Socio-economic status and self-reported tuberculosis: a multilevel analysis in a low-income township in the Eastern Cape, South Africa

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Abstract

Few studies have investigated the interplay of multiple factors affecting the prevalence of tuberculosis in developing countries. The compositional and contextual factors that affect health and disease patterns must be fully understood to successfully control tuberculosis. Experience with tuberculosis in South Africa was examined at the household level (overcrowding, a leaky roof, social capital, unemployment, income) and at the neighbourhood level (Gini coefficient of inequality, unemployment rate, headcount poverty rate). A hierarchical random-effects model was used to assess household-level and neighbourhood-level effects on self-reported tuberculosis experience. Every tenth household in each of the 20 Rhini neighbourhoods was selected for inclusion in the sample. Eligible respondents were at least 18 years of age and had been residents of Rhini for at least six months of the previous year. A Kish grid was used to select one respondent from each targeted household, to ensure that all eligible persons in the household stood an equal chance of being included in the survey. We included 1,020 households within 20 neighbourhoods of Rhini, a suburb of Grahamstown in the Eastern Cape, South Africa. About one-third of respondents (n=329; 32%) reported that there had been a tuberculosis case within the household. Analyses revealed that overcrowding ($P \leq 0.05$) and roof leakage ($P \leq 0.05$) contributed significantly to the probability of a household tuberculosis experience experience, whereas higher social capital ($P \leq 0.01$) significantly reduced this probability. Overcrowding, roof leakage and the social environment affected tuberculosis prevalence in this economically disadvantaged community. Policy makers should consider the possible benefits of programs that deal with housing and social environments when addressing the spread of tuberculosis in economically poor districts.

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Introduction

Tuberculosis (TB) prevalence has not been thoroughly examined at lower geographical levels of aggregation, such as within a single economically deprived community. A smaller spatial unit of analysis and consistent economic deprivation may dramatically affect the variables that contribute to the development of the disease, so it is essential that these areas be examined.

This multilevel research seeks to identify the socio-economic risk factors that are associated with household-level TB experience in Rhini, a small township of Grahamstown in the Eastern Cape province of South Africa. This community is characterized by high levels of poverty and unemployment.[1,2] Furthermore, this region reports one of the worst TB cure rates in the world with high TB incidence and prevalence numbers.[3,4] While individual-level factors, such as HIV infection, may increase a person's susceptibility to TB, the differential prevalence of TB among various population subgroups can be better explained by the quality of the physical and social environments inhabited by these subgroups.[5,6] We therefore investigated socio-economic environmental risk factors instead of host-related risk factors (e.g. HIV status, age, gender, smoking).

Materials and Methods

Participants and sampling

Data from a survey of 1020 Grahamstown East/Rhini households on the social stigma of TB, conducted in November 2007, were used for this study.[7-11] The survey covered the black residential areas in the city of Grahamstown.[12,13] This study used a neighbourhood-level stratified sampling design. The multilevel analytical approach allowed us to differentiate between household-level and neighbourhood-level mechanisms affecting the relationship between socio-economic status and TB prevalence.[5,14,15] Every tenth household in each of the 20 Rhini neighbourhoods was selected for inclusion in the sample, resulting in 1042 targeted households. This method ensured that all households in all neighbourhoods of Rhini stood an equal chance of being included in the survey. Respondents were then identified in each targeted household.

Eligible respondents were at least 18 years of age and had been residents of Rhini for at least six months of the previous year. A Kish grid was used to select one respondent from each targeted household to ensure that all eligible persons in the household stood an equal chance of being included in the survey. The selected respondent was then interviewed, either immediately or at a later time. Up to four attempts were made to interview selected respondents. An interview was conducted in 1020 of the 1042 targeted households (97.9%). The researchers were unable to conduct an interview in the remaining cases because respondents were absent from their home during the four attempted visits, were impaired by old age or poor health, or were unwilling to participate.

Ethical approval

This study was approved by the Rhodes University Ethical Standards Committee. All personal identifiers have been removed or disguised.

Measurements: outcome measurement

TB prevalence was assessed by a dichotomized lifetime tuberculosis item: *There has been a case of TB in this household*. We did not assess individual-level experience with TB because the interview was held face-to-face; given the stigmatization of TB, we felt that respondents might not answer such questions truthfully. The investigation of host-related indicators was additionally beyond the scope of this work, which investigated the compositional and contextual effects of socio-economic status on TB risk at the household and neighbourhood levels. Household TB experience was, therefore, the most appropriate scale for our inquiries.

Under apartheid there was no choice in housing. Thirty-four percent of the respondents in our sample had lived in the same house for over 20 years, and 99.5% had never lived outside the Eastern Cape. These data indicate constant socio-economic conditions during the participants' lifetimes,[13] and led to our investigation of lifetime TB experience. A recent nationwide multilevel analysis of self-reported TB experience in South Africa revealed no differences in risk factors between self-reported lifetime TB experience and TB experience within the last year.[16]

Household-level indicators

TB spreads easily in damp and crowded conditions, which are common among township households. Water incursion from internal (e.g. leaking pipes) or external (e.g. rainwater) sources causes dampness, which becomes problematic when a leaking roof causes structural materials (e.g. walls, ceiling) to become wet for extended periods of time. Housing quality was thus assessed with a dichotomized item: *Has the roof leaked in the past year?* To measure overcrowding, respondents were asked to state the number of people in the household and the number of rooms in the house. Overcrowding was then calculated by dividing the number of household members by the number of rooms.

Following Putman, we measured social capital through respondents' perceptions of the norms of reciprocity and their trust in others; these are factors that facilitate cooperation for mutual benefit.[17] Social capital was assessed with three statements for which respondents rated their level of agreement on a four-point scale. These statements read: *People in this neighbourhood are friendly*; *People in this neighbourhood help each other without having to be asked*; and *People in this neighbourhood trust their neighbours*. The Cronbach's alpha of this scale was 0.87. We used a household assets index to measure the possession of household goods: radio, television, car, refrigerator, stereo, telephone or cell phone, computer. The questionnaire further assessed unemployment: with the statement *None of the household members is employed*, and income by which respondents were asked to report the household's average monthly income.

Neighbourhood-level indicators

The Gini coefficient of inequality was used to measure income inequality. The coefficient ranges from 0 (complete equality) to 1 (complete inequality) and has been shown to be valid and reliable.[4] The Gini coefficient is a standardized measure of the absolute differences between each household's size-adjusted income and every other household's size-adjusted income. The headcount poverty rate measured the proportion of targeted households in each neighbourhood earning less than R500 per adult equivalent per month. Children were valued as 0.5 adults. The unemployment rate was determined by the proportion of households without an employed adult member.

Data analysis

Our data analysis sought to verify the influence of household-level and neighbourhood-level variables on self-reported household TB experience. We generated descriptive summary statistics and used Spearman's rank correlations to explore univariate associations between the independent variables and household TB experience. To account for the hierarchical structure of the study design and the dichotomous nature of the responses, we fitted a multivariable multilevel logistic regression model. We generated Odds Ratios for untransformed (crude) and standardized variables (adjusted) to describe associations with household TB experience. This analysis used binominal logistic regression with a hierarchical random-effects model to account for multiple levels of data and intra-neighbourhood correlation that might compromise the efficiency of neighbourhood-level parameter estimates. The hierarchical structure comprised 1020 households (level 1) nested in 20 neighbourhoods (level 2). Households were excluded if observations were missing for any outcome, which led to the inclusion of 977 households in our multilevel regression analyses. All statistical analyses were conducted with SPSS version 16.0.

Results

About one-third (32.3%) of the respondents reported that there had been a TB case within the household. Just over half (52%) were single, a third (33%) were married, and the others widowed (9%) or separated/divorced (6%). Sixty-two percent of the respondents were unemployed and 51% stated that the roof had leaked in the past year.

Table 1 provides descriptive statistics for the other household-level independent variables of TB experience and Table 2 provides this information at the neighbourhood level.

Univariate analyses of the effects of overcrowding, a leaky roof, social capital, unem-

Table 1. Descriptive statistics for the variables used in the multilevel regression analyses (n=977).

Model	Mean	SD	Min	Max
Overcrowding (n. persons per room)	1.65	1.20	0.20	8.00
Social capital	2.97	0.54	1.00	4.00
Income	1250	2.13	0.00	>7001

Table 2. Summary descriptive statistics neighbourhood-level indicators.

Neighbourhood	TB experience	Headcount poverty rate	Unemployment rate	Gini
1	29.3	76.3	66.4	0.20
2	28.0	72.5	53.7	0.17
3	45.0	75.0	40.0	0.19
4	53.3	89.7	56.7	0.19
5	37.4	65.2	57.1	0.19
6	20.0	37.9	40.0	0.18
7	34.6	69.2	57.7	0.16
8	16.0	44.0	57.6	0.16
9	28.8	74.2	30.0	0.17
10	24.0	84.0	57.6	0.21
11	35.6	68.2	52.0	0.23
12	36.7	70.0	66.7	0.18
13	30.3	83.3	66.7	0.25
14	40.5	68.3	71.2	0.19
15	34.3	88.2	75.0	0.22
16	41.7	86.1	85.7	0.21
17	40.0	95.0	77.8	0.14
18	13.3	100.0	70.0	0.24
19	31.0	68.0	66.7	0.24
20	25.0	77.8	64.3	0.20

ployment, income, Gini coefficient of inequality, unemployment rate and headcount poverty rate on self-reported household TB prevalence showed that social capital, overcrowding and a leaky roof (P≤0.01) were the only significant predictors of TB prevalence at the household level (*data not shown*).

The full multilevel regression model simultaneously evaluated the influence of household-level indicators i) a leaky roof; ii) overcrowding; iii) social capital; iv) unemployment; v) income; vi) marital status; and neighbourhood-level indicators i) Gini coefficient of inequality; ii) unemployment rate; and iii) headcount poverty rate on self-reported household TB prevalence at the household level. We present crude and adjusted OR of TB in Table 3.

These analyses revealed that overcrowding (P≤0.05) and roof leakage (P≤0.05) significantly contributed to the probability of a household TB experience, whereas higher social capital (P≤0.01) significantly reduced this probability. No significant multilevel correlations were found between the neighbourhood-level indicators i) unemployment rate; ii) Gini coefficients of inequality; iii) head count poverty rate; and the household-level indicators i) unemployment; ii) income; and iii) household TB experience (Table 3). The OR for overcrowding was 1.13, indicating a 1.13-fold increase in the odds for household TB experience with each extra person per room, assuming that all other factors in the model remained constant. Similarly, a leaky roof increased the odds for household TB experience by a factor of 0.28, compared to housing without a leaking roof. Social capital was related to a decrease in the probability of household TB experience, as indicated by the OR of 0.69. The ORs for the standardized variables were 1.13 for a leaky roof, 1.16 for overcrowding, and 0.82 for social capital. These results show the similarity in the relative strengths of these factors.

Table 3. Crude and adjusted log Odds Ratios of tuberculosis experience based on multilevel logistic regression analyses.

	Odds Ratio (crude)	CI		Odds Ratio (adjusted)	CI	
Overcrowding (n. persons per room)	1.14	1.02	1.28*	1.17	1.02	1.34*
Poor housing quality (leaking roof)	1.37	1.03	1.81*	1.17	1.02	1.35*
Social capital	0.70	0.54	0.91**	0.83	0.72	0.95**
Unemployment	1.18	0.85	1.64	1.08	0.93	1.27
Income	1.01	0.94	1.09	1.02	0.87	1.20
Marital status	1.13	0.85	1.52	1.06	0.93	1.22

*P≤0.05; **P≤0.01.

Discussion

This research used multilevel logistic regression analysis of self-reported TB experience to identify socio-economic status risk factors at the household and neighbourhood levels for household-level experience with TB in South Africa.

Poor housing quality (a leaking roof) and overcrowding were significantly correlated with the increased prevalence of TB within the household. These results are consistent with those of earlier studies, which found that the differential prevalence of TB among various population subgroups was explained by the quality of the physical and social environments.[5,6] We also found that higher social capital was associated with significantly lower TB prevalence within a household. Social capital may have promoted the diffusion of TB-related knowledge, since people obtain much of their health information through social connections.[16] Higher levels of social capital may, therefore, have led to increased knowledge, as well as healthy and TB-preventive behaviour. A recent study confirmed that social capital led to improved awareness, preventive actions, and healthier lifestyles, even for highly stigmatized diseases such as HIV.[18] These findings may be extended to explain the association between social capital and TB outcomes in our study.

Public health practitioners and policy makers have recently turned to more comprehensive and participatory approaches to enhancing social capital, and thereby improving health and TB outcomes.[19] Instead of adopting a top-to-bottom approach, policy makers increasingly work with community members to plan and implement health programs. Farquhar and colleagues[20] found an association between health and social capital, and determined that increased social capital generated through community-based participatory interventions led to significantly improved health outcomes. Our findings also highlighted this effect of social capital. Interventions aimed at strengthening social capital may thus reduce TB prevalence. While other research has uncovered significant associations between low household-level socio-economic status and TB prevalence, income and unemployment did not emerge as significant indicators for TB experience in our study. The neighbourhood-level socio-economic status indicators were also not significantly associated with TB prevalence. These differences may be related to the scale of analysis. Previous studies have been conducted at higher geographical levels of aggregation, and have compared people living in economically deprived areas with those living in non-deprived areas. For example, Harling and colleagues[16] found income inequality to be a strong predictor for TB outcomes. They performed a nationwide multilevel analysis in South Africa using a study sample with a Gini coefficient of inequality of 0.67. In contrast, our study investigated the relationships of multilevel characteristics with TB prevalence at a lower geographical level of aggregation, within a single South African township. The Gini coefficients of inequality of the 20 neighbourhoods in our Eastern Cape suburb ranged from 0.14 to 0.25. Compared to South Africa's national level of inequality (0.67), the residents of Rhini shared equal (low) incomes. Investigation of a larger region with more pronounced neighbourhood income inequalities may produce different results. The same explanation may be applied to the other socio-economic status indicators at the household and neighbourhood levels.

We only investigated socio-economic status indicators of TB risk at the household and neighbourhood levels. As we did not collect information on host-related indicators (e.g. HIV status, smoking habits, and health status), we could not investigate individual-level health associations. The interactions between such factors and socio-economic status, therefore, require further investigation. The cross-sectional design of our study constituted another limitation; it reduced our ability to capture neighbourhood dynamics and to draw causal inferences. Furthermore, we investigated TB experience by eliciting subjective verbal reports of past household TB experience. Evidence from South Africa has suggested that reliance on self-reported past TB experience may lead to an underreporting of lifetime TB experience.[16] If such underreporting is not correlated with explanatory variables in the analysis, any introduced bias may lead to the coincident underestimation of associations between variables. A further reporting bias might arise if social stigma caused individuals to conceal household TB experience.

Conclusions

The present study demonstrated that social capital, overcrowding, and poor housing quality are associated with TB prevalence within the low-income South African township of Rhini. While existing TB prevention policies in South Africa emphasize disease treatment, our findings suggest that a greater emphasis on social, economic, and housing policies focused on assisting township residents would also be beneficial. The improvement of housing quality and reduction of overcrowding in low-income townships are advisable policy goals. In addition, the strengthening of social capital could decrease TB risk in poor communities with high TB and HIV/AIDS prevalence rates. Such policies may also improve a wide range of health issues by promoting healthy behaviour, disease awareness, and disease preventive behaviour.

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