Social determinants of tuberculosis evaluation among household contacts: a secondary analysis

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Setting: Seven public sector tuberculosis (TB) units and surrounding communities in Kampala, Uganda.

Objective: To evaluate the influence of household-level socio-economic characteristics on completion of TB evaluation during household contact investigation.

Design: A cross-sectional study nested within the control arm of a randomized, controlled trial evaluating home-based sputum collection and short messaging service communications. We used generalized estimating equations to estimate the association between completion of TB evaluation and socio-economic determinants.

Results: Of 116 household contacts referred to clinics for TB evaluation, 32 (28%) completed evaluation. Completing evaluation was strongly clustered by household. Controlling for individual symptoms, contacts from households earning below-median income (adjusted risk ratio [aRR] 0.28, 95%CI 0.09–0.88, $P = 0.029$) and contacts from households in which the head of household had no more than primary-level education (aRR 0.40, 95%CI 0.18–0.89, $P = 0.025$) were significantly less likely to complete evaluation for TB.

Conclusion: Socio-economic factors such as low income and education increase the risk that household contacts of TB patients will experience barriers to completing TB evaluation themselves. Further research is needed to identify specific mechanisms by which these underlying social determinants modify the capability and motivation of contacts to complete contact investigation.

Tuberculosis (TB) continues to play a major role in global morbidity and mortality, affecting over 10 million people and causing up to 2 million deaths annually.^{1,2} In 2012, the World Health Organization (WHO) proposed the End TB Strategy, which aims to greatly reduce the TB burden by 2035, and ultimately eradicate TB. The End TB Strategy promotes household contact investigation to broaden TB case finding in pursuit of these goals.³ Contact investigation involves screening those who live with a TB patient as soon as possible after the patient is diagnosed to identify and refer contacts with symptoms of or risk factors for active TB for clinical and laboratory evaluation.⁴ Household contact investigation led by community health workers (CHWs) has been shown to be a feasible, effective, and cost-effective way to screen and identify new TB patients.^{5,6}

Following home-based screening, symptomatic and at-risk contacts are typically invited to visit a health center for further laboratory and clinical evaluation.

However, many referred contacts do not attend the clinic to complete evaluation.^{7–11} Incomplete evaluation may lead to delayed diagnosis and treatment, more severe TB presentations at diagnosis, and continued transmission of TB within communities.¹²

Index patients and their household contacts may face a variety of barriers to participation in contact investigation, evaluation, and treatment for TB. These include stigma, preferences for alternative or traditional medical practices, lack of knowledge about TB and its treatment, costs of missed work and travel to clinics, and mistrust of the public health care system.^{10,13,14} Despite the identification of these potential barriers to linkage to TB evaluation and care, there have been relatively few quantitative analyses estimating the influence of socio-economic factors on completion of TB evaluation in the context of contact investigation.

Social determinants encompass the broader, non-medical conditions into which individuals are born and live; they are the social conditions that put certain individuals 'at risk of risk'.¹⁵ The American College of Physicians recently called for increased efforts to identify these social mechanisms, which are thought to be responsible for the persistence of many health disparities, including infection with TB.¹⁶ Adapting this goal to a more global scale, we conducted a cross-sectional study to determine how contact- and household-level socio-economic characteristics impact the completion of TB evaluation during contact investigation in Kampala, Uganda.

STUDY POPULATION, DESIGN AND METHODS

Study design

Our objective was to investigate associations between household socio-economic status (SES) and completion of evaluation for TB following standard TB contact investigation. We therefore conducted a secondary, cross-sectional analysis nested in the control arm of a household-randomized trial. The parent study evaluated the effect of home sputum collection, delivery to the laboratory for microbiologic testing, and reporting of results using short messaging service (SMS) on the proportion of household contacts¹⁷ completing TB evaluation (Pan-African Trials Registry #20150900877140). We restricted our analysis to its control arm, in which Uganda National TB and Leprosy Programme (NTLP) guidelines were followed for routine household contact investigation.¹⁸

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Setting

Our study took place in seven public sector TB units offering routine household contact investigation and their surrounding communities in Kampala, where the Uganda NTLP introduced household contact investigation to all TB units in 2013. A recent prevalence survey carried out by the Uganda Ministry of Health estimated a prevalence of 253 TB cases per 100 000 individuals, and found that >60% of culture-confirmed TB patients had not been previously diagnosed.¹⁹ Moreover, an increase in TB-specific mortality has been observed since 2011.²⁰

Study population and procedures

The study population included all household contacts in the control arm of the parent study who were referred for TB evaluation following standard contact investigation procedures. Index patients were eligible if they were microbiologically confirmed as having active TB disease, resided within Kampala, spoke English or Luganda, and had access to a mobile phone. Household contacts who spoke English or Luganda, were not currently in treatment for TB, had access to a mobile phone, and were willing to receive personal health information via SMS were eligible (Appendix Figure A). From August 2016 to August 2017, CHWs offered household contact investigation to consecutive index patients being treated for active, drug-susceptible pulmonary TB, and visited their homes, typically within 2 weeks of the diagnosis. If the CHWs did not screen all reported contacts during the initial visit, they returned to screen missed contacts.

During the home visits, CHWs screened household contacts and provided written clinic referrals for those reporting symptoms (cough $\geq$ 2 weeks, subjective fever, night sweats, and/or weight loss) and/or risk factors for progression to active TB (living with human immunodeficiency virus [HIV] or being aged <5 years). The CHWs collected fingerprints, demographic data, and clinical information such as self-reported HIV status from all contacts, and household-level information such as income and education from household heads. The CHWs recorded all information on a mobile tablet using a customized survey application (CommCare; Dimagi, Cambridge, MA, USA). At the TB units, the CHWs used fingerprint scans and name look-up to locate the records of contacts who presented for evaluation.

For this analysis, we included household contacts who were referred for clinical evaluation by a CHW. We excluded individuals from households that did not identify the head of household or report their income because they were missing data on the main variables of interest. We found no evidence that contacts from households with missing data differed from the contacts included in the analysis by sex, age, HIV status, or completion of TB evaluation (Appendix Tables A.1 and A.2).

Statistical analysis

The primary outcome of interest was completion of TB evaluation, which was coded dichotomously. We defined completion as a documented visit to the clinic for laboratory or clinical evaluation.

We evaluated three household-level variables thought to be significant to TB or general health outcomes:^{12,21,22} household income, education level of the head of the household, and household head's sex. Income was divided at the median level of approximately US\$25 per week (90 000 Ugandan Shillings). Furthermore, we evaluated four individual-level variables: age, sex, self-reported HIV status, and presence of TB symptoms as a control variable. Contact age was coded categorically as 1) <5

years, 2) 5–14 years, or 3) $\geq$ 15 years. If the contact reported unknown HIV status, HIV status was recorded as non-positive.

To assess the extent of household clustering for completion of TB evaluation, we estimated the intraclass correlation coefficient (ICC). We fit bivariate generalized linear models with log links and Poisson distributions using generalized estimating equations to estimate population-averaged associations. Clustering was accounted for at the household level with a robust covariance estimator, and adjusted risk ratios (aRRs) are reported for both bivariate and multivariable analyses. We used a manual, step-wise forward selection process to construct a multivariable model using the quasi-likelihood under the independence-model criterion (QIC). We also fit a model for a subsample that included only symptomatic contacts (Appendix Table A.3). All analyses were carried out using SAS Enterprise v 7.1 (Statistical Analysis System, Cary, NC, USA).

Human subjects

The study protocol was reviewed by the institutional review boards of the Makerere University School of Medicine, Kampala, Uganda; the Yale School of Public Health, New Haven, CT, USA; and the Uganda National Council for Science and Technology Kampala, Uganda. All participants provided written informed consent.

RESULTS

Characteristics of the study population

In the parent study, 471 households were eligible for contact investigation, and 372 (80%) were visited. Among these households, index patients identified 1228 household contacts, of which CHWs met 1193 (97%); 989 (83%) met the contact definition¹⁷ and were eligible, and 919 (93%) of these completed screening for TB symptoms and risk factors during the home visit; 488 contacts from 160 households were assigned to the control arm (Appendix Figure A).

In the control arm, 74 (46%) households did not indicate a household head or did not report income. Of the remaining contacts, 116 individuals from 61 households were referred to the clinic for evaluation based on TB symptoms or risk factors. Thirty-two individuals who received a referral (28%) completed TB evaluation (Figure); 11 (34%) were diagnosed and treated for active TB.

FIGURE Contact TB evaluation outcomes. TB = tuberculosis.

TABLE 1 Contact and household characteristics

Variables	Overall (<i>n</i> = 116) <i>n</i> (%)	Completed TB evaluation (<i>n</i> = 32) <i>n</i> (%)	Did not complete TB evaluation (<i>n</i> = 84) <i>n</i> (%)	RR (95%CI)*	<i>P</i> value
Household variables					
Below median income	49 (42)	3 (9)	46 (55)	0.20 (0.06–0.64)	0.007
Primary education only†	48 (41)	5 (16)	43 (51)	0.47 (0.17–1.25)	0.129
Male head of household	87 (75)	28 (87)	59 (70)	2.46 (0.72–8.37)	0.149
Contact variables					
TB symptoms present	68 (59)	29 (91)	39 (46)	3.30 (1.14–9.54)	0.028
Age, years					
<5	56 (48)	11 (34)	45 (54)	1	—
5–14	23 (20)	12 (38)	11 (13)	1.52 (0.39–3.26)	0.435
>14	37 (32)	9 (28)	28 (33)	1.35 (0.15–10.60)	0.410
Male	50 (43)	17 (53)	33 (39)	0.73 (0.34–1.58)	0.426
Living with HIV	17 (15)	2 (6)	15 (18)	1.59 (0.89–2.87)	0.120

*Adjusted for household clustering using generalized estimating equations.

†Educational level of head of household.

TB = tuberculosis; RR = risk ratio; CI = confidence interval; HIV = human immunodeficiency virus.

Eighty-seven (75%) contacts belonged to households in which the household head was male, 36 (31%) belonged to households in which the household head was living with HIV (PLHIV), and 61 (53%) came from households in which the head of household was diagnosed with TB as the index patient. Fifty (43%) referred contacts were male, and 17 (15%) were PLHIV. Sixty-eight (59%) referred household contacts reported one or more symptoms of active TB. Of the 48 who did not report symptoms, 36 (75%) were aged <5 years and 12 (25%) were PLHIV.

Bivariate analyses

Completion of TB evaluation was very strongly clustered by household (ICC 0.978, 95% confidence interval [CI] 0.97–0.98). Adjusting for clustering, contacts in households earning below-median income and contacts without TB symptoms were significantly less likely to complete TB evaluation (Table 1). Only two (6%) of the 36 asymptomatic household contacts aged <5 years completed evaluation; one was diagnosed and treated for active TB. One (8%) of the 12 asymptomatic PLHIV completed evaluation.

Multivariable analysis

In the final multivariable model, household income and household head's level of education were significantly associated with TB evaluation completion, controlling for age and presence of TB symptoms (Table 2). Household contacts with lower household income (aRR 0.28, 95%CI 0.09–0.88, *P* = 0.029) were less likely to complete evaluation than those in households above the median income level. Lower levels of household head education were independently associated with lower likelihood of completion (aRR 0.40, 95%CI 0.18–0.89, *P* = 0.025). Those who reported TB symptoms (aRR 4.48, 95%CI 1.43–14.00, *P* = 0.010) were significantly more likely to complete evaluation than those who had no TB symptoms.

In a supplemental model excluding contacts who did not report symptoms, below-median income (aRR 0.23, 95%CI 0.06–0.82, *P* = 0.024) and lower education levels for the household head (aRR 0.43, 95%CI 0.20–0.93, *P* = 0.032) remained significantly associated with diminished likelihood of completion (Appendix Table A.3).

DISCUSSION

Household contact investigation strategies can bring TB case detection into the community, where most missing TB cases remain in Uganda and other high-burden countries.^{5,23} These strategies are particularly effective in high TB burden regions.^{23,24} However, in Uganda and other settings, many contacts referred for evaluation during contact investigation never visit the clinic.^{8,11,13,23} We found that two underlying social determinants were strongly associated with a failure to complete TB evaluation: household income and educational level of the household head.

In our study, below-median income reduced the likelihood of completing TB evaluation among household contacts with symptoms or risk factors for TB. Although evaluation and treatment for TB is offered free of charge in Uganda, our findings suggest the persistence of substantial indirect economic barriers to care, similar to those observed in other high TB burden regions.^{21,25,26} Our data do not reveal the mechanisms through which income influences completion of TB evaluation. However, they may point to a role for financial support or incentive to ensure that symptomatic contacts are linked to evaluation and care. Transportation assistance, reimbursement for time away from work, or innovative evaluation models that do not require contacts to visit the clinic^{27,28} might mitigate the influence of income on linking to

TABLE 2 Multivariable model predicting completion of TB evaluation

Variables	RR (95%CI)*	<i>P</i> value
Below median income	0.28 (0.09–0.88)	0.029
Primary education only†	0.40 (0.18–0.89)	0.025
TB symptoms present	4.48 (1.43–14.00)	0.010
Contact age, years		
<5	1	—
5–14	0.96 (0.77–2.58)	0.863
>14	0.68 (0.59–6.68)	0.266

*Adjusted for household clustering using generalized estimating equations.

†Educational level of head of household.

TB = tuberculosis; RR = risk ratio; CI = confidence interval.

evaluation for TB. Further research is needed to evaluate the effectiveness of such approaches.

Contacts in households where the household head had primary-level education or less were also significantly less likely to complete evaluation for TB. Education is associated with higher income, increased health literacy, more effective communication with health providers, and better treatment adherence, all of which may ultimately improve health outcomes.^{29–31} In the context of TB contact investigation, education may impact communication between CHWs and contacts, or affect decision making regarding whether to attend the clinic for evaluation. Interventions to increase completion of TB evaluation might tailor TB education for contacts with fewer years of formal education. By better conveying TB knowledge to those at highest risk of incomplete evaluation, contact investigation can become more patient-centered and improve health equity.³⁰

We found a very high degree of intra-household correlation in completion of evaluation, which may suggest that the decision to travel to a clinic for evaluation is a household, rather than an individual, decision. Children, in particular, are unable to travel to a clinic to complete evaluation themselves, and so their completion is driven by the decisions of adult household contacts. Among adults, individual decisions may be influenced by cultural context, household values, wealth, sex, and age of the individual who is ill or at risk.^{22,32,33} Because clustering of completion outcomes may also be the consequence of other household- or neighborhood-level characteristics, future research should examine the process by which individuals and households reach decisions about traveling to the clinic in greater detail.

Our study had some limitations. First, a large proportion of households in the parent study did not identify a household head or disclose their income, and they were therefore excluded from this analysis. We did not find any evidence that the excluded households differed from included households in outcome or demographic composition. However, it is possible that households that identified a household head or that chose to disclose income may have differed from those that did not. Furthermore, some household contacts may have misreported their income. While CHWs' rapport with index households and training in the collection of sensitive information reduces this risk, it is evident that obtaining complete and accurate socio-economic information was difficult in this setting. Measuring economic status is a universal challenge in public health research.³⁴ Future studies may benefit from the use of alternative income proxies based on occupation or presence of household amenities instead of self-reported income, which is sensitive and difficult to verify.³⁵ Finally, our study measured education at the level of the household head, preventing us from reaching conclusions about the influence of individual education levels on TB evaluation completion. However, household heads likely have a considerable influence on household behaviors, and individual education levels tend to be similar within households.

Our study also had a number of strengths. First, we conducted this study at seven TB clinics throughout Kampala and in coordination with local public health partners. Our findings are therefore likely generalizable to other urban, high TB burden, resource-constrained environments. Because the parent study was a pragmatic trial, selection criteria were broad, and conditions reflected routine practice. Second, our study contributes to an understanding of the role of social determinants in clinical evaluation, the final stage in the TB contact investigation cascade. This is one of the first quantitative studies to analyze the underlying

determinants of household contact dropout during this crucial step.

Socio-economic factors, including household income and education, contribute to the high rate of household contact dropout during the final stage of TB contact investigation. If the End TB Strategy is to succeed, creative interventions should be developed to address the socio-economic context in which at-risk household contacts are asked to complete follow-up evaluation for TB. Further studies are needed to identify the mechanisms through which household income and education influence the motivation, opportunity, and capability to complete TB evaluation of at-risk contacts, and to develop targeted interventions to increase completion among the most vulnerable households.

References

- 1 World Health Organization. Global tuberculosis report, 2017. WHO/HTM/TB/2017.23. Geneva, Switzerland: WHO, 2017.
- 2 Glaziou P, Sismanidis C, Floyd K, Raviglione M. Global epidemiology of tuberculosis. *Cold Spring Harb Perspect Med* 2015; 5: a017798.
- 3 World Health Organization. Recommendations for Investigating contacts of persons with infectious tuberculosis in low- and middle-income countries. WHO Guidelines Approved by the Guidelines Review Committee. WHO/HTM/TB/2012.9. Geneva, Switzerland: WHO, 2012.
- 4 Narasimhan P, Wood J, Macintyre C R, Mathai D. Risk factors for tuberculosis. *Pulm Med* 2013; 2013: 828939.
- 5 Fox G J, Nhung N V, Sy D N, et al. Household-contact investigation for detection of tuberculosis in Viet Nam. *N Engl J Med* 2018; 378: 221–229.
- 6 Sekandi J N, Dobbin K, Oloya J, Okwera A, Whalen C C, Corso P S. Cost-effectiveness analysis of community active case finding and household contact investigation for tuberculosis case detection in urban Africa. *PLOS ONE* 2015; 10: e0117009.
- 7 Fox G J, Barry S E, Britton W J, Marks G B. Contact investigation for tuberculosis: a systematic review and meta-analysis. *Eur Respir J* 2013; 41: 140–156.
- 8 Fox G J, Loan le P, Nhung N V, et al. Barriers to adherence with tuberculosis contact investigation in six provinces of Viet Nam: a nested case-control study. *BMC Infect Dis* 2015; 15: 103.
- 9 Nyirenda M, Sinfield R, Haves S, Molyneux E M, Graham S M. Poor attendance at a child TB contact clinic in Malawi. *Int J Tuberc Lung Dis* 2006; 10: 585–587.
- 10 Ross J M, Cattamanchi A, Miller C R, et al. Investigating barriers to tuberculosis evaluation in Uganda using geographic information systems. *Am J Trop Med Hyg* 2015; 93: 733–738.
- 11 Armstrong-Hough M, Turimumahoro P, Meyer A J, et al. Drop-out from the tuberculosis contact investigation cascade in a routine public health setting in urban Uganda: a prospective, multi-center study. *PLOS ONE* 2017; 12: e0187145.
- 12 Getnet F, Demissie M, Assefa N, Mengistie B, Worku A. Delay in diagnosis of pulmonary tuberculosis in low-and middle-income settings: systematic review and meta-analysis. *BMC Pulm Med* 2017; 17: 202.
- 13 Ayakaka I, Ackerman S, Gita J M, et al. Identifying barriers to and facilitators of tuberculosis contact investigation in Kampala, Uganda: a behavioral approach. *Implement Sci* 2017; 12: 33.
- 14 Asres M, Gedefaw M, Kahsay A, Weldu Y. Patients' delay in seeking health care for tuberculosis diagnosis in East Gojjam Zone, Northwest Ethiopia. *Am J Trop Med Hyg* 2017; 96: 1071–1075.
- 15 Link B G, Phelan J. Social conditions as fundamental causes of disease. *J Health Soc Behav* 1995; Spec No: 80–94.
- 16 Daniel H, Bornstein S S, Kane G C; Health and Public Policy Committee of the American College of Physicians. Addressing social determinants to improve patient care and promote health equity. An American College of Physicians position paper. *Ann Intern Med* 2018; 168: 577–578.
- 17 Fair E, Miller C R, Ottmani S E, Fox G J, Hopewell P C. Tuberculosis contact investigation in low- and middle-income countries: standardized definitions and indicators. *Int J Tuberc Lung Dis* 2015; 19: 269–272.
- 18 Uganda National Tuberculosis and Leprosy Control Programme. Manual for management and control of tuberculosis and leprosy in Uganda. 3rd ed. Kampala, Uganda: Ministry of Health, The Republic of Uganda, 2017.
- 19 Ministry of Health, The Republic of Uganda. The Uganda National Tuberculosis Prevalence Survey, 2014–2015 survey report. Kampala, Uganda: MoH, 2017.
- 20 World Health Organization. Uganda tuberculosis profile. Geneva, Switzerland: WHO, 2016.
- 21 Oxlade O, Murray M. Tuberculosis and poverty: why are the poor at greater risk in India? *PLOS ONE* 2012; 7: e47533.
- 22 Osamor P E, Grady C. Women's autonomy in health care decision-making

in developing countries: a synthesis of the literature. *Int J Womens Health* 2016; 8: 191–202.

- 23 Blok L, Sahu S, Creswell J, Alba S, Stevens R, Bakker M I. Comparative meta-analysis of tuberculosis contact investigation interventions in eleven high burden countries. *PLOS ONE* 2015; 10: e0119822.
- 24 Morrison J, Pai M, Hopewell P C. Tuberculosis and latent tuberculosis infection in close contacts of people with pulmonary tuberculosis in low-income and middle-income countries: a systematic review and meta-analysis. *Lancet Infect Dis* 2008; 8: 359–368.
- 25 Wingfield T, Tovar M A, Huff D, et al. The economic effects of supporting tuberculosis-affected households in Peru. *Eur Respir J* 2016; 48: 1396–1410.
- 26 Barter D M, Agboola S O, Murray M B, Barnighausen T. Tuberculosis and poverty: the contribution of patient costs in sub-Saharan Africa—a systematic review. *BMC Public Health* 2012; 12: 980.
- 27 Boccia D, Pedrazzoli D, Wingfield T, et al. Towards cash transfer interventions for tuberculosis prevention, care and control: key operational challenges and research priorities. *BMC Infect Dis* 2016; 16: 307.
- 28 Boccia D, Hargreaves J, Lönnroth K, et al. Cash transfer and microfinance interventions for tuberculosis control: review of the impact evidence and policy implications. *Int J Tuberc Lung Dis* 2011; 15 (Suppl 2): 37–49.
- 29 Fields G S. Education and income distribution in developing countries: a review of the literature. Washington DC, USA: World Bank, 1980.
- 30 Tola H H, Shojaeizadeh D, Tol A, et al. Psychological and educational intervention to improve tuberculosis treatment adherence in Ethiopia based on health belief model: a cluster randomized control trial. *PLOS ONE* 2016; 11: e0155147.
- 31 Berkman N D, Sheridan S L, Donahue K E, Halpern D J, Crotty K. Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med* 2011; 155: 97–107.
- 32 Adamowicz W, Dickie M, Gerking S, Veronesi M, Zinner D. Household decision making and valuation of environmental health risks to parents and their children. *J Assoc Environ Res Econ* 2014; 1: 481–519.
- 33 Pokhrel S, Sauerborn R. Household decision-making on child health care in developing countries: the case of Nepal. *Health Policy Plan* 2004; 19: 218–233.
- 34 Krieger N, Williams D R, Moss N E. Measuring social class in US public health research: concepts, methodologies, and guidelines. *Annu Rev Public Health* 1997; 18: 341–378.
- 35 Clemens T, Dibben C. A method for estimating wage, using standardised occupational classifications, for use in medical research in the place of self-reported income. *BMC Med Res Methodol* 2014; 14: 59.

APPENDIX

Among control-arm households, 46% were excluded because they did not identify a household head or report income. To assess possible selection bias arising from this exclusion, we compared excluded households with included households using con-

TABLE A.1 Association between household enrollment and evaluation outcome + additional variables

Variables	Contact-level association		Household-adjusted association	
	χ^2	P value	χ^2	P value
Evaluation completion	3.632	0.057	0.280	0.598
Contact male sex	0.249	0.618	0.380	0.538
Contact HIV-positive	0.843	0.359	0.780	0.378
Contact age	3.554	0.169	2.500	0.114

HIV = human immunodeficiency virus.

TABLE A.2 Association between missing income data and evaluation outcome + additional variables

Variables	Contact-level association		Household-adjusted association	
	χ^2	P value	χ^2	P value
Evaluation completion	1.747	0.186	2.340	0.126
Education level of household head	0.695	0.404	0.000	0.957
Sex of household head	0.115	0.734	0.720	0.396
Sex of contact	0.529	0.467	0.580	0.446
Contact HIV	1.145	0.285	1.340	0.247
Contact age	4.189	0.123	3.57	0.059

HIV = human immunodeficiency virus.

tact-level, household-cluster-adjusted χ^2 analyses (Tables A.1 and A.2). We tested associations between study outcomes and covariates and 1) the presence or absence of a household head, and 2) the presence or absence of complete income information. We found no significant differences and no evidence of selection bias.

To further analyze the socio-economic variables without interference from motivational differences in contacts based upon clinical variables (presence of TB symptoms vs. belonging to risk groups), the contact sample was stratified to include only con-

FIGURE A Parent study enrollment flow diagram. TB = tuberculosis; PHI = personal health information; SMS = short messaging service.

TABLE A.3 Multivariable model for contacts reporting TB symptoms

Variables	Bivariate results		Multivariate results	
	RR (95%CI)	P value	RR (95%CI)*	P value
Below median income	0.19 (0.08–0.49)	0.018	0.23 (0.06–0.82)	0.024
Primary education only†	0.41 (0.27–0.59)	0.048	0.43 (0.20–0.93)	0.032
Contact age, years				
<5	1	—	1	—
5–14	0.97 (0.85–1.10)	0.941	0.82 (0.77–2.83)	0.405
>14	0.91 (0.80–1.03)	0.903	0.55 (0.59–8.02)	0.101

*Adjusted for household clustering using generalized estimating equations.

†Educational level of head of household.

TB = tuberculosis; RR = risk ratio; CI = confidence interval.

tacts reporting tuberculosis (TB) symptoms. This analysis included 68 contacts from 39 households, 29 (42%) of whom completed TB evaluation. In this stratified model, lower household income (adjusted risk ratio [aRR] 0.23, 95% confidence interval [CI] 0.06–

0.82, $P = 0.024$) and lower education levels of the household head (aRR 0.43, 95%CI 0.20–0.93, $P = 0.032$) remained statistically significant. Contact age improved model fit, but was not statistically significant.

Contexte : Sept unités de tuberculose (TB) du secteur public et les communautés qui les entourent à Kampala, Ouganda.

Objectif : Evaluer l'influence des caractéristiques socioéconomiques des foyers sur l'achèvement de la recherche de TB lors de l'investigation des contacts domiciliaires.

Schéma : Une étude transversale au sein du bras témoin d'un essai randomisé, contrôlé, évaluant le recueil de crachats à domicile et les communications par messagerie SMS. Nous avons utilisé des équations d'estimations généralisées afin d'estimer l'association entre l'achèvement de l'évaluation de la TB et les déterminants socioéconomiques.

Résultats : Parmi les 116 contacts domiciliaires qui ont été référés à des centres de santé pour un bilan de TB, 32 (28%) ont achevé cette évaluation. L'achèvement de l'évaluation a été fortement regroupé

par foyer. En contrôlant les symptômes individuels, les contacts des foyers ayant un revenu inférieur à la médiane (ratio de risque ajusté [RRa] 0,28 ; IC95% 0,09–0,88 ; $P = 0,029$) et les contacts des foyers dont le niveau d'instruction du chef ne dépassait pas l'école primaire (RRa 0,40 ; IC95% 0,18–0,89 ; $P = 0,025$) ont été significativement moins susceptibles de terminer le bilan de TB.

Conclusion : Les facteurs socioéconomiques tels qu'un faible revenu et un faible niveau d'études augmentent le risque que les contacts domiciliaires de patients TB soient confrontés à des obstacles à l'achèvement de l'évaluation de la TB. Davantage de recherche est nécessaire pour identifier les mécanismes spécifiques par lesquels des déterminants sociaux sous-jacents modifient la capacité et la motivation des contacts à terminer leur bilan.

Marco de Referencia: Siete unidades de tuberculosis (TB) del sector público y las comunidades aledañas en Kampala, Uganda.

Objetivo: Evaluar la influencia de las características socioeconómicas de los hogares en la compleción de la evaluación de la TB durante la investigación de contactos domiciliarios.

Método: Fue este un estudio transversal anidado en la rama de referencia de un ensayo clínico aleatorizado, que evaluaba la recogida de esputo en los hogares y las comunicaciones por servicio de SMS. Se aplicaron ecuaciones de estimación generalizadas con el fin de apreciar la asociación entre la compleción de la investigación de la TB y los determinantes socioeconómicos.

Resultados: Se remitieron a los consultorios 116 contactos domiciliarios para investigación de la TB y 32 completaron la evaluación (28%). La compleción de la investigación exhibió una importante distribución en

conglomerados por hogares. Al ajustar con respecto a los síntomas individuales, se observó que era mucho menos probable que se completase la investigación de la TB en los contactos de hogares con un ingreso familiar por debajo de la mediana (razón de riesgos ajustada [aRR] 0,28; IC95% 0,09–0,88; $P = 0,029$) y en los contactos de hogares cuya cabeza de familia no tenía un grado de instrucción superior al nivel primario (aRR 0,40; IC95% 0,18–0,89; $P = 0,025$).

Conclusión: Los factores socioeconómicos como un bajo ingreso y un grado inferior de instrucción aumentan el riesgo de que los contactos domiciliarios encuentren obstáculos propios para completar la investigación de TB. Se precisan nuevas investigaciones que definan los mecanismos mediante los cuales estos determinantes sociales subyacentes modifican la capacidad y la motivación de las personas a finalizar la investigación de contactos.