Socio-Demographic Determinants of Adult Tuberculosis: A Matched Case-Control Study in Bangladesh

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Abstract: Tuberculosis (TB) is a multi-systemic infectious disease that has evoked a substantial disease burden in developing countries, including Bangladesh. The aim of this study is to determine the socio-demographic risk factors for adult tuberculosis. A matched case-control study was conducted with 178 cases and 179 controls from a selected TB hospital in Dhaka. Data was collected via face-to-face interview using a standard structured questionnaire, posing questions about socio-demographic, clinical and behavioral factors where tuberculosis patients were matched for age and sex to controls. Crude and multivariate logistic regression analyses were used to analyze the data. The multivariate logistic regression analysis indicated that over-crowding in a house (OR = 3.49, CI = 2.08-5.93), contact with TB patients during the last 6 months (OR = 1.789, CI = 0.917-3.559) and employed participants (OR = 1.99, CI = 1.175-3.458) were positively associated with the development of TB. Besides, monthly income (>25000 taka) (OR = 0.291, CI = 0.151-0.547) and urban living (OR = 0.295, CI = 0.163-0.527) are found negatively associated with the TB status. The identified determinants for the development of adult tuberculosis reflect a complex interaction among socio-demographic conditions. Tuberculosis control would benefit from a collaboration of broad public health activities in improving the socio-demographic factors.

Keywords: Tuberculosis, Risk Factors, Matched Case-Control Study, Infectious Disease, Bangladesh

Introduction

Tuberculosis (TB) is a multi-systemic infectious disease that contributes to communicable disease morbidities worldwide (Rajeswari et al., 1999). Developing countries, such as Bangladesh, often suffer from high burden of TB, primarily due to poverty (Shetty et al., 2006). In Bangladesh, the incidence rate was approximately 225/100,000 per year while the mortality rate was 46% in 2010 (Banu et al., 2012). Approximately 64,000 people die solely due to TB in Bangladesh per year, on average (Gupta et al., 2002). According to previous studies in developed countries in Europe and North America, the most predominant risk factors of TB development include: Homelessness, unemployment, a high-risk lifestyle and the spread of HIV infection. Since Bangladesh is a developing country, major proportion of the population of Bangladesh is prone to the aforementioned risk factors.

According to the current estimate, Bangladesh ranks fifth on the list of countries facing the highest TB burden. Moreover, TB patients in Bangladesh lack access to an adequate supply of medications that they can take in order to effectively eliminate their health issues (de Vries et al., 2010; MMWR, 2011). Malnutrition is primarily quantified by Body Mass Index (BMI) (WHO, 2008), which could potentially worsen TB prognosis, resulting in delayed recovery and higher mortality rates (UNAIDS, 2013; Boccia et al., 2011; NICUS, 2016; Jeon and Murray, 2008; Kim et al., 2008). Bangladesh being a country riddled with a large number of population living under the poverty line, malnutrition may play a significant role as a precursor to TB and this study sought to determine if there is any such association using BMI data. Finding a correlation between nutrition and TB can help justify nutritional interventions as an integral component of attaining Millennium Development Goal 6 (MDG6).
According to previous literatures, TB cases are heavily skewed towards low-income and emerging economies, where the Indian subcontinent contains the largest cluster of TB cases (Ahmed et al., 1999; Dye et al., 1999; Raviglione et al., 1995; Sundre et al., 1992). The National Tuberculosis Program (NTP) of Bangladesh adopted the Directly Observed Treatment Short course (DOTS) strategy and rapidly expanded to reach almost full coverage in 2006 (Hossain et al., 2012). However, there are still gaps in accessibility for urban slum dwellers due to the highly stigmatized nature of TB in highly impoverished areas, as well as limited healthcare access. The same urban slum dwellers also struggle to attain proper nutrition.

According to a similar study in Kenya, poor nutrition was a prominent factor for TB reactivation and mortality, while food supplementation was observed to accelerate therapeutic benefits (Mazars et al., 2001). Although the study yielded an association, the cross-sectional design did not allow for the determination of a causal relationship.

Poor nutrition is a predominant risk factor for contracting TB and mortality (Zachariah et al., 2002; WHO, 2012; Pakasi et al., 2009), but there is insufficient evidence that nutritional support can improve TB treatment response and outcomes. Hence, this study aimed to identify the other socio-demographic determinants of tuberculosis among the Bangladeshi adult population, after adjusting for various clinical and behavioral factors.

Methods

Study Area, Design, Study Population and Sample Size

This case control study was conducted in Shyamoli TB Hospital in Dhaka, Bangladesh, which houses the largest number of TB referral cases. The cases were TB patients (age 18 years and older) who were diagnosed after the Shyamoli TB Hospital. They were interviewed immediately after diagnosis and we enrolled the TB patients in the study until the sample size was achieved.

The controls were patients in the same hospital who did not manifest signs and symptoms of TB that had no history of TB during the last one year. The controls were selected from the outpatient unit of the Shyamoli TB Hospital and presented with minor diseases such as colds, diarrhea, or fever. We selected the controls individually to match cases according to the values of unadjusted odds ratios. Among these covariates, education beyond the secondary level, crowding, average monthly income and area of living were found significantly associated with the TB status according to the values of unadjusted odds ratios. Since BMI and age are continuous variables, the box plots for age and BMI are illustrated in Fig. 1. According to Fig. 1, the average age indicates that cases were slightly older than the control groups (case: 28.3 ± 2 and sex.

Given 5% significance level and 80% power, the calculated sample size for a case-control study design was 358, which yielded 179 cases and 179 controls. The individuals had to be aged 18 or above in order to be eligible for this study. Pregnant women were not considered eligible to participate in the study.

Research Methodology

Data was collected via an in-person interview, using a standard semi-structured questionnaire that posed questions about important socio-demographic characteristics such as: Date of birth, gender, height, weight, marital status, education, number of rooms in the living house, family history of TB during the last one year, average monthly family income, family size, professional status, type of residence, water supply, chronic disease history and smoking history. The age was inferred from the participant’s date of birth and the Body Mass Index (BMI) was calculated based on measured height and weight (kg/m²). With the exception of BMI and age, which were considered continuous variables, the rest of the adjusted variables were categorical. We calculated crowding intensity levels, which refers to the average number of people living per room (family size/number of rooms).

Ethical Approval

Ethical approval for the study protocol was obtained from the North South University Ethics Review Committee and Shyamoli TB hospital. Written informed consent was obtained from each participant.

Statistical Analysis

R software was used to analyze the data. The responses to the questionnaires were classified into categorical variables and continuous variables. The descriptive statistics were calculated for all the variables, including mean, standard deviation, frequencies and percentages. The results were expressed in terms of their adjusted Odds Ratio (OR) and corresponding 95% Confidence Intervals (CI). Independent factors associated with TB were established using the multivariate logistic regression analysis.

Results

Characteristics of the Study Participants

About 178 cases (TB patients) and 179 controls (non-TB patients) consented to participate in the study and fulfilled the eligibility criteria. The mean age of the participants was 28.0 years and the mean BMI was 21.03. Table 1 shows the patients characteristics corresponding to TB status. Among these covariates, education beyond the secondary level, crowding, average monthly income and area of living were found significantly associated with the TB status according to the values of unadjusted odds ratios. Since BMI and age are continuous variables, the box plots for age and BMI are illustrated in Fig. 1. According to Fig. 1, the average age indicates that cases were slightly older than the control groups (case: 28.3 ± 2 years and control: 28.0 ± 2 years).
years; controls: 27.6 years), which is expected as the cases were matched to controls by age. Moreover, the average BMI of cases was found lower than the average BMI of controls. This is also expected because nutritional status usually found lower in patients with active pulmonary tuberculosis compared with controls.

Table 2 shows clinical and behavioral factors associated with TB along with their adjusted odds ratios. The risk factors for adult TB were found as: Contact with TB patients during the last 6 months, unemployed (housewife/students), crowding (more than 2 persons living in one room), poverty (family income less than 25000 BDT) and rural living. A multivariate logistic regression model was fitted after adjusting the extraneous variables, as illustrated in Table 2. It appears that participants who lived in a residence with more than 2 persons in one room are 3.49 times more likely to have TB compared to the persons who are living 2 persons or single person in one room (OR = 3.49, CI = 2.08-5.93). The study suggests that urban living reduces 70% risk of having TB compared to the rural living (OR = 0.30, CI = 0.16-0.53). The contact with TB patients during the last 6 months increases 79% chance of developing TB (OR = 1.79, CI = 0.92-3.56). The poverty is also found a significant variable in the TB status. The participants having average family income greater than 25000 BDT are 71% less likely to have TB compared to the participants having average family income less than 25000 BDT.

Table 1: Patient’s characteristics and unadjusted odds ratio of each covariates and case-control

| Factors                        | Categories          | Case    | Control   | OR (CI)     | P-Value |
|-------------------------------|---------------------|---------|-----------|-------------|---------|
| Sex                           | Female              | 77 (50%)| 78        | 1.00 (0.67-1.54) | 0.952   |
|                               | Male                | 101 (50%)| 101       | 1.00 (0.67-1.54) | 0.952   |
| Educational status            | <=5 years schooling | 114 (60%)| 77        | 0.42 (0.28-0.65)  | <0.001  |
|                               | 6+ years schooling  | 64 (39%) | 102       | 1.00 (0.67-1.54) | 0.952   |
| Marital status                | Unmarried           | 38 (44%) | 49        | 1.00 (0.67-1.54) | 0.952   |
|                               | Married             | 140 (52%)| 130       | 1.00 (0.67-1.54) | 0.952   |
| Occupation                    | Unemployed          | 109 (47%)| 124       | 1.00 (0.67-1.54) | 0.952   |
|                               | Employed            | 69 (56%) | 55        | 1.00 (0.67-1.54) | 0.952   |
| Crowding*                     | ≤ 2.0               | 67 (33%) | 134       | 1.00 (0.67-1.54) | 0.952   |
|                               | > 2.0               | 111 (71%)| 45        | 1.00 (0.67-1.54) | 0.952   |
| Monthly income                | < 25000 BDT         | 157 (61%)| 102       | 1.00 (0.67-1.54) | 0.952   |
|                               | > 25000 BDT         | 21 (21%) | 77        | 1.00 (0.67-1.54) | 0.952   |
| Area of living                | Rural               | 105 (66%)| 53        | 1.00 (0.67-1.54) | 0.952   |
|                               | Urban               | 73 (37%) | 126       | 1.00 (0.67-1.54) | 0.952   |
| Water supply                  | Others (pond etc.)  | 56 (60%) | 38        | 1.00 (0.67-1.54) | 0.952   |
|                               | Tap                 | 122 (46%)| 141       | 1.00 (0.67-1.54) | 0.952   |
| Family history of TB          | Yes                 | 29 (60%) | 19        | 1.00 (0.67-1.54) | 0.952   |
|                               | No                  | 149 (48%)| 160       | 1.00 (0.67-1.54) | 0.952   |
| Contact with TB patients      | Yes                 | 38 (64%) | 21        | 1.00 (0.67-1.54) | 0.952   |
|                               | No                  | 140 (47%)| 158       | 1.00 (0.67-1.54) | 0.952   |
| Diabetic history              | Yes                 | 21 (44%) | 27        | 1.00 (0.67-1.54) | 0.952   |
|                               | No                  | 157 (51%)| 152       | 1.00 (0.67-1.54) | 0.952   |
| Chronic disease history       | Yes                 | 39 (46%) | 46        | 1.00 (0.67-1.54) | 0.952   |
|                               | No                  | 139 (51%)| 133       | 1.00 (0.67-1.54) | 0.952   |
| Smoking history               | Yes                 | 69 (54%) | 58        | 1.00 (0.67-1.54) | 0.952   |
|                               | No                  | 109 (47%)| 121       | 1.00 (0.67-1.54) | 0.952   |

*Family members to room ratio

Table 2: Adjusted relationship between covariates and case-control that is analyzed by multivariate logistic regression model

| Factors                        | Reference          | Estimate | OR (LCL) | OR (UCL) | P-value |
|-------------------------------|--------------------|----------|----------|----------|---------|
| Education (6+ years schooling) | ≤ 5 years schooling| -0.265   | 0.767    | 0.451    | 1.308   | 0.327   |
| Marital status (married)      | Unmarried          | 0.211    | 1.235    | 0.678    | 2.245   | 0.488   |
| Professional status (Employed)| Unemployed         | 0.693    | 1.999    | 1.175    | 3.458   | 0.011   |
| Crowding ≥ 2.0                | ≤ 2.0              | 1.251    | 3.492    | 2.079    | 5.933   | <0.001  |
| Monthly income > 25000 BDT    | < 25000 BDT        | -1.231   | 0.291    | 0.151    | 0.547   | <0.001  |
| Area of living (urban)        | Rural              | -1.217   | 0.295    | 0.163    | 0.527   | <0.001  |
| Water (tap)                   | Others             | 0.503    | 1.653    | 0.879    | 3.148   | 0.121   |
| Contact with TB patients (yes)| No                 | 0.582    | 1.789    | 0.917    | 3.559   | 0.091   |
| Diabetics history (yes)       | No                 | 0.148    | 1.160    | 0.553    | 2.432   | 0.692   |
| Chronic disease history (yes) | No                 | -0.482   | 0.617    | 0.337    | 1.116   | 0.113   |
| Smoking history (yes)         | No                 | 0.254    | 1.289    | 0.769    | 2.166   | 0.335   |
Discussion

This case control study of 178 cases and 179 controls showed that there are multiple factors contributing to the development of adult TB.

The association between diabetes and tuberculosis was found in previous studies in the same discipline. A recent systematic review by Jeon and Murray (2008) demonstrated that diabetes carried a Relative Risk (RR) of 3.11 in cohort studies, while the case-control studies displayed heterogeneous odds ratio (OR=1.16) with confidence interval of 0.55-2.43. Since the association between diabetes and TB is borderline significant, this study portrays a complex relationship between communicable and non-communicable diseases, thus warranting further investigation.

Based on the findings from the multivariate analysis in this particular study, rural residents were more likely to contract tuberculosis, compared to urban-dwelling residents. It is also asserted in other studies that rural residents were more susceptible to TB due to late health care services and more rapid transmission rates (Geng et al., 2002; Story et al., 2007). This current study also observed a significant association between the overcrowding and TB. Overcrowding is a prominent risk factor of rapid transmission of communicable diseases such as TB, which explains why, based on the findings of the current study, residents who inhabited smaller houses with a smaller number of rooms were more likely to contract TB.

This study posited that patients with a higher monthly income (>25000 BDT/month) were less susceptible to tuberculosis. A study from China showed that lower socio-economic status was associated with increased vulnerability to tuberculosis (CTCC, 2004). Since rural residents in Bangladesh typically receive smaller monthly wages, they are more prone to poverty than urban residents (Ullah, 2004). Therefore, they will not necessarily receive the same access to readily available and affordable healthcare services that their urban counterparts would (Khan et al., 2012).

In this study, pursuing an education beyond the secondary level showed a protective effect against TB, which is also supported by the findings from an age- and sex-matched case control study in South Africa with similar results (Gandhi et al., 2006).
Conclusion

The public health dimension of Bangladesh is highly complex, with multifaceted risk factors contributing to chronic infectious diseases such as tuberculosis. Based on the findings of the study, education level, monthly income, crowding and area of living were significantly associated with the susceptibility to tuberculosis in the adult population of Bangladesh. In order to reduce TB burden in Bangladesh, ensuring accessible education to the poor and rural communities. Moreover, nutritional interventions and supplementation mandates, along with preventive measures against non-communicable diseases, would be helpful, for reducing chances of adults contracting TB.

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Author's Contributions

Samira Dishri Irfan: Manuscript writing.
Mohammad Omar Faruque: Data collection and design.
Mahabub Ul Islam: Data collection and data screening.
Shubrandu Sutradhar Sanjoy: Manuscript writing and review.
Dilshad Afrin: Manuscript review.
Ahmed Hossain: Research design, Manuscript writing, data screening, data analysis.

Declarations

Ethics, Consent and Permissions

All the participants signed the informed consent forms prior to enrolment in the study. This study was approved in February 2016 by the Research Ethics Committee of the School of Health and Life Sciences of North South University in Dhaka, Bangladesh.

Consent to Publish

Consent for publication is included in the consent to participate in research.

Availability of Data

Click here for the data file. http://indindividual.utoronto.ca/ahmed_3/index_files/data/data.html

Competing Interests

The authors declare that they have no competing interests.

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Abbreviations
TB: Tuberculosis
BMI: Body mass index
OR: Odds ratio
CI: Confidence interval
SD: Standard deviation