Journal of Epidemiology and Global Health
Vol. **11**(**1**); March (2021), *pp.* 83–91
DOI: https://doi.org/10.2991/jegh.k.200530.001; ISSN 2210-6006; eISSN 2210-6014
https://www.atlantis-press.com/journals/jegh

Research Article

Estimating Catastrophic Costs due to Pulmonary Tuberculosis in Bangladesh

Anita Sharif Chowdhury[1], Md Shakil Ahmed[2], Sayem Ahmed[3,4], Fouzia Khanam[1], Fariha Farjana[5], Saifur Reza[6], Shayla Islam[6], Akramul Islam[6], Jahangir A.M. Khan[4,7], Mahfuzar Rahman[1,8,*]

[1]*BRAC Research and Evaluation Division, BRAC Centre, Dhaka, Bangladesh*
[2]*BRAC Institute of Governance and Development, BRAC University, Dhaka, Bangladesh*
[3]*icddr,b, Dhaka, Bangladesh*
[4]*Department of Learning, Informatics, Management and Ethics, Karolinska Institutet, Sweden*
[5]*Economics Discipline Khulna University, Khulna-9208, Bangladesh*
[6]*BRAC Tuberculosis Control Programme, BRAC Centre, Dhaka 1212, Bangladesh*
[7]*Department of International Public Health, Liverpool School of Tropical Medicine, Liverpool, UK*
[8]*Centre for Injury Prevention, Health Development and Research, Bangladesh (CIPRB), Dhaka, Bangladesh*

ARTICLE INFO

Article History
Received 30 September 2019
Accepted 13 May 2020

Keywords
Tuberculosis
catastrophic health expenditure
cost drivers
out-of-pocket payment
Bangladesh

ABSTRACT

To eliminate TB from the country by the year 2030, the Bangladesh National Tuberculosis (TB) Program is providing free treatment to the TB patients since 1993. However, the patients are still to make Out-of-their Pocket (OOP) payment, particularly before their enrollment Directly Observed Treatment Short-course (DOTS). This places a significant economic burden on poor-households. We, therefore, aimed to estimate the Catastrophic Health Expenditure (CHE) due to TB as well as understand associated difficulties faced by the families when a productive family member age (15–55) suffers from TB. The majority of the OOP expenditures occur before enrolling in. We conducted a cross-sectional study using multistage sampling in the areas of Bangladesh where Building Resources Across Communities (BRAC) provided TB treatment during June 2016. In total, 900 new TB patients, aged 15–55 years, were randomly selected from a list collected from BRAC program. CHE was defined as the OOP payments that exceeded 10% of total consumption expenditure of the family and 40% of total non-food expenditure/capacity-to-pay. Regular and Bayesian simulation techniques with 10,000 replications of re-sampling with replacement were used to examine robustness of the study findings. We also used linear regression and logit model to identify the drivers of OOP payments and CHE, respectively. The average total cost-of-illness per patient was 124 US$, of which 68% was indirect cost. The average CHE was 4.3% of the total consumption and 3.1% of non-food expenditure among the surveyed households. The poorest quintile of the households experienced higher CHE than their richest counterpart, 5% vs. 1%. Multiple regression model showed that the risk of CHE increased among male patients with smear-negative TB and delayed enrolling in the DOTS. Findings suggested that specific groups are more vulnerable to CHE who needs to be brought under innovative safety-net schemes.

1. INTRODUCTION

Tuberculosis (TB), a chronic infectious disease, is a major public health concern that accounted for 10 million new cases and 1.2 million deaths globally in 2018 [1], and was among the top 10 causes of death [2]. Different preventive measures along with Directly Observed Treatment Short-course (DOTS) have been used globally to reduce the prevalence of TB that resulted in the reduction of TB incidence by 1.6% annually between the years 2000 and 2018. The sustainable development goals, adopted by the United Nations aspire to end the TB epidemic by 2030 [2].

The major social determinants of TB include food insecurity and malnutrition, poor housing and environmental conditions, as well as financial, geographic and cultural barriers to health care access [3]. The incidence of TB has been falling more quickly in countries with high human development index, low child mortality and denizens with better access to improved sanitation [4]. Consequently, higher incidences of TB were less likely countries with higher per-capita income and higher health expenditure compared to other countries [4]. At the household level, TB was mostly associated with smoking, alcohol consumption, low body mass index, lower level of personal education, unemployment, and lower household wealth [5]. Therefore, higher incidences of TB are likely in societies with high economic inequalities among families with low Socioeconomic Status (SES), and where people suffer from food insecurity and malnutrition.

Almost half of the world's TB burden is in the South-East Asian region, and Bangladesh ranked fifth among the highest TB burden countries in this region [6]. In 2015, the incidence and mortality rate of TB in Bangladesh was 225 and 45 per 100,000 population,

*Corresponding author. Email: *mahfuzar_r@yahoo.com*
Data availability statement: Interested researcher may contact the corresponding author [MR] for data and study materials.

respectively [1]. The major consequences of TB include drug resistance with higher morbidity and deaths, and significant impact on the economic development since the diseases generally affects the most economically productive age group of the population [7–12]. In Bangladesh, the TB eradication interventions are mostly funded by the international donors that demand quick case detection and successful treatment to stop TB before these funds support are exhausted [6].

Since 1993, the National TB Control Program (NTP) of the Government of Bangladesh (GoB), has been offering free treatment to TB patients under the popularly known DOTS program as recommended by the World Health Organization (WHO). This package includes direct diagnostic tests and medication costs but not the other associated costs. These indirect expense along with lost income is an increasing concern in the control of TB [13]. Patients and their households incur direct, "Out-of-Pocket (OOP)" expenses, i.e. health payments borne by the patients and their households while receiving health services. This includes expenses for transport, hospitalization, other medicines, and additional food costs [14]. OOP spending is the major component of health care payment in most low- and middle-income countries [15–17]. Globally, around 150 million people experience Catastrophic Health Expenditure (CHE) while around 100 million are forced into poverty consequent to OOP [18]. In the case of TB, expenses are generally observed to be higher before the commencement of DOTS, which is also likely in Bangladesh context [19,20]. These expenses turn out to be catastrophic for the socially and economically marginalized population who are more likely to have TB than the rest of the population [21–24]. Tanimura et al. [16] reported that the total cost of TB treatment involved was over a-half (58%) of the individual income and 39% of the household income. We thus strongly suspected that in Bangladeshi households with one or more TB patients might have faced CHE due to their OOP direct medical and/or non-medical costs. Abolhallaje et al. [25] have found CHE to be closely associated with demographic and economic characteristics of the households, e.g. age, sex, employment status of household heads, dependency ratio at household and the status of health insurance [6]. Notably, CHE was faced by households expending more than 10% of their consumption expenditure/income or 40% of their non-food consumption. The findings suggest that even minor illness expenditures may lead to financial erosion among the poor-households [9]. CHE reflects the economic burden and barriers that negatively influence access to TB care by individuals. Consequently, in the health system financing, the WHO and others, such as STOP TB movement emphasize on reducing 'catastrophic costs', because of its serious implications such as impoverishment, delay in seeking treatment and/or its discontinuation of TB treatment and emergence of multidrug-resistant TB [26]. Failure or delay in seeking TB treatment additionally favors increasing transmission to others. Therefore, equity and universal healthcare for TB patients and preventing CHE of their households have long been identified as crucial by the health policymakers [2,3]. The current WHO have also included prevention/reduction of CHE as one of their strategies to stop TB [14,27,28].

It is thus essential for the policymakers to innovate and/or adopt context-specific measures to reduce the incidence of CHE during illness episodes. In devising measures to reduce CHE, the first logical step would be to assess the prevailing situation and identify the major drivers of cost and consequent CHE. There is a serious lack of information on the incidence of catastrophic cost of TB patients and its determinants in Bangladesh to inform the policymakers. This is why we conducted the current study to estimate the cost-of-illness of TB and the incidence of CHE, and also identify their determinants.

2. MATERIALS AND METHODS

2.1. Study Settings

The Building Resources Across Communities (BRAC) Bangladesh, a Dhaka-based international non-government organization (NGO), is implementing the NTP in partnership with the GoB, in 298 sub-districts under 42 districts and additional seven city corporations serving a total of 92.9 million people. BRAC Health Centers (BHCs) in various parts of the country are equipped with the necessary human resources and logistics for the TB control program. BRAC's *Shasthya Shebikas* (frontline community health volunteers, *SSs*) are the first line health workers for TB screening and delivering DOTS in the rural communities. *SSs* initiate DOT under the guidance of the BRAC program organizers or para-professionals. The study was conducted in BRAC TB areas with TB patients who were enrolled in DOTS.

2.2. Study Design and Sampling

This was a cross-sectional study to assess the TB treatment costs and the incidence of CHE from the onset of TB illness to its diagnosis and through to the DOT treatment period. A multistage sampling technique (from district to sub-district) was adopted for selecting 30 sub-districts, using the probability proportional to size method. The sample size was determined based on the maximum proportion (0.5) with a 5% significance level, and with a 5% precision. Thus, the minimum calculated sample size was 400. To reduce the design effect (2) and keep provision for non-response (100 households), we needed a total of 900 samples (400 × 2 + 100 = 900) for this study. The sample enrolled in each cluster/sub-district was 900/30 = 30. The study participants were identified by systemic random sampling from the TB patients enrolled in BRAC DOTS centers between January and April 2016. Only newly diagnosed TB patients, aged 15–55 years, completing a minimum of 1 and a maximum of 6 months treatment were included. Extrapulmonary TB patients, previously treated TB patients, multi-drug-resistant tuberculosis (MDR-TB) patients, and patients who discontinued treatment or had a fatal outcome were excluded. We excluded them because such patients take longer time to diagnose as well as their treatments are also different and more complex, and consequently their overall, as well as component costs, would also be different than pulmonary TB.

Applying systematic random sampling and defining inclusion and exclusion criteria, we prepared a list of eligible patients from the BRAC TB Program records maintained at each sub-district. Eventually, we identified 1780 eligible patients – there were 60 eligible patients, on average, at each of the 30 study sub-districts and we thus selected every second patient in our study sample. Consequent to non-response and missing households, we ended up having a total of 866 households.

2.3. Data Collection

In a review of existing literature, we developed a structured questionnaire in the local language, Bangla, for our field survey, and sent it to the experts of these fields for their feedbacks. We prepared a revised version adjusting for their suggestions/advice and pretested that on a few patients. The questionnaire was then submitted to the ethical review committee for their approval. We recruited research assistants and enumerators (master degree holders) and trained them for 5 days for data collection that included mock interviews, one-on-one and group discussions, field exposure, and testing. The interviews were conducted at respective homes of the patients in Bangla. A detailed list of demographic variables, service utilization, pre-diagnostic costs, direct and indirect expenses, household food and non-food expenses, earnings, income, assets, and lost income of patients and caregivers information was collected. To accomplish the field survey our enumerators visited every selected household, and those not found after several visits within a given period of time were recorded as missing sample.

The interview team was supervised and monitored by trained supervisors during data collection, and the researchers stayed most of the time in the field to oversee the data collection process as well as to ensure data quality by resurveying few households. Costs data were validated throughout the interview by repeated questioning and spot-checking.

2.4. Outcome Data Assessments

Information on treatment costs was determined for the newly diagnosed pulmonary TB patients. All costs were calculated from the moment of onset of symptoms up to the field survey that included diagnosis and treatment costs, and all direct and indirect costs in both the pre-treatment and treatment periods. Direct patient cost included all OOP expenditures of patients concerning TB. Table 1 describes the different cost heads, e.g. medical costs were classified as doctors consultation fees[1], diagnostic costs[2] related to TB infection, medicine costs[3] other than DOTS (if required); and for in-patients the hospital admission fees, bed charge for an overnight stay in hospital, and treatment. Food and travel costs of both patients and caregivers, when involved, were classified as direct non-medical costs (Table 1). Indirect patient costs included the cost of work absenteeism and loss of wages due to the inability to work because of the illness (Table 1). To assess the degree of income loss, the number of absent days was multiplied by the estimated daily income of the patients and their caregivers.

Table 1 | Cost classifications and their indicators

Heads of cost	Sub-head	Indicators	Time span
Direct	Medical cost	Doctor's consultation fees, diagnostic test costs, medicine costs (other than DOTS, if any), hospital admission fees and bed charges.	All costs were calculated from the onset of symptoms until the interview date
	Direct non-medical cost	Food and travel costs during TB episode for both patients and caregivers.	
Indirect	Loss of income/ wage	Income loss due to TB infections for both patients and caregivers.	

[1]The amount paid to the doctors from the onset of symptoms till the interview date.
[2]All the diagnostic costs related to TB from the onset of symptoms till the interview date.
[3]The total cost of medicines from the onset of symptoms till the interview date.

The primary outcome variable for this study was the CHE, which has no single accepted definition. Some studies assessed payments made in relation to the budget share [29], while others argued that the catastrophic cost needs to be measured in relation to the capacity to pay (i.e. household net expenditure of food). Nonetheless, all agree that often households spend a large proportion of their budget on health care, at the expense of other goods and services that negatively impacts their living standards. Often, the choice of the threshold is arbitrary but two commonly used ones are 10% of total income or 40% of non-food income [29]; the average annual household income is 2305 US$[4] and consumption expenditure including food (47.70%) and non-food (52.30%) is 2272 US$ in Bangladesh [30]. From our survey, we found that the per-capita annual income was 441.05 US$ and per-capita annual food and non-food expenditures were 245.88 and 167.67 US$, respectively for our study patients (Supplementary Table 1).

2.5. Data Analysis

The direct TB treatment costs to a household were calculated by adding all direct medical and non-medical costs both before enrolling in DOTS centers and during the DOTS treatment. Indirect costs were estimated using friction method in which the difference between the income before TB infection of the patients and after TB infection of patients and caregivers is estimated as productivity loss due to TB [31]. For this study, we considered indirect costs as the income loss of the patients and their caregivers due to TB infection during the entire episode starting from the beginning of symptom that illustrates productivity loss. The total cost-of-illness was obtained by summing all direct and indirect costs. All the monetary values were collected in local currency (Taka or BDT) and then transformed into US$ value using the current exchange rate (1 US$ = 83 BDT). Descriptive statistics focusing on frequency distribution, average illness cost, and their standard deviation were analyzed to report demographic characteristics, distribution of illness cost according to different socioeconomic characteristics of the TB patients as well as their affected households. We adopted two most commonly used measures to estimate the incidence of CHE among the TB patients and their affected households: OOP payments greater than 10% of the household annual income, and OOP payments greater than 40% of household non-food expenditure [14,29]. To check the robustness of the CHE estimation, regular and Bayesian simulations with 10,000 re-sampling with replacements were used.

A linear and a logistic regression model were used to predict the determinants of direct, indirect cost, and CHE. The models were as follows:

$$\ln E_i = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + u_i \quad (1)$$

$$\mathrm{CHE}_i = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + u_i \quad (2)$$

[4]1 US$ = 83 BDT.

Equation (1) represents the linear regression model where Ln (E) is the natural logarithm of household expenditure due to TB, β_0 is the constant term and β_i is the coefficients of explanatory variables to be estimated. Equation (2) represents the logistic regression model in which CHE is the binary variable stands CHE; CHE takes the value of 1 if the expenditure is catastrophic for the household else a 0. The explanatory variables included demographic and socioeconomic characteristics of the households, health-seeking behaviors of the patients, and types of TB. The odds ratios were calculated for the logistic regression to examine the constant effect of the predictor on the likelihood of CHE to occur. The Principal Component Analysis (PCA) was applied for constructing the asset quintiles.

3. RESULTS

3.1. Cost-of-Illness

The cost-of-illness was categorized under direct and indirect costs. Table 2 reports the average costs (by category) per patient during the TB infection. The total cost per patient was 124.8 US$ in which the largest proportion (67%) was due to income loss of the patients and their caregivers. The patients' income loss was 61% of the total cost-of-illness. Among various components of the direct costs, a major proportion was made up of TB diagnostic and medicine cost together they constitute 24% of the total cost-of-illness (Table 2). The TB patients additionally spent a significant amount of money on food and travel during the TB episodes.

3.2. Distribution of Cost-of-Illness based on Socioeconomic Profile of TB Patients

The average cost-of-illness, based on demographic and socioeconomic features of the TB patients and their households, have been presented in Table 3. Among the study participating TB patients, 54% were males with an average total cost-of-illness of 173 US$, which was much higher than their female counterparts (Table 3). Among the four age groups, the total cost-of-illness was highest among the 25–35 years age group (154 US$) who constituted 23% of the total sample. This higher cost can be explained by the higher indirect costs; the average income loss of this age group was 107 US$ during the TB episode. The average expense of patients without formal education reported was 123 US$, and that for those tertiary level of education was higher than the other groups. Thus, the cost-of-illness also related to the level of education and this was explained by their higher indirect costs.

Table 2 | Cost-of-illness (US$) of TB patient by cost component

Variable	Average (US$)	Standard deviation	Share of total cost
Consultation fees	3.07	5.47	2.50
Diagnostic cost	15.15	33.22	12.10
Medicine	15.33	25.98	12.30
Admission fees	0.03	0.35	0.00
Bed charges	0.17	2.43	0.10
Food cost	1.35	4.07	1.10
Travel cost	3.26	5.83	2.60
Attendant cost	2.73	7.18	2.20
Total direct cost (sub-total)	41.10	67.23	32.90
Indirect cost of patient	76.21	153.51	61.10
Indirect cost of attendant	7.51	32.51	6.00
Total indirect cost (sub-total)	83.73	155.04	67.10
Total cost per patient	124.82	179.63	–

Number of observations, n = 866.

The cost-of-illness also varied depending on the patient's occupation. In our sample, 15% and 17% of the patients were employed in agricultural and non-agricultural labor, respectively. The average expense of non-agricultural laborers was 186 US$ and that for agricultural laborers was 118 US$ during their TB episode. Patients in services spent the highest amount of 193 US$ during their TB episode. Housewives, the largest group in our sample (37%), spent the lowest amount of 64 US$, and their indirect costs were much lower than other occupational groups. We divided the households into five asset quintiles by wealth index, which placed the households into a continuous scale of relative wealth reflecting their cumulative living standards (Table 3). The households of the TB patients were equally distributed (20%) among the five quintiles starting from the poorest to the richest, and their total average treatment costs are shown in Table 3. The total average cost per patient increased with wealth quintiles - the richest quintiles spent over 200 US$ during their TB episodes, while those in the lowest quintile spent 128 US$; the cost for the patients in the second through the fourth quintiles gradually increased from 136 to 198 US$ (Table 3).

Table 3 shows that the average total cost-of-illness highly discrepant among different groups which resulted from mainly variation in indirect costs. The variations in direct costs depended on the type of service providers. The richest group mostly preferred private service providers, e.g. private hospitals and clinics. Conversely, the poorest group mostly sought care from government or NGO operated hospitals, which were cheaper than the private hospitals and clinics. Table 3 shows that the richest and the poorest quintiles spent 54 and 33 US$, respectively as the direct cost-of-illness.

3.3. Incidence of Catastrophic Health Expenditure

As mentioned earlier, we considered two different definitions of estimating CHE, i.e. health expenditure exceeding 10% of total consumption expenditure (or income) and 40% of total non-food consumption. We noted that the incidence of catastrophic cost was 4.3% vs. 3.1% using these two definitions respectively with their confidence intervals of 3–6% and 2–4%, respectively (Table 4).

To examine the robustness of our findings, we used statistical simulation methods, i.e. regular simulation and Bayesian simulation with 10,000 replication of resampling with replacement. The regular and Bayesian simulation are shown in Supplementary Tables 2 and 3, respectively which produced a similar mean value and confidence intervals with the original findings (Table 4). In the Bayesian technique, a prior distribution was used along with data to provide a posterior distribution, using a binary prior in the analysis. From 10,000 Markov Chain Monte Carlo, we observed similar results with a very small variation in the cardinal confidence interval (Supplementary Table 3). Supplementary Figure 1 describes the diagnostic test of Bayesian estimation. The trace plots demonstrated that the

Table 3 | Socioeconomic background of TB patients and average cost of illness

Characteristic	*N* = 866	(%)	Average direct cost-of-illness (US$)	Average indirect cost-of-illness (US$)	Average total cost-of-illness (US$)
Sex					
Male	465	53.7	42.23	130.53	172.76
Female	401	46.3	39.79	29.45	69.24
Age group					
15–25	195	22.5	43.61	56.09	99.70
25–35	198	22.9	46.18	107.32	153.50
35–45	212	24.5	41.04	89.80	130.84
>45	261	30.1	35.41	81.55	116.96
Marital status					
Married	680	78.5	40.31	87.24	127.56
Unmarried	105	12.1	47.96	86.12	134.08
Others (divorced, widowed)	81	9.40	38.79	51.11	89.90
Education					
No formal education	376	43.4	35.30	87.60	122.90
Primary	243	28.1	38.87	86.26	125.13
Secondary	232	26.8	51.14	70.49	121.63
Tertiary	15	1.7	67.37	150.34	217.71
Occupation					
Agriculture labor	126	14.6	32.51	85.59	118.10
Non-farm labor	96	11.09	30.78	139.47	170.25
Transport worker	49	5.66	51.86	164.22	216.08
Service (Salaried job)	67	7.7	68.35	125.08	193.43
Business	108	12.5	33.20	154.69	187.89
Unemployed	37	4.3	71.11	112.30	183.41
Housewife	316	36.5	37.52	26.16	63.68
Student	35	4	55.61	2.45	58.06
Other	32	3.7	43.74	84.17	127.90
Asset quintiles					
Poorest	174	20.1	32.89	95.24	128.13
Second	176	20.3	33.34	102.19	135.53
Third	173	20	37.18	121.30	158.48
Fourth	174	20.1	48.60	148.98	197.58
Richest	169	19.5	53.90	157.58	211.48

Table 4 | Incidence of CHE

Threshold level	Obs.	Mean	SD	[95% confidence	interval]
10% of total consumption expenditure	866	0.043	0.202	0.029	0.056
40% of total non-food expenditure	866	0.031	0.174	0.019	0.043

mean values were convergent at a single point, autocorrelation was almost zero, the mean values were normally distributed, and the prior distribution overlapped with the posterior distribution providing strong support to our original findings.

3.4. Incidence CHE by Socioeconomic Characteristics

We observed that the incidence of CHE varied by sex (Supplementary Table 4). Males had a higher chance of experiencing CHE than the females (4.5% for men vs. 4% for women under the 10% threshold; and 4% for men vs. 2.5% for women under the 40% threshold). Incidence among the unemployed was the highest at 8% (using both thresholds) compared to other occupations that varied between 2% and 4% (Supplementary Table 4). Smear-negative patients experienced a higher proportion of CHE incidences than smear-positive ones (7% and 6.5% vs. 3.4% and 2.1% under 10% and 40% thresholds, respectively), likely due to the involvement of the need for greater and more complex diagnostic procedures at higher costs. Most of these patients sought the services of different health care systems for multiple lab tests before being diagnosed with TB (Supplementary Table 4).

3.5. Determinants of Cost-of-Illness and CHE

The results of linear and logistic regression models can be found in Supplementary Table 5. The outcome variables in our linear regression models were: total cost-of-illness per patient, and direct and indirect costs related to TB patients and their caregivers, and the distribution of the outcome variables were normalized using natural logarithm. For the logistic regression model, the outcome variables (CHE) took value 1 for household facing CHE and 0 otherwise. Corresponding odds ratios are presented in Supplementary Table 5. Demographic and socioeconomic characteristics of the TB patients and their households constituted the covariates.

Models 1–3, presented in Supplementary Table 5, describe the estimated coefficients for the linear regression model, which suggest a close relation of cost-of-illness with and SES of the patients. Male patients are more cost-sensitive than female patients, the coefficients for males in models 1 and 3 were positive and significantly different from zero implying that they incur more indirect costs than the females increasing their total cost-of-illness. The level of education of the patients also influenced the cost-of-illness, compared to the patients without any formal educations, those only with a secondary level of education had slightly higher income loss, likely because many of them were continuing with their education and were yet to enter into the job market.

In our analyses, we used agricultural labor as the reference for occupation. In reference to this group, non-agricultural labor, service holders or salaried job holders, the unemployed, students, and housewives all had significant associations with the cost-of-illness. Throughout the three models, the coefficients for non-agricultural labor were positive and significantly different from zero (Supplementary Table 5), implying that those in non-agricultural labor incurred higher cost-of-illness than the agricultural labor. Their loss of income was also higher. The service holders and the unemployed patients had positive associations only with the direct cost. In addition to receiving BRAC DOTS, the service holders had a fixed income and the unemployed patients depended on their family members for their treatment costs and these groups had greater opportunity to avail treatments at private clinics. Additionally, the indirect cost of the unemployed were less by 2.15% as they hardly had any income. The cost-of-illness for students and housewives was also significantly less. The income loss of the housewives is lower than that of the agricultural labors since their contributions in household works are not always monetized.

The cost-of-illness was positively related to the type of TB and the health-seeking behavior of the patients. The direct cost increased by 28% for those with smear-negative TB. Interestingly, the direct cost of patients receiving medicines at home were higher likely because of their availing of other treatments. The interaction dummy with medicines given at home and taking other treatment is positive and significantly different from zero (Supplementary Table 5). This implies that the direct as well as the indirect costs were higher for those availing both private as well as cost-free services. Similarly, the cost-of-illness was higher for those receiving treatment prior to their enrollment in DOT and those who delayed their treatment after noticing the symptom of TB (Supplementary Table 5).

In Supplementary Table 5, models 4 and 6 represent the coefficients of a logistic regression model, and models 5 and 6 represent the corresponding OR for models 4 and 6, respectively. The outcome variable for model 4 is the incidence of CHE as defined by cost-of-illness ≥10% of consumption expenditure; and for model 6 the outcome variable is CHE defined as cost-of-illness ≥40% of the non-food expenditure. It can be observed from model 6 that sex of patient was an important factors influencing the CHE - males had relatively higher chance of CHE than the females, and was related to higher indirect costs for the males. Model 6 demonstrated that divorced and widows were more prone to CHE.

Both models 4 and 6 demonstrates that the type of TB and health-seeking behavior of patients are major contributors to the incidence of CHE. There is 85% greater chance of consumption expenditure-based CHE and 200% greater chance (for non-food-based CHE) for smear-negative patients compared to the smear-positives. Provision of medicines at homes make both type of patients less likely to face CHE - the chances of reducing CHE incidence are 53% and 46% in consumption and non-food expenditure-based CHE, respectively. Thus, delay in enrolling into DOTS increases the chances of experiencing CHE.

4. DISCUSSION

This study was based on a household survey to assess the incidence of CHE of the households of TB patients enrolled in BRAC DOTS, covering two-third areas of Bangladesh. Our study using two different indicators of CHE, 10% of the total consumption and 40% of non-food expenditure, noted the average incidence of 4.3% and 3.1%, respectively. The highest incidence of over 5% was noted among the poorest quintiles for both the thresholds. This was in agreement with the earlier studies that reported a greater likelihood of CHE among poorer households in terms of social opportunities and income [17,27,32–34].

Previous studies in Bangladesh, lacking TB-specific data, reported the incidences of CHE, based on the proportion of overall health cost, at 7.1%, 9%, and 14.2% [35,36]. Studies in other countries reported higher CHE: 44% in Nigeria, 18% in India, and 71% in Benin [27,32]. A lower rate (10%) was reported for CHE for TB in a study conducted among Indian tribal population. Poor knowledge about TB in the community, less effective DOTS program, delay in diagnosis, and absence of informal caregiver were major drivers in those settings where high catastrophic costs are reported [27,32]. A more comprehensive and effective TB control program in Bangladesh could be the reason for our observed lower CHE [37].

We noted CHE to vary by sex, marital status and employment status of the patients enrolled in BRAC DOTS. In the logit model, we observed higher incidence of CHE among males and currently single TB patients. Higher CHE among divorced and widowed patients can be explained by their lesser social support. The incidence was also higher among TB patients with delayed enrollment into the DOTS, and those with smear-negative TB Studies conducted in contexts similar to Bangladesh reported gender, age, education and place of residence as significant determinants of CHE, in addition to poverty [35,38–41].

In the absence of TB-specific data in Bangladesh, the earlier reported CHE from different countries provided us with an idea about possible CHE among Bangladeshi TB patients, and helped us make comparisons across different settings. In comparing results, it would be important to remember different approaches of estimating CHE used by different studies.

We estimated the average total cost of TB illness at 124 US$ of which 68% was indirect expenses. We identified loss of income of the patients and caregivers as the largest drivers of cost-of-illness, and consultation fees, diagnostic cost and medicine to make a large share of the total costs. Russell et al. [42] reported the direct and indirect costs of TB in the resource-poor countries were catastrophic for households that impose high and regressive cost burdens on the families TB-related social stigma has been noted as potential cause of loss of income and economic stability of the family. This is likely to influence TB health-seeking behavior that needs to be considered in devising strategies for the eradication of TB in Bangladesh and elsewhere.

The findings of our study may help set a roadmap to ensure that no household is burdened by TB-related CHE by 2030. Given the high incidence of CHE among the poor and vulnerable populations special intervention would be required to reduce or compensate for the cost-of-illness of TB. The NTP can play a pivotal role in discussing this issue and in shaping the strategy. This study identified the high cost of TB illness are contributed by its diagnostics, medicine, food and travel cost, and loss of income and that the costs are higher for sputum-negative patients. Thus, the complete package of treatment should have provision for partial or full reimbursement all sorts of treatment costs including diagnostics of TB and medicine cost with compensation of income loss, depending on the income level of the patients' families. In the absence of such provisions, TB patients and their families will continue to suffer from high CHE that is likely to result in reduced food consumption, more children out of school, and even selling of household assets to become more poor and vulnerable fueling the vicious cycle of poverty [43].

4.1. Strength and Limitation

This study follows the WHO recommended survey design techniques and data collection tools that enhanced the reliability of its findings. The sample size was large enough to run statistical models and to get precise estimates. This study used simulation of the findings with Bayesian and regular simulation techniques that made the results more acceptable by different policymaking bodies.

All the information related to annual household income and expenditure, spending on food and health care were self-reported with possible recall bias. We, however, made efforts to minimize the recall bias by categorizing daily expenditures (for example rice, vegetables, etc.) and collecting such data on a weekly basis. Monthly food expenditure and other bills and fees (outsourcing, tobacco, betel leaf, school fees, amenity bills, etc.) were collected with monthly, and yearly expenditures (clothes, festivals, furniture gazettes, etc.) collected with annual reference time. The study participants were only limited to BRAC managed DOTS centers but the fact remained that it represented two-third of the country's population under DOTS intervention. TB patients enrolled in other partner NGO management or sought care from other sources or might be exposed to different levels of CHE. It should also be noted that this study did not accommodate for those who left the treatment with perceived or real financial and non-financial barriers that might have resulted in an underestimation of the incidence of household CHE. The MDR patients were purposefully excluded from our study, to avoid greater complexity in collecting data, but it is conceivable that their inclusion would have provided a higher incidence of CHE. Like some others, ours was a cross-sectional survey and consequently lacked data required for a robust causal effect of impoverishment of the disease [32,44,45].

5. CONCLUSION

Despite free TB care, our study patients incurred considerable amount of cost-of-illness, both in direct and indirect (income loss) costs. The cost-of-illness of TB was largely contributed by income loss of the patients and their caregivers. The direct costs varied by their SES. The direct costs of the patients led to the incidence of CHE for many households. Though indirect costs do not influence the CHE incidences, special attention should be given to reduce the indirect cost incurred by TB patients and caregivers, which made up the largest share of the total cost-of-illness per patient. To comply with the "WHO's End TB Strategy" of eliminating TB related CHE by 2030, it is important to make special provision for smear-negative TB patients and address the issue of delay in enrolment in DOTS. Special attention is necessary for the poorer segments of the population and other specific vulnerable groups, as noted in this study. Strategy needs to be developed for improving health-seeking behavior of people as well as home delivery of medicine that are likely to reduce the rates of CHE among the TB patients.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

AUTHORS' CONTRIBUTION

ASC, SA, JK and MR conceptualized the study. SA, FF and SA analyzed the data. ASC, SA and FF wrote the first draft and finalized the manuscript. SR, SI and ASC supervised the field work. JK, AI and MR edited and reviewed the manuscript.

FUNDING

This study was funded as part of a larger project at BRAC Tuberculosis programme supported by the Global Fund to Fight AIDS, Tuberculosis and Malaria. There was no specific funding for the study. The funding body had no influence on study design, analysis and manuscript writing.

ACKNOWLEDGMENTS

The authors share their sincere thanks to the BRAC TB programme and BRAC Research and Evaluation (RED) colleagues for their kind support. They acknowledge Dr Mohammad Abdus Salam, ex-Senior Director, icddr,b for editing the manuscript. They would also like to share their sincere thanks to all the respondents – patients, caregivers, frontline programme staffs and also the field research team who worked hard during the fieldwork.

ETHICAL APPROVAL

The ethical approval was obtained (reference number-2017-05) from the James P Grant School of Public Health of the BRAC University, Bangladesh. Individual written informed consent was obtained from each participating patients and confidentiality of their information was strictly maintained.

CONSENT FOR PUBLICATION

All authors approved the manuscript and consented for journal submission.

SUPPLEMENTARY MATERIALS

Supplementary data related to this article can be found at https://doi.org/10.2991/jegh.k.200530.001.

REFERENCES

[1] World Health Organization (WHO). Tuberculosis (TB). Geneva, Switzerland: World Health Organization; 2019. Available from: https://www.who.int/news-room/fact-sheets/detail/tuberculosis [cited December 13, 2019] [Internet].

[2] World Health Organization (WHO). Global Tuberculosis Report 2019. Geneva, Switzerland: World Health Organization; 2019. Available from: https://apps.who.int/iris/bitstream/handle/10665/329368/9789241565714-eng.pdf?ua=1 [Internet].

[3] Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JDH. The social determinants of tuberculosis: from evidence to action. Am J Public Health 2011;101;654–62.

[4] Dye C, Lönnroth K, Jaramillo E, Williams BG, Raviglione M. Trends in tuberculosis incidence and their determinants in 134 countries. Bull World Health Organ 2009;87;683–91.

[5] Harling G, Ehrlich R, Myer L. The social epidemiology of tuberculosis in South Africa: a multilevel analysis. Soc Sci Med 2008;66;492–505.

[6] World Health Organization (WHO). Bending the curve - ending TB: annual report 2017. Geneva, Switzerland: World Health Organization; 2017. Report No.: 924156539X.

[7] World Health Organization (WHO). Global tuberculosis report 2015. Geneva, Switzerland: World Health Organization; 2015.

[8] World Health Organization (WHO). The world health report 2000 - Health systems: improving performance. Geneva, Switzerland: World Health Organization; 2000.

[9] Falkingham J. Poverty, out-of-pocket payments and access to health care: evidence from Tajikistan. Soc Sci Med 2004;58;247–58.

[10] Holtgrave DR, Crosby RA. Social determinants of tuberculosis case rates in the United States. Am J Prev Med 2004;26;159–62.

[11] Kamolratanakul P, Hiransuthikul N, Singhadong N, Kasetjaroen Y, Akksilp S, Lertmaharit S. Cost analysis of different types of tuberculosis patient at tuberculosis centers in Thailand. Southeast Asian J Trop Med Public Health 2002;33;321–30.

[12] Paluzzi JE. A social disease/a social response: lessons in tuberculosis from early 20th century Chile. Soc Sci Med 2004;59;763–73.

[13] Wingfield T, Boccia D, Tovar M, Gavino A, Zevallos K, Montoya R, et al. Defining catastrophic costs and comparing their importance for adverse tuberculosis outcome with multi-drug resistance: a prospective cohort study, Peru. PLoS Med 2014;11;e1001675.

[14] Xu K, Evans DB, Kawabata K, Zeramdini R, Klavus J, Murray CJL. Household catastrophic health expenditure: a multicountry analysis. Lancet 2003;362;111–17.

[15] Mauch V, Bonsu F, Gyapong M, Awini E, Suarez P, Marcelino B, et al. Free tuberculosis diagnosis and treatment are not enough: patient cost evidence from three continents. Int J Tuberc Lung Dis 2013;17;381–7.

[16] Tanimura T, Jaramillo E, Weil D, Raviglione M, Lönnroth K. Financial burden for tuberculosis patients in low-and middle-income countries: a systematic review. Eur Respir J 2014;43;1763–75.

[17] Ukwaja KN, Modebe O, Igwenyi C, Alobu I. The economic burden of tuberculosis care for patients and households in Africa: a systematic review. Int J Tuberc Lung Dis 2012;16;733–9.

[18] Xu K, Evans DB, Carrin G, Aguilar-Rivera AM, Musgrove P, Evans T. Protecting households from catastrophic health spending. Health Aff (Millwood) 2007;26;972–83.

[19] Nhlema B, Kemp J, Steenbergen G, Theobald S, Squire S. A systematic analysis of TB and poverty. Geneva, Switzerland: World Health Organization; 2003.

[20] Rajeswari R, Balasubramanian R, Muniyandi M, Geetharamani S, Thresa X, Venkatesan P. Socio-economic impact of tuberculosis on patients and family in India. Int J Tuberc Lung Dis 1999;3;869–77.

[21] Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. Soc Sci Med 2009;68;2240–6.

[22] Jackson S, Sleigh AC, Wang GJ, Liu XL. Poverty and the economic effects of TB in rural China. Int J Tuberc Lung Dis 2006;10;1104–10.

[23] Zhang T, Tang S, Jun G, Whitehead M. Persistent problems of access to appropriate, affordable TB services in rural China: experiences of different socio-economic groups. BMC Public Health 2007;7;19.

[24] Spence DP, Hotchkiss J, Williams CS, Davies PD. Tuberculosis and poverty. BMJ 1993;307;759–61.

[25] Abolhallaje M, Hasani S, Bastani P, Ramezanian M, Kazemian M. Determinants of catastrophic health expenditure in Iran. Iran J Public Health 2013;42;155–60.

[26] Peabody JW, Shimkhada R, Tan C, Luck J. The burden of disease, economic costs and clinical consequences of tuberculosis in the Philippines. Health Policy Plan 2005;20;347–53.

[27] Laokri S, Weil O, Drabo KM, Dembelé SM, Kafando B, Dujardin B. Removal of user fees no guarantee of universal health coverage: observations from Burkina Faso. Bull World Health Organ 2013;91;277–82.

[28] Raviglione MC, Ditiu L. Setting new targets in the fight against tuberculosis. Nat Med 2013;19;263.

[29] O'Donnell O, van Doorslaer E, Wagstaff A, Lindelow M. Analyzing health equity using household survey data: a guide to techniques and their implementation. Washington, DC: The World Bank; 2008.

[30] Bangladesh Bureau of Statistics (BBS). Preliminary Report on Household Income and Expenditure Survey 2016. Dhaka: Statistics and Informatics Division, Ministry of Planning; 2017. Available from: http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/b343a8b4_956b_45ca_872f_4cf9b2f1a6e0/HIES%20Preliminary%20Report%202016.pdf [cited December 16, 2019] [Internet].

[31] Koopmanschap M, Burdorf A, Jacob K, Meerding WJ, Brouwer W, Severens H. Measuring productivity changes in economic evaluation. Pharmacoeconomics 2005;23;47–54.

[32] Ukwaja KN, Alobu I, Abimbola S, Hopewell PC. Household catastrophic payments for tuberculosis care in Nigeria: incidence,

determinants, and policy implications for universal health coverage. Infect Dis Poverty 2013;2;21.

[33] Li Y, Wu Q, Xu L, Legge D, Hao Y, Gao L, et al. Factors affecting catastrophic health expenditure and impoverishment from medical expenses in China: policy implications of universal health insurance. Bull World Health Organ 2012;90;664–71.

[34] Su TT, Kouyaté B, Flessa S. Catastrophic household expenditure for health care in a low-income society: a study from Nouna District, Burkina Faso. Bull World Health Organ 2006;84;21–7.

[35] van Doorslaer E, O'Donnell O, Rannan-Eliya RP, Somanathan A, Adhikari SR, Garg CC, et al. Catastrophic payments for health care in Asia. Health Econ 2007;16;1159–84.

[36] Rahman MM, Gilmour S, Saito E, Sultana P, Shibuya K. Health-related financial catastrophe, inequality and chronic illness in Bangladesh. PLoS One 2013;8;e56873.

[37] Islam MA, May MA, Ahmed F, Cash RA, Ahmed J. Making tuberculosis history: community-based solutions for millions: BRAC health program. Dhaka, Bangladesh: The University Press Limited; 2011, p. 268.

[38] Dorjdagva J, Batbaatar E, Svensson M, Dorjsuren B, Kauhanen J. Catastrophic health expenditure and impoverishment in Mongolia. Int J Equity Health 2016;15;105.

[39] Ekman B. Catastrophic health payments and health insurance: some counterintuitive evidence from one low-income country. Health Policy 2007;83;304–13.

[40] Daneshkohan A, Karami M, Najafi F, Matin BK. Household catastrophic health expenditure. Iran J Public Health 2011; 40;94–9.

[41] Kien VD, Van Minh H, Giang KB, Dao A, Tuan LT, Ng N. Socioeconomic inequalities in catastrophic health expenditure and impoverishment associated with non-communicable diseases in urban Hanoi, Vietnam. Int J Equity Health 2016;15;169.

[42] Russell S. The economic burden of illness for households in developing countries: a review of studies focusing on malaria, tuberculosis, and human immunodeficiency virus/acquired immunodeficiency syndrome. Am J Trop Med Hyg 2004;71;147–55.

[43] Mchenga M, Chirwa GC, Chiwaula LS. Impoverishing effects of catastrophic health expenditures in Malawi. Int J Equity Health 2017;16;25.

[44] Laokri S, Dramaix-Wilmet M, Kassa F, Anagonou S, Dujardin B. Assessing the economic burden of illness for tuberculosis patients in Benin: determinants and consequences of catastrophic health expenditures and inequities. Trop Med Int Health 2014;19;1249–58.

[45] Zhou C, Long Q, Chen J, Xiang L, Li Q, Tang S, et al. Factors that determine catastrophic expenditure for tuberculosis care: a patient survey in China. Infect Dis Poverty 2016;5;6.