ORIGINAL ARTICLE

Prevalence and determinants of Tuberculosis Preventive Treatment (TPT) completion in Latent Tuberculosis Infection (LTBI) among TB contacts in Selangor, from January 2022-December 2024: National TB Registry (NTBR)

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ABSTRACT

Introduction: Tuberculosis (TB) remains a major public health challenge globally and in Malaysia, where TB incidence reached 113 per 100,000 population in 2022. Latent tuberculosis infection (LTBI) affects an estimated 30% of exposed individuals, with 5-10% at risk of progression to active disease if untreated. Tuberculosis preventive treatment (TPT) effectively reduces this risk. However, completion rates remain suboptimal. In Malaysia, data on TPT completion among TB contacts, particularly at the state level, are limited. This study aimed to determine the prevalence and identify determinants of TPT completion in LTBI among TB contacts in Selangor.

Materials and Methods: A cross sectional study was conducted using secondary data from National Tuberculosis Registry (NTBR). LTBI among TB contacts who initiated TPT in Selangor between January 2022 until December 2024 were included. Multiple logistic regression analysis was performed to identify determinants of TPT completion.

Results: A total 1832 LTBI among TB contacts who initiated TPT were analyzed. The prevalence of TPT completion was 77.2% (95% CI 75.2, 79.1). Higher odds of TPT completion were observed among individuals aged 15- 24 years (aOR 2.128; 95% CI 1.280, 3.539) and 25-34 years (aOR 1.720; 95% CI 1.160, 2.551), those of Indian ethnicity (aOR 1.763; 95% CI 1.159, 2.680) and others ethnicities (aOR 2.290; 95% CI 1.157, 4.259), and those residing within 5km of a health facility in Kuala Langat (aOR 11.738; 95% CI 2.377, 57.958). In contrast, lower odds of completion were observed in LTBI among TB contacts residing in Kuala Selangor (aOR 0.149; 95% CI 0.031, 0.717) and those living more than 10km from a health facility (aOR 0.147; 95% CI 0.061, 0.350).

Conclusion: TPT completion in LTBI among TB contacts in Selangor is influenced by sociodemographic and health system-related factors, with substantial locality variation. Targeted intervention adapted to local health system and service delivery conditions, together with strengthened LTBI surveillance and data quality within the NTBR, are essential to improve TPT completion and support TB prevention efforts in Malaysia.

KEYWORDS:
TPT completion, Latent tuberculosis infection, tuberculosis contacts

INTRODUCTION

Tuberculosis (TB) continues to cause a major public health threat globally and in Malaysia.[1] In 2023, it regained its status as the leading cause of death from a single infectious agent, exceeding COVID-19 after three years.[2] Malaysia has classified into middle income country with upper moderate TB epidemiological classification.[3] TB incidence rate in Malaysia was increased to 113 per 100,000 population in 2022 as compared to 97 per 100,000 population per year in 2021.[4] It was estimated 30% of individuals exposed to *M. tuberculosis* will develop LTBI as supported by Fox, G. J., et al (5). And if left untreated, 5-10% will progress to active TB.[1,6] Those who having contact with TB cases are a well-recognized group that is likely to benefit from TPT. TPT has been demonstrated to effectively prevent the progression from LTBI to active diseases by eliminating replicating *mycobacteria*. Globally, according to Treatment Asia Group (7), TPT coverage among household contacts increased markedly, reaching 21% in 2023 compared to less than 1% in 2015 and 5% in 2019. The administration of TPT has been shown to effective in reducing the risk of progression from latent TB infection (LTBI) to active disease by 60-90% in individuals who complete the treatment regimen.[8]

However, despite the established effectiveness, TPT uptake and completion in LTBI among TB contacts remain suboptimal in many settings. The efficacy is dependent on patient adherence throughout the course of treatment and the completion of entire course.[9] Study by Alsdurf et al[10] revealed that only 18.8% of individuals eligible for TPT completed the treatment. According to a meta-analysis involving 58 study in India by Sagili KD et al[11], reported LTBI prevalence was 41%, TPT initiation 91% and TPT completion was 65%. In recent cluster-randomized trial held in China by Chen, et al[12] reported 87.1% completed TPT. In addition, a cross sectional study in USA involving 1,221 subjects have higher TPT completion with 94% among other studies.[13]

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Among risk factors contributing to TPT completion reported in previous literature worldwide includes sociodemographic factors (age, citizenship, gender), social and environmental factors (category contact, diagnosis and treatment completion of index case and screening test for LTBI), TPT-related factors (interval of initiation TPT, drug regimen, presence of side effect of treatment) and healthcare system related factors (healthcare supervision). Factors that discourage adherence causing failure in TPT completion and increasing the risk of progression to active TB. In cases where the immune system fails to control the latent infection, this can lead to severe, fulminant forms of TB, including sepsis.[14]

In Malaysia, TPT has been integrated into National TB Control Program and the enrolment to TPT was 56.1% in 2019. Despite these promising outcomes, there still limitation in recent and specific data on TPT completion in LTBI among TB contacts in Malaysia. This gap is particularly pronounced in Selangor, the most populous and urbanized state, which accounted for highest TB burden with 5,071 cases in 2018,[15] and contributed up to total 20% of total TB mortality in Malaysia.[16-18] There is lack of recent and comprehensive state level data on prevalence and determinants of TPT completion limits the ability to design targeted interventions to improve treatment adherence and outcomes. Addressing this gap, the presents study will generate critical evidence on the prevalence and identify the determinants of TPT completion in LTBI among TB contacts in Selangor. The findings of this study are anticipated to inform targeted intervention strategies to improve TPT initiation, adherence and completion. This study also aims to provide valuable input to strengthen the implementation of LTBI surveillance system in NTBR and guide policymakers in ensuring that data quality is closely monitored and periodically reviewed by the respected team. These efforts will help align national surveillance practices with both national and global TB elimination goals, thereby supporting Malaysia's commitment to achieve TB elimination objectives.

MATERIALS AND METHODS

Study Design

This is a cross-sectional study utilizing secondary data acquired from the National Tuberculosis Registry (NTBR) obtained from Tuberculosis/ Leprosy Unit, Selangor State Health Department.

Locations and Study Population

The study was carried out in LTBI patients among TB contacts started on TPT in Selangor who were registered in NTBR from January 2022 until December 2024. From *Manual Sistem Maklumat Jangkitan TIBI Laten (LTBI) Kebangsaan 2020*[19], TPT is defined as treatment for LTBI, a drug regimen that prevents the progression of LTBI to TB disease; while LTBI as a person who has been exposed to a TB-positive index case and is confirmed positive by IGRA / TST or both, without any lesions indicating TB on chest X-ray, and does not exhibit any symptoms of active TB; and TB contacts are any person who was exposed to a case of TB.

Data Collection

The inclusion criteria encompassed all individuals diagnosed as LTBI among TB contacts in Selangor who started on TPT from January 2022- December 2024. NTBR is a surveillance system database of all TB, TB contacts and LTBI cases with status of treatment. Module from NTBR used includes database on TBIS 10A1: *Daftar Kes TB Daerah*, TBIS 101C: *Pemeriksaan Kontak* and LTBIS 401A: *Senarai daftar kes LTBI*. The NTBR dataset used in this study does not include specific variable identifying incarceration status. TB contacts registered in correctional facilities are recorded within the routine surveillance system; however, incarceration status could not be distinguished in this analysis. The exclusion criteria were patients who died during TPT course, change of diagnosis during TPT course, diagnosed with TB during the TPT course, or still undergoing TPT, individuals transferred out from Selangor before completed treatment, duplicated data and those missing data > 20%. All missing data greater than 20% were managed according to pairwise deletion while missing data in independent variables less than 20% were managed using listwise deletion. The study included all patients who met the eligibility criteria by using universal sampling. To safeguard the privacy and confidentiality of the subjects, a unique identification number assigned for each participant.

Sample Size

The sample size was determined using OpenEpi for a single population proportion based on the largest sample size identified in a study by Chen, H et al[12], which reported aOR 2.09, 95% confidence interval (CI), 80% power, percent of exposed to outcome= 87.1%. The minimum sample size required for this study was 490 after as estimated 20% was added to the final sample size estimates to account for potential incomplete data.

Operational Definition

The outcome of TPT for LTBI was not defined by WHO. However, the treatment outcome operational definitions employed in the study were based on *Manual Sistem Maklumat Jangkitan TIBI Laten (LTBI) Kebangsaan 2020* [19] and *Management of Tuberculosis (4th ed.)*.[20] The operational definition for TPT outcome in this study was as follows:

1. Completion treatment: LTBI patient who has completed treatment within the scheduled duration as outlined in the guidelines for LTBI infection management
2. Non completion treatment: LTBI patient who has loss to follow up and interrupted treatment for two consecutive months or more.

Below are the operational definition for those met the exclusion criteria:

1. Still on treatment: LTBI patient on TPT who are still receiving treatment up to the 12th month of the treatment period
2. Transferred out: LTBI patient on TPT who move out of Selangor state during treatment course
3. Died during TPT course: LTBI patient who dies for any reason during course of treatment
4. Treatment failed: LTBI patient who has developed active TB during treatment or within 18 months post treatment
5. Change of diagnosis during TPT course by treating doctor

In this study, the dependent variable was the TPT outcome. It was categorized as a dichotomous variable, either TPT completion or TPT non-completion. Those who not evaluated (or no TPT outcome) was not included as TPT non-completion as this will lead to inaccurate data that limits efforts to control and eliminate TB. This group has higher risk to develop drug - resistant later on. For independent variable, age categories were classified according to the US CDC surveillance groupings, while ethnicity analysis was limited to Malaysian citizens, excluding all non-citizen participants.

Data Analysis

All statistical analyses were performed by using Statistical Package for the Social Sciences (SPSS) Version 29.0. Descriptive statistics were used to describe the study population's characteristics. All independent variables were in categorical and presented in frequency and percentage (%). Then inferential statistics were carried out to determine the factors associated with TPT completion in LTBI among TB contacts. Simple Logistic Regression (SLogR) analysis was performed to examine crude associations between sociodemographic factors (age, gender, ethnicity, citizenship, locality), social and environmental factors (category contact, diagnosis TB in index case based on anatomical location, screening test), TPT- related factors (type of treatment facility started TPT, interval time between diagnosis LTBI and initiation TPT) and healthcare system-related factor (distance from place of residence to treatment facility). Only variables with a p-value <0.25 in SLogR were selected for Multiple Logistic Regression (binary) analysis to obtain the adjusted Odds Ratio (aOR). A backward likelihood ratio (LR) approach was applied to derive the final multivariable model. Variables were subsequently removed based on statistical non-significance while assessing potential confounding effects and model stability. Variables that did not meaningfully alter the adjusted effect estimates of retained predictors were excluded from the final model. Collinearity diagnostics were assessed, and no evidence of multicollinearity was identified. Records with missing information on category of contact were retained in the analysis, as this variable was not included in the final multivariable model. Excluding these records would have resulted in unnecessary loss of sample size and reduced statistical power. A complete case analysis excluding records with missing category of contact (n=1095) was additional conducted as a sensitive analysis to assess the robustness of the findings. A p value of 0.05 with a 95% confidence interval was used to indicate statistical significance in all analyses. The Hosmer-Lemeshow test was used to assess the model's reliability and goodness- of-fit. A p-value greater than 0.05 indicates that the model fits the data well.

Ethics approval

This study was conducted according to the guidelines of the Declaration of Helsinki and approved by Faculty Ethics Review Committee, Faculty of Medicine, MARA University of Technology (UiTM) (Ref. 100- FPR (PT.9/10) (FERC-EX-25-02) and The Medical Research and Ethics Committee, Ministry of Health Malaysia (NMRR ID-25-00523-PNC (IIR). This study utilized secondary data and did not contain any patient-identifying information. As all cases were anonymized, informed consent was not obtained from individual patients. Official permission also was granted by the Director of Selangor State Health Department prior to data collection.

RESULTS

From January 2022 to December 2024, 3,128 LTBI among TB contacts started TPT recorded in the National TB Registry in Selangor. After excluding cases still on treatment (n=252), treatment failure (n=3), duplicated data (n=138) and records with incomplete data on TPT outcome incomplete data on TPT outcome (n=913), 1,832 cases of LTBI among TB contacts who started TPT in Selangor were included in the main analysis. Of these, 1,095 cases had complete information on all covariates and were included in the sensitivity analyses. Using the total number of LTBI cases who initiated TPT in Selangor (n=1,832), the prevalence of TPT completion was 77.2% (95% CI 75.2, 79.1). The flow diagram of data extraction was summarized in Figure 1.

Characteristics of TPT completion in LTBI among TB contacts in Selangor

As shown in Table I, highest frequency of TPT completion are those participants under age group 35- 44 years old, male, citizen, Malay ethnic, Hulu Langat locality and rural residence. This classification of residence was based on Household Income Selangor, 2019.[21] About 95.4% of participants has no comorbid DM and all the participants are not people living with HIV (PLHIV) patients. For social and environmental factors, majority participants are from category contact Close/ Family/ Household and the diagnosis of TB in index case based on anatomical location was Pulmonary TB. 85.7% had positive screening test by using Tuberculin Skin Test (TST). For TPT- related factors, the majority of TPT initiation was made at health clinic and the interval time between diagnosis of LTBI and initiation TPT was <2 weeks (89.3%). For healthcare system- related factors, most of participants stay 5-10km distances from treatment facility.

Determinants of TPT completion in LTBI among TB contacts in Selangor

The study variables were analyzed using SLogR for univariate analysis and multiple logistic (binary) regression, as shown in Table II. In univariate analysis, all variables except the diagnosis of index case (based on an atomical location) were the factors potentially associated with TPT completion. The following potential confounders were included in the model: gender, citizenship, residence, category contact, screening results LTBI, types of treatment facility initiate TPT and the interval time between diagnosis LTBI and initiation TPT, did not remain statistically significant in the multivariable model and were subsequently removed during the backward selection process.

After adjusting with other potential confounders, compared to reference group, the patients aged 15-24 years old and 25-34 years old had 2.13 and 1.72 times the odds of TPT completion (aOR 2.13; 95% CI 1.28, 3.54, p= 0.004; and (aOR 1.72; 95% CI 1.16, 2.55, p= 0.007) respectively. Ethnicity also found to be determinants of TPT completion. Indian and 'Others' ethnic has higher odds TPT completion compared to Malay ethnic with aOR 1.76; 95% CI 1.16, 2.68 and aOR

Table I: Characteristics of individuals with TPT completion status in LTBI among TB contacts in Selangor from January 2022- December 2024 (N=1832)

Variable	TPT Completion n (%)	TPT non- completion n (%)	Total (n=1832) n (%)[a]
Age (years)			
<5	113 (8.3)	19 (4.6)	132 (7.5)
5-14	175 (12.9)	43 (10.5)	218 (12.3)
15-24	207 (15.3)	60 (14.6)	267 (15.1)
25-34	245 (18.1)	108 (26.3)	353 (20.0)
35-44	262 (19.3)	75 (18.3)	337 (19.1)
45-54	175 (12.9)	57 (13.9)	232 (13.1)
55-64	126 (9.3)	32 (7.8)	158 (8.9)
>65	54 (4.0)	16 (3.9)	70 (4.0)
Gender			
Male	729 (51.6)	229 (54.8)	958 (52.3)
Female	685 (48.4)	189 (45.2)	874 (47.7)
Citizenship			
Citizen	1220 (86.3)	380 (90.9)	1600 (87.3)
Non-citizen	194 (13.7)	38 (9.1)	232 (12.7)
Ethnic[b]			
Malay	884 (72.5)	275 (72.6)	1159 (72.5)
Chinese	190 (15.6)	42 (11.1)	232 (14.5)
Indian	117 (9.6)	47 (12.4)	164 (10.3)
Others	28 (2.3)	15 (4.0)	43 (2.7)
Locality			
Hulu Langat	370 (26.2)	99 (23.7)	469 (25.6)
Klang	338 (76.5)	104 (24.9)	442 (24.1)
Petaling	240 (17.0)	38 (9.1)	278 (15.2)
Gombak	195 (13.8)	52 (12.4)	247 (13.5)
Kuala Selangor	100 (7.1)	12 (2.9)	112 (6.1)
Sabak Bernam	62 (4.4)	29 (6.9)	91 (5.0)
Hulu Selangor	45 (3.2)	14 (3.3)	59 (3.2)
Sepang	43 (3.0)	26 (6.2)	69 (3.8)
Kuala Langat	21 (1.5)	44 (10.5)	65 (3.5)
Residencec			
Rural	936 (66.2)	302 (72.2)	1238 (67.6)
Urban	478 (33.8)	116 (27.8)	594 (32.4)
Category contact			
Close/ Family/ Household	589 (72.8)	236 (66.3)	825 (70.8)
Social/ Institutional/ Workplace	220 (27.2)	120 (33.7)	340 (29.2)
Diagnosis of index case (based on anatomical location)			
Pulmonary TB	716 (93.2)	305 (92.7)	1021 (93.1)
Extrapulmonary	52 (6.8)	24 (7.3)	76 (6.9)
Screening results LTBI			
TST[d] positive	1191 (84.4)	377 (90.2)	1568 (85.7)
IGRA[e] test positive	150 (10.6)	25 (6.0)	175 (9.6)
Both TST and IGRA positive	70 (5.0)	16 (3.8)	86 (4.7)
Types of treatment facility initiate TPT			
Health Clinic	1273 (91.8)	332 (80.6)	1605 (89.2)
Government Hospital	113 (8.1)	25 (6.1)	138 (7.7)
Private Hospital	1 (0.1)	55 (13.3)	56 (3.1)
Interval time between diagnosis LTBI and initiation TPT			
<2 weeks	1262 (89.3)	312 (74.6)	1574 (85.9)
>2 weeks- 2 months	110 (7.8)	36 (8.6)	146 (8.0)
>2 months- 2 years	42 (3.0)	70 (16.7)	112 (6.1)
Distance from place of residence to the health facility			
<5km	472 (33.4)	91 (21.8)	563 (30.7)
5-10km	576 (40.7)	195 (46.7)	771 (42.1)
>10km	366 (25.9)	132 (31.6)	498 (27.2)

[a]Within total sample
[b]Ethnicity among Malaysian citizen only
[c]Residence: Rural residence including Hulu Langat, Klang, Kuala Selangor, Sabak Bernam, Hulu Selangor and Kuala Langat, Urban residence including Petaling, Gombak and Sepang; based on Household Income Selangor, 2019 (Department of Statistics Malaysia, 2020)
[d]TST Tuberculin Skin Test (or Mantoux test)
[e]IGRA Interferon-Gamma Release Assay

Table II: Univariate and Multivariable analysis results of determinants of TPT completion in LTBI among TB Contacts in Selangor from January 2022- December 20224 (N=1832)

Variable	Simple Logistic Regression		Multiple Logistic Regression	
	Crude OR[a] (95% CI)	p value	Adjusted OR[b] (95% CI)	p value
Age (years)				
<5	0.587 (0.339, 1.018)	0.058	0.620 (0.334, 1.153)	0.131
5'-14	0.858 (0.563, 1.308)	0.477	1.612 (0.945, 2.747)	0.079
15-24	1.013 (0.689, 1.489)	0.949	2.128 (1.280, 3.539)	**0.004***
25-34	1.540 (1.094, 2.168)	0.013*	1.720 (1.160, 2.551)	**0.007***
35-44	Reference		Reference	
45-54	1.138 (0.767, 1.687)	0.521	1.205 (0.768, 1.891)	0.418
55-64	0.887 (0.557, 1.413)	0.614	1.694 (0.955, 3.005)	0.072
>65	1.035 (0.560, 1.913)	0.912	1.169 (0.592, 2.309)	0.652
Gender				
Male	Reference			
Female	0.878 (0.706, 1.093)	0.246*		
Citizenship				
Citizen	Reference			
Non-citizen	0.629 (0.436, 0.907)	0.013*		
Ethnic				
Malay	Reference		Reference	
Chinese	0.711 (0.495, 1.019)	0.063*	0.990 (0.652, 1.503)	0.962
Indian	1.291 (0.897, 1.859)	0.169	1.763 (1.159, 2.680)	**0.008***
Others	1.722 (0.907, 3.271)	0.097*	2.290 (1.157, 4.529)	**0.017***
Locality				
Hulu Langat	Reference		Reference	
Klang	1.15 (0.842, 1.571)	0.38	1.607 (0.771, 3.347)	0.205
Petaling	0.592 (0.394, 0.890)	0.012*	0.381 (0.110, 1.323)	0.129
Gombak	0.997 (0.683, 1.454)	0.986	0.651 (0.252, 1.678)	0.374
Kuala Selangor	0.448 (0.237, 0.849)	0.014*	0.149 (0.031, 0.717)	**0.018***
Sabak Bernam	1.748 (1.067, 2.864)	0.027*	0.536 (0.146, 1.971)	0.348
Hulu Selangor	1.163 (0.613, 2.204)	0.644	0.495 (0.138, 1.780)	0.282
Sepang	2.260 (1.323, 3.859)	0.003*	1.636 (0.409, 6.555)	0.487
Kuala Langat	7.831 (4.450, 13.780)	<0.001*	1.898 (0.594, 6.071)	0.28
Residence				
Rural	Reference			
Urban	0.752 (0.591, 0.957)	0.02*		
Category contact				
Close/ Family contact/ Household	Reference			
Social/ Institutional/ Workplace	1.361 (1.040, 1.781)	0.025*		
Diagnosis of index case (anatomical location)				
Pulmonary TB	Reference			
Extrapulmonary TB	1.083 (0.656, 1.790)	0.754		
Screening results LTBI				
TST positive	Reference			
IGRA test positive	0.527 (0.339, 0.817)	0.004*		
Both TST & IGRA positive	0.722 (0.414, 1.258)	0.25		
Types of treatment facility initiate TPT				
Health Clinic	Reference			
Government Hospital	0.848 (0.541, 1.330)	0.473		
Private Hospital	210.889 (29.077, 1529.531)	<0.001*		
Interval time between diagnosis LTBI and initiation TPT				
<2 weeks	Reference			
>2 weeks- 2 months	1.324 (0.891, 1.967)	0.165*		
>2 months- 2 years	6.741 (4.509, 10.078)	<0.001*		
Distance from place of residence to the health facility				
<5km	0.569 (0.432, 0.751)	<0.001*	0.526 (0.265, 1.044)	0.066
5-10km	Reference		Reference	
>10km	1.065 (0.824, 1.377)	0.629	0.147 (0.061, 0.350)	<0.001*
Interaction Distance*Locality				
<5km*Kuala Langat			11.738 (2.377, 57.958)	0.003*

OR= Odds Ratio, aOR= Adjusted OR, CI= Confidence Interval, LTBI= latent tuberculosis infection, TPT= Tuberculosis preventive treatment
Statistical test used [a]Crude OR (Simple Logistic Regression), [b]Ajdusted OR (Multiple Logistic Regression)
The Cox & Snell R2 value is 0.123, indicating the proportion of variance explained by the model. The Hosmer-Lemeshow test, (p= 0.31), suggesting good model fit. Classification: 79% and area under the ROC curve (AUC) is 72.1% (95% CI: 69.2, 75.1), p-value <0.001). Backward LR Multiple Logistic Regression Model was applied. Constant value: -0.747 and the model assumption is met. There is no multicollinearity and interaction.
Significant values are in bold

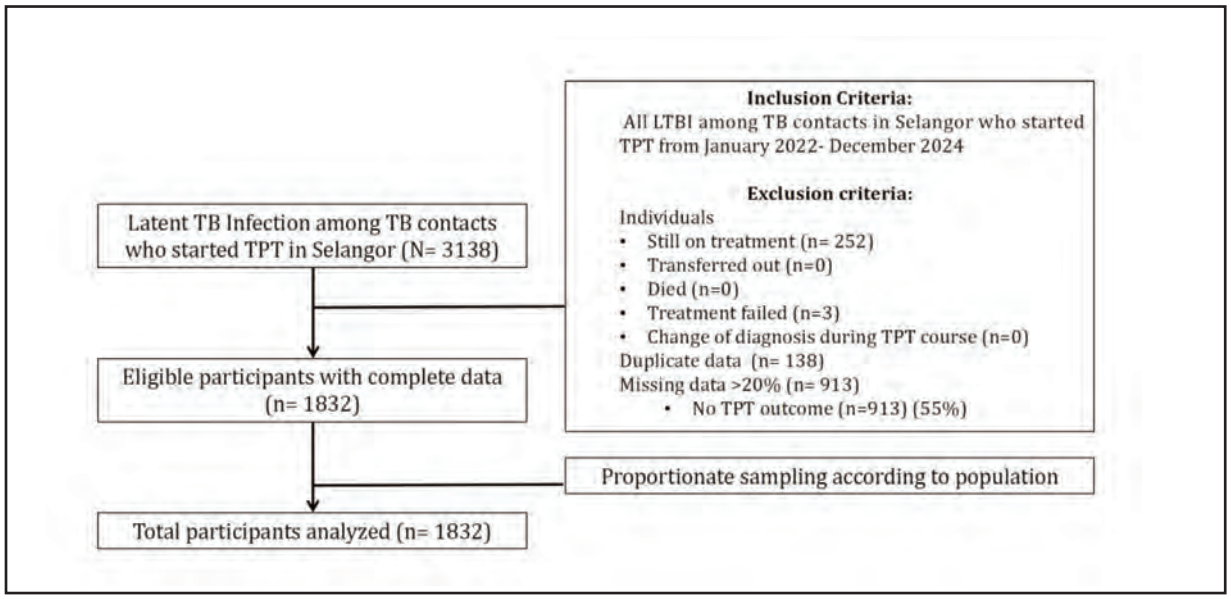

Fig. 1: Flow chart of data retrieval and extraction

2.29; 95% CI 1.16, 4.53 respectively. For locality, Kuala Selangor district has much lower odds of TPT completion with aOR 0.15; 95% CI 0.03, 0.72, compared to Hulu Langat district. Distance to health facility also affected TPT completion. LTBI individuals whom the distance from place of residence to the health facility >10km showing 0.147-time odds of TPT completion (aOR 0.147; 95% CI 0.061, 0.350). And lastly, the factor of interaction between distance and locality also found to be determinant of TPT completion. LTBI individuals who stay in Kuala Langat and the distance from residence place to health facility less than 5km has higher odds of TPT completion as compared to reference group with aOR 11.738; 95%CI 2.377, 57.958. The prediction of this model was 72.1% (95% CI:69.2, 75.1, p-value <0.001).

Overall, the direction and magnitude of effect estimates were broadly comparable between the main analysis and the sensitivity analysis, although some variables demonstrated reduced statistical significance in the smaller complete case dataset.

DISCUSSION

Based on our best knowledge, this is the first study to explore prevalence and determinants of TPT completion in Selangor using NTBR database. The present study found that TPT completion was 77.2% (95% CI 75.2, 79.1). This proportion is slightly lower that TPT completion rates in other studies.[12, 22-23]

After adjustment for potential confounders, age group, ethnicity, locality, distance to health facility and the interaction between distance and locality were significantly associated with TPT completion in LTBI among TB contacts in Selangor. Sensitivity analyses yielded largely consistent effect estimates, supporting the robustness of the main findings. The main analysis was therefore prioritized for interpretation, as it maximized available data and improved model stability without introducing additional sources of bias.

Age group

Previous studies have consistently reported age as an important determinant TPT adherence and compliance, although the direction of association varies across settings. In this study, younger age was significantly associated with higher odds of TPT completion. Compared with individuals aged 35-44 years old, those age 15-24 years and 25-34 years demonstrated significantly higher odds of TPT completion. Similar age-related patterns have been reported in other settings, where younger individuals demonstrated higher adherence and completion of TPT, likely due to fewer competing health conditions and stronger engagement with follow-up mechanism.[9,12,24] This finding suggests that working-age adults in the mid-life group may face greater barriers to treatment completion than younger individuals. Several factors may explain this association. First, individuals age 35-44 years often experience greater competing demands related to employment and childcare responsibilities, which may limit their ability to attend follow up visits consistently. Second, younger adults may exhibit higher responsiveness to health messaging, appointment reminders, and counselling particularly when concerns about future health and work capacity are emphasized. Third, younger contacts may be more frequently engaged through structured contact investigation processes and clinic based follow up systems that facilitate adherence.

Ethnicity

In this study, ethnicity emerged as important factor influencing TPT completion in LTBI among TB contacts in Selangor. Ethnic differences in TB or LTIB treatment outcomes have been reported previously and are often as proxies for underlying social, cultural and healthcare access factors rather than intrinsic behavioral differences.[25-26] Our analysis found that Indian participants and those classified under other ethnic groups demonstrating significantly higher odds of TPT completion compared with Malay participants. Possible explanations include differences in family support structures, health literacy and engagement with healthcare services across communities. Additionally, the observed

ethnic differences may be partly attributable to residual confounding by unmeasured socioeconomics factors, including occupation type, population mobility and urban density among Malaysian citizens.

Locality (district)
Variation in TPT completion across localities is likely to reflect differences in local health system capacity and the effectiveness of programmatic implementation, consistent with the TPT cascade framework, which highlights setting-specific barriers across multiple stages of care.[28] Locality based heterogeneity in TB outcomes within Selangor has been previously documented, with urban districts such as Petaling exhibiting distinct socioeconomic characteristics and disease burden profiles that may influence treatment engagement and continuity of care.[18,27] Similar locality or district level variation has also been reported in Sabah, where incomplete LTBI preventive treatment was significantly associated with region of residence, reflecting disparities in healthcare accessibility, workforce distribution and local socioeconomic conditions.[29] In contrast, a study by Musaazi et al[30], reported higher TPT completion among individuals initiating treatment at rural facilities compared with urban health centers, demonstrating that the role of service delivery context in shaping treatment adherence and influence the treatment completion. In the present study, locality was significantly associated with TPT completion with markedly lower odds observed in LTBI among TB contacts residing in Kuala Selangor compared with the reference district. This finding reinforces the influence of district level health system and contextual factors on preventive therapy outcomes. Differences in service availability, healthcare workforce capacity and the effectiveness of defaulter tracing systems may partly explain these patterns. Furthermore, population mobility related to employment and commuting, as well as variability in clinic workflows may affect patient engagement. The clinic may have different counselling quality, documentation practices and follow up mechanisms. Overall, these findings emphasize the importance of implementing district-level, context-responsive strategies to overcome local barriers and enhance TPT completion.

Distance to health facility from the place of residence
Access-related barriers, including challenges in reaching screening, diagnostic and treatment services have been consistently associated with poor completion of preventive therapy in high an intermediate incidence settings.[28] In the present study, distance to the treatment facility was a strong determinant of TPT completion, with LTBI among TB contacts residing more than 10km from a health facility demonstrating substantially lower odds of completion compared to those living 5-10km away, while a similar trend was observed among those residing within 5km. Longer travel distances increase transportation costs and time burden, contributing to miss appointments and treatment interruptions, while opportunity costs related to work and family responsibilities may further discourage repeated clinic visits. In addition, individuals living farther from healthcare facilities maybe more likely to change care locations or to be lost to follow up, compromising continuity of preventive therapy. These findings are consistent with previous studies demonstrating that geographic access barriers are strongly associated with poor TPT completion.[10,25,31]

Interaction between distance and locality
A significant interaction between distance and locality was observed, with LTBI among TB contacts residing within 5km of a health facility in Kuala Langat exhibiting substantially higher odds of TPT completion compared with the reference group. This finding suggests that the effect of geographic proximity may be shaped by local health system and service delivery conditions, whereby proximity to healthcare services may have greater benefit in certain district or locality. The observed association may reflect local service delivery characteristics, such as more efficient clinic workflows, stronger follow up mechanisms, or targeted community outreach in Kuala Langat. However, the wide confidence interval (CI) indicates potential small cell effects, and the estimate should therefore be interpreted with caution. Accordingly, this interaction appears to represent a facility or district level pathway rather than an effect that can be generalized across settings. These findings align with programmatic management framework for TPT which emphasizes that the impact of geographic access varies according to local health-system organization and service delivery.[28]

The strength of our study is that this is the first population-based analysis in Selangor to examine the prevalence and determinants of TPT completion in LTBI among TB contact using National TB Registry data. The large registry-based dataset enhances statistical power and reflects real world programmatic conditions, improving the generalizability and practical relevance of the findings or TB control planning. The inclusion of sociodemographic and healthcare access-related determinants including district-level locality, distance to health facilities and their interaction, provides insight into health-system heterogeneity within Selangor. Furthermore, the use of multivariable logistic regression with prior simple logistic regression and supporting sensitivity analyses improved internal validity and demonstrated the robustness of the findings despite missing data.

Several limitations should be considered. This study relied on secondary data analysis that were not designed for research purposes, and certain important determinants such as detailed socioeconomic status and incarceration status were not captured in the NTBR dataset. Preventive therapy delivered within correctional facilities may follow different adherence dynamics compared to community settings due to structured supervision and restricted mobility. The inability to distinguish incarcerated individuals may therefore limit generalizability and introduce residual confounding.

In addition, a substantial proportion of cases (n=913) were excluded due to missing TPT outcome data within the registry system. Although exclusion was necessary to ensure accurate outcome classification, this may introduce selection bias if the missing data were related to treatment adherence. Despite sensitive analysis to assess the robustness of findings, residual bias may remain. And the differences in data completeness across districts may also have influences the locality geographical findings. Furthermore, some interaction estimates demonstrated wide confidence intervals, likely reflecting small cell sizes in specific locality-distance subgroups, resulting in limited statistical precision.

Finally, the cross-sectional design precludes causal inference and some associations particularly interaction effects may reflect local health system or facility level factors. Despite this limitation, the consistency of results across sensitivity analyses and the population- based dataset reinforce the robustness and public health relevance of the findings.

CONCLUSION

In conclusion, this population-based study demonstrates that TPT completion in LTBI among TB contacts in Selangor is determined by combination of sociodemographic and health system-related factors including age, ethnicity, locality and distance to health facilities with evidence that effects vary according to local health system and service delivery conditions. The observed locality and access-related disparities demonstrate the importance of addressing structural and service delivery barriers that influence engagement and continuity of preventive therapy. These findings support the implementation of district level, context-adapted programmatic interventions, including strengthening patient follow up and defaulter tracing systems, improving service accessibility in underserved areas, and optimizing TPT service delivery in line with local health system capacity and operational realities.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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