Published in final edited form as:

Int J Tuberc Lung Dis. 2016 July ; 20(7): 948–954. doi:10.5588/ijtld.15.0759.

The impact of social conditions on patient adherence to pulmonary tuberculosis treatment

H. Choi^{*,†}, H. Chung^{‡,§}, C. Muntaner[¶], M. Lee^{*}, Y. Kim^{*}, C. E. Barry III[#], and S-N Cho^{*,**}

^{*}Clinical Research Section, International Tuberculosis Research Center, Changwon

[†]Department of Research and Development, The Korean Institute of Tuberculosis, Cheongju

[‡]BK21PLUS Program in Embodiment: Health-Society Interaction, Department of Public Health Sciences, Graduate School, Korea University, Seoul

[§]School of Health Policy & Management, College of Health Science, Korea University, Seoul, Republic of Korea

[¶]Bloomberg Faculty of Nursing, Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada

[#]Tuberculosis Research Section, Laboratory of Clinical Infectious Disease, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland, USA

^{**}Department of Microbiology and Institute for Immunology and Immunological Diseases, BK21PLUS Project for Medical Science, Yonsei University College of Medicine, Seoul, Republic of Korea

SUMMARY

SETTING—Tuberculosis (TB) remains one of the main concerns in global health. One of the main threats to treatment success is patient non-adherence to anti-tuberculosis treatment.

OBJECTIVE—To identify the relation between social conditions and treatment adherence in a prospective cohort setting in an intermediate TB burden country.

DESIGN—To identify associations between poor adherence and social conditions, including educational level, type of residence and occupation, we constructed hierarchical logistic regression models.

RESULTS—A total of 551 participants were included in the study. Low educational levels, poor housing and occupations in the construction and manufacturing industries and service sectors were associated with poor adherence; this association was likely to be differentiated by previous history of anti-tuberculosis treatment.

CONCLUSION—Policy making should focus on improving the social conditions of patients by working towards better housing conditions and providing health promoting working conditions to enable treatment adherence.

Correspondence to: H Chung, B-365, Hana Science Hall, 145, Anam-ro, Seongbuk-gu, Seoul, Republic of Korea.
hpolicy@korea.ac.kr.

Conflicts of interest: none declared.

RESUME

La tuberculose (TB) reste l'une des préoccupations majeures de santé dans le monde. L'une des principales entraves au succès du traitement réside dans l'adhésion médiocre des patients au traitement de la TB.

Déterminer l'association entre les conditions sociales et l'adhésion au traitement de TB dans un contexte de cohorte dans un pays à fardeau de TB intermédiaire.

Pour identifier les associations entre une adhésion médiocre et les conditions sociales, notamment le niveau d'instruction, le statut du logement et la profession, nous avons construit des modèles de régression logistique hiérarchique.

Un total de 551 participants ont été inclus dans l'étude. Un faible niveau d'instruction, un logement pauvre et des professions particulières comme ouvriers du bâtiment, ouvriers d'usine et travailleurs dans les métiers de service, ont été associés avec une adhésion médiocre. Ces associations ont eu tendance à être différenciées en fonction des antécédents de traitement préalable de la TB.

Les interventions de politique devraient être attentives à améliorer les conditions sociales des patients, notamment par la promotion d'un habitat amélioré et de conditions de travail favorables à la santé, tous facteurs qui contribueraient à l'adhésion au traitement.

RESUMEN

La tuberculosis (TB) sigue siendo uno de los mayores problemas de salud en el mundo. Uno de los principales obstáculos a la eficacia terapéutica es el incumplimiento del tratamiento antituberculoso por parte de los pacientes.

Definir la relación de las condiciones sociales del paciente con el cumplimiento terapéutico en un país con una carga intermedia de morbilidad por TB.

Con el propósito de definir la asociación entre el incumplimiento y las condiciones sociales, como el grado de escolaridad, las condiciones de vivienda y la ocupación, se construyeron modelos jerárquicos de regresión logística.

Se incluyeron en el estudio 551 pacientes. Los factores que se asociaron con el incumplimiento terapéutico fueron el bajo grado de escolaridad, las condiciones desfavorables de vivienda y determinadas ocupaciones como el trabajo en los sectores de la construcción, las fábricas y los servicios. Con frecuencia esta asociación estuvo determinada por el antecedente de un tratamiento antituberculoso.

Las intervenciones normativas deben abordar el mejoramiento de las condiciones sociales del paciente, como fomentar una situación adecuada de vivienda y entornos laborales favorables a la salud, que faciliten el cumplimiento terapéutico.

Keywords

TB; socio-economic position; adherence; loss to follow-up; infectious epidemiology

Tuberculosis (TB) remains a major global health concern, with 9.0 million persons with active disease notified in 2013.¹ One of the main threats to treatment success is patient adherence to antituberculosis treatment,² as poor adherence directly increases the likelihood of developing drug-resistant TB, and it is also a risk factor for relapse or death.³ As a consequence of global concerns about this problem, strategies to improve treatment outcomes focus heavily on extending directly observed treatment (DOT) coverage to ensure adherence.⁴ Such programmes, while well-intentioned, emphasise medical supervision of drug intake as a method of preventing unfavourable results rather than attempting to address underlying social issues such as human immunodeficiency virus (HIV) infection,⁵ substance use,^{6–8} low education levels⁹ and low socio-economic position,¹⁰ all of which predispose patients to nonadherence from the start of treatment. However, according to a recent World Health Organization (WHO) report, factors likely to improve adherence include socio-economic factors, individual behavioural factors and the health delivery system;¹¹ social interventions should therefore be beneficial.

Many quantitative studies have investigated risk factors associated with poor adherence to antituberculosis treatment. However, few studies have examined the relationship between socio-economic determinants of treatment adherence in the field of social epidemiology. Some studies have reported that previous history of TB, including number of previous TB episodes and previous treatment interruptions, were risk factors for current adherence.^{12,13} However, previous TB history may not be causal but simply an indicator of vulnerability. Conceptually, we may consider treatment-related factors, including previous history, as effect modifiers,¹¹ and previous TB history may affect the association between social conditions and treatment adherence.

In the present study, we aimed to identify the relation between conditions and TB adherence. The secondary objective of the study was to determine whether or not the association differs according to previous TB history.

STUDY POPULATION AND METHODS

Study population and design

Data were extracted from a prospective cohort project conducted at the National Masan Tuberculosis Hospital (NMTH), Masan, and the National Medical Center (NMC), Seoul, South Korea, in 2005–2012 ([ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT00341601) ID: NCT00341601). The original study protocol aimed to identify predictors of unfavourable treatment outcomes among new and previously treated TB cases. There were two study sites: a government-supported tertiary hospital, and NMTH, a TB referral hospital. The study team enrolled participants aged ≥ 20 years with confirmed sputum positivity on acid-fast bacilli (AFB) smear microscopy or any molecular tests. Participants were excluded if they were aged > 65 years, as we included only the working-age population to examine the impact of occupation on adherence.

Investigators first obtained informed consent from all new or previously treated TB cases who had started a new treatment regimen within the last 2 months. Trained study nurses then collected baseline information from consenting participants using a questionnaire. The study team collected clinical information by regularly reviewing medical records and/or by phone

during the treatment period and during up to 40 months of follow-up after the end of treatment.

Measures

The main outcome variable was poor adherence or loss to follow-up (LTFU), defined as treatment interruption for at least 2 consecutive months and not restarting the same regimen within 6 months.

As independent variables, social conditions were measured using level of education, type of accommodation and occupation at baseline. Educational level was categorised into three groups: university or higher, high school, and middle school or lower or refusal to respond. Type of accommodation was categorised into two groups: private and shared accommodation. Occupation was classified into five groups: 1) non-employment, 2) professional, health care or office workers, 3) service workers, 4) workers in the construction or manufacturing industries, and 5) agriculture or aquaculture workers. Non-employment was defined as unemployment or having no income, regardless of job-seeking efforts, as unemployment and economic inactivity were indistinguishable in the data collected.

We also analysed other covariates that had been reported to be risk factors of poor adherence in previous studies, including age,¹⁴ side effects of antituberculosis chemotherapy,^{6,7} HIV co-infection,⁵ previous TB history⁸ and harmful behaviours such as drug and alcohol use and smoking.^{6–8} As some data on the variables were not available, we collected data on other sociodemographic information, including sex, age and place of residence, at baseline. Age was categorised into three groups: 20–34, 35–49 and 50–65 years, and place of residence into two groups: large cities (metropolitan city) and small cities/towns (provincial city and town). Clinical information included previous history of anti-tuberculosis treatment (new cases and previously treated cases), previous history of treatment failure, previous history of LTFU, diabetes mellitus (DM) status, body mass index (BMI), treatment regimen (first- and second-line drugs) and extent of disease as seen on chest X-ray (CXR) (unilateral or bilateral lesions). We followed the WHO definition for previous TB history.¹ DM was defined as currently being on medication for DM at entry. Behavioural factors such as smoking history and alcohol consumption were also included.

Data analysis

The proportion of poor adherence for all variables was estimated using Pearson's χ^2 test. To estimate the association between poor adherence and social conditions, we constructed hierarchical logistic regression models to examine the impact of covariates, including demographic, clinical and behavioural factors. Model 1 was adjusted for demographic factors, including age, sex and place of residence. Clinical factors were added to Model 2, which included DM, BMI, treatment regimen and extent of disease as seen on CXR. In Model 3, behavioural factors, including smoking status and alcohol uses, were added. To determine associations that differed according to previous TB history (new cases or previously treated cases), hierarchical logistic regression analyses stratified with each variable were performed using the same structure as the unstratified models described above. In addition, we analysed the association between social conditions and poor adherence that

differed according to history of poor adherence and previous history of failure among previously treated cases. All statistical analyses were performed using Stata/SE version 12.0 (StataCorp, College Station, TX, USA).

Ethical considerations

All study participants provided informed consent. The study was approved by the Institutional Review Boards of the National Medical Center, Seoul, and the National Masan Tuberculosis Hospital, Masan, South Korea, and the National Institute of Allergy and Infectious Disease, Bethesda, MD, USA.

RESULTS

A total of 551 participants were included in the study. The general distribution of the poorly adherent proportion by covariates is shown in Table 1. Males and the 35–49 year age group were more likely to be recorded as LTFU; however, this difference was not statistically significant. Among clinical factors, patients treated with second-line drugs were significantly more likely to be recorded as poor adherence than those receiving first-line drugs. Among previously treated cases, the proportion of LTFU was higher in cases with a history of LTFU. With regard to behavioural factors, patients who consumed alcohol at least once a week or who had ever smoked presented a statistically significantly higher proportion of poor adherence. As regards social conditions, individuals with low educational level, poor housing status or service industry workers and workers in the construction or manufacturing industries presented a higher rate of poor adherence; all differences, except for educational level, were statistically significant (Table 2).

In unstratified hierarchical logistic regression, all social conditions were associated with poor adherence (Table 3). In Models 1 and 2, the group with the lowest educational level was significantly more likely to be LTFU than those with university education (adjusted odds ratio [aOR] 2.32, 95% confidence interval [CI] 1.12–4.83 in Model 1; aOR 2.39, 95%CI 1.14–5.02 in Model 2). Poor accommodation was significantly associated with poor adherence in Models 2 and 3, with borderline significance in Model 1. aORs in Model 2 and 3 were respectively 2.28 (95%CI 1.11–4.72) and 2.60 (95%CI 1.22–5.56). Compared to non-employment, the ORs for poor adherence for service industry workers in Models 1 and 2 were respectively 2.27 (95%CI 1.18–4.38) and 2.33 (95%CI 1.20–4.53). Workers employed in the construction or manufacturing industries were also more likely to be recorded as LTFU than those non-employed (aOR 2.39, 95%CI 1.26–4.55 in Model 1; aOR 2.68, 95%CI 1.40–5.15 in Model 2; aOR 2.10, 95%CI 1.07–4.14 in Model 3).

In stratified analysis with previous TB history, the group with the lowest educational level and previous TB history was more likely to be associated with poor adherence than new cases in Model 2 (OR 3.03, 95%CI 1.27–7.23 vs. aOR 1.28, 95%CI 0.28–5.88). Moreover, the association between construction or manufacturing workers and poor adherence was higher in previously treated cases than in new cases in Model 3 (aOR 2.41, 95%CI 1.06–5.49 vs. aOR 1.61, 95%CI 0.46–5.65); however, the 95%CIs overlapped. In the model stratified by history of previous treatment failure, the lowest educational level and shared accommodation without previous history of treatment failure presented a higher risk of

treatment interruption than those with previous history of failure; however, the 95% CIs overlapped (Appendix Table A).*

DISCUSSION

Our analysis is one of few studies to examine social factors associated with adherence to pulmonary TB treatment. We found that low education levels, poor accommodation and certain occupations such as construction and manufacture workers and those in the service sectors were associated with poor adherence and that their associations were likely to differ according to previous TB treatment history.

Low educational levels may be related to poor adherence due to lack of awareness about treatment or the importance of treatment adherence.^{15,16} In addition, the disappearance of statistical significance in Model 3 might be related to a possible interaction with behavioural factors and previous TB history (Model 3 of Table 4). More importantly, low educational levels often determine a 'lifetime effect of socio-economic deprivation'.¹⁷ Educational level therefore determines one's position in the social hierarchy through its impact on choice of occupation.¹⁸ The association between education and adherence therefore indicates a relationship between social hierarchy and adherence. Although no direct measures for working conditions and income were used in the study, it is likely that less educated individuals work in more vulnerable conditions and earn less than individuals with higher education.

Some studies have reported that poor housing might be the cause of other unhealthy conditions; however, few studies have examined the association between type of accommodation and TB adherence.¹⁹ Our study clearly showed that shared accommodation was associated with low adherence to antituberculosis treatment in comparison with private accommodation. The stress of crowding may affect autonomy and thus adherence.

The issue of whether a certain occupation could be harmful for treatment adherence is not clear. Some studies have reported that unemployment is a risk factor for poor adherence,^{10,20,21} while another study reported that employment, rather than unemployment, was associated with low adherence.²² Other studies found that there was no difference in the rate of LTFU between employed and unemployed patients, but that certain occupations such as labourers or the occurrence of 'missed treatment due to employment' among workers could be a risk factor for low treatment adherence.²³ Our results were more in line with the latter. We identified evidence in support of our study results in qualitative studies.^{9,24–26} TB patients stated that their treatment could cause them to lose their jobs or be dismissed from work.^{9,24} Some patients who interrupted treatment reported that they were too busy with work to continue with the treatment and that there was no 'supportive work environment'.^{25,26} Poor employment conditions might reduce the worker's control and autonomy over the labour process, which could affect health care behaviour such as treatment adherence.²⁷ To sum up, vulnerable employment conditions (i.e., whether or not the patient's environment is

*The appendix is available in the online version of this article, at <http://www.ingentaconnect.com/content/ijatld/ijatld/2016/00000020/00000007/art00019>.

favourable for undergoing treatment for ≥ 6 months) appear to be a risk factor for poor treatment adherence.

Finally, the association between social conditions and treatment adherence is likely to differ according to previous TB history. One possible reason could be the longer treatment period for previously treated cases than for new cases. In general, the treatment duration for previously treated drug-susceptible TB cases is extended by 2 months compared to treatment for new cases, while multidrug-resistant TB requires treatment for at least 20 months.^{28,29} Patients with previous TB history may therefore suffer more due to their social vulnerability because of the longer treatment duration than new TB patients. Moreover, lower educational levels or poor accommodation and previous history of treatment failure were associated with better adherence than no prior history of failure. Even if a previous history of failure is often considered a negative factor for treatment adherence, the direction of effect might be altered by the context.³⁰ Based on our results, patients with a previous history of failure with low educational levels or who were exposed to poor housing may be more willing to complete full treatment.

This study has some limitations. First, the original cohort was designed to identify risk factors for drug-resistant TB among previously treated TB cases compared with new TB cases. Those with a previous history of TB were therefore over-recruited, and the study findings should be interpreted with caution. Second, some key variables were not measured in this study setting, such as individual or household income and marital status. Social support from family members or others could prevent poor adherence, and the patient's status as the main earner in the household might have had an impact on adherence. These social factors could also affect treatment adherence.

CONCLUSION

Adverse social conditions are associated with poor adherence to anti-tuberculosis treatment. Patients with a previous history of TB with low educational level or poor accommodation had poorer adherence than new cases with the same adverse social conditions. Many studies related to treatment adherence have been performed on the basis of such psychological models.³¹ However, these approaches have limitations in designing an intervention programme, as the approaches don't take social conditions into account. If we consider adherence as a health behaviour, our concerns should take into account not only individual beliefs and attitudes but also structural conditions such as social class and living conditions as determinants of treatment adherence.³² In addition, the positive effect of social interventions on TB has been emphasised in the 'Papworth Experiment' conducted in 1918–1943.³³ Policy intervention should therefore pay attention to better social conditions by promoting housing and providing health care and improved working conditions to facilitate treatment adherence.

Acknowledgments

This study was supported in part by the Intramural Research Program of the National Institute of Allergy and Infectious Diseases (NIAID), US National Institutes of Health (NIH), Bethesda, MD, USA, in part by continuous support from the Korean Centers for Disease Control of the Korean Ministry of Health and Welfare, Seoul, to the

International Tuberculosis Research Center, Masan, and in part by the Social Science Korea Program through the National Research Foundation of Korea, Daejeon, funded by the Ministry of Education, Seoul, South Korea, (NRF-2012S1A5A8022889). The authors would like to thank the patients who enrolled in this research study and the clinical staff who supported the trial.

APPENDIX

Table A

Previous history of failure and history of LTFU: stratified associations between social conditions and treatment adherence *

Variables	Education			Housing status			Health care/ professional/ office worker aOR	Occupation		
	University or higher aOR	High school aOR	Middle school or lower/refused to answer aOR	Private aOR	Shared aOR	Non-employment OR		Service industry worker aOR	Workers in construction or manufacturing aOR	Agriculture/aquaculture aOR
	(95%CI) †	(95%CI) †	(95%CI) †	(95%CI) †	(95%CI) †	(95%CI) †	(95% CI) †	(95 %CI) †	(95%CI) †	(95%CI) †
Among previously treated cases (n = 369)										
1		1.44 (0.61–3.43)	3.03 (1.27–7.23) ‡	1	2.90 (1.10–7.67) ‡	1	0.91 (0.31–2.68)	2.41 (1.10–5.26) ‡	3.08 (1.41–6.72) §	1.11 (0.21–5.84)
History of failure										
No	1	3.76 (0.77–18.25)	6.47 (1.33–31.52) ‡	1	5.31 (1.42–19.92) ‡	1	0.51 (0.05–5.08)	2.27 (0.73–7.06)	3.15 (1.01–9.79) ‡	1.26 (0.19–8.27)
Yes	1	0.71 (0.23–2.18)	1.79 (0.58–5.49)	1	1.57 (0.29–8.35)	1	1.15 (0.31–4.26)	2.48 (0.80–7.70)	2.36 (0.75–7.47)	No cases
History of LTFU										
No	1	1.39 (0.42–4.59)	1.95 (0.53–7.16)	1	7.15 (1.51–33.85) ‡	1	3.08 (0.64–14.77)	3.77 (0.84–16.93) ¶	3.49 (0.81–15.06) ¶	No cases
Yes	1	1.43 (0.36–5.55)	3.45 (0.90–13.25) ‡	1	1.88 (0.49–7.26)	1	0.19 (0.02–1.65)	1.85 (0.71–4.81)	2.63 (1.00–6.95) ¶	0.78 (0.13–4.56)

* Interruption of treatment for >2 consecutive months and not restarting the same regimen within 6 months.

† Adjusted for age, sex, place of residence, diabetes mellitus, body mass Index, treatment regimen and disease severity on chest X-ray, consistent with Model 2.

‡ $P < 0.05$.

§ $P < 0.01$.

¶ $P < 0.1$.

LTFU = loss to follow-up; aOR = adjusted odds ratio; CI = confidence Interval.

References

1. World Health Organization. Global tuberculosis report 2014. Geneva, Switzerland: WHO; 2014. WHO/HTM/TB/2014.08
2. Addington WW. Patient compliance: the most serious remaining problem in the control of tuberculosis in the United States. *Chest*. 1979; 76:741–743. [PubMed: 510021]
3. Volmink J, Garner P. Systematic review of randomised controlled trials of strategies to promote adherence to tuberculosis treatment. *BMJ*. 1997; 315:1403–1406. [PubMed: 9418086]
4. World Health Organization, Stop TB Partnership. Global Plan to Stop TB: 2011–2015. Geneva, Switzerland: WHO; 2010.
5. Naidoo P, Peltzer K, Louw J, Matseke G, McHunu G, Tutshana B. Predictors of tuberculosis (TB) and antiretroviral (ARV) medication non-adherence in public primary care patients in South Africa: a cross sectional study. *BMC Public Health*. 2013; 13:396. [PubMed: 23622516]
6. Rocha M, Pereira S, Ferreira L, Barros H. The role of adherence in tuberculosis HIV-positive patients treated in ambulatory regimen. *Eur Respir J*. 2003; 21:785–788. [PubMed: 12765421]
7. Gelmanova IY, Keshavjee S, Golubchikova VT, et al. Barriers to successful tuberculosis treatment in Tomsk, Russian Federation: non-adherence, default and the acquisition of multidrug resistance. *Bull World Health Organ*. 2007; 85:703–711. [PubMed: 18026627]
8. Cayla JA, Rodrigo T, Ruiz-Manzano J, et al. Tuberculosis treatment adherence and fatality in Spain. *Respir Res*. 2009; 10:121. [PubMed: 19951437]

9. Xu WG, Lu W, Zhou Y, Zhu LM, Shen HB, Wang JM. Adherence to anti-tuberculosis treatment among pulmonary tuberculosis patients: a qualitative and quantitative study. *BMC Health Serv Res.* 2009; 9:169. [PubMed: 19765290]
10. Mishra R, Hansen EH, Sabroe S, Kafle KK. Socio-economic status and adherence to tuberculosis treatment: a case-control study in a district of Nepal. *Int J Tuberc Lung Dis.* 2005; 9:1134–1139. [PubMed: 16229225]
11. World Health Organization. Adherence to long-term therapies: evidence for action. Geneva, Switzerland: WHO; 2003.
12. Garrido MD, Penna ML, Perez-Porcuna TM, et al. Factors Associated with tuberculosis treatment default in an endemic area of the Brazilian Amazon: a case control study. *PLOS ONE.* 2012; 7:e39134. [PubMed: 22720052]
13. Marx FM, Dunbar R, Hesseling AC, Enarson DA, Fielding K, Beyers N. Increased risk of default among previously treated tuberculosis cases in the Western Cape Province, South Africa. *Int J Tuberc Lung Dis.* 2012; 16:1059–1065. [PubMed: 22691549]
14. Li JH, Munsiff SS, Tarantino T, Dorsinville M. Adherence to treatment of latent tuberculosis infection in a clinical population in New York City. *Int J Infect Dis.* 2010; 14:E292–E297. [PubMed: 19656705]
15. Obuku EA, Meynell C, Kiboss-Kyeyune J, et al. Sociodemographic determinants and prevalence of tuberculosis knowledge in three slum populations of Uganda. *BMC Public Health.* 2012; 12:536. [PubMed: 22824498]
16. Al-Hajjaj MS, Al-Khatim IM. High rate of non-compliance with anti-tuberculosis treatment despite a retrieval system: a call for implementation of directly observed therapy in Saudi Arabia. *Int J Tuberc Lung Dis.* 2000; 4:345–349. [PubMed: 10777084]
17. Muller A. Education, income inequality, and mortality: a multiple regression analysis. *BMJ.* 2002; 324:23–25. [PubMed: 11777800]
18. Tachibanaki T. Education, occupation and earnings: a recursive approach for France. *Eur Econ Rev.* 1980; 13:103–127.
19. Thomson H, Petticrew M, Morrison D. Health effects of housing improvement: systematic review of intervention studies. *BMJ.* 2001; 323:187–190. [PubMed: 11473906]
20. Bergel FS, Gouveia N. Frequent return as a novel strategy for tuberculosis treatment adherence. *Revista de Saude Publica.* 2005; 39:898–905. [PubMed: 16341398]
21. Kliiman K, Altraja A. Predictors and mortality associated with treatment default in pulmonary tuberculosis. *Int J Tuberc Lung Dis.* 2010; 14:454–463. [PubMed: 20202304]
22. Bhagat VM, Gattani PL. Factors affecting tuberculosis retreatment defaults in Nanded, India. *Southeast Asian J Trop Med Public Health.* 2010; 41:1153–1157. [PubMed: 21073036]
23. Finlay A, Lancaster J, Holtz TH, Weyer K, Miranda A, van der Walt M. Patient- and provider-level risk factors associated with default from tuberculosis treatment, South Africa, 2002: a case-control study. *BMC Public Health.* 2012; 12:56. [PubMed: 22264339]
24. Khan MA, Walley JD, Witter SN, Shah SK, Javeed S. Tuberculosis patient adherence to direct observation: results of a social study in Pakistan. *Health Policy Plan.* 2005; 20:354–365. [PubMed: 16183735]
25. Martins N, Grace J, Kelly PM. An ethnographic study of barriers to and enabling factors for tuberculosis treatment adherence in Timor Leste. *Int J Tuberc Lung Dis.* 2008; 12:532–537. [PubMed: 18419889]
26. Naidoo P, Dick J, Cooper D. Exploring tuberculosis patients' adherence to treatment regimens and prevention programs at a public health site. *Qual Health Res.* 2009; 19:55–70. [PubMed: 18997153]
27. Muntaner C, O'Campo PJ. A critical appraisal of the demand/control model of the psychosocial work environment: epistemological, social, behavioral and class considerations. *Soc Sci Med.* 1993; 36:1509–1517. [PubMed: 8511639]
28. World Health Organization. Treatment of tuberculosis: guidelines. 4th. Geneva, Switzerland: WHO; 2010. WHO/HTM/TB/2009.420
29. World Health Organization. Guidelines for the programmatic management of drug-resistant tuberculosis 2011 update. Geneva, Switzerland: WHO; 2011. WHO/HTM/TB/2011.6

30. McDonald RJ, Memon AM, Reichman LB, et al. Successful supervised ambulatory management of tuberculosis treatment failures. *Ann Intern Med.* 1982; 96:297. [PubMed: 7059091]
31. Munro S, Lewin S, Swart T, et al. A review of health behaviour theories: how useful are these for developing interventions to promote long-term medication adherence for TB and HIV/AIDS? *BMC Public Health.* 2007; 7:104–119. [PubMed: 17561997]
32. Cockerham WC. Health lifestyle theory and the convergence of agency and structure. *J Health Soc Behav.* 2005; 46:51–67. [PubMed: 15869120]
33. Bhargava A, Pai M, Bhargava M, Marais BJ, Menzies D. Can social interventions prevent tuberculosis? *Am J Respir Crit Care Med.* 2012; 186:442–449. [PubMed: 22773730]

Table 1The general distribution of poorly adherent proportion by covariates ($n = 551$)

Variables	Cases <i>n</i>	Frequency of LTFU* <i>n</i> (%)	<i>P</i> value [†]
Demographic			
Sex			
Female	81	14 (17.3)	0.390
Male	470	101 (21.5)	
Age group, years			
20-34	154	32 (20.8)	0.188
35-49	258	61 (23.6)	
50-65	139	22 (15.8)	
Place of residence			
Small city and town	309	62 (20.06)	0.599
Large city	242	53 (21.90)	
Clinical			
TB history			
New TB case	182	33 (18.1)	0.266
Previously treated TB case	369	82 (22.2)	
DM			
Non-DM	430	87 (20.2)	0.487
DM	121	28 (23.1)	
BMI, kg/m ²			
<18.5	274	58 (21.2)	0.865
≥18.5	277	57 (20.6)	
Chest X-ray			
Unilateral lesion	83	13 (15.7)	0.205
Bilateral lesion	468	102 (21.8)	
Treatment regimen			
First-line drugs	299	53 (17.7)	0.048
Second-line drugs	252	62 (24.6)	
Failure history [‡]			
No	203	49 (24.14)	0.328
Yes	166	33 (19.88)	
History of LTFU [‡]			
No	165	26 (15.8)	0.007
Yes	204	56 (27.5)	
Behavioural			
Alcohol use, per week [§]			
<1	268	39 (14.6)	<0.001
71	283	76 (26.9)	
Smoking status			

Variables	Cases <i>n</i>	Frequency of LTFU [*] <i>n</i> (%)	<i>P</i> value [†]
Never smoked	103	12 (11.7)	0.011
Ever smoked [¶]	448	103 (23.0)	

^{*} Treatment interruption at least >2 consecutive months and not restarting the same regimen within 6 months.

[†] Pearson's χ^2 test.

[‡] Including only previously treated TB cases (*n* = 369).

[§] Number of drinks consumed by the participant on average (a drink equals about one 50 ml bottle of beer or 50 ml whisky).

[¶] Current and ex-smokers.

LTFU = loss to follow-up; TB = tuberculosis; DM = diabetes mellitus; BMI = body mass index.

Table 2

General distribution of poorly adherent proportion by social conditions

Variables	Cases <i>n</i>	Frequency of LTFU* <i>n</i> (%)	<i>P</i> value [†]
Education			
University or higher	79	11 (13.9)	0.111
High school	253	50 (19.8)	
Middle school or lower, or refused to answer	219	54 (24.7)	
Type of housing			
Private	513	103 (19.9)	0.036
Shared	38	13 (34.2)	
Occupation			
Non-employment	118	15 (12.7)	0.011
Health care/professional/office worker	62	9 (14.5)	
Service worker	154	39 (25.3)	
Workers in the construction or manufacturing industries	188	49 (26.1)	
Agriculture/aquaculture	29	3 (10.3)	

* Treatment interruption at least >2 consecutive months and not restarting the same regimen within 6 months. Pearson's χ^2 test.

LTFU = loss to follow-up.

Table 3Association between social conditions and treatment adherence ($n = 551$)

Variables	Model 1 aOR (95%CI) *	Model 2 aOR (95%CI) *	Model 3 aOR (95%CI) *
Education			
University or higher	1	1	1
High school	1.56 (0.76–3.18)	1.65 (0.80–3.41)	1.44 (0.69–3.00)
Middle school or lower, or refused to answer	2.32 (1.12–4.83) [†]	2.39 (1.14–5.02) [†]	1.91 (0.90–4.08)
Type of housing			
Private	1	1	1
Shared	2.05 (1.00–4.19)	2.28 (1.11–4.72) [†]	2.60 (1.22–5.56) [†]
Occupation			
Non-employment	1	1	1
Health care/professional/office worker	1.12 (0.46–2.75)	1.13 (0.46–2.79)	1.15 (0.46–2.85)
Service worker	2.27 (1.18–4.38) [†]	2.33 (1.20–4.53) [†]	1.93 (0.97–3.83)
Workers in the construction or manufacturing industries	2.39 (1.26–4.55) [‡]	2.68 (1.40–5.15) [‡]	2.10 (1.07–4.14) [†]
Agriculture/aquaculture	0.82 (0.22–3.11)	0.91 (0.24–3.46)	0.73 (0.19–2.86)

* Model 1 = adjusted for age, sex and place of residence; Model 2 = adjusted for Model 1 + diabetes mellitus, body mass index, treatment regimen and disease severity on chest X-ray; Model 3 = adjusted for Model 2 + smoking and alcohol.

[†] $P < 0.05$.

[‡] $P < 0.01$.

aOR = adjusted odds ratio; CI = confidence interval.

Table 4
Treatment history-stratified associations between social conditions and treatment adherence ($n = 551$)

Variables	Model 1		Model 2		Model 3	
	New case ($n = 182$)	Previously treated case ($n = 369$)	New case ($n = 182$)	Previously treated case ($n = 369$)	New case ($n = 182$)	Previously treated case ($n = 369$)
	aOR (95%CI)*	aOR (95%CI)*	aOR (95%CI)*	aOR (95%CI)*	aOR (95%CI)*	aOR (95%CI)*
Education						
University or higher	1	1	1	1	1	1
High school	1.86 (0.47–7.32)	1.52 (0.65–3.57)	1.97 (0.39–7.91)	1.44 (0.61–3.43)	1.71 (0.41–7.10)	1.27 (0.52–3.07)
Middle school or lower, or refused to answer	1.22 (0.38–2.43)	3.18 (1.35–7.51) [†]	1.28 (0.28–5.88)	3.03 (1.27–7.23) [‡]	1.02 (0.22–4.77)	2.48 (1.02–6.04) [‡]
Type of housing						
Private	1	1	1		1	1
Shared	1.85 (0.57–6.03)	2.65 (1.02–6.87) [‡]	2.01 (0.61–6.62)	2.90 (1.10–7.67) [‡]	2.81 (0.79–9.99)	3.08 (1.11–8.52) [‡]
Occupation						
Non-employment	1	1	1	1	1	1
Health care/professional/office worker	1.69 (0.32–9.03)	0.90 (0.31–2.62)	1.64 (0.30–8.88)	0.91 (0.31–2.68)	1.70 (0.31–9.44)	0.92 (0.31–2.74)
Service industry worker	2.20 (0.60–8.08)	2.22 (1.03–4.79) [‡]	2.14 (0.57–7.95)	2.41 (1.10–5.26) [‡]	1.95 (0.51–7.39)	1.99 (0.89–4.47)
Workers in the construction or manufacturing Industries	1.78 (0.52–6.10)	2.70 (1.26–5.80) [‡]	1.79 (0.52–6.18)	3.08 (1.41–6.72) [†]	1.61 (0.46–5.65)	2.41 (1.06–5.49) [‡]
Agriculture/aquaculture	0.56 (0.54–5.82)	0.99 (0.19–5.10)	0.59 (0.05–6.29)	1.11 (0.21–5.84)	0.51 (0.05–5.58)	0.93 (0.17–5.01)

* Model 1 = adjusted for age, sex and place of residence; Model 2 = adjusted for Model 1 + diabetes mellitus, body mass index, treatment regimen and disease severity on chest X-ray; Model 3 = adjusted for Model 2 + smoking and alcohol.

[†] $P < 0.01$.

[‡] $P < 0.05$.

aOR = adjusted odds ratio; CI = confidence interval.