ORIGINAL ARTICLE

A cohort study of factors associated with LTBI treatment initiation and completion in Hamilton, Ontario, Canada

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ABSTRACT

The Public Health Agency of Canada attributes the majority of active Tuberculosis (TB) cases in Canada to the reactivation of Latent Tuberculosis Infection (LTBI) post immigration. Since 70% of recent migrants to Canada originate from TB endemic regions of which PHAC anticipates 50% have LTBI, LTBI management and control is of growing importance in Canada. LTBI treatment is provided without cost to clients through Public Health Departments but treatment initiation and completion is suboptimal. The objective of the study was to identify the socio-economic characteristics, including those related to immigration, that are associated with LTBI treatment initiation and completion among the LTBI foreign-born population in Hamilton, Ontario, an important immigrant and refugee resettlement community.

Method: A retrospective population cohort of all LTBI cases reported between January 2, 2009 to December 23, 2014. Multivariable probit and oprobit regression analysis was used and the results tested using sensitivity analyses.

Results: Among 1,960 cases that are foreign-born, the LTBI treatment initiation rate was 22% and the unconditional completion rate 13%. LTBI medical screening at point of entry into Canada was strongly associated with initiation and completion of LTBI treatment ($p<.01$). Relative to young adults (aged 18-30 years), middle-aged adults (aged 31-49 years) were less likely to complete LTBI treatment ($p<.05$) and children (aged <18 years) were more likely to initiate treatment ($p<.01$) but not more likely to complete treatment. Having been born in a TB-endemic country and having immigrated within the past five years were not associated with treatment initiation or completion.

Conclusion: The low rates of treatment initiation and completion in this population highlight a need for better strategies to improve use of LTBI treatment by foreign-born populations. Attempts to pursue such improvements through development of evidence-based policies for LTBI management are limited by incomplete reporting on key characteristics such as risk factors and demographic information.

KEY WORDS:
Emigrants and immigrants; latent tuberculosis; bacterial infections; medication adherence

INTRODUCTION

Worldwide, tuberculosis (TB) is the number one infectious disease killer, responsible for 3.2 million deaths in 2015 (WHO, 2017b), but in Canada, like other high-income countries, TB is relatively uncommon[1]. Migrants account for 65% of all active TB cases in Canada (Greenaway et al., 2011) and the majority of these active TB cases have been attributed to the reactivation of Latent Tuberculosis Infection (LTBI), inactive TB, post immigration (Public Health Agency of Canada, 2014; Varughese, Langlois-Klassen, Long, & Li, 2014).

Canada welcomes around 300,000 refugees and immigrants annually, with around 70% originating from endemic TB zones (Public Health Agency of Canada, 2015). To protect Canadians from TB and other communicable diseases and ensure health care for migrants, Immigration, Refugees and Citizenship Canada (IRCC) requires migrants seeking to remain in Canada for longer than six months to undergo medical screening for active TB, including a chest x-ray (Box 1). The chest x-ray can identify active and past incidences of pulmonary TB due to scarring on the lungs. If evidence of infection is found, further

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Contributions and statement: The study was conceived, designed and managed by DM, SB, JH, FS, BN and BE. DM led the analysis of the data in consultation with the other authors and wrote the first draft of the paper. All authors provided critical feedback and comments on the paper, contributed to the writing, and approved the final draft.

[1] Canada reports 1,600 new cases of TB annually.

BOX 1: Overview of processes for detection and treatment of LTBI in Ontario

TB is a reportable condition in Ontario, however LTBI is not explicitly indicated. This can result in inconsistencies in the reporting of LTBI cases and relevant risk factors.

There are five ways in which LTBI can be detected:

a) *Immigration medical exam*: A medical exam is required for all migrants to Canada who intend to remain in the country for greater than six months. Includes a chest x-ray to rule out active TB.
b) *Contacts of active TB cases*: Public Health recommends certain contacts of individuals with active TB be tested.
c) *Occupation and education requirements:* Training programs, volunteer placements and some professions require applicants to receive screening and/or diagnostic testing to confirm they do not have active TB.
d) *Adhoc provider screening*: Some providers routinely test patients who are from or who travel regularly to TB endemic countries.
e) *Incidental finding*: Individuals may receive a chest x-ray for other reasons (e.g. to diagnose heart failure).

In all cases, testing is aimed at detecting active TB. If LTBI is detected, individuals are referred to their local public health unit or health provider to discuss treatment options. Information, including known risk factors on all detected cases of LTBI should be reported to the local public health unit for follow up.

Treatment is provided free. Some health units dispense medications via pharmacies as well as directly through health care providers. There can be out-of-pocket costs associated with testing (i.e. depending on whether the TST or IGRA test is used), and routine monitoring (i.e. liver tests). This varies by jurisdiction and provider.

testing will be conducted to determine whether the infection is active or stable. Active cases must be treated prior to entering Canada (Citizenship and Immigration Canada, 2013). Any close contacts of the active TB case will receive a tuberculin skin test (TST) and if found to be positive for LTBI but not TB, be required to report to public health within 30 days for medical surveillance (Citizenship and Immigration Canada, 2013; Government of Canada, 2013). It is estimated around 50% of current immigrants to Canada have LTBI (Public Health Agency of Canada, 2014) but the majority pass through to Canada undetected.

Individuals with LTBI are estimated to have a 5-10% lifetime risk of developing active TB with the greatest risk occurring within the first two to five years post exposure to Mycobacterium tuberculosis (Greenaway et al., 2011; Hirsch-Moverman, Daftary, Franks, & Colson, 2008; Public Health Agency of Canada, 2014; WHO, 2017a). Treatment for LTBI can mitigate the risk of TB reactivation and is therefore offered to the recipients without cost at point of delivery; however, LTBI treatment initiation and completion is suboptimal (Hirsch-Moverman et al., 2008; Kane et al., 2013; Lui, Birch, Newbold, & Essue, 2017; Sandgren et al., 2016). A physician and patient's decision to engage in treatment can be influenced by many factors besides direct cost such as medical contraindications, socio-economic factors, culture, language, lifestyle choices, fear of side effects, health knowledge, treatment duration and healthcare access (Greenaway et al., 2011; Lui et al., 2017; WHO, 2014).

The aim of this study was to identify the socio-economic factors, including those relating to the immigration process, that are associated with LTBI treatment initiation and completion among the LTBI foreign-born in Hamilton, Ontario, an important immigrant and refugee resettlement community. The results will be of interest to public health jurisdictions with large migrant populations.

METHODS

Study population, design, and data

We analyzed data from a retrospective population cohort of all LTBI cases, both foreign-born and domestic, reported to the Hamilton Public Health Services (HPHS) between January 2, 2009 and December 23, 2014. Data were from the integrated Public Health Information System (iPHIS), which is an information system used for reporting case information for all provincially and nationally reportable communicable diseases. The database contains information on age, sex, country of birth, origin (Canadian-born, Foreign-born), date the individual was entered into the database, time since immigration, means of identification as LTBI, the first three digits in the postal code (forward sortation area, FSA) at time of LTBI diagnosis, whether medication was dispensed, and whether treatment was completed. While these fields are contained in iPHIS, reporting data for each of the fields is not mandatory. Hamilton is located approximately 60 kilometres from Toronto. In 2016 the population was 536,917, with a total immigrant population of 130,365 (24.3%); 13,150 of whom arrived between 2011 and 2016 (Statistics Canada, 2018). Recent immigrants (past 5 years) mostly originate from Asia (7,555), with over 1,000 from each of India, Iraq, Syria, and the Philippines (Statistics Canada, 2018). Hamilton is also the destination for a large number of refugees, and has been designated as a settlement centre. The study was approved by the Hamilton Integrated Research Ethic Board.

Outcome variables

The two dependent variables for the analysis were a) initiation of treatment (defined as dispensed LTBI medication) and b) completion of treatment (defined as completed the course of medication as prescribed by the clinician). The conditional completion rate is the proportion that completed medication given that treatment was initiated.

Dispensed medication was used as a proxy for initiation of treatment. This captures most individuals who initiate treatment, as it is unlikely that an individual would opt to

receive medication through an alternative source since the medication is available free of charge through the public health department.

Completion of treatment was analysed using a binary measure derived from data entered into the database by a public health nurse based on the notes of the treating clinicians. We coded treatment as completed if the nurse entered 'completed as recommended' or 'completed satisfactory'. We coded treatment as incomplete if the nurse entered 'incomplete,' 'non-compliance,' 'other' or 'unknown.'

Covariates

The following explanatory variables were included in the analysis: age, sex, origin (foreign-born, domestic), TB-endemic country of birth, time since immigration, income, identified with LTBI through immigration medical screening program.

The variable 'country of birth' was used to derive a variable to identify individuals who were born in a WHO identified TB endemic country (WHO, 2012). Country of birth was used as a proxy for country of immigration because the country of immigration variable was incomplete. The date the individual was entered into the database was considered the episode start date. Time since immigration was derived by subtracting the immigration date from the episode start date. Since the greatest risk of reactivation of TB is in the first five years after exposure and greater risk may be associated with higher rates of initiation and completion of LTBI treatment, the variable was dichotomized to identify those who had immigrated less than six years before the episode start date. Because different life stages may result in different healthcare seeking behaviours, the age variable was coded into five groups, <18 years, 18-30 years (young adults), 31-49 years (middle age), 50-64 years (older adults), and >64 years (seniors). The youngest adult age group was the reference category. The episode start date was the date the individual was entered into the database.

We created a proxy for socio-economic status using the median individual income variable from Canada's 2006 FSA-level census[2]. Since the average family size in the City of Hamilton (Statistics Canada, 2007) was three, the SES variable used in this analysis was a binary variable that uses the before tax LICO (Low Income Cut-Off) threshold for a family of three ($31,801 rounded to $32,000), which is similar in value to the median individual income of immigrants in Hamilton aged 25-54 years with no university education ($32,350) (Social Planning and Research Council of Hamilton, 2009; Wayland, 2010). We opted to use median individual income at the FSA-level rather than economic family income because the HPHS database did not contain information on the family status of the individual (i.e. single, married, married with child). (See Appendix A at *https://ipac-canada.org/cjic-abstracts-online-journal-2.php*.)

ANALYSIS

Probit multivariable regression analysis was used to explore the relationship between both initiation and completion, and the covariates listed above. Cases were omitted from the regression analysis if country of origin was missing. A secondary analysis investigated the association between individual characteristics and those individuals lost to follow-up.

The model was fitted using all available and relevant variables. Variables that did not contribute to the model were backwards eliminated using the joint F-test and the Likelihood Ratio Test.

Because several variables were aggregated at the FSA level, where possible, models were fitted using bootstrapping and robust cluster errors at the FSA. Clustering the errors at the FSA level controlled for intergroup correlation – individuals that live near each other may be similar in unobservable ways, while bootstrapping should help control for the potential of model misspecification due to small sample size (Ong, 2014). The data were analyzed using Stata 14.

RESULTS

Descriptive analysis

The data were pooled for the 5 years of the study period. The full sample consisted of 3,036 LTBI cases, of which 1,970 were reported as foreign-born. Of the 780 who were dispensed medication, our proxy for initiation, 441 were reported as foreign-born. However, the foreign-born is likely under-reported since the origin variable (foreign-born versus Canadian-born) is missing for 33% of the full sample and 40% of those dispensed medication (see Table 1). Those of unknown origin tended to be older than foreign-born (>50 years, 33% vs 20%, respectively). The treatment initiation rate in the full sample is 25.7% whereas the initiation rate is marginally lower among the foreign-born at 22.4%.

TABLE 1: Sample distribution by birth country

	Full Sample	Sub-sample (dispensed med)
ORIGIN	n(%)	n(%)
Canadian Born	74 (2.4)	27 (3.5)
Foreign Born	1,970 (64.9)	441 (56.5)
Unknown	992 (32.7)	312 (40.0)
Total	**3,036 (100)**	**780 (100)**

*Canadian-born non-Aboriginal and Canadian-born Aboriginal were combined due to the small number of Aboriginal Canadians in the sample.

The binary completion variable was missing for 9% of the sample (41 of 441 who were foreign-born and dispensed medication) (see Table 2).

[2] We use the 2006 Census because researchers have voiced concerns around data quality due to the voluntary nature of the 2011 long-form census. Prior to 2011, the Canadian long-form census and the short-form census were mandatory. The concern with the voluntary nature of the census is that those who are most likely to benefit from social programs are the least likely to participate. As a result, they would be under-represented in the data. Since the first year of this study is 2009, the 2006 Census should be reasonably reflective of the time-period of this study.

TABLE 2: Characteristics of Foreign-Born Persons with Latent Tuberculosis Infection Who Initiated and Completed Treatment; Hamilton, Canada 2009 – 2014

	Sample	Initiation		Sample	Completion		
	N	NO	YES	N	NO	YES	Missing
		n (%)	n (%)		n (%)	n (%)	n (%)
Age<18 yrs	93	56 (60)	37 (40)	37	10 (29)	25 (72)	2 (5)
18-30 yrs	703	572 (81)	131 (19)	131	48 (40)	71 (60)	12 (9)
31-49 yrs	786	607 (77)	179 (23)	179	49 (31)	109 (69)	21 (12)
50-64 yrs	227	160 (70)	67 (30)	67	12 (19)	52 (81)	3 (4)
>64 yrs	161	134 (83)	27 (17)	27	3 (31)	21 (82)	3 (11)
Total	**1,970**	1529 (78)	441	**400**	122 (31)	278 (70)	41 (9)
Missing				41			
Pearson chi2(4) = 31.5295 Pr = 0.000				Pearson chi2(8) = 17.3842 Pr = 0.026			
Male	875	692 (79)	183 (21)	183	56 (35)	106 (65)	21 (11)
Female	1,095	837 (76)	258 (24)	258	66 (28)	172 (72)	20 (8)
Total	**1,970**	1529 (78)	441 (22)	**400**	122 (31)	278 (70)	41 (9)
Missing				41			
Pearson chi2(1) = 1.9619 Pr = 0.161				Pearson chi2(2) = 3.8700 Pr = 0.144			
Immigrated five years ago or less							
No	820	650 (79)	170 (21)	170	40 (26)	113 (74)	17 (10)
Yes	591	446 (75)	145 (25)	145	47 (35)	86 (65)	12 (8)
Total	**1,411**	1096 (78)	315 (22)	**315**	87 (30)	199 (70)	29 (9)
Missing	559	433 (77)	126 (23)	126	35 (28)	79 (63)	12 (10)
Pearson chi2(1) = 2.8645 Pr = 0.091				Pearson chi2(4) = 3.1332 Pr = 0.536			
Born in TB endemic country							
No	1,080	846 (78)	234 (22)	234	70 (33)	141 (67)	23(10)
Yes	826	639 (77)	187 (23)	187	49 (28)	124 (72)	14 (7)
Total	1,906	1485 (78)	421 (22)	**421**	119 (31)	265 (69)	37 (9)
Missing	64	44 (69)	20 (31)	20	3 (15)	13 (65)	12 (10)
Pearson chi2(1) = 0.2572 Pr = 0.612				Pearson chi2(4) = 5.5439 Pr = 0.236			
FSA income less than or equal to $35,000							
No	185	152 (82)	33 (18)	33	12 (41)	17 (59)	4 (12)
Yes	1,770	1365 (77)	405 (23)	405	108 (29)	260 (71)	37 (9)
Total	1,955	1517 78)	438 (22)	**397**	120 (30)	277 (70)	41 (10)
Missing	15	12 (80)	3 (20)	44	2 (67)	1 (33)	0 (0)
Pearson chi2(1) = 2.4508 Pr = 0.117				Pearson chi2(4) = 4.4728 Pr = 0.346			
LTBI identified by immigration screening							
No	1,822	1449 (80)	373 (20)	340	114 (34)	226 (66)	33 (9)
Yes	128	66 (52)	62 (48)	54	7 (13)	47 (87)	8 (13)
Total	1,950	1515 (78)	435 (22)	**394**	121 (28)	273 (63)	41 (9)
Missing	20	14 (70)	6 (30)	47	1 (17)	5 (83)	0 (0)
Pearson chi2(1) = 53.9680 Pr = 0.000				Pearson chi2(4) = 11.2603 Pr = 0.024			

The chi square test for treatment initiation and individual characteristics suggests an association between initiation and age, and initiation and identification of LTBI through immigration screening (see Table 2). Of the 1,970 foreign born individuals, 7% were identified with LTBI through immigration screening, which is consistent with the national average (Greenaway et al., 2011).

REGRESSION RESULTS

Children (age <18 years) were more likely to initiate treatment than all other age groups (OR 2.8, p<.01). Individuals identified through immigration medical screening programs were more likely to initiate and complete treatment relative to the reference group individuals not identified at immigration (OR 3.2 and 5.2, p<.01, respectively) (see Table 3).

Relative to young adults (aged 18-30 years), immigrants aged 31-49 and 50-64 were less likely to complete treatment (OR .53 and .33, P<.05). Females were more likely to complete treatment (OR 1.8, p<.05) and those with low income (FSA income proxy <CDN$32,000) were less likely to complete treatment (OR .38, p<.05).

For 'Lost to follow up' individuals identified with LTBI through immigration medical screening and female sex were less likely to be lost to follow-up (OR .08, p<.01 and OR .47, p<.05, respectively).

We conducted several robustness checks including alternative models such as a self-reported completion variable, the Heckman selection model and the generalized linear model as well as recoded some variables. The results reported here were robust to model specification and recoding. (See Appendix B at *https://ipac-canada.org/cjic-abstracts-online-journal-2.php*.)

DISCUSSION

LTBI treatment would reduce the number of active TB cases, yet the observed initiation and completion rates for LTBI treatment have been universally suboptimal (Hirsch-Moverman

TABLE 3: Regression results for the final three models with the factors explaining a) treatment initiation, b) treatment completion, and c) lost to follow up in this study population

	A Treatment initiation	B Treatment completion	C Lost to follow up
VARIABLES	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Under 18 yrs	2.812*** (1.449 - 5.456)	1.965 (0.753 - 5.128)	0.863 (0.263 - 2.833)
31 to 49 yrs (ref)	0.767 (0.495 - 1.188)	0.537** (0.310 - 0.931)	2.676* (0.948 - 7.554)
50 to 64 yrs	0.960 (0.663 - 1.389)	0.331** (0.126 - 0.871)	2.715 (0.749 - 9.847)
Over 64 yrs	0.966 (0.485 - 1.924)	1.871 (0.196 - 17.87)	1.403 (0.113 - 17.42)
Female	1.302* (0.960 - 1.766)	1.793** (1.134 - 2.834)	0.467** (0.249 - 0.876)
High TB birth country	0.967 (0.690 - 1.356)	1.525 (0.897 - 2.591)	0.849 (0.426 - 1.692)
Immigrated <6yrs	0.964 (0.679 - 1.368)	0.579 (0.271 - 1.237)	1.074 (0.415 - 2.776)
FSA income =<$32,000	1.299 (0.848 - 1.991)	0.376** (0.161 - 0.880)	1.092 (0.406 - 2.936)
Identified by immigration	3.166*** (1.994 - 5.026)	5.217*** (2.426 - 11.22)	0.0808*** (0.0164 - 0.399)
Observations	1,357	276	276
Pseudo R-squared	0.0316	0.109	0.105

*** p<0.01, ** p<0.05, * p<0.1

While the main analysis used probit modelling, the results are reported as Odds Ratios for ease of interpretation. 95% confidence intervals are in parentheses. Model A and B were bootstrapped with robust clustered errors at the FSA-level. Model C used robust cluster errors at the FSA-level. See the online supplement for full details of each model (*https://ipac-canada.org/cjic-abstracts-online-journal-2.php*).

et al., 2008; Kane et al., 2013; Lui et al., 2017; Sandgren et al., 2016). We found an initiation rate (defined as dispensed medication) for LTBI treatment between 22%, a conditional completion rate (conditioned on starting treatment) of 59%, and an unconditional completion rate of 13%. Other public health regions elsewhere in Ontario have reported higher initiation rates (42%) but similar completion rates (Nguyen & Frenette, 2012). A Quebec study that used a similar definition of initiation (dispensed medication) reported a conditional completion rate of 31.3% (Rivest, Street, & Allard, 2013).

We also found that, controlling for multiple factors, immigrant children were more likely to initiate LTBI treatment relative to young adults (18-30 years) but not more likely to complete the treatment. Since children under five years of age are at greater risk of developing TB and at greater risk of complications including mortality, the initiation results were as expected for this age group (Lonnroth et al., 2015; Public Health Agency of Canada, 2014). However, despite being well tolerated by children, poor completion rates for the nine-month INH protocol has been documented (A. Cruz & Starke, 2014; A. T. Cruz, Ahmed, Mandalakas, & Starke, 2013).

Other studies have found inconsistent results for age and completion. Bieberly and Ali (2008) found greater rates of non-completion for ages 19-35, while Trauer and Krause (2011) found greater failure to complete treatment among older age groups. Li et al. (2010) report greater completion rates after age 35, while other studies report no effect of age on completion (Ailinger, Black, Nguyen, & Lasus, 2007; Shieh et al., 2006).

The inconsistency for age and completion may be due to how various studies defined age. Some studies used a pivotal age point, 35 years of age; whereas we considered differences in initiation and completion at different stages of adulthood. For example, relative to younger adults, middle-age adults (age 31 to 49) may face greater opportunity costs due to family responsibilities, child care needs and workplace insecurity, which could make it more difficult for them to keep the frequent medical appointments (every six weeks). Adults aged 50 years and older face a greater risk of hepatoxicity due to LTBI treatment (Greenaway et al., 2011; Public Health Agency of Canada, 2014), which might make them less likely to be recommended treatment and therefore less likely to initiate treatment and more likely to discontinue treatment due to medical complications. Finally, those 65 years and older have likely left the workforce and have reduced family responsibilities, leaving them more able to initiate and adhere to treatment. Older adults in Canada also have greater access to medical coverage for prescription drugs and other health care services, which could facilitate the decision to seek LTBI treatment. As anticipated, we found a strong, robust and negative association with middle age (31 to 49 years) and completion relative to younger adults (18 to 30 years).

We also found that foreign-born women were more likely to complete LTBI treatment and less likely to be lost to follow-up than foreign-born males. These results are consistent with some LTBI literature (Rogo et al., 2017; Trauer & Krause, 2011) but inconsistent with other literature that found a negative association (Kan, Kalin, & Bruchfeld, 2013; Lui et al., 2017; Rivest et al., 2013). Other studies found no effect of sex on completion (Ailinger et al., 2007; Shieh et al., 2006).

The strongest and perhaps most compelling result is the strong and robust relationship between each dependent variable (initiation, completion, and lost to follow-up) and identification through immigration screening. We cannot conclude, however, that improved immigration screening would increase initiation and completion rates or reduce the numbers lost to follow-up because there could be unobservable differences between the people identified through immigration screening and those who are not. IRCC identifies opportunistically either by finding evidence of past TB infection on the chest x-ray or through TST testing of close contacts of active TB cases. For these individuals, the knowledge of being recently exposed to TB or seeing visible evidence of a past TB infection on the chest x-ray may make them more receptive to LTBI treatment. However, for the majority of migrants from TB endemic countries, LTBI has become normalized and LTBI is not typically treated in the source country. Although Canada may be inadvertently reinforcing the message that LTBI is a low priority health concern by not specifically screening for it, a change in IRCC screening policy may not have any impact on a group that views LTBI as normal. In addition, there is anecdotal evidence that some individuals may intentionally conceal evidence of TB exposure or other health issues during the immigration medical screening process. While this viewpoint has not been documented in the published literature, it is an area worthy of further investigation given that only 1-3% of active TB cases and 3-5% of LTBI cases (Greenaway et al., 2011; Khan et al., 2015) are identified through immigration screening, prompting calls for changes to IRCC screening policy (Khan et al., 2015; Varughese et al., 2014).

Identifying the extent of the data gaps in the Public Health administrative data is another important contribution of this study (Essue et al., 2018). LTBI is not a mandatory reportable condition in Canada and so vital information on known risk factors and demographic information is not consistently available, which hinders efforts to develop evidence-informed policy. For example, a Swedish study on LTBI completion rates observed a high failure rate among migrants from specific countries (Kan et al., 2013). In our dataset, over 35% of observations were missing for country of origin. Data gaps like this result in missed opportunities to ensure that the current strategies are well targeted and reaching the groups who would benefit most from LTBI treatment.

LIMITATIONS

The dataset had a high proportion of missing observations for some key explanatory variables such as country of birth and immigration country. Ideally, we would like to use immigration country as a proxy for high TB risk; but due to data limitations we relied on country of birth. Country of birth has some potential shortcomings because an individual's birth country could be a low TB risk country while the country immigrated from could be a high TB risk country. In addition, the origin (foreign-born, Canadian-born) was missing for 40% of the sample. However, as

a robustness check, we recoded the missing observations for birth country to foreign-born and found that the results were generally consistent. A notable exception was the strong and positive association between aged 50-64 years and lost to follow-up. Observations were also missing for almost a third of the ordinal dependent variable and nearly a tenth of the binary dependent variable. However, the results remained consistent across models irrespective of differences in the proportion of missing observations. Nonetheless, the high proportion of missing observations for country of birth and completion variables along with observable differences between the known and unknown origin groups suggests that the results may not be generalizable.

In addition, some of the bootstrapped probit models encountered problems with the number of replicates that could not be estimated – most likely due to the small number of positive results associated with some variables. Where we encountered problems with bootstrapping, we took our inference from the model with the largest standard errors. This did not alter our findings.

We were unable to control for underlying medical conditions and/or health status as this information was either incomplete or not available. Finally, the finding that lower income is associated with lower likelihood of completing treatment should be interpreted with caution as we used a neighbourhood proxy for income and it is possible that other characteristics of the individual or neighbourhood could explain this relationship.

CONCLUSION

The main contribution of this study is the finding that immigrants in Hamilton, Ontario identified with LTBI at the point of entry into Canada, relative to those identified through other means, were more likely to be receptive to LTBI treatment initiation and completion, an important component of TB control. We have also demonstrated that more consistent and comprehensive data could reveal valuable and actionable insights into population characteristics that are associated with treatment completion.

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