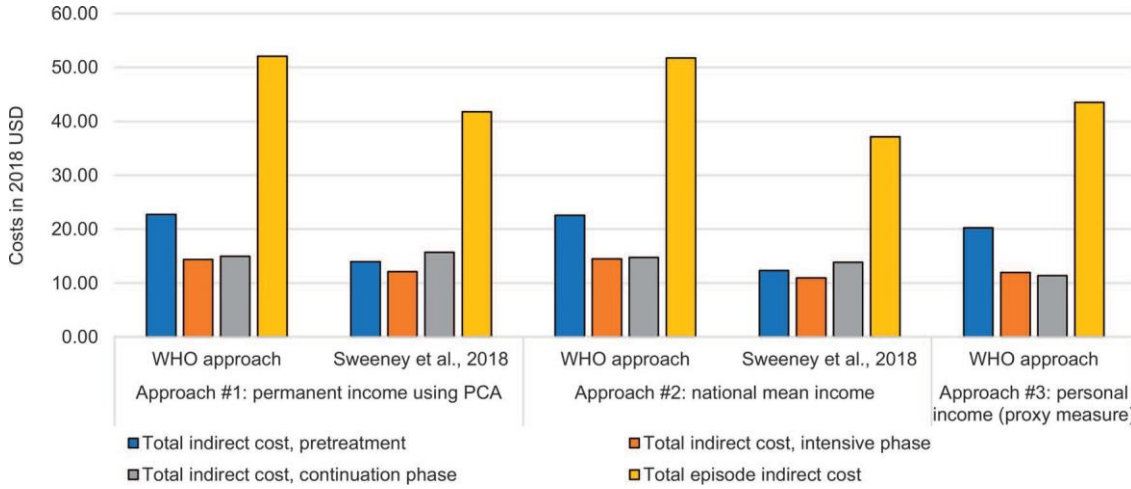

Figure 2 Indirect cost by time-period and income estimation approach in 2018 USD. Approach #1: income calculated using a principal components analysis; Approach #2: income calculated using the national mean income of The Gambia; Approach #3: income calculated using self-reported personal income. Where missing income was imputed as $1 (2018 USD). The WHO Approach was calculated using the human-capital approach. Sweeney et al. divided monthly household income by the total number of reported adults in the household, which was divided by self-reported monthly working hours to estimate the hourly wage. USD ¼ US dollar; PCA ¼ principal components analysis.

DISCUSSION

Despite treatment being free at the point of access, this study suggests DS-TB patients can incur substantial and possibly catastrophic costs during a TB episode in The Gambia. The mean cost of the TB episode to the patient exceeded $100 for the 244 patients included in this analysis. Before treatment, patients incurred the highest direct costs by treatment stage; these accounted for nearly 47% of total direct expenses, and 22% of total episode costs. These findings are similar to those of a systematic review on TB patient costing studies across LMICs, which found total episode costs to range from $55 to $8,198, demonstrating the wide range of patient costs experienced across LMICs.[1] The mean total costs from this study are on the lower end of this range; however, the breakdown of results are in line with other TB patient costing studies in LMICs and sub- Saharan Africa, where patients incurred the highest proportion of direct costs before treatment, and few participants experienced direct medical expenses during the intensive or continuation phases of treatment due to existing treatment policies.[1,20,26–28] Overall, the high direct-medical costs before treatment and direct non-medical costs during treatment stages mirrors the actual trends in costs faced by TB patients in sub-Saharan Africa and LMICs.[1,4]

Depending on the approach used to estimate income, the proportion of patients experiencing catastrophic costs varied greatly. Using permanent or mean national income, the catastrophic costs estimates resemble those in Sweeney et al.,[7] where few participants experienced catastrophic costs, but a much higher proportion of participants reported the use of coping strategies. The catastrophic cost estimates using individual income and a 10% threshold are comparable to those in Foster et al.,[20] which also used individual income and a 10% threshold, where 53% of TB participants experienced catastrophic costs compared to 52% of participants in this study. The proportion of patients using coping strategies in this study was much higher than in Sweeney et al.,[7] Pedrazzoli et al.,[29] and Foster et al.,[20] plausibly due the high unemployment rate, difference in study setting or limited recall bias from longitudi-

Table 2 Mean visit number, direct costs and hours seeking care before treatment by provider type in 2018 USD (*n* ¼ 244)

Facility type*	Mean total number visits *N*	Median total time spent seeking care (hours)	Total direct costs per provider (in 2018 USD) Mean 6 SD	Median [IQR]
Pharmacy, drug or grocery store (*n* ¼ 115)	2	3	11.48 6 14.28	6.87 [3.70–12.89]
Traditional practitioner (*n* ¼ 32)	2	50	30.80 6 40.70	12.84 [4.17–43.45]
Primary care, public (*n* ¼ 78)	2	5	4.46 6 7.85	2.09 [0.87–5.39]
Private practitioner (*n* ¼ 39)	2	5	14.84 6 28.66	6.13 [1.94–12.39]
Public hospital (*n* ¼ 191)	2	8	5.13 6 6.73	2.56 [0.95–7.21]
Private/mission hospital (*n* ¼ 214)	1	11	7.52 6 26.41	2.86 [0–5.39]
Other (*n* ¼ 2)	2	3	4.49 6 6.35	4.49 [0–8.98]

* Total number of included participants who attended visits at the specified provider.
USD ¼ US dollar; SD ¼ standard deviation; IQR ¼ interquartile range.

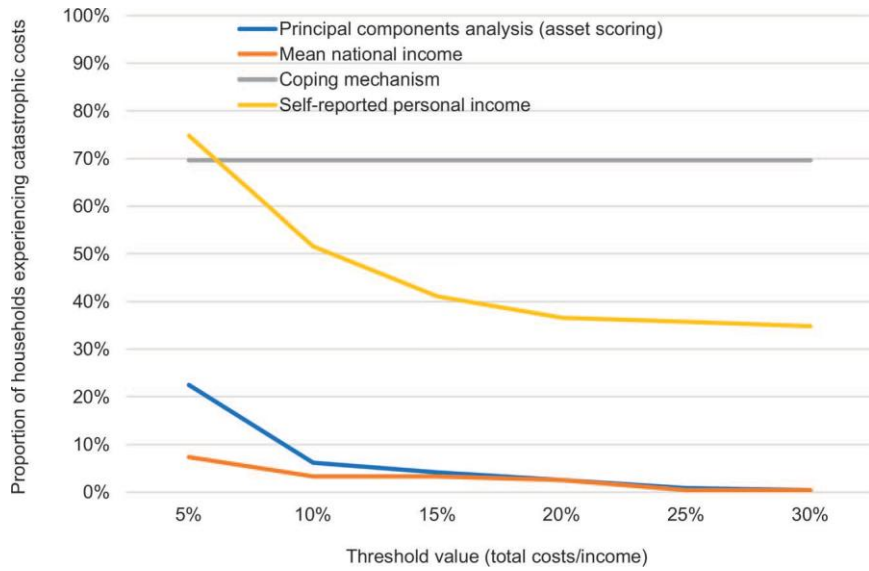

Figure 3 Catastrophic cost prevalence by threshold value and income variation approach (*n* ¼ 244). Indirect costs calculated using the human capital approach and the WHO method of hourly wage valuation. Approach #1: income calculated using permanent income; Approach #2: income calculated using mean national income; Approach #3: income calculated using self-reported personal income (missing income was imputed as $1 USD). PCA ¼ principal components analysis; USD ¼ US dollar.

nal surveys. A recent study in Uganda,[30] where the GDP per capita and TB incidence are similar to The Gambia, found a higher range of costs and cata- strophic costs than our study. However, a study from Malawi, where the GDP per capita and TB incidence are also similar,[31] reported total patient costs that were comparable to those in our study.

Nonetheless, cross-country catastrophic cost comparisons are difficult to make due to the variety of approaches utilised in the literature to enumerate household income and patient costs. Such approaches and the assumptions used to obtain estimates can vastly differ; this highlights the importance of sensitivity analyses surrounding household ability to pay. This study reinforces the findings of Sweeney et al.[7]—that the methods used to estimate income significantly affect catastrophic cost estimates.

The use of consumption or expenditure is the most accurate method of enumerating household capacity to pay and would increase the validity surrounding the catastrophic cost estimates presented in this study. However, consumption and expenditure surveys are time-consuming and still subject to recall and social desirability bias.[22,32] In lieu of data on consumption or expenditure, it is challenging to obtain precise estimates of catastrophic costs using measures such as self-reported household income, permanent income and other proxy measures. Future TB patient costing studies could utilise consumption or expenditure to measure household income; however, the time taken to conduct such surveys could lead to misclassification of other survey elements like cost and socio- economic information due to an increased level of survey fatigue.[7]

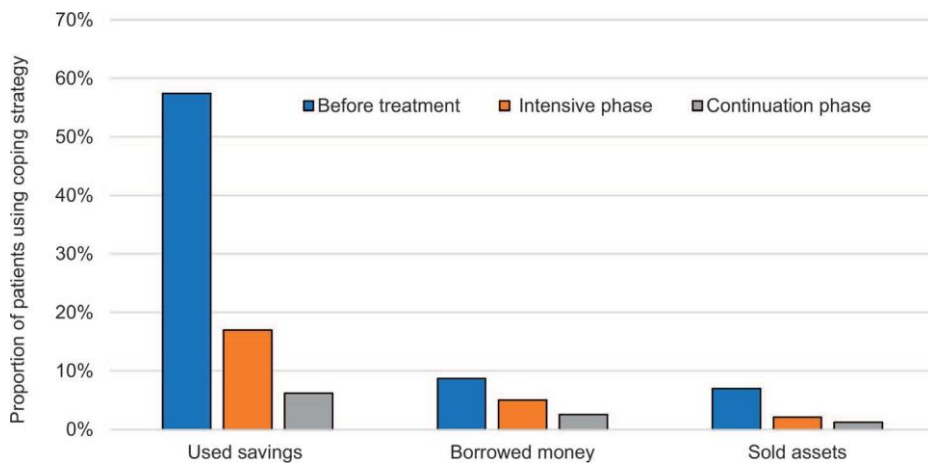

Figure 4 Proportion of patients employing different coping strategies by time point (*n* ¼ 244).

Our use of longitudinal surveys is plausibly less prone to recall bias, whereas most patient costing studies use one survey conducted at the end of treatment. This was especially true before treatment, where our study was able to capture a variety of indicators on patients' care-seeking behaviours.

This study had several limitations. For enrolment in our study, patients needed to be diagnosed and have started treatment; thus, we potentially excluded those who died or were lost to follow-up before treatment could be started. Such patients are perhaps most prone to financial catastrophe, which could have led to an underestimation of the catastrophic cost prevalence. Therefore, this study gives a true estimation of patient and catastrophic costs for those who were able to engage in care for the entire TB episode, as the same barriers limiting those in the richer/wealthier quintiles from accessing care, could likely have limited those in the poorest quintile from ever accessing care.

Indirect costs were only estimated using the human capital approach, which can undervalue groups like the unemployed, informal workers and ageing populations.[33] The cohort had a large percentage of unemployed and informal workers, which could have led to an underestimation of indirect costs, as income data are likely not missing at random and are subject to social desirability and recall bias. Moreover, missing direct cost data were imputed with the value zero on the assumption that participants had not incurred any direct cost during this period, which may have resulted in an underestimation of direct costs of the TB episode, and thereby, an underestimation of the proportion of participants incurring catastrophic costs. The MRCG@LSHTM stopped study activities on 27 March 2020 due to COVID-19, and in-person interviews were not resumed until September 2020.

The high costs experienced before treatment demonstrate the need for policy shifts to relieve the burden patients experience pre-TB diagnosis. Community education on TB symptoms along with adequate access to affordable diagnostics could potentially alleviate the 6-week period from diagnosis to treatment. Such approaches could ensure patients are diagnosed early, thus, saving money on non-governmental facility visits, where large expenditures often occur. Integrating such facilities into the continuum of care could shorten the period from symptom onset to diagnosis. Two systematic reviews found better outcomes and linkage to care through public-private partnerships,[34,35] but further research is needed to fully understand how to integrate traditional practicioners where patients exhausted sizeable direct and indirect costs.

CONCLUSION

This is the first study to assess the economic burden of TB in The Gambia. Patients can experience large costs associated with DS-TB, despite free treatment in The Gambia. Catastrophic costs varied vastly ac- cording to the approach taken to estimate income; this stresses the importance for future research of using a variety of approaches and acknowledging biases from such approaches carefully.

Acknowledgements

The authors thank the study teams for the TB Sequel study for use of their data; all colleagues and partners in this project for their hard work and valuable contributions; and the National Leprosy and Tuberculosis Programme and other national health authorities for their support of the project.

TB Sequel Consortium members: G Churchyard, M Hoelscher, R Wallis, S Charalambous, K Velen, F Sathar, F Munedzimwe, A Rachow, O Ivanova, A-M Mekota, A Bakuli, C Geldmacher, F Riess, F Zekoll, U von Both, K Lo¨ nnroth, S Nimann, M Merker, V Dreyer, U Schaible, C Leschczyk, B Kampmann, J Sutherland, B Sambou, C Muefong, F Darboe, A-J Riley, B Sarr, O Owolabi, B Dowsing, A Sallahdeen, S Jayasooriya, A K Sillah, N E Ntinginya, I Sabi, D Mapamba, M Chachage, E Siyame, J M Lalashowi, I Sanne, M Rassool, L Singh, J Bennet, N Mwelase, I Jani, C Khosa, N Bhatt, S Viegas, K Azam, N Sitoe, P Nhassengo, D Evans, K Hirasen, C Govathson, T Sineke, S Rosen.

This project is funded by the German Ministry for Education and Research (BMBF; grant ID 01KA1613) and is a part of the Research Networks for Health Innovations in Sub-Saharan Africa.

ID works for the Centers for Medicare and Medicaid Services (CMS; Baltimore, MD, USA. The views reflected in this study are not reflective of views or policy of CMS, and ID is writing in a personal capacity.

Conflicts of interest: none declared.

Data availability statement: The datasets generated and/or analysed during the current study are not publicly available as the data are owned by TB Sequel consortium and the study sites and are governed by the respective IRB or ethics committee in each country. Data cannot be shared publicly because the local ethics committee in each country restricts access. Data requests can be sent to the TB Sequel secretariat (Fadzai Munedzimwe ,FMunedzimwe@ auruminstitute.org).

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OBJECTIF : De´terminer les coûts et les coûts catastrophiques assume´s par les patients atteints de TB pulmonaire pharmacosensible (DS-TB) en Gambie.
ME´THODES : Cette e´tude observationnelle a recueilli les donne´es de coût et les donne´es socio-e´conomiques à l'aide d'une approche de micro-costing, en se concentrant sur le point de vue des foyers de 244 patients adultes atteints de DS-TB sous traitement via le programme national de traitement de Gambie. Nous avons utilise´ les donne´es recueillies de 2017 à 2020 en utilisant une version adapte´e du Manuel d'enquête de l'OMS sur les coûts de la tuberculose pour les malades, afin d'estimer les coûts et la proportion de patients faisant face à des coûts catastrophiques (2:20% des revenus du foyer).
RE´SULTATS : Le coût total moyen de l'e´pisode tuberculeux e´tait de 104,11 $ (USD 2018). Les coûts directs e´taient plus e´leve´s avant traitement (22,93 $). Les coûts indirects repre´sentaient plus de 50% de l'ensemble des coûts de l'e´pisode. En utilisant diffe´rentes approches d'estimation des revenus et des valeurs seuils pour les coûts catastrophiques, 0,4–75% des participants faisaient face à des coût catastrophiques. Cela te´moigne de la variabilite´ des re´sultats au vu des diffe´rentes me´thodes d'estimations utilise´es.
CONCLUSIONS : Malgre´ les avantages d'une prise en charge et d'un traitement gratuits de la TB, les patients atteints de DS-TB font toujours face à des coût indirects et directs conse´quents, et les cas de de´penses appauvrissantes varient conside´rablement selon l'approche d'estimation des revenus utilise´e

9.3 Publication III Submitted (Not published):

Socio-economic Burden of Tuberculosis and its Impact on Child Contacts in The Gambia

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Socio-economic Burden of Tuberculosis and its Impact on Child Contacts in The Gambia

Journal:	*Public Health Action*
Manuscript ID	Draft
Manuscript Type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Sillah, Abdou; Medical Research Council - The Gambia Unit, Vaccinology Theme; 2CIHLMU Center for International Health, University Hospital, Ludwig Maximilian University of Munich, Center for International Health (CIH)
Key Words:	tuberculosis, socioeconomic impact, child household contacts

Socio-economic Burden of Tuberculosis and its Impact on Child Contacts in The Gambia

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Germany KEY WORDS: tuberculosis; socioeconomic impact, child household contacts

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Abstract

Background and Objectives: This study aimed to determine the social impact of adult TB on child household contacts living in the Greater Banjul Area, The Gambia. Setting and methods: This prospective observational cohort study among adults (≥18 years) starting treatment for drug-susceptible pulmonary TB between 06/2019 and 07/2021 who reported having at least one child household contact. We collected data from 51 adults and 180 child contacts at the start of TB treatment and again at 6 months of treatment. Participants were asked about expenses for school fees, healthcare, festivities, and food security of child contacts.

Results: While school attendance of the child contacts remained largely unaffected, there was a significant drop in school performance 6 months later ($p<0.001$). Furthermore, child contacts faced significant food insecurity in terms of food quantity and variety available with increases by at least four-fold post TB-treatment ($p<0.001$)

Conclusion: Child contacts face a potential decline in school performance and risk of food insecurity. While a plethora of work is being undertaken to alleviate costs of care for TB patients, further emphasis is needed to ensure educational and social prosperity for child contacts, as caregiver TB has socio-economic implications for the wider household.

Introduction

While the COVID-19 pandemic has strained health systems across the world, tuberculosis (TB) has contributed substantially to the global burden of disease (1) with significant impact on childhood TB management (2). Many patients suffer long-term consequences due to pulmonary TB (PTB) even after completion of treatment and complete bacteriological cure (3), and many patients face economic and social consequences that can have implications on their households, including children (4).

There is a growing consensus among governments, researchers, and non-governmental organizations that progress to control TB in low- and middle-income countries (LMICs) will require both strengthening TB control programs, as well as an emphasis on the social determinants of health (5,6). Attention on the social determinants of health is partly due to a growing body of literature documenting the association between substantial TB patient costs that can cause or exacerbate poverty and negatively impact TB treatment outcomes and adherence (7). Such literature has influenced a variety of social protection schemes across LMICs to enable patients to complete treatment and limit the likelihood of financial catastrophe for their households. In The Gambia, TB treatment is provided free at the point of access across governmental facilities; however, patients can still incur substantial non-medical direct (e.g., transport, food, care provided by family) and indirect costs (i.e., loss of income) in accessing treatment (8). While tools to assess the household economic burden of TB, such as the World Health Organization's generic TB patient cost survey contains questions on household food security, the instrument does not capture the full spectrum of social and economic consequences that children of a caregiver with TB may encounter (9) While research on the social and economic consequence of adult TB in children is limited, a study in India from Geetharamani et al., showed that TB infection in caregivers can result in declining school performance in children, with some children leaving school entirely to support their households financially (10).

While it may already be difficult for households to recover from the economic shocks of TB disease, school performance, dropout, and food security can have implications on children that last into adulthood (11,12) .While research focusing on TB patient costs has been paramount in designing social protection schemes, it is imperative that research addresses in what way children are impacted, to ensure that future policies can efficaciously protect this vulnerable population. Therefore, this study aims to explore the social and economic consequences of household TB on children in The Gambia, a country with a relatively low incidence of TB but is among the poorest in the world.

Methods

Study setting

The Gambia is a small country in West Africa which has a relatively low prevalence of TB with an incidence rate of 149 cases per 100,000 population (13) .Two-thirds of TB patients are diagnosed in the Greater Banjul Area (GBA), which has a population of nearly 700,000 inhabitants and spans Banjul, Kanifing Municipality (KM) and parts of Brikama Administrative Area (14).

Study participants and data collection

This prospective observational study collected data at the Medical Research Council Unit The Gambia at the London School of Hygiene and Tropical Medicine (MRCG at LSHTM) in the GBA. Longitudinal collection of socio-economic data was nested in the large multi-country multi-site TB Sequel study (NCT03251196). Within the TB Sequel study, participants were referred to the MRCG at LSHTM from public (governmental) facilities where diagnostic confirmation, routine clinical examinations and biological samples were collected. Adults (≥18 years) with pulmonary TB were enrolled at TB treatment initiation between September 2017 and January 2020 and received TB treatment according to the local standard of care. Participants were followed for up to 48 months, with interviews conducted at study enrolment (Day 0 ±14 days), 2, 6, 12, 24, 36 and 48 months.3

Informed consent was obtained from eligible participants. Demographic information including site of disease, age, gender, ethnicity, marital status, and HIV status were collected from longitudinal surveys at baseline (start of treatment). Questionnaires were administered in English and where necessary translated into the local languages in the study clinics or at the homes of study participants by trained interviewers.

For this country-specific study, TB Sequel participants enrolled between 06/2019 and 07/2021 reporting having at least one child household contact (children < 15 years of age) were identified. Eligible participants provided written informed consent to participate and were interviewed at baseline and at 6 months. We defined a household contact as a person who shared the same enclosed living space as the index case for one or more nights or for frequent or extended daytime periods (15). The interview included questions on sociodemographic and household information such as employment status, education, family type, size of family, number of child contacts and their age ranges, child contacts education such as school attendance, school performance and other educational needs for both

integrated preschool (3-5 years) and school-aged children (5-15 years). Data on school attendance and school performance was extracted from school report cards.

To determine the participant's ability to spend money on education, healthcare or social needs for child contacts, we collected information on spending for items such as clothing, shoes, and gifts during feast celebrations (when parents buy new clothes, shoes and gifts for the family on celebrating such events) and on direct out-of-pocket expenses (medical and non-medical direct costs), for accessing healthcare for sick household child contacts, and on school essentials (e.g., uniform, school fees, extra classes, meals, transportation and stationary). The recall period for reporting on socioeconomic and cost data was four months. We also collected information on the ability of adult TB parent to provide enough quality food before and during TB illness for the child contacts.

Data Analysis

Analysis was done using SPSS software and Microsoft Excel. First, to describe the characteristics of adult participants at baseline (start of TB treatment) and their child contacts, we summarize data using means (standard deviation) for parametric or median (interquartile range) for non-parametric continuous data and proportions for categorical data. We only collected the age, and not the gender, of child contacts. Figure 1 shows a graphical depiction of the relationship between the various characteristics, TB treatment and impact on household child contacts.

Second, to describe the economic status and participant's ability to spend money on household child contacts, we present the change in employment, social support received (monetary and non-monetary), direct out-of-pocket expenses on healthcare for sick contacts, and buying power from baseline to 6 months on treatment. Categorical questions were transformed into grades, and these were compared at baseline and 6 months on treatment using test for symmetry, Chi-square test and McNemar's test for categorical variables, where appropriate. Continuous variables were compared using the Wilcoxon sign rank test (two groups; paired data). Comparative analyses were conducted where data was available at both baseline and 6 months with significance level of 0.05.

Last, using the same approach described above, we describe the impact on adult TB on school performance, school attendance, spending on child or school needs and child nutrition in terms of provision of types and quantity of food.

Ethical considerations

Local ethics approval was gained from The Gambia Government/MRCG at LSHTM Joint Ethics Committee (SCC1636). The study also received ethics approval from Ludwig Maximilian University of Munich (LMU) Ethics Commission (Projekt Nr: 19-481). Informed consent was obtained from all participants.

Results

Characteristics of adult TB patients and their child contacts

Table 1 shows the baseline demographic characteristics of adult patients with PTB and at least one child household contact. A total of 53 patients (66.7% male, mean age 39 years SD 11.0) with child contacts were enrolled in this country-specific study. One participant died before the six months visit and another participant declined further participation; therefore, a total of 51 adults and 180 child contacts were included, providing an average of 3.5 child contacts per adult index case.

Economic status and participant's ability to spend money on household child contacts.

Table 2 shows the proportion of participants receiving childcare or financial support at 6 months on TB treatment was almost double that reported at baseline, both of which were statistically significant (p=0.037 and p=0.027, respectively). At 6 months on TB treatment compared to baseline, there was strong evidence of a decrease in buying power for clothes and shoes for feasts (e.g., during Muslim EIDs and Christmas celebrations) from 96.1% (49/51) and 94.1% (48/51) to 64.0% (32/51) and 60% (30/51) respectively (p<0.001 and p<0.001 respectively). These were also accompanied by strong evidence of a decrease in the monetary sum used to buy clothes or shoes for feasts at 6 months on treatment, compared to baseline (p=0.006 and p=0.014 respectively).

The impact of adult TB on the education and nutrition of child contacts Table 3 shows that school attendance slightly declined; however, there was strong evidence of a decline in the academic performance of child contacts (end of term examination scores) with 7.3% (3/41) performing very well at 6-month TB follow up compared with 51.2% (21/41) at baseline (p<0.001).

When we assessed the impact on the different school expenditures on the child contacts before and during TB illnesses, we found evidence of a decline in expenditures on school

fees, uniforms, shoes, school feeding and stationaries for child contacts at 6-month follow-up for TB treatment compared to baseline ($p<0.05$). Conversely, there was evidence of an increase on expenditure on extra classes from 575 GMD at baseline to 675 GMD at 6-month follow-up ($p=0.042$).

After 6 months of TB treatment follow-up, 56% (28/50) of participants were worried child contacts won't have enough food, 40% (20/50) where child contacts were unable to eat preferred foods, 32% (16/50) where child contacts ate limited variety of foods and 28% (14/50) where child contacts ate unwanted food types all of which were significant increases compared to baseline ($p<0.001$). Additionally, there was evidence of an increase in the proportion of participants whose child contacts ate small quantities of food from 4% (2/50) at baseline to 16% (8/50) at 6 months ($p=0.031$).

Discussion

Our study reports on the economic and social consequences faced by childhood contacts of adult TB patients in The Gambia. Our results suggest that TB in adults is associated with a wide range of effects on the educational, social, and nutritional components of childhood contacts lives. There was strong evidence of an increase in participants reporting household food insecurity, including child contacts having insufficient, unwanted, and small proportions of food. Moreover, at 6 months TB treatment follow-up there was a decline in buying power for adults, as well as a decline in spending on school fees, stationary, and school shoes.

To our knowledge, this is the first study to collect direct cost and school performance data from adults with TB pertaining to their child contacts; however, several studies have descriptively captured social factors of TB illness like school-drop out and food insecurity due to TB in a caregiver. Children in our study did not experience school dropouts or exhibit significant evidence of a decline in regular school attendance.
However, in Geetharamani et al,Chand et al and Honavar et al, 11%, 12%, and 8% of child contacts dropped out of school (10,19,11). The difference is plausibly due to study setting as the aforementioned studies all took place in non-African settings. Additionally, in our study there was substantial caring and financial support from the affected families that potentially enabled the children to remain in school. While school attendance remained consistent, factors of household food insecurity could have led to the decline in school performance for the children. Previous literature has exhibited an association between malnutrition in children

with adult TB contacts. For example, in Geetharamani et al, 34% of adults reported not being able to buy adequate food for their children. In our study, there was a negative association between adult TB and measures of household food insecurity, suggesting that child contacts may have had inadequate food portions, as well as limited and unwanted varieties of foods (10). A plethora of research has found an association between food insecure households and negative physical health outcomes like underweight, stunting, and wasting (17,18). In addition to physical health outcomes, there is a negative association between food insecure households and academic and cognitive functions such as lower literacy, numeracy, and short-term memory in children (20, 21). Thus, it is plausible that the decrease in children's school performance post-TB illness is associated with the increase in food insecure households. Furthermore, the decline in spending on school-related supplies suggests that caregivers likely don't have the monetary or physical or psychological wellbeing to support their child contacts in school through their TB illness.

While our study has immediate policy implications for The Gambia, they also warrant consideration for other countries, specifically LMICs. The decline in spending, household food security, and school performance exhibits the need for policy shifts to address the social and economic consequences that children living in households with TB face. Like many countries in sub-Saharan Africa, The Gambia provides free TB diagnosis and treatment at government facilities. However, a recent study from the same cohort of TB cases exhibited that patients can still incur catastrophic costs (costs that exceed 20% of household income) despite the provision of free treatment. Economic support such as food and transportation vouchers can reduce patient costs throughout the TB episode, preserving the household's disposable income to spend on essentials such as food and school related supplies (8). While engaging adult TB patients in care is especially important to reducing direct and indirect costs that patients and ultimately their families incur, future policy should address secondary effects on children.

Cash transfer programs have long been used to improve TB treatment retention, outcomes, and reduce the proportion of patients encountering catastrophic costs (22). Typically, TB cash transfers are given to households with a confirmed TB case to enable access to treatment and nutritional support (23). However, there is evidence that conditional cash transfers can improve school attendance (24,25). Future policymakers could consider educational cash transfer programs for poor families, conditional on child contacts maintaining regular school attendance. Such an approach would incentivize school

attendance for child contacts, while providing needed funds to address household food insecurity, allowing children to focus on school.
While our research provides valuable information on school performance, spending on children, and household food security, future research on child TB contacts should include specific healthcare measurements such as child malnutrition, wasting, and mental health outcomes as well as the impact of stigma on social networks and relationships.

Our study has limitations. Our study collected costs and outcomes data from TB patients recruited at the MRCG at LSHTM and government health facilities, meaning we likely excluded the poorest TB patients who didn't have the resources, were too sick to engage in formal care, or died. Additionally, our results are prone to social desirability bias as adults are likely to over report more desirable outcomes such as adequate funds to pay for supplies or foods, thus, potentially underestimating the proportion of food insecure households and households able to buy basic school supplies.

Conclusion:

While there is a growing body of literature detailing the health and economic impacts that TB patients face, this is among the first studies to quantitively assess the impact on their children in sub-Saharan Africa. These children experienced decreases in school performance, spending on their school supplies, and declines in household food insecurity. Policy changes are needed to ensure that child contacts aren't impeded in their growth and education.

Acknowledgements

The authors are grateful to the study teams for the TB Sequel study for use of their data. We would like to recognize the hard work and valuable contributions of all colleagues and partners in this project. We are also thankful to the National Leprosy and Tuberculosis Programme and other national health authorities for their support of the project.
TB Sequel Consortium members: Gavin Churchyard, Michael Hoelscher, Robert Wallis, Salome Charalambous, Kavindhran Velen, Farzana Sathar, Fadzai Munedzimwe, Andrea Rachow, Olena Ivanova, Anna-Maria Mekota, Abhishek Bakuli, Christof Geldmacher, Friedrich Riess, Fidelina Zekoll, Ulrich von Both, Knut Lönnroth, Stefan Nimann, Matthias Merker, Viola Dreyer, Ulrich Schaible, Christoph Leschczyk, Beate

Kampmann, Jayne Sutherland, Basil Sambou, Caleb Muefong, Fatoumatta Darboe, Abi-Janet Riley, Binta Sarr, Olumuyiwa Owolabi, Ben Dowsing, Azeezat Sallahdeen, Shamanthi Jayasooriya, Abdou K Sillah, Nyanda Elias Ntinginya, Issa Sabi, Daniel Mapamba, Mkunde Chachage, Elimina Siyame, Julieth M. Lalashowi, Ian Sanne, Mohammed Rassool, Lyndel Singh, Jaclyn Bennet, Noluthando Mwelase, Ilesh Jani, Celso Khosa, Nilesh Bhatt, Sofia Viegas, Khalide Azam, Nadia Sitoe, Pedroso Nhassengo, Denise Evans, Kamban Hirasen, Caroline Govathson, Tembeka Sineke, Sydney Rosen, we are grateful. We are grateful to Isatou Loum and Awa Touray for collecting data for this study.

AKS works as a research clinician at TB Sequel consortium at MRCG@LSHTM in The Gambia. The views reflected in this study are not reflective of views or policy of TB Sequel Consortium or indeed the MRCG@LSHTM.

Author contributions

AKS led the data collection and drafted the initial and subsequent drafts of the paper. ID contributed to formatting the drafts and compiling the write-ups. JJN and GM conducted the analysis. BK, OI, and DE supported the design and supervised the entire work of the paper. AR, JS, and OO also supported in supervising the work.IL and AT collected the data. All co-authors reviewed and approved the final version of the paper.

Data availability statement

Part of the datasets generated and/or analyzed during the current study are not publicly available as the data are owned by TB Sequel consortium and the study sites and are governed by the respective IRB or ethics committee in each country. Data cannot be shared publicly because the local ethics committee in each country restricts access. Data requests can be sent to the TB Sequel secretariat (Fadzai Munedzimwe <FMunedzimwe@auruminstitute.org) and (Abdou K. Sillah <asillah@mrc.gm)

Funding

This project is funded by the German Ministry for Education and Research (BMBF; grant ID 01KA1613) and is a part of the Research Networks for Health Innovations in Sub-Saharan Africa.

Conflict of interest

None declared.

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Tables and figure for the manuscript

Figure1: Graphical depiction to show the relationship between the various characteristics, TB treatment and impact on household child contacts.

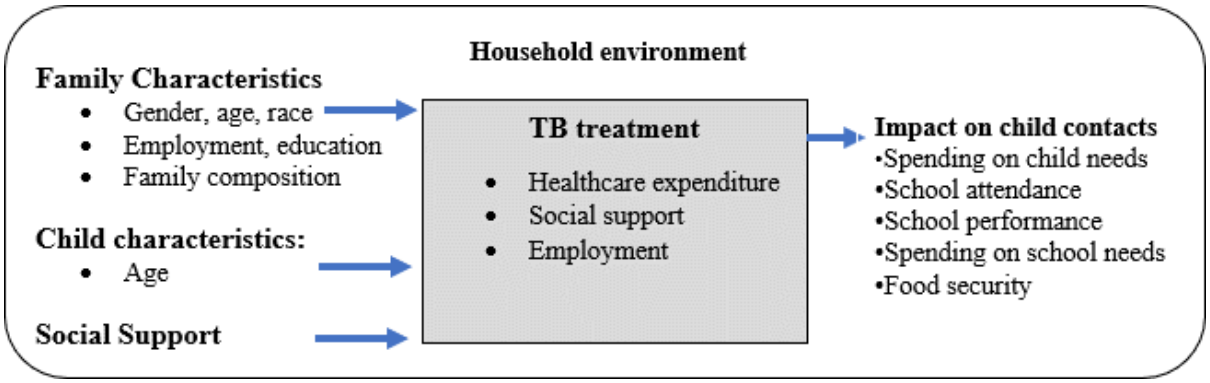

Table 1: Characteristics of adult participants at the start of TB treatment (baseline) and their child contacts.

Adult Characteristics	Total (n=51) n, (%)	Male (n=34) n, (%)	Female (n=17) n, (%)
Age in years (mean, SD)	39.0 (11.0)	40.7 (10.7)	35.5 (11.1)
18-30	14 (27.4)	6 (17.65)	8 (47.06)
31-40	16 (31.4)	12 (35.29)	4 (23.53)
>40	21 (41.2)	16 (47.06)	5 (29.41)
Marital Status			
Single	6 (11.5)	4 (11.43)	2 (11.76)
Married/Have partner	41 (78.8)	30 (85.71)	11 (64.71)
Divorced	3 (5.8)	1 (2.86)	2 (11.76)
Widowed	2 (3.8)	0	2 (11.76)
Education			
No formal Education	3 (5.9)	1 (2.94)	2 (11.76)
Primary education	6 (11.8)	3 (8.82)	3 (17.65)
Arabic/Daara	21 (41.2)	12 (35.29)	9 (52.94
Secondary education	18 (35.3)	16 (47.06)	2 (11.76)
University/Vocational	3 (5.9)	2 (5.88)	1 (5.88)
Primary income earner in the household	27 (52.9)	23 (85.2)	4 (14.8)
Type of family			
Single parent family	8 (15.7)	3 (8.82)	5 (29.41)
Nuclear family	19 (37.3)	19 (55.88)	0
Extended family	24 (47.1)	12 (35.29)	12 (70.59)
Family size (number of children)			
1-3	28 (54.9)	18 (52.94)	10 (58.82)
4-5	13 (25.5)	9 (26.47)	4 (23.53)
6+	10 (19.6)	7 (20.59)	3 (17.65)
Child contacts characteristics	Total (n=180)		
0 – 5 years	63 (35.0)		
6 – 10	68 (37.8)		
11 – 15	49 27.2)		

Table 2: Economic status and participant's ability to spend money on household child contacts.

Indicator		Baseline n (%)	6 months n (%)	p value
Employment	Unemployed	6 (12)	4 (8)	0.270S
	Student	5 (10)	3 (6)	
	Employed – informal	24 (48)	25 (50)	
	Employed – formal	15 (30)	18 (36)	
Social support	Childcare support received			0.037
	No	42 (82.4)	32 (64.0)	
	Yes	9 (17.6)	18 (36.0%)	
	Financial support received			0.027C
	No	39 (78.0)	28 (57.1)	
	Yes	11 (22.0)	21 (42.9)	
	If Yes frequency of financial support			0.452C
	Yearly	0 (0)	1 (5.3)	
	Quarterly Monthly	1 (9.1)	4 (21.1)	
	On demand	5 (45.5)	4 (21.1)	
		5 (45.5)	10 (52.6)	
Direct costs on healthcare	Cost of medical care for sick contacts (median GMD, IQR)	175 (75-225)	125 (0-250)	0.655R
	Cost of non-medical care for sick contacts (median GMD, IQR)	42 (0-110)	65 (50-80)	0.655R
	Total healthcare expenditure (median, IQR)	175 (117-335)	190 (80-300)	0.180R
Buying power	Bought clothes for feast	49 (96.1)	32 (64.0)	<0.001C
	If yes, amount (median GMD, IQR)	2500 (1000-4700)	2000 (700-3500)	0.006R
	Bought shoes for feast	48 (94.1)	30 (60.0)	<0.001C
	If yes, amount (median GMD, IQR)	750 (400-1000)	425 (300-888)	0.014R
	Bought items/gifts for feast	15 (29.4)	8 (16.3)	0.120C
	If yes, amount (median GMD, IQR)	200 (100-400)	80 (15-250)	0.777R

S Test of symmetry

R Wilcoxon signed rank test

C Chi-square test

Table 3. Impact of adult TB on the education and nutrition of child contacts.

Indicator		Baseline n (%)	6 months n (%)	p-value
School attendance	Regular school attendance	42 (87.5)	38 (79.2)	0.220M
	Inconsistent school attendance	6 (12.5)	10 (20.8)	
School performance	Average	3 (7.3)	9 (22.0)	<0.001S
	Above average	0 (0)	10 (24.4)	
	Good	17 (41.5)	19 (46.3)	
	Very good	21 (51.2)	3 (7.3)	
School expenditure, (median GMD, IQR)	School fees	2000 (3500 – 1500)	1200 (2400 - 1100)	0.003R
	Uniform	1500 (2345 – 675)	950 (1500 – 500)	<0.001R
	Physical education set	438 (600-400)	275 (575-100)	0.162R
	Extra classes	575 (1400-250)	675 (1175-250)	0.042R
	School shoes	750 (1200-500)	550 (850-300)	0.004R
	Prepare school feeding	3000 (4000-700)	1000 (3200-400)	0.153R
	Expenditure on food supplies at school	70 (20-225)	30 (20-58)	<0.001R
	Stationary	988 (1473-500)	700 (1500-450)	0.021R
	Transportation	1800 (3600-1600)	1360 (2340-900)	0.113R
Nutrition	Concerns that contacts won't have enough food	5 (10.0)	28 (56.0)	<0.001M
	Contacts unable to eat preferred foods	5 (10.0)	20 (40.0)	0.0006M
	Contacts eat limited variety of foods	2 (4.0)	16 (32.0)	<0.001M
	Contacts eat unwanted types of food	3 (6.0)	14 (28.0)	<0.001M
	Contacts eat small quantity of food	2 (4.0)	8 (16.0)	<0.001M
	Food not available at all	2 (4.0)	4 (8.0)	0.500M
	Contacts go to bed at night hungry	2 (3.9)	2 (3.9)	1.000M

S Test of symmetry,
R Wilcoxon signed rank test,
M McNemar's test
Mean (SD) unless otherwise specified

Supplementary data

Study Variables

The nuclear family was defined as a family group consisting of parents and their children, while an extended family was defined as a family that includes in one household near relatives (such as grandparents, aunts, or uncles) in addition to a nuclear family. We measured academic performance by assessing examination report cards brought to the facility by study participants with the following categories: excellent, very good, good, above average, and average. Regular school attendance was defined as +>80% the actual attendance of a student during the school day, whereas inconsistent school attendance was < 80% the actual attendance of a student during the school day. Childcare support received refers to any cash or in-kind (non-monetary goods or services) provided to TB patients to assist with childcare. Participants received the equivalent of 3 USD per visit for transport and time lost. Costs are reported in 2021 Gambian dalasi (100 GMD) (approximately $1.64 USD).16

Survey development

Questions were developed internally by the study team, by adapting existing tools (e.g., WHO patient cost survey tool (9) and the Household Food Insecurity for Access Scale1 or by adding relevant questions for other sections (e.g., school performance, school attendance and social needs). Responses were entered on paper forms and later captured into REDCap; an electronic data capture tool developed by Vanderbilt University17

10. Statement of contribution

I coordinated the TB Sequel Socioeconomic arm at the MRCG at LSHTM where my entire PhD is nested and hence responsible for the quality of data collected, entered, queried, and verified. In order to do so, I worked with a team of clinicians, nurses, field and laboratory staff who participated in the TB Sequel consortium at Medical Research Council Unit The Gambia at London School of Hygiene and Tropical Medicine (MRCG at LSHTM) where I was involved in clinical assessment of study participants which include history taking, physical examination, reading and interpreting Chest-X-rays, electrocardiogram (ECGs), spirometer readings, determining on their TB status, referring for TB treatment at Government facilities and attaining to their routine and unscheduled follow ups. I supervised the nurses and field/social workers in administration of study questionnaires both in the clinic and at the houses. I was also involved solving the internal and external queries emanating from the study. I trained the nurses and field workers on interpreting and administering the study questionnaires.

For my PhD project, I developed the concept, worked on the proposal, developed the questionnaire, and worked with the data management team at MRCG at LSHTM to set up the electronic database which was used to capture data after we initially collected data on paper Case Record Forms (CRF). I was involved in the data collection together with two field/social workers (Isatou Loum and Awa Touray) both at the patients' house and at the MRCG at LSHTM TB Clinic. I verified all data collected and entered on the REDCap by the field workers.

I worked with the project data manager in cleaning and verification of the datasets and conducted the analysis with the assistance of my two PhD colleagues (Jackson Jr Ndenkeh and Given Moonga) under the supervision of Prof Beate Kampmann, Dr. Denise Evans, Dr. Olena Ivanova, Dr. Andrea Rachow and Prof. Dr. Michael Hölscher.

My senior colleagues supported my work by standing in for me and managed the field and clinic activities when I attended the Modules in Munich.

After deciding with my supervisors which papers ought to be published from our work, I undertook the analysis of the relevant data wrote up together with an MSc student from the LSHTM (Isaac Devoid). Isaac had access to our dataset to write his MSc project at LSHTM. We jointly wrote the first draft as joint first author paper and managed the process of senior author review and reviewers' comments. I presented part of my data at local and international conferences, as well as during MRCG at LSHTM academic seminars.

Throughout the period of the project, I represented the TB Clinic of MRCG at LSHTM in meetings with the Gambian National Leprosy and TB Control Programme (NLTP) where I was involved in drafting the National Strategic Plan, programmatic guidelines for both drug-susceptible and drug-resistance TB of the country. I also participated in the TB/HIV quarterly coordinating committee meeting, and I was appointed as a member of the Technical Committee of the Country Coordinating Mechanism (CCM) of the Global Fund, The Gambia advising the TB programme. I also facilitated the training of frontline health care workers on both adult and childhood TB for the NLTP.

11. Acknowledgements

I would like to thank my local supervisor, Prof Beate Kampmann, for her dedication, understanding and exceptional approach to supervision, which was very valuable for this PhD training. She consistently motivated me and maintained an incredible turnaround time with every material submitted to her for review. She is constantly reminding me of meetings to discuss the progress of my work, data analysis and manuscript preparation, and the challenges we are facing.

She was proactive in providing unflinching support to ensure I fulfilled in a timely manner all the requirements for completing this PhD.

My gratitude also goes to my direct supervisor, Dr Olena Ivanova, for her invaluable input and guidance. She spent time with me whenever possible while on module visits in Munich and whenever we had TB-Sequel meeting. She maintained constant communication throughout the period of this PhD. She went the extra mile to liaise on my behalf, on many occasions, with the coordinating team at the CIH, whenever the need arose. She prioritized my research period reports and provided a timely review of manuscripts and the thesis summary. I drew a lot of encouragement from her personal messages to me in time of personal challenges. In the same vein, I thank Prof. Dr. Michael Hölscher, my habilitated supervisor and Dr. Andrea Rachow my third LMU supervisor for laying solid foundation during the module blocks and for ongoing senior oversight they provided throughout the PhD. I profoundly thank Dr. Denise Evans for her immense support, especially in critical appraisal and analysis of data, manuscript critique and review, and for generally being there for me.

My PhD would have been impossible without the solid support of my colleagues at the MRCG at LSHTM. I thank Dr Olumuyiwa Owolabi for competently holding the fort at the TB Clinic and ensuring the research project went on undisturbed during my module blocks in Munich. He continued to provide invaluable support in the field and clinic. I thank Prof. Jayne Sutherland for her immense support, especially in the manuscript critique and review, and for generally being there for me. I thank Binta Saidy for her continued support in database development, data management and IT support throughout my PhD program. My colleague in the TB research platform, Dr Mariama Sonko, Alhagie Jobe, Monica Davis and the entire team, I thank you so much for your dedication, understanding and support. Special gratitude to Isatou Loum, Awa Touray and Alpha Omar Jallow for their immense work in data collection and entries and working within and outside regular work hours.

I am immensely grateful to my PhD colleagues Jackson Jr Ndenkeh and Given Moonga for their support in assisting with statistical analysis throughout this PhD program. Equally indebted to

Isaac Devoid for closely working with me drafting manuscripts and endlessly making sure we respond to the comments from the supervisors.

My gratitude also goes to the National Leprosy and Tuberculosis Control Program of The Gambia for their ongoing support, which positively impacted this PhD work. The PhD research period was yet another opportunity to continue our ongoing relationship with our study communities and the families affected by tuberculosis. I therefore thank all our parents/caregivers and their children without whose cooperation and support this research project would not have been undertaken in the first place.

I would like to thank the entire TB Sequel consortium for sponsoring my PhD work and facilitating my access to the database and using the dataset of the socioeconomic sub-study of the project. I would also like to thank the Centre for International Health CIH-LMU for accepting me into the PhD program and their assistance throughout my PhD program. Dr. Gunther Froschl, Dr. Arlett Heiber, and Sarah deserve special mention for their exceptional assistance in ensuring a comfortable stay during the program.

I would like to thank my family for their continued support and prayers. I thank my lovely wife, Mariama Sonko, for her belief in me, the patience, the constant support, the resilience in time of stress. Am indebted to you. I thank my mother for her continuous prayers and motivation. My friends and colleagues, Dr John Jabang and Dr. Abdoulie Badjan, I thank you immensely for your support and invaluable advice.

Finally, I give thanks to Allah for seeing me through this important journey of my life.

12. Appendix

12.1 Study questionnaires (Baseline and 6-month)

Impact of Adult TB on Household Child Contacts in the Greater Banjul area of The Gambia

Patient/Index Case's Information

Demographic information

Interviewer/field worker's initial	_____
1. Sex	○ Male ○ Female
2. Age in years	_____
2a. Date of birth (day unknown=99, Month unknown=999, year unknown=9999)	_____
3. Marital status	○ 1. Single ○ 2. Married ○ 3. Divorce ○ 4. Widowed ○ 5. Have a partner
4. Education	☐ 1. No formal education ☐ 2. Arabic school ☐ 3. Dara/Madarassa ☐ 4. Primary school ☐ 5. Secondary school ☐ 6. High school ☐ 7. Vocational training ☐ 8. University
5. Occupation	☐ 1. Professional, technical ☐ 2. Own business ☐ 3. Service worker (including Government servant) ☐ 4. Trader ☐ 5. Agricultural, fisherman ☐ 6. Driver ☐ 7. Housewife ☐ 8. Student ☐ 9. Clergy/Imam ☐ 10.Teacher

Family structure/composition

6. What type of family do you have?
- ○ Single parent family
- ○ Nuclear family
- ○ Extended family

7. How many children do you have?

_____

8. Apart from your children, do you have other dependents?
- ○ 1.Yes
- ○ 2.No
- ○ 2.Refuse to answer

9. How old are your children?
- ☐ 1.One to five years
- ☐ 2.Six to ten years
- ☐ 3.Eleven to fifteen years

9a. How many are One to five years?

_____

9b. How many are six to ten years?

_____

9c. How many are eleven to fifteen years?

_____

Adult tuberculosis impacts on children's education

School information: this information is to be collected for school aged children (aged 7 years to 15 years)

10. Thinking back to before your TB illness, do all your children of school age attend school regularly?
- ○ 1. Yes
- ○ 2. No
- ○ 3. N/A

11. If no: Why not?
- ☐ 1. Needs to help around the house
- ☐ 2. No money for school fees
- ☐ 3. Also, sick
- ☐ 4. Has to work to earn income
- ☐ 5. Other

12. How many are going to school before you experienced TB symptoms?
- ○ 1. One
- ○ 2. Two
- ○ 3. Three
- ○ 4. Four
- ○ 5. Five to ten
- ○ 6. Eleven and more
- ○ 7. None

13. What type(s) of school were your children Attending?
- ☐ 1. Western/English school
- ☐ 2. Arabic school
- ☐ 3. Dara/Madrassa
- ☐ 4. 1 and 2
- ☐ 5. 1 and 3
- ☐ 6. None attending school

14. How has been their performance in school? (to be assessed from the child's report cards)

- ☐ 1. Good
- ☐ 2. Very good
- ☐ 3. Average
- ☐ 4. Above average
- ☐ 5. None attending school

15. Do you have their term examination report cards?

- ○ Yes
- ○ No

School Fees

16. Thinking back before your TB illness, were you paying school fees for your children?

- ○ Yes
- ○ No

17. If yes, how much do you pay per child for the academic year (in GMD)? _____

17a. Total amount _____

School uniforms

18. Thinking back before your TB illness, were you buying school uniforms(clothes)?

- ○ Yes
- ○ No

19. How many sets of uniforms were you providing for your children per academic year?

- ☐ 1. One
- ☐ 2. Two
- ☐ 3. Three
- ☐ 4. None

20.How much were you spending on uniforms per academic year? _____

Physical education (PE) sets

21. Thinking back before your TB illness, were you buying physical education (PE) kits for your children?

- ○ Yes
- ○ No

22. How much were you spending on PE kits per academic year? _____

Extra classes for children

23. Thinking back before your TB illness, were you providing extra classes for your children?

- ○ Yes
- ○ No

23a. If yes, how many children are attending extra Classes?

- ○ 1. One
- ○ 2. Two
- ○ 3. Three
- ○ 4. Four
- ○ 5. All the children going to school

23b. If q23a is 5, state the number of children.

_____

23c. If yes, where do these extra classes take place?

- ☐ 1. School
- ☐ 2. At my home
- ☐ 3. At the teacher's home

24. How frequent do you pay for these extra classes?

- ◯ 1. Monthly
- ◯ 2. Once every term
- ◯ 3. Once every academic year
- ◯ 4. I do not pay at all (skip to q26)
- ◯ 5. Can't remember (skip to q26)

25. How much were you spending on extra classes per school term? _____

School shoes

26. Thinking back before your TB illness, were your children going to school with shoes?

- ◯ Yes
- ◯ No

27. How frequent do you buy shoes for your children?

- ◯ 1. Once every academic year
- ◯ 2. Once every term
- ◯ 3. Whenever shoes are spoiled
- ◯ 4. Could not afford shoes for them

28. What type of shoes do you buy for children to go to school with?

- ☐ 1. Slippers
- ☐ 2. Sport shoes
- ☐ 3. Full/leader shoes
- ☐ 4. Plastic strap/sandals shoes
- ☐ 5. Leader strap/sandals

29. How many sets of shoes do you buy for per student?

- ☐ 1. One
- ☐ 2. Two
- ☐ 3. Three
- ☐ 4. Four

30. How much were you spending on shoes per academic Years? _____

Feeding at school

31. Thinking back before your TB illness, were you preparing food for children to take to school?

- ◯ 1. Yes daily
- ◯ 2. Most days
- ◯ 3. No

32. How much were you spending on preparing food for your children per school calendar term? _____

33. Were your children receiving school feeding?

- ◯ Yes
- ◯ No

34. Were you paying for school feeding for your Children?

- ◯ 1. Yes
- ◯ 2. NO
- ◯ 3. It's part of the school program

35. How much were you paying on school feeding per school calendar term? _____

36. Were you giving money to your children to take to school each day?
- ○ Yes
- ○ No

37. How much money were you giving to your children (in Dalasis) _____

Stationeries

38. Thinking back before your TB illness, were you buying stationeries for your children? (if no skip to Q35)
- ○ Yes
- ○ No

39. If yes, how frequent do you buy the stationeries?
- ○ 1. Once every academic year
- ○ 2. Once every term
- ○ 3. On demand

40. What were the items?
- ☐ 1.Exercise books only
- ☐ 2. Textbooks only
- ☐ 3. Both exercise and textbooks
- ☐ 4. Pencils/pens
- ☐ 5. Erasers and set box
- ☐ 6. School bag
- ☐ 7. All the above

41. How much were you spending on stationaries per academic year? _____

Transportation

42. Thinking back before your TB illness, were you transporting your children to and from school on each school day?
- ○ Yes
- ○ No

43. What are the means of transportation?
- ☐ 1. Private car
- ☐ 2.School bus
- ☐ 3.Commercial vehicle
- ☐ 4.Transport by neighbour/family

44. How much were you spending on transportation (GMD)? _____

School attendance

45. Thinking back before your TB illness, were your children regular at school? (if no skip to Q35)
- ☐ 1.Yes
- ☐ 2.No
- ☐ 3.I don't know (skip to 46)

45a. If no, state the reason(s) why they were not regular at school?
- ☐ 1.They were helping with household duties
- ☐ 2.I cannot afford their school needs
- ☐ 3.Others

45b. If other specify _____

45c. If no, how many days did they miss per term?

- ◯ 1. One to ten days
- ◯ 2. Eleven to twenty days
- ◯ 3. Twenty-one to thirty days
- ◯ 4. More than thirty days
- ◯ 5. I don't know

46. Were your children punctual at school?

- ☐ 1. Yes (skip to 47)
- ☐ 2. No
- ☐ 3. I don't know (skip to 47)

46b. If no, how many days were they late for school?

- ◯ 1. One to ten days
- ◯ 2. Eleven to twenty days
- ◯ 3. Twenty-one to thirty days
- ◯ 4. More than thirty days
- ◯ 5. I don't know

46c. If no, state the reason(s) why they were not regular at school?

- ☐ 1. They were helping with household duties
- ☐ 2. I cannot afford their school needs
- ☐ 3. Others

Adult tuberculosis impacts on children's social wellbeing

Social information

47. Thinking back before your TB illness, how frequent were you buying clothes for your children?

- ☐ 1.On needs/demand
- ☐ 2.Once every festivity
- ☐ 3.Two times per year
- ☐ 4.Three times in a year
- ☐ 5.I cannot remember

48. For the past festivities [EidulAdha (Tobaski), Eidul Fitr (Koriteh)], Christmas, New year), did you buy clothes for your children?

- ◯ 1.Yes
- ◯ 2.No (Skip to Q50)
- ◯ 3.I cannot remember
- ◯ 4.Refuse to answer

49. How much did you spend on clothes during the past Festivities? _____

50. During the past Eids, Christmas or New Year, before you experienced your TB symptoms, did you buy shoes for your children?

- ◯ 1.Yes
- ◯ 2.No (Skip Q52)

51. How much did you spend on shoes during the past Festivities? _____

52. During the past Eids, Christmas or New Year, before you experienced your TB symptoms, did you buy any other present for your children?

- ◯ 1.Yes
- ◯ 2.No (Skip t0 Q54)

53. How much did you spend on gifts during the past Festivities? _____

Adult tuberculosis impacts on children's health

Health Status of the children

54. Thinking back before your TB illness, (past 2 months), did you seek medical care for any of your child(ren)?

- ○ 1. Yes
- ○ 2. No (Skip to Q67)
- ○ 3. I don't know (Skip to Q67)

Thinking back before your TB illness, (past 2 months), did any of your children demonstrate the following symptoms.

55a. Cough?

- ○ Yes
- ○ No

55b. Duration of cough (days or weeks)?

_____

55c. Night sweat?

- ○ Yes
- ○ No

55d. Coughing up blood?

- ○ Yes
- ○ No

55e. Duration in weeks?

_____

55f. Weight loss?

- ○ Yes
- ○ No

55g. Duration in weeks?

_____

55h. If other, specify

_____

56. Where did you seek treatment or advice for these Symptoms?

- ☐ 1. Pharmacy/Drug Store
- ☐ 2. Traditional Healer/Practitioner
- ☐ 3. Public Health Centre
- ☐ 4. Private Practitioner
- ☐ 5. Public Hospital
- ☐ 6. Mission Health Centre
- ☐ 7. I do not seek any treatment

57. For the past two months before you were diagnosed of TB, has any of your children been admitted for any ill health?

- ○ 1. Yes
- ○ 2. No (Skip to Q59)

58. Where were the child(ren) admitted?

- ☐ 1. Public Health Centre
- ☐ 2. Private Practitioner
- ☐ 3. Public Hospital
- ☐ 4. Mission Health Centre

REDCap

59. For the child(ren) taken to seek health care, what was the diagnosis?

- ☐ 1. Respiratory tract infection
- ☐ 2. Tuberculosis
- ☐ 3. Diarrhoeal diseases
- ☐ 4. Fever
- ☐ 5. Surgical conditions (wounds, cut, injuries, etc
- ☐ 6. Urinary tract conditions
- ☐ 7. Continuous weight loss/failure to thrive
- ☐ 8. I don't know the diagnosis

60. At the time of seeking health care for the child (ren), what were the services provided?

- ☐ 1. Consultation
- ☐ 2. Lab test/investigations
- ☐ 3. Radiography or other imaging or other procedures
- ☐ 4 Medication
- ☐ 5. Hospitalization
- ☐ 6. None of the above
- ☐ 7. I can't remember

61. Did you use any transport when seeking health care for your child(ren)?

- ○ 1. Yes
- ○ 2. No (Skip to Q63)

62. What was the means of transportation?

- ☐ 1. Private car
- ☐ 2. Hired commercial taxi
- ☐ 3. Commercial vehicle
- ☐ 4. Transport by neighbour/family

63. Did you spend any money on food during visit/hospital stay or accommodation?

- ○ Yes
- ○ No

64. In total how much did you spend on each of the following for visits to this particular provider (GMD)?

64a. Consultation fee (GMD)

_____

64b. Radiography or other imaging (e.g. X-ray)

_____

64c. Other procedures

_____

64d. Lab tests

_____

64e. Medication

_____

64f. Other (e.g. Supplements) (GMD)

_____

64g. Hospitalization (day charges for time in hospital)

64h. Total medical costs

_____

64i. Transport (return for each visit)

_____

64j. Food during the visit/hospital stay _____

64k. Accommodation _____

64l. Other non-medical payment _____

64m. Total non-medical costs _____

64n. Total medical and non-medical costs _____

64o. Reason for no medical or non-medical costs
- ☐ 1. No additional costs incurred
- ☐ 2. Don't know
- ☐ 3. Refuse to answer

65. non-financial cost when seeking health care for your child(ren)
- ☐ 1. Animals
- ☐ 2. Chicken
- ☐ 3. Farm produce
- ☐ 4. Clothes
- ☐ 5. Other

65a. specify If animals, Farm produce, Clothes or Other _____

66. What were the reasons for the non-financial costs?
- ○ 1. Mode of payment for the service provided
- ○ 2. I can't provide cash/cheque at that time
- ○ 3. It is an additional demand
- ○ 4. I voluntarily gave that
- ○ 5. I don't know for reason

Family social support

67, Thinking back before your TB illness, did you have any relative support in caring for your children?
- ○ 1. Yes
- ○ 2. No (if No skip to Q68)

67. Who provide the support
- ☐ 1. Niece
- ☐ 2. Nephew
- ☐ 3. Friends' child
- ☐ 4, My mother
- ☐ 5. Sister
- ☐ 6. Brother
- ☐ 7. Sister in-law
- ☐ 8. Brother in-law
- ☐ 9. Other

67a. If other, specify.
_____

68. Do you make any remuneration to this help? (if no skip to q72)
- ○ 1.Yes
- ○ 2.No (If no skip to Q70)

71

69. How do you effect the payment?
- ☐ 1. Monthly
- ☐ 2. Quarterly
- ☐ 3. Yearly
- ☐ 4. I don't know

70. Do you receive regular financial support before your TB illness?
- ○ 1 Yes
- ○ 2. No (if no skip to Q74)

71. How frequent was this support?
- ☐ 1. Monthly
- ☐ 2. On demand
- ☐ 3. Quarterly
- ☐ 4. Yearly

72. Who was supporting you?
- ☐ 1. Niece
- ☐ 2. Nephew
- ☐ 3. Friends' child
- ☐ 4, My mother
- ☐ 5. Sister
- ☐ 6. Brother
- ☐ 7. Sister in-law
- ☐ 8. Brother in-law
- ☐ 9. Other

73. How much support were you receiving? (In GMD)

_____

Household food security affecting the children nutrition.

74. In the past four weeks before your TB diagnosis, did you worry that your children would not have enough food?
- ○ 1. Yes
- ○ 2. No (if no skip to Q76)

75. How often did this happen?
- ○ 1. Rarely (once or twice in the past four weeks)
- ○ 2. Sometimes (three to ten times in the past four weeks)
- ○ 3. Often (more than ten times in the past four weeks)

76. In the past four weeks before your TB diagnosis, were your children not able to eat the kind of foods you preferred because of a lack of resources?
- ○ 1. Yes
- ○ 2. No (if no skip to Q78)

77. How often did this happen?
- ○ 1. Rarely (once or twice in the past four weeks)
- ○ 2. Sometimes (three to ten times in the past four weeks)
- ○ 3. Often (more than ten times in the past four weeks)

78. In the past four weeks before your TB diagnosis, did your children have to eat a limited variety of foods due to lack of resources?
- ○ 1. Yes
- ○ 2. No (if no skip to Q80)

79. How often did this happen?
- ○ 1. Rarely (once or twice in the past four weeks)
- ○ 2. Sometimes (three to ten times in the past four weeks)
- ○ 3. Often (more than ten times in the past four weeks)

80. In the past four weeks before your TB diagnosis, did your children have to eat some foods that you really did not want them to eat because of a lack of resources to obtain other types of food?

- ◯ 1. Yes
- ◯ 2. No (if no skip to Q82)

81. How often did this happen?

- ◯ 1. Rarely (once or twice in the past four weeks)
- ◯ 2. Sometimes (three to ten times in the past four weeks)
- ◯ 3. Often (more than ten times in the past four weeks)

82. In the past four weeks before your TB diagnosis, did your children have to eat a smaller meal than needed because there was not enough food?

- ◯ 1. Yes
- ◯ 2. No (if no skip to Q84)

83. How often did this happen?

- ◯ 1. Rarely (once or twice in the past four weeks)
- ◯ 2. Sometimes (three to ten times in the past four weeks)
- ◯ 3. Often (more than ten times in the past four weeks)

84. In the past four weeks before your TB diagnosis, was there ever no food for your children to eat because of lack of resources to get food?

- ◯ 1. Yes
- ◯ 2. No (if no skip to Q86)

85. How often did this happen?

- ◯ 1. Rarely (once or twice in the past four weeks)
- ◯ 2. Sometimes (three to ten times in the past four weeks)
- ◯ 3. Often (more than ten times in the past four weeks)

86. In the past four weeks before your TB diagnosis, did your children go to sleep at night hungry because there was not enough food?

- ◯ 1. Yes
- ◯ 2. No (if no skip to Q88)

87. How often did this happen?

- ◯ 1. Rarely (once or twice in the past four weeks)
- ◯ 2. Sometimes (three to ten times in the past four weeks)
- ◯ 3. Often (more than ten times in the past four weeks)

88. Additional comment

_____

Investigator's name

_____

Investigator's Signature

_____

Date

_____

Impact of Adult TB on Household Child Contacts in the Greater Banjul area of The Gambia

MRC Unit The Gambia / LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE		TB Sequel PhD Project	TB Sequel	
SCC	1636	VERSION		
		2.007 November 2017	DATE	25TH MAY 2019
Visit	6 Months	Visit date /__/__/ /__/__/__/ /__/__/__/__/		Participant ID /__/__/__/__/__/__/

Patient/Index Case's Information

Demographic information

Interviewer/field worker's initial _____

1. Sex	Male Female
2. Age in years _____	
2a. Date of birth (day unknown=99, Month unknown=999, year unknown=9999) _____	
3. Marital status	1. Single 2. Married 3. Divorce 4. Widowed 5. Have a partner
4. Education	1. No formal education 2. Arabic school 3. Dara/Madarassa 4. Primary school 5. Secondary school 6. High school 7. Vocational training 8. University
5. Occupation	1. Professional, technical 2. Own business 3. Service worker (including Government servant) 4. Trader 5. Agricultural, fisherman 6.Driver 7. Housewife 8. Student

☐ 9. Clergy/Imam
☐10. Teacher

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Family structure/composition

6. What type of family do you have?
- ○ Single parent family
- ○ Nuclear family
- ○ Extended family

7. How many children do you have?

_____

8. Apart from your children, do you have other dependents?
- ○ 1.Yes
- ○ 2.No
- ○ 2.Refuse to answer

9. How old are your children?
- ☐ 1.One to five years
- ☐ 2.Six to ten years
- ☐ 3.Eleven to fifteen years

9a. How many are One to five years?

_____

9b. How many are six to ten years?

_____

9c. How many are eleven to fifteen years?

_____

Adult tuberculosis impacts on children's education

School information: this information is to be collected for school aged children (aged 7 years to 15 years)

10. Thinking back to after you are diagnosed with TB, do all your children of school age attend school Regularly
- ○ 1.Yes (Skip to Q11)
- ○ 2.No
- ○ 3.N/A

10a. If no: Why not
- ☐ 1.Needs to help around the house
- ☐ 2.No money for school fees
- ☐ 3.Also, sick
- ☐ 4.Has to work to earn income
- ☐ 5.Other

10c. If other, specify.

_____

11. How many are going to school after you experienced TB symptoms
- ○ 1. One
- ○ 2. Two
- ○ 3. Three
- ○ 4. Four
- ○ 5. Five to ten
- ○ 6. Eleven and more
- ○ 7. None

12. What type(s) of school are your children attending after you became ill with TB

- ☐ 1. Western/English school
- ☐ 2. Arabic school
- ☐ 3. Dara/Madrassa
- ☐ 4. 1 and 2
- ☐ 5. 1 and 3
- ☐ 6. None attending school

13. How has been their performance in school after you became ill with TB? (to be assessed from the child's report cards)

- ☐ 1. Good
- ☐ 2. Very good
- ☐ 3. Average
- ☐ 4. Above average
- ☐ 5. None attending school

14. Do you have their term examination report cards

- ○ Yes
- ○ No

School Fees

15. Thinking back after you are diagnosed with TB illness, are you paying school fees for your children

- ○ 1. Yes
- ○ 2. No (Skip to Q17)

16. If yes, how much do you pay per child for the academic year (in GMD) _____

School uniforms

17. Thinking back after you are diagnosed with TB illness, are you buying school uniforms(clothes)

- ○ Yes
- ○ No

18. How many sets of uniforms are you providing for your children per academic year

- ☐ 1. One
- ☐ 2. Two
- ☐ 3. Three
- ☐ 4. More than 3 (state number)
- ☐ 5. None

18a. If more than three (state number) _____

19. How much are you spending on uniforms per academic Year _____

Physical education (PE) sets

20. Thinking back after you are diagnosed with TB, are you buying physical education (PE) kits for your Children

- ○ 1. Yes
- ○ 2. No (Skip to Q22)

21. How much were you spending on PE kits per academic year _____

Extra classes for children

22. Thinking back after you are diagnosed with TB illness, are you providing extra classes for your children

- ○ 1.Yes
- ○ 2.No (Skip to Q25)

22a. If yes, how many children are attending extra classes

- ○ 1.One
- ○ 2.Two
- ○ 3.Three
- ○ 4.Four
- ○ 5.All the children going to school

22b. If q23a is 5, state the number of children.

_____

22c. If yes, where do these extra classes take place

- ☐ 1. School
- ☐ 2. At my home
- ☐ 3. At the teacher's home

23. How frequent do you pay for these extra classes

- ○ 1. Monthly
- ○ 2. Once every term
- ○ 3. Once every academic year
- ○ 4. I do not pay at all (skip to q26)
- ○ 5 Can't remember (skip to q26)

24. How much are you spending on extra classes per school term

_____

24a. Total cost

_____

School shoes

25. Thinking back after you are diagnosed with TB illness, did you buy school shoes for your children

- ○ 1. Yes
- ○ 2. No (Skip to Q30)

26. How frequent do you buy shoes for your children

- ○ 1 Once every academic year
- ○ 2. Once every term
- ○ 3. Whenever shoes are spoiled
- ○ 4. Could not afford shoes for them

27. What type of shoes do you buy for children to go to school with

- ☐ 1. Slippers
- ☐ 2. Sport shoes
- ☐ 3. Full/leader shoes
- ☐ 4. Plastic strap/sandals shoes
- ☐ 5. Leader strap/sandals

28. How many sets of shoes do you buy for per student

- ☐ 1. One
- ☐ 2. Two
- ☐ 3. Three
- ☐ 4. Four

29. How much are you spending on shoes per academic Years

_____

29a. Total cost

_____

Feeding at school

30. Thinking back after you are diagnosed with TB illness, are you preparing food for children to take to school
- ○ 1.Yes daily
- ○ 2.Most days
- ○ 3.No (Skip to Q32)

31. How much were you spending on preparing food for your children per school calendar term _____

31a. Total cost _____

32. Are your children receiving school feeding
- ○ 1.Yes
- ○ 2.No (Skip to Q35)

33. Are you paying for school feeding for your children
- ○ 1.Yes
- ○ 2.NO
- ○ 3.It's part of the school program

34. How much are you paying on school feeding per school calendar term _____

35. Are you giving money to your children to take to school each day
- ○ 1.Yes
- ○ 2.No (Skip to Q37)

36. How much money were you giving to your children (in Dalasis) _____

Stationeries

37. Thinking back after you are diagnosed with TB illness, were you buying stationeries for your children (if no skip to Q35)
- ○ 1. Yes
- ○ 2. No (Skip to Q41)

38. If yes, how frequent do you buy the stationeries
- ○ 1. Once every academic year
- ○ 2.Once every term
- ○ 3. On demand

39. What are the items
- ☐ 1. Exercise books only
- ☐ 2. Textbooks only
- ☐ 3. Both exercise and textbooks
- ☐ 4. Pencils/pens
- ☐ 5. Erasers and set box
- ☐ 6. School bag
- ☐ 7.All the above

40. How much are you spending on stationaries per academic year _____

Transportation

41. Thinking back after you are diagnosed with TB illness, are you transporting your children to and from school on each school day
- ○ 1.Yes
- ○ 2.No (Skip to Q44)

42. What ere the means of transportation
- ☐ 1.Private car
- ☐ 2.School bus
- ☐ 3.Commercial vehicle
- ☐ 4.Transport by neighbour/family

43. How much are you spending on transportation (GMD) _____

School attendance

44. Thinking back after you are diagnosed with TB illness, are your children regular at school?
- ☐ 1. Yes
- ☐ 2. No (Skip to Q45)
- ☐ 3. I don't know (skip to 47)

44a. If no, state the reason(s) why they are not regular at school
- ☐ 1. They were helping with household duties
- ☐ 2. I cannot afford their school needs
- ☐ 3.Others

44b. If other specify _____

44c. If no, how many days did they miss per term
- ○ 1. One to ten days
- ○ 2. Eleven to twenty days
- ○ 3. Twenty-one to thirty days
- ○ 4. More than thirty days
- ○ 5. I don't know

45. Are your children punctual at school
- ☐ 1. Yes (skip to 46)
- ☐ 2.No
- ☐ 3.I don't know (skip to 46)

45a. If no, how many days did they miss per term
- ○ 1. One to ten days
- ○ 2.Eleven to twenty days
- ○ 3.Twenty-one to thirty days
- ○ 4.More than thirty days
- ○ 5.I don't know

45b. If no, state the reason(s) why they were not regular at school
- ☐ 1. They were helping with household duties
- ☐ 2. I cannot afford their school needs
- ☐ 3.Others

Adult tuberculosis impacts on children's social wellbeing

Social information

46. Thinking back after you are diagnosed with TB illness, how frequent are you buying clothes for your children
- ☐ 1. On needs/demand
- ☐ 2.Once every festivity
- ☐ 3.Two times per year
- ☐ 4.Three times in a year
- ☐ 5.I cannot remember

47. For the past festivities [EidulAdha (Tobaski), Eidul Fitr (Koriteh)], Christmas, New year), did you buy clothes for your children
- ○ 1.Yes
- ○ 2.No (Skip to Q49)
- ○ 3.I cannot remember
- ○ 4.Refuse to answer

48. How much did you spend on clothes during the past Festivities _____

49. During the past Eids, Christmas or New Year, after you experienced your TB symptoms, did you buy shoes for your children
- ○ 1.Yes
- ○ 2.No (Skip to Q51)

50. How much did you spend on shoes during the past Festivities _____

51. During the past Eids, Christmas or New Year, after you experienced your TB symptoms, did you buy any other present for your children
- ○ 1.Yes
- ○ 2.No (Skip to Q53)

52. How much did you spend on gifts during the past Festivities _____

Adult tuberculosis impacts on children's health

Health Status of the children

53. Thinking back after you are diagnosed with TB illness, (past 6 months), did you seek medical care for any of your child(ren)
- ○ 1. Yes
- ○ 2. No (Skip to Q66)
- ○ 3. I don't know (Skip to Q66)

54. Thinking back before your TB illness, (past 2 months), did any of your children demonstrate the following symptoms?

54a. Cough
- ○ Yes
- ○ No

54b. Duration of cough (days or weeks) _____

54c. Night sweat
- ○ Yes
- ○ No

54d. Duration of night sweats in weeks _____

55d. Coughing up blood
- ○ Yes
- ○ No

54e. Duration in weeks _____

54f. Weight loss
- ○ Yes
- ○ No

54g. Duration in weeks

_____

54h. If other, specify

_____

55. Where did you seek treatment or advice for these Symptoms

- ☐ 1. Pharmacy/Drug Store
- ☐ 2. Traditional Healer/Practitioner
- ☐ 3. Public Health Centre
- ☐ 4. Private Practitioner
- ☐ 5. Public Hospital
- ☐ 6. Mission Health Centre
- ☐ 7. I do not seek any treatment

56. For the past six months after you are diagnosed of TB, has any of your children been admitted for any ill health

- ○ 1. Yes
- ○ 2. No (Skip to Q58)

57. Where were the child(ren) admitted

- ☐ 1. Public Health Centre
- ☐ 2. Private Practitioner
- ☐ 3. Public Hospital
- ☐ 4. Mission Health Centre

58. For the child(ren) taken to seek health care, what was the diagnosis

- ☐ 1. Respiratory tract infection
- ☐ 2. Tuberculosis
- ☐ 3. Diarrhoeal diseases
- ☐ 4. Fever
- ☐ 5. Surgical conditions (wounds, cut, injuries, etc
- ☐ 6. Urinary tract conditions
- ☐ 7. Continuous weight loss/failure to thrive
- ☐ 8. I don't know the diagnosis

59. At the time of seeking health care for the child (ren), what were the services provided

- ☐ 1. Consultation
- ☐ 2. Lab test/investigations
- ☐ 3. Radiography or other imaging or other procedures
- ☐ 4 Medication
- ☐ 5. Hospitalization
- ☐ 6. None of the above
- ☐ 7. I can't remember

60. Did you use any transport when seeking health care for your child(ren)

- ○ 1. Yes
- ○ 2. No (Skip to Q62)

61. What was the means of transportation

- ☐ 1. Private car
- ☐ 2. Hired commercial taxi
- ☐ 3. Commercial vehicle
- ☐ 4. Transport by neighbour/family

62. Did you spend any money on food during visit/hospital stay or accommodation

- ○ 1. Yes
- ○ 2. No (Skip to Q63)

Economic impacts of the health care for the children

63. In total how much did you spend on each of the following for visits to this particular provider (GMD)

63a. Consultation fee (GMD) _____

63b. Radiography or other imaging (e.g. X-ray) _____

63c. Other procedures _____

63d. Lab tests _____

63e. Medication _____

63f. Other (e.g. Supplements) (GMD) _____

63g. Hospitalization (day charges for time in hospital) _____

63h. Total medical costs _____

63i. Transport (return for each visit) _____

63j. Food during the visit/hospital stay _____

63k. Accommodation _____

63l. Other non-medical payment _____

63m. Total non-medical costs _____

63n. Total medical and non-medical costs _____

63o. Reason for no medical or non-medical costs

- ☐ 1.No additional costs incurred
- ☐ 2.Don't know
- ☐ 3.Refuse to answer

64. Non-financial cost when seeking health care for your child(ren)

- ☐ 1.Animals
- ☐ 2.Chicken
- ☐ 3.Farm produce
- ☐ 4.Clothes
- ☐ 5.Other

64a. specify If animals, Farm produce, Clothes or Other _____

65. What were the reasons for the non-financial costs

- ◯ 1. Mode of payment for the service provided
- ◯ 2. I can't provide cash/cheque at that time
- ◯ 3. It is an additional demand
- ◯ 4. I voluntarily gave that
- ◯ 5. I don't know for reason

Family social support

66, Thinking back after you are diagnosed TB, did you have any relative support in caring for your children

- ◯ 1. Yes
- ◯ 2. No (Skip to Q68)

67. Who provide the support

- ☐ 1. Niece
- ☐ 2. Nephew
- ☐ 3. Friends' child
- ☐ 4, My mother
- ☐ 5. Sister
- ☐ 6. Brother
- ☐ 7. Sister in-law
- ☐ 8. Brother in-law
- ☐ 9. Other

67a. If other, specify _____

68. Do you make any remuneration to this help

- ◯ 1. Yes
- ◯ 2. No (Skip to Q70)

69. How do you effect the payment

- ☐ 1. Monthly
- ☐ 2. Quarterly
- ☐ 3. Yearly
- ☐ 4. I don't know

70. Do you receive regular financial support before your TB illness

- ◯ 1. Yes
- ◯ 2. No (Skip to Q74)

71. How requent was this support

- ☐ 1. Monthly
- ☐ 2. On demand
- ☐ 3. Quarterly
- ☐ .4 Yearly

72. Who is supporting you

- ☐ 1. Niece
- ☐ 2. Nephew
- ☐ 3. Friends' child
- ☐ 4, My mother
- ☐ 5. Sister
- ☐ 6. Brother
- ☐ 7. Sister in-law
- ☐ 8. Brother in-law
- ☐ 9. Other

73. How much support were you receiving _____

73a. If more D4000, state the amount. _____

Household food security affecting the children nutrition

74. In the past six months after you are diagnosed with TB illness, did you worry that your children would not have enough food

1. ○ Yes
2. ○ No (Skip to Q76)

75. How often did this happen

1. ○ Rarely (once or twice in the past four weeks)
2. ○ Sometimes (three to ten times in the past four weeks)
3. ○ Often (more than ten times in the past four weeks)

76. In the past six months after you are diagnosed with TB illness, are your children not able to eat the kinds of foods you preferred because of lack of Resources

1. ○ Yes
2. ○ No (Skip to Q78)

77. How often did this happen

1. ○ Rarely (once or twice in the past four weeks)
2. ○ Sometimes (three to ten times in the past four weeks)
3. ○ Often (more than ten times in the past four weeks)

78. In the past six months after you are diagnosed with TB illness, are your children having to eat a limited variety of foods due to lack of resources

1. ○ Yes
2. ○ No (Skip to Q80)

79. How often did this happen

1. ○ Rarely (once or twice in the past four weeks)
2. ○ Sometimes (three to ten times in the past four weeks)
3. ○ Often (more than ten times in the past four weeks)

80. In the past six months after you are diagnosed with TB illness, are your children have to eat some foods that you really did not want them to eat because of a lack of resources to obtain other types of food

1. ○ Yes
2. ○ No (Skip to Q82)

81. How often did this happen

1. ○ Rarely (once or twice in the past four weeks)
2. ○ Sometimes (three to ten times in the past four weeks)
3. ○ Often (more than ten times in the past four weeks)

82. In the past six months after you are diagnosed with TB illness, do your children have to eat smaller meal than needed because of a lack resourced to obtain other types of food

1. ○ Yes
2. ○ No (Skip to Q84)

83. How often did this happen

1. ○ Rarely (once or twice in the past four weeks)
2. ○ Sometimes (three to ten times in the past four weeks)
3. ○ Often (more than ten times in the past four weeks)

84. In the past six months after you are diagnosed TB illness, is there ever no food for your children to eat because of lack of resources to get food

1. ○ Yes
2. ○ No (Skip to Q86)

85. How often did this happen

1. Rarely (once or twice in the past four weeks)
2. Sometimes (three to ten times in the past four weeks)
3. Often (more than ten times in the past four weeks)

86. In the past six months after you are diagnosed With TB illness, do your children go to sleep at night hungry because there was not enough food

1. Yes
2. No (Skip to Q88)

87. How often did this happen

1. (once or twice in the past four weeks) Rarely
2. Sometimes (three to ten times in the past four weeks)
3. Often (more than ten times in the past four weeks)

88. Additional comment

_____

Investigator's name

_____

Investigator's Signature

_____

Date

_____