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Tuberculosis-related hospital use among recent immigrants to Canada • Research Article

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Abstract

Background: While the incidence of active tuberculosis (TB) in Canada is among the lowest in the world, the rates of TB among immigrants and Indigenous people remain high. In fact, the majority of new active TB cases are disproportionately found among immigrants. This study profiles TB-related acute care hospitalizations among new immigrants to Canada by selected characteristics.

Data and methods: This study is based on the 2000-to-2013 Longitudinal Immigration Database (IMDB) linked to the Canadian Institute for Health Information's Discharge Abstract Database (DAD) from 2001/2002 to 2013/2014. It examines the timing of first TB-related acute care hospitalization occurring from the fiscal year 2001/2002 to the fiscal year 2013/2014 among immigrants who landed in Canada from 2000 to 2013 outside of Quebec and the territories. Mean and median hospital days and the percentage of total TB hospitalizations incurred by these new immigrants are calculated to measure the burden of hospital care among recent immigrants.

Results: From 2001/2002 to 2013/2014, 1,120 out of 2.7 million immigrants arriving between 2000 and 2013 were found to have, in total, 1,340 TB-related hospital discharges. The majority of cases (97%) were among immigrants from the Immigration, Refugees and Citizenship Canada (IRCC) designated country list for TB, in which about three quarters of the cases were from the World Health Organization (WHO) list of high TB-burden countries. Approximately half (45%) of immigrants hospitalized for TB were aged 18 to 34 at the time of hospitalization. Around 10% of all TB patients had been hospitalized before formally landing as immigrants. Mean and median length of hospital stay were 17 days and 11 days, respectively (22 days and 14 days, respectively, for the overall population in Canada). While new immigrants who landed between 2000 and 2013 represent 7% of the overall population of Canada, they incurred 17% of all TB-related hospital discharges occurring during this period.

Interpretation: This paper demonstrates the value of linked administrative data to understanding immigrant health and is important for future work in this area. Current immigration protocols surrounding TB involve screening for active pulmonary TB and identifying some migrants with latent TB. Results of this study, linking TB-related hospitalizations to immigrant landing files, provide unique information that can inform public health action, as well as migration policy and program development to contribute to the efforts to eliminate TB.

Keywords: Tuberculosis, immigrant health, health policy, health care utilization.

Globally, tuberculosis (TB) is responsible for the largest number of deaths of any infectious disease, surpassing HIV and malaria combined.[1] In 2015, there were an estimated 10.4 million new cases of active TB worldwide.[2] Global targets and milestones for reducing the burden of TB have been established as part of the United Nations Sustainable Development Goals and the World Health Organization (WHO) End TB Strategy.[3,4] Recommendations for countries with low TB incidence, such as Canada, as well as the Government of Canada's federal framework for action on TB, are directed at decreasing rates of TB in Canada.[5,6,7]

There is an overall shift of TB epidemiology in countries with low incidence of TB, in that the local-born population has a lower TB incidence than immigrants.[8,9] This is also the case in Canada, with the notable exception of Indigenous people. Among the 1,737 cases of active TB reported in 2016, the incidence among the non-Indigenous Canadian-born population was 0.6 per 100,000 population (8% of total cases), compared with 15.2 among the foreign-born population (70% of total cases) and 23.5 among Canadian-born Indigenous people (19% of total cases).[8] TB cases among immigrants originated primarily from countries with relatively high TB incidence rates.[2,8]

TB is monitored in Canada by the Public Health Agency of Canada (PHAC), in collaboration with provincial and territorial public health authorities through the Canadian Tuberculosis Reporting System (CTBRS) and the Canadian Tuberculosis Laboratory Surveillance System (CTLSS). While these systems can be used to report on TB rates by country of birth, reporting by immigrant class (e.g., economic, family, refugee) is not possible.[10] Information about TB exists in health administrative data such as hospital records from the Canadian Institute for Health Information (CIHI), available at Statistics Canada. Although active TB can usually be treated on an outpatient basis, some patients require in-hospital management. Active TB includes patients with pulmonary and non-pulmonary TB (e.g., meningeal TB). As such, the number of TB-related hospitalizations is not identical to the reporting of active TB done for the CTBRS. Instead, the reported number can indicate the severity of TB disease in Canada and reflect the management of TB cases as part of the continuum of TB-related care.[11] However, immigration-related variables are not routinely collected in hospital data.[12] Linking hospital data to immigrant landing records in Canada enables immigrant-related analyses.[13,14]

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What is already known on this subject?

- Global targets to eliminate tuberculosis (TB) have been established by the United Nations and the World Health Organization, and the Government of Canada is committed to further reducing the rate of TB in Canada.

- While the incidence of active TB in Canada is among the lowest in the world, immigrants represented the majority of new active TB cases. Therefore, there is a need to understand and reduce TB among immigrants in Canada.

What does this study add?

- This is the first national study (outside of Quebec) addressing TB-related hospitalizations among new immigrants to Canada.

- Data linkage provides a new and innovative data source on TB among immigrants across the country in a way that complements national surveillance data.

- Top countries for TB cases correspond with the top three source countries of immigrants to Canada. In terms of incidence, Ethiopia and Somalia are among the top countries with post-landing TB hospitalization rates.

- Approximately 10% of the study cohort had pre-landing TB hospitalization in Canada, with a high representation of refugees as well as individuals from the Philippines.

- While immigrants arriving to Canada from 2000 to 2013 represented 7% of the overall population, this group disproportionately incurred 17% of all TB-related hospital discharges during this period.

This study provides new evidence on TB-related hospitalizations among new immigrants to Canada. It uses a unique linked data file that brings together information from immigrant landing records and hospital data for a maximum of 13 years to identify a TB-related hospital event after landing. Specifically, this paper provides a profile of the timing of TB-related acute care hospitalization, starting from the time of landing among immigrants who officially landed in Canada from 2000 to 2013, as well as an estimation of the burden of TB hospital care in Canada incurred by these recent immigrants relative to the total Canadian population.

Methods and data

Data linkage

The Immigrant Landing File (ILF) data were linked to the CIHI Discharge Abstract Database (DAD) using the Social Data Linkage Environment (SDLE) at Statistics Canada. SDLE is a highly secure linkage environment that helps create linked population data files for social analysis by creating a central depository called the Derived Record Depository (DRD).[15] The DRD is a national dynamic relational database containing only basic personal identifiers. It was created by linking selected Statistics Canada source index files, including tax, birth and death data, to produce a list of unique individuals. The DRD is the core of SDLE, to which all other databases are linked. The linkage was approved by Statistics Canada's senior management,[16] and use of the linked data is governed by the Directive on Microdata Linkage.[17]

The ILF contains administrative information for all individuals who have landed in Canada since 1980, which is provided to Statistics Canada on a monthly basis by Immigration, Refugees and Citizenship Canada (IRCC). The ILF includes information on year of birth, sex, time of entry (month and year), intended province of destination, source country and admission category (e.g., economic, refugee).[18] Landing records from 1980 to 2013 were eligible for linkage (8,450,469 records for a total

of 6,896,592 immigrants). The linkage of the ILF to the DRD was conducted using probabilistic methods based on the following variables: date of birth, names (surnames and given names), postal code, city, sex, marital status, entry date, and dates of birth of the immediately younger and older person in the family. Overall, 85% (n=5,854,949) of immigrant records were linked. This is consistent with previous linkages conducted based on the ILF.[19] Since the DRD is primarily based on tax data, analysis of linked records versus non-linked records revealed that younger immigrants were underrepresented because they do not file taxes.

The DAD contains demographic, administrative and clinical data for all acute care hospital discharges and some psychiatric, chronic rehabilitation and day-surgery hospital discharges for all provinces and territories, excluding Manitoba before April 2004 and Quebec.[20] The data are provided to Statistics Canada annually by CIHI for each hospital fiscal year (from April to March of the following year). Hospital discharges occurring from April 1, 1994, to March 31, 2015, were eligible for linkage (n=77,925,269). The linkage was conducted using a deterministic approach using the following variables: date of birth, postal code, sex and health insurance number. Overall, 85% (n=66,246,909) of hospital records were linked to the DRD. Analysis of linked records versus non-linked records revealed similar distributions of individual-level characteristics (e.g., age, sex, year of entry), indicating no evidence of bias.[21]

Study cohort

The study cohort comprises new immigrants who landed from January 2000 to December 2013 and were linked to the DRD (n=2,730,390): immigrants in the Longitudinal Immigration Database (IMDB), which included only taxfiling immigrants (n=2,200,420), and immigrants who landed in the same period but never filed taxes, and, therefore, were not included in the IMDB (n=529,970). The IMDB is derived from the ILF and is a

research database representing unduplicated immigrant records that have also been linked to tax data.[18] The post-2000 cohort of immigrants was chosen to ensure continuous follow-up after arrival and to minimize the possibility of immigrants who entered the country having already gone back to their home country or moved on to another country. To correct for the underrepresentation of younger immigrants noted above, the study cohort also includes the unique immigrants who landed during the same period from 2000 to 2013 who were not originally included in the IMDB, most of whom were young immigrant non-tax-filers (nearly 50% of immigrants younger than 20 years of age). These non-taxfilers also include some seniors (about 15% of immigrants older than 60 years of age). Adding these non-taxfilers back to the linkage with the IMDB ensures that the analysis is not confined only to taxfilers. For simplicity, the rest of this paper will use the IMDB cohort to describe the study cohort. Approximately 840,000 hospital discharges occurring from April 1, 2001, to March 31, 2014, were linked to an immigrant record.

Variables of interest

Age was derived from the IMDB as the date of birth to 2013. Age at hospitalization among those hospitalized for TB was derived based on the difference between birth year, from the IMDB, and the year of hospitalization, from the DAD. Age was grouped as follows: 0 to 17 years, 18 to 24 years, 25 to 34 years, 35 to 44 years, 45 to 64 years, and 65 years and older. Landing year was defined as the year immigrants became legal permanent residents (this is not necessarily the same as the year of arrival in Canada), as recorded in the IMDB. The categories for period of immigration were used as a proxy for the duration since landing and were categorized as follows: 2000 to 2003, 2004 to 2008, and 2009 to 2013. Because immigrants could be temporary residents in Canada before immigration, individuals in this group could be hospitalized before landing. The time to the

first TB hospitalization during the follow-up time (a maximum of 13 years) was classified from the landing month as follows: less than 0 months after landing (i.e., occurred before landing), 0 to 12 months after landing, 13 to 60 months after landing, and 60 or more months after landing. Any hospitalization that occurred in the same month as landing is classified as post-landing in this study.

Immigrants were identified as having come from a country of birth with high risk of TB based on the designated country list for TB from IRCC. The IRCC list includes all countries already on the WHO list of countries with high TB burden,[22] as well as any other IRCC-specific countries (see Appendix 1). The latter group (IRCC-specific) was identified as any country not in the WHO list but with a TB incidence level of 30 per 100,000 population or more. This level is consistent with mathematical models estimating that this TB incidence level is cost-effective for interventions that aims at limiting the reactivation of post-landing latent TB infection.[23,24] Results among the immigrants from countries with high risk of TB were presented for all designated countries overall and by source: the WHO list, and countries added by IRCC (i.e., IRCC-specific). All remaining countries are categorized as low risk. The 12 countries among recent immigrants with the highest number of TB-related hospital events were also highlighted.

Province of residence was measured in two ways: (1) based on the province of intended residence, as reported in the IMDB; and (2) based on the province submitting the data to the DAD. Since some immigrants may move to another province after landing, the province of intended residence may

not be the same as the province of hospitalization. Therefore, the province information submitted for the hospital discharge abstract was used as a proxy for the province of residence. Because of low numbers, selected provinces were grouped as follows: the Atlantic region (Newfoundland and Labrador, Nova Scotia, New Brunswick, and Prince Edward Island) and the Prairies (Manitoba, Saskatchewan and Alberta).

Immigrant category, as reported on the IMDB, is defined as immigrants admitted to Canada under the economic, family or refugee class defined in the 2001 Immigration and Refugee Protection Act.[25] The immigrant classes examined were the following: (1) economic, principal applicant; (2) economic, spouse or children (including provincial nominees, available as of 1996); (3) family (for family reunion purposes); (4) refugee (for humanitarian purposes); and (5) others, unknown or missing.

Outcomes

The primary outcome is TB-related acute care hospitalizations of immigrants discharged from April 1, 2001, to March 31, 2014, as identified using the International Classification of Diseases (ICD-9 and ICD-10) codes for the most responsible diagnosis (Table 1).[26,27] Hospitalizations among immigrants were derived from the linked IMDB–DAD data; hospitalizations among the remaining population were identified using the full DAD files linked in SDLE, minus records linked to an IMDB record for the same period.

Statistical methods

Descriptive statistics were generated to profile the study cohort. The distributions of immigrants with at least one TB-related hospitalization overall and

Table 1
ICD-9 and ICD-10 codes used to identify tuberculosis in this study

	ICD-9	ICD-10
Respiratory tuberculosis	010,011,012	A15, A16
Tuberculosis of nervous system	013	A17
Tuberculosis of other organs	014,015,016,017	A18
Miliary tuberculosis	018	A19
Sequelae of tuberculosis	137	B90

Source: World Health Organization, International Classification of Diseases (ICD) revisions 9 and 10.

of immigrants by duration of time from immigration landing to the first hospitalization are presented by selected characteristics. Person-year adjusted incidence of TB per 100,000 population is also calculated to present rates adjusted for years of follow-up. Hospitalizations occurring before landing were excluded from this calculation, since time of entry before official landing is needed to derive the exposure-adjusted incidence rate.

To measure the burden of TB-related hospitalizations among new immigrants, the mean, median and 90th percentile of all TB-related hospitalizations are derived for each of the characteristics of interest. Because the length of hospitalization for TB has a skewed distribution to the right, the results will include means and medians. The percentage of TB-related hospital discharges among recent immigrants is derived from two sources: the number of TB-related hospital discharges among recent immigrants included in the hospital file from 2001 to 2013, and the total number of discharges among all people within SDLE, regardless of immigrant status. This percentage is calculated by age at hospitalization, sex, region of submitting province, and hospital fiscal year, each available from the DAD database.

Results

Baseline characteristics of immigrant cohort

Around 2.7 million immigrants who arrived in Canada from 2000 to 2013 were in the study cohort (outside of Quebec and the territories, as well as Manitoba before April 2004). Approximately 52% of the cohort were females, and more than 45% were 25 to 44 years of age (Table 2). The majority (73%) of the cohort landed in Canada after 2003. Approximately half of the study cohort were from the following six countries: China (15%), India (15%), the Philippines (11%), Pakistan (4%), Iran (3%) and the United States (3%) (data not shown). Approximately 74% of the study cohort came from countries on the IRCC designated list for TB, composed of countries from the WHO high

TB-burden list (58%) and IRCC-specific countries (16%). Most immigrants intended to reside in Ontario (60%). The majority (59%) of the cohort arrived as immigrants in the economic category, while 28% arrived in the family category and 11% arrived in the refugee category.

Distribution of immigrants with at least one TB-related hospitalization

Approximately 1,120 immigrants were found to have at least one acute care hospital discharge for TB from the fiscal year 2001/2002 to the fiscal year 2013/2014 (Table 3), totalling 1,340 TB-related hospitalizations. Approximately half (45%) of immigrants hospitalized for TB were aged 18 to 34 at the time of hospitalization. More males than females were

found to have had TB-related hospitalization (52% males compared with 48% females). Most cases occurred among immigrants who landed before 2009. A large majority of cases (97%) occurred among immigrants from the IRCC list of designated countries for TB: 77% were from the WHO list of high TB-burden countries, while an additional 20% were from IRCC-specific countries. India, the Philippines, China, Ethiopia, Pakistan and Somalia were the leading countries of birth of immigrants hospitalized for TB; immigrants from these countries together represented 61% of all recent immigrants with TB-related hospitalization. By immigrant category, most cases occurred among the family and refugee categories (37% and 29%, respectively).

Table 2

Characteristics of the 2000-to-2013 linked cohort of recent immigrants to Canada by selected characteristics, Canada excluding Quebec and the territories†

Characteristics	number	%
Total	**2,730,390**	**100**
Age groups in 2013		
0 to 17 years	413,990	15.2
18 to 24 years	265,860	9.7
25 to 34 years	547,795	20.1
35 to 44 years	694,750	25.5
45 to 64 years	640,805	23.5
65 years and older	167,195	6.1
Sex		
Male	1,322,655	48.4
Female	1,407,715	51.6
Landing year		
2000 to 2003	741,420	27.2
2004 to 2008	985,285	36.1
2009 to 2013	1,003,685	36.8
Country risk level‡		
Low	713,785	26.1
High (WHO+IRCC-specific)	2,016,605	73.9
WHO	1,585,925	58.1
IRCC-specific	430,680	15.8
Intended region of residence		
Atlantic	67,990	2.5
Ontario	1,635,210	59.9
Prairies†	500,575	18.3
British Columbia	526,420	19.3
Immigrant class		
Economic, principal applicants	637,110	23.3
Economic, spouse/children	974,805	35.7
Family	764,190	28.0
Refugee	290,605	10.6
Other/unknown/missing	63,685	2.3

† The Manitoba landing cohort includes only individuals who landed after March 2004, when hospital data were made available.
‡ The country risk level is based on the IRCC list (Appendix 1).

Notes: Subtotals may not add up to the total because of rounding or missing information. WHO stands for World Health Organization. IRCC stands for Immigration, Refugees and Citizenship Canada. IMDB stands for Longitudinal Immigration Database. DAD stands for Discharge Abstract Database.
Source: 2000-to-2013 IMDB–DAD linked database.

Table 3
Distribution of new immigrants with at least one tuberculosis-related acute care hospitalization, by time of the first hospitalization from time of immigration landing, by selected characteristics among immigrant cohorts from 2000 to 2013, Canada excluding Quebec and the territories†, 2001/2002 to 2013/2014

			Time since landing (pre- and post-immigration), in months				
				Post-landing, by time since immigration landing			
	Total first tuberculosis-related hospitalizations		Pre-landing (Less than 0 months at landing)	All (On or after landing)	Months since landing		
					0 to 12 months‡	13 to 60 months	More than 60 months
Total	1,120		110	1,015	200	545	270
2000-to-2013 landing cohort	100		9.6	90.4	17.7	48.6	24.1
	number	% distribution	% distribution by characteristics within each time duration (column %)				
Characteristics							
Age at hospitalization							
0 to 17 years	75	6.5	5.6	6.6	10.1	6.2	4.8
18 to 24 years	190	17.1	15.7	17.3	18.6	21.1	8.5
25 to 34 years	315	28.3	41.7	26.8	32.7	28.6	18.9
35 to 44 years	190	17.1	23.2	16.5	17.2	14.7	20.0
45 to 64 years	195	17.4	5.6	18.6	15.4	17.4	23.7
65 years and older	155	13.6	8.3	14.2	9.2	11.9	24.1
Sex							
Male	590	52.4	50.0	52.7	49.3	54.3	51.9
Female	535	47.6	50.0	47.3	50.8	45.7	48.2
Landing year							
2000 to 2003	420	37.3	5.6	40.7	27.1	33.9	64.4
2004 to 2008	460	40.9	48.2	40.1	37.2	43.5	35.6
2009 to 2013	245	21.8	46.3	19.1	35.7	22.6	n.a.
Country risk level§							
Low	35	3.1	4.6	3.0	x	x	x
High (WHO+IRCC-specific)	1,085	96.9	95.4	97.0	x	x	x
WHO	860	76.5	68.5	77.3	74.4	77.8	78.5
IRCC-specific	230	20.4	26.9	19.7	x	x	x
Top 12 source countries for TB hospitalizations in Canada							
India	250	22.4	6.5	24.1	18.1	24.8	27.0
Philippines	190	16.9	15.7	17.1	11.1	19.8	15.9
China	80	7.0	9.3	6.7	3.5	6.6	9.3
Ethiopia	70	6.1	x	x	x	6.8	x
Pakistan	50	4.6	4.6	4.5	7.5	3.1	5.2
Somalia	50	4.4	5.6	4.2	6.5	3.7	3.7
Sri Lanka	35	3.2	4.6	3.1	2.5	2.8	4.1
Afghanistan	35	3.1	0	3.5	4.5	2.9	3.7
Viet Nam	30	2.9	x	x	x	x	x
Nepal	30	2.5	x	x	x	x	x
Sudan	30	2.5	0	2.8	4.0	2.4	2.6
Bangladesh	25	2.2	x	x	x	x	x
All others	250	22.4	44.0	20.1	26.6	18.9	17.8
Intended region of residence							
Atlantic	20	1.8	x	x	x	x	x
Ontario	705	62.9	65.7	62.6	57.6	64.2	63.0
Prairies†	245	21.9	23.2	21.7	27.3	21.8	17.4
British Columbia	150	13.5	x	x	x	x	x
Immigrant category							
Economic, principal applicants	175	15.5	29.6	14.0	12.1	14.5	14.4
Economic, spouse/children	180	16.1	x	x	x	x	x
Family	405	36.1	12.0	38.7	33.0	37.2	45.6
Refugee	330	29.4	38.9	28.4	39.7	27.9	21.1
Other/unknown/missing	30	2.9	x	x	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*
† The Manitoba landing cohort includes only individuals who landed after March 2004, when hospital data were made available
‡ This includes individuals hospitalized in the same month as landing
§ The country risk level is based on the IRCC list (Appendix 1)

Notes: Subtotals may not add up to the total because of rounding. WHO stands for World Health Organization. IRCC stands for Immigration, Refugees and Citizenship Canada. IMDB stands for Longitudinal Immigration Database. DAD stands for Discharge Abstract Database.
Source: 2000-to-2013 IMDB–DAD linked database.

Time from landing year until first TB hospital event

Pre-landing TB hospital event

Nearly 10% (n=110) of immigrants with a TB-related hospitalization experienced their first TB hospital event before "landing" as permanent residents (Table 3). This proportion differed by characteristics, varying from 3% among those aged 45 to 64 to 14% among those aged 25 to 34 (Table 4). By immigrant category, this ranged from 3% among the family category to 41% among others (including unknown and missing). Among the top source countries, Sri Lanka had the highest proportion of immigrants experiencing their first TB hospital event before landing at 14%, while Sudan and Afghanistan each had a proportion of 0%.

Among pre-landing TB hospital events (Table 3), 42% occurred among immigrants aged 25 to 34. The majority (95%) occurred among immigrants from high-risk countries. Among the top source countries, a total of 32% of TB hospital events before landing occurred among immigrants from the Philippines (16%), China (9%) and India (7%). Most of these events occurred among immigrants intending to stay in Ontario (66%). Approximately 39% occurred among refugees, followed by 30% among immigrants entering as principal applicants in the economic category.

Post-landing TB hospital event

Among the 1,120 new immigrants, 18% experienced their first TB-related hospitalization within 12 months of landing, 49% within 13 to 60 months of landing, and 24% after more than 60 months since landing (Table 3). Around 41% of post-landing TB discharges occurred among immigrants who landed in Canada from 2000 to 2003. Immigrants aged 25 to 34 had the highest proportion of post-landing TB-related discharges, at 27%. These TB-related hospital patients tended to be male (53%), be from high-risk countries (97%) such as India and the Philippines, intend to reside in Ontario (63%), and be from the family category

Table 4

New immigrants with at least one tuberculosis-related acute care hospitalization from 2001/2002 to 2013/2014, overall and individuals with first hospitalization before immigration landing, by selected characteristics, immigrant cohorts from 2000 to 2013, Canada excluding Quebec and the territories[†]

	Overall	Pre-landing[‡]	
Total (number)	1,120	110	
%	100	9.6	
	Total number	**Pre-landing tuberculosis-related hospitalization**	
		number	**%**
Age at hospitalization			
0 to 17 years	75	5	8.2
18 to 24 years	190	15	8.9
25 to 34 years	315	45	14.2
35 to 44 years	190	25	13.0
45 to 64 years	195	5	3.1
65 years and older	155	10	5.9
Sex			
Male	590	55	9.2
Female	535	55	10.1
Landing year			
2000 to 2003	420	5	1.4
2004 to 2008	460	50	11.3
2009 to 2013	245	50	20.5
Country risk level[§]			
Low	35	5	14.3
High (WHO+IRCC-specific)	1,085	105	9.5
WHO	860	75	8.6
IRCC-specific	230	30	12.7
Top 12 source countries for tuberculosis hospitalizations in Canada			
India	250	5	2.8
Philippines	190	15	9.0
China	80	10	12.8
Ethiopia	70	x	x
Pakistan	50	5	9.8
Somalia	50	5	12.2
Sri Lanka	35	5	13.9
Afghanistan	35	0	0.0
Viet Nam	30	x	x
Nepal	30	x	x
Sudan	30	0	0.0
Bangladesh	25	x	x
All others	250	45	18.7
Intended region of residence			
Atlantic	20	x	x
Ontario	705	70	10.1
Prairies[†]	245	25	10.2
British Columbia	150	x	x
Immigrant category			
Economic, principal applicants	175	30	18.4
Economic, spouse/children	180	10	4.4
Family	405	15	3.2
Refugee	330	40	12.7
Other/unknown/missing	30	15	40.6

x suppressed to meet the confidentiality requirements of the *Statistics Act*
[†] The Manitoba landing cohort includes only individuals who landed after March 2004, when hospital data were made available
[‡] Pre-landing is defined as hospitalizations occurring before the month of immigration landing as recorded in the IMDB
[§] The country risk level is based on the IRCC list (Appendix 1)

Notes: Subtotals may not add up to the total because of rounding. WHO stands for World Health Organization. IRCC stands for Immigration, Refugees and Citizenship Canada. IMDB stands for Longitudinal Immigration Database. DAD stands for Discharge Abstract Database.
Source: 2000-to-2013 IMDB–DAD linked database.

(39%)—with some exceptions by time of landing. For example, more females than males experienced a TB-related hospitalization within 12 months of arrival, but not in other periods.

Incidence of TB hospitalization since landing

On average, incidence of TB-related hospitalization in person-years adjusted per 100,000 population was 5.2 per 100,000 person-years for the landing cohort from 2000 to 2013 (Table 5). Among immigrants in the landing cohort, rates were highest among those aged 65 and older (11.3), males (5.6), and those who arrived from 2009 to 2013 (6.8). The rate among immigrants from high-risk countries was more than 11 times that of those from low-risk countries (6.8 compared with 0.6, respectively). The incidence was highest among those from Ethiopia (51), followed by Somalia (43) and Nepal (42). In addition, the incidence was highest among refugees (14) and immigrants intended to live in the Prairies (8).

Burden of TB-related hospitalizations among new immigrants

The overall mean length of stay for all TB-related hospitalizations was 22 days, while the median was 14 days. In comparison, the average among the new immigrant cohort from 2001 to 2013 was lower, at a mean of 17 days and a median of 11 days (Table 6). Among new immigrants, those who are older, male, residing in British Columbia, and from the family category tended to have longer stays. The mean length of stay differed only slightly between high-risk and low-risk countries, at 17 days and 16 days, respectively. The corresponding median lengths of stay were 11 days and 8 days, respectively. New immigrants from Sudan had the highest mean length of stay (26 days), while immigrants from Sri Lanka and Afghanistan had the highest median stay (14 days).

Approximately 17% of the total number of TB-related hospitalizations (n=7,675) occurred to immigrants who arrived in Canada from 2000 to 2013. Immigrants arriving during this 13-year

Table 5

Number of recent immigrants with post-landing tuberculosis-related hospitalization and incidence of first tuberculosis-related hospitalization since landing per 100,000 person-years at risk, by selected characteristics, immigrant cohorts from 2000 to 2013, Canada excluding Quebec and the territories†, 2001/2002 to 2013/2014

	First tuberculosis-related hospitalization after landing		
		95% confidence interval	
	number	Incidence adjusted for person-years	from	to
All	1,015	5.2	4.8	5.5
Age at hospitalization				
0 to 17 years	65	1.5	0.8	2.1
18 to 24 years	175	3.4	2.5	4.2
25 to 34 years	270	7.1	6.1	8.0
35 to 44 years	165	5.8	5.0	6.5
45 to 64 years	190	3.4	3.2	3.9
65 years and older	145	11.3	9.8	12.8
Sex				
Male	535	5.6	5.1	6.1
Female	480	4.7	4.3	5.2
Landing year				
2000 to 2003	415	4.5	4.1	5.0
2004 to 2008	410	5.3	4.8	5.8
2009 to 2013	195	6.8	5.9	7.8
Country risk level‡				
Low	30	0.6	0.3	0.8
High (WHO+IRCC-specific)	985	6.8	6.3	7.2
WHO	785	6.9	6.4	7.4
IRCC-specific	200	6.2	5.4	7.2
Top 12 source countries for tuberculosis hospitalizations in Canada				
India	245	8.5	7.4	9.6
Philippines	175	10.6	9.1	12.4
China	70	2.1	1.6	2.7
Ethiopia	65	51.1	39.7	65.7
Pakistan	45	3.8	2.8	5.2
Somalia	45	42.8	31.3	58.5
Sri Lanka	30	7.4	5.1	10.6
Afghanistan	35	14.8	10.4	21.0
Viet Nam	30	17.5	12.1	25.1
Nepal	25	42.4	27.8	64.1
Sudan	30	24.3	16.5	35.7
Bangladesh	25	8.2	5.2	12.6
All others	205	2.2	1.9	2.5
Intended region of residence				
Atlantic	20	4.7	2.9	7.5
Ontario	635	5.0	4.6	5.4
Prairies†	220	8.0	7.0	9.2
British Columbia	140	3.7	3.1	4.3
Immigrant category				
Economic, principal applicants	140	3.1	2.6	3.6
Economic, spouse/children	175	2.5	2.1	2.9
Family	390	7.1	6.4	7.8
Refugee	290	13.5	12.0	15.2
Other/unknown/missing	20	5.6	3.5	8.9

† The Manitoba landing cohort includes only individuals who landed after March 2004, when hospital data were made available.
‡ The country risk level is based on the IRCC list (Appendix 1).

Notes: Subtotals may not add up to the total because of rounding. WHO stands for World Health Organization. IRCC stands for Immigration, Refugees and Citizenship Canada. IMDB stands for Longitudinal Immigration Database. DAD stands for Discharge Abstract Database.
Source: 2000-to-2013 IMDB–DAD linked database.

period represented 7% of the Canadian population (Table 7).[28] The percentages of TB-related hospitalizations varied by age group, from 8% among new immigrants aged 65 and older to 37% among new immigrants aged 18 to 24 and 25 to 34. Each group represented only 2% (aged 65 and older),12% (aged 18 to 24) and 8% (aged 25 to 34) of the population share. Among recent immigrants to Ontario, representing 8% of Ontario's population, had 24% of the TB-related hospitalizations.

Discussion

This is the first national study (excluding Quebec) of TB-related hospitalizations among new immigrants based on the linked IMDB–DAD database. It demonstrates the value of linking administrative data to understand immigrant health, even for uncommon outcomes such as TB in Canada, complementing the results from the annual TB reports issued by PHAC. This study focused on TB-related hospitalizations, which are generally the most costly component of TB control programs.[29] The results reveal that new immigrants represent a disproportionate number of people in Canada undergoing TB-related hospitalizations. This finding is supported by previous evidence suggesting that immigrants are overrepresented among TB cases in low-incidence countries such as Canada.[7] The sociodemographic factors highlighted in this study are comparable with previous studies that look at predictors of TB-related hospitalizations in Canada.[30]

While this study focused on TB-related hospitalizations, the characteristics of hospitalized patients generally reflected the characteristics of TB patients included in the case-based surveillance system maintained by PHAC.[8] For example, while males accounted for 54% of reported cases in the CTBRS, males represented around 52% of the IMDB cohort with TB-related hospitalizations. In terms of age, around 33% of the reported TB cases were from individuals aged 25 to 44, while around 45% of immigrants hospitalized for TB were

Table 6

Mean and selected percentiles of all lengths of tuberculosis-related hospital stays (in days), immigrant landing cohorts from 2000 to 2013, Canada excluding Quebec and the territories†, 2001 to 2013

Total	Number of tuberculosis-related hospitalizations	Mean	Median (50th percentile)	90th percentile
All tuberculosis-related hospitalizations in 2001/2002-to-2013/2014 DAD within SDLE	7,675	22.4	14.0	51.0
All 2000-to-2013 tuberculosis-related hospitalizations in the IMDB linked to the 2001/2002-to-2013/2014 DAD in SDLE	1,340	17.4	11.0	36.0
Age at hospitalization				
0 to 17 years	90	12.0	7.0	24.0
18 to 24 years	230	15.4	10.0	33.0
25 to 34 years	375	15.1	10.0	30.0
35 to 44 years	220	15.3	9.5	35.0
45 to 64 years	235	23.4	13.0	53.0
65 years and older	185	22.0	16.0	49.0
Sex				
Male	725	17.5	12.0	38.0
Female	615	17.2	10.0	34.0
Landing year				
2000 to 2003	485	18.0	12.0	41.0
2004 to 2008	565	17.1	11.0	35.0
2009 to 2013	285	16.9	11.0	35.0
Country risk level‡				
Low	45	15.6	8.0	40.0
High (WHO+IRCC-specific)	1,290	17.4	11.0	36.0
WHO	1,020	17.2	11.0	35.0
IRCC-specific	275	18.2	11.0	41.0
Top 12 source countries for TB hospitalizations in Canada				
India	300	20.9	12.0	49.0
Philippines	235	17.0	11.0	33.0
China	90	15.9	10.5	35.0
Ethiopia	80	16.0	13.0	34.0
Pakistan	55	14.0	9.0	26.0
Somalia	65	15.9	13.0	30.0
Sri Lanka	45	21.3	14.0	41.0
Afghanistan	35	18.5	14.0	51.0
Viet Nam	35	14.7	12.0	33.0
Nepal	40	11.2	8.5	21.0
Sudan	35	26.1	11.5	36.0
Bangladesh	25	18.1	13.0	42.0
All others	290	15.2	10.0	35.0
Intended region of residence				
Atlantic	15	12.8	11.0	31.0
Ontario	785	15.7	9.0	33.0
Prairies†	335	16.7	13.0	33.0
British Columbia	200	25.2	15.0	57.0
Immigrant category				
Economic, principal applicants	200	14.6	10.0	31.0
Economic, spouse/children	225	13.8	9.0	32.0
Family	480	20.7	13.0	42.0
Refugee	395	16.8	10.5	34.0
Other/unknown/missing	35	17.6	10.0	32.0

† The Manitoba landing cohort includes only individuals who landed after March 2004, when hospital data were made available.
‡ The country risk level is based on the IRCC list (Appendix 1).

Notes: Subtotals may not add up to the total because of rounding. WHO stands for World Health Organization. IRCC stands for Immigration, Refugees and Citizenship Canada. IMDB stands for Longitudinal Immigration Database. DAD stands for Discharge Abstract Database. SDLE stands for Social Data Linkage Environment.
Source: 2000-to-2013 IMDB–DAD linked database.

Table 7

Percentage of total tuberculosis-related acute care hospital events among recent immigrants, by selected characteristics, immigrant landing cohorts from 2000 to 2013, Canada excluding Quebec and the territories[†], 2001/2002 to 2013/2014

Total	Total tuberculosis-related hospital events from hospital file within SDLE	Total tuberculosis-related hospital events among new immigrants (2000 to 2013)	% of total tuberculosis-related hospital events among new immigrants	Estimated % of new immigrant population, from 2011 National Household Survey
Overall	7,675	1,340	17	7
Age at hospitalization				
0 to 17 years	460	90	20	7
18 to 24 years	630	230	37	8
25 to 34 years	1,025	375	37	12
35 to 44 years	1,105	220	20	12
45 to 64 years	2,005	235	12	5
65 years and older	2,450	185	8	2
Sex				
Male	4,430	725	16	7
Female	3,240	615	19	7
Region of submitting province				
Atlantic	260	15	6	1
Ontario	3,235	785	24	8
Prairies[†]	2,600	335	13	6
British Columbia	1,580	200	13	7
Hospital fiscal year				
2001 to 2003	1,605	155	10	..
2004 to 2008	3,015	505	17	..
2009 to 2013	3,050	680	22	..

.. not available for a specific reference period
[†] The Manitoba landing cohort includes only individuals who landed after March 2004, when hospital data were made available
Notes: Subtotals may not add up to the total because of rounding. IMDB stands for Longitudinal Immigration Database. DAD stands for Discharge Abstract Database. SDLE stands for Social Data Linkage Environment.
Source: 2000-to-2013 IMDB–DAD linked database.

among the same age group. However, direct comparison of the CTBRS with the linked IMDB–DAD database is challenging. The CTBRS did not contain information on the immigrant categories, the type of care provided (outpatient or hospital care), or hospital admissions not related to an active TB diagnosis (e.g., hospitalizations related to side effects of TB treatment). Further studies would be required to make an appropriate comparison.

Based on its linkage to the IMDB, this study revealed that immigrants in the refugee and the family categories are disproportionately represented among individuals with TB. In addition, the CTBRS reported more than 1,600 active TB cases per year across Canada during the study period, approximately 1,000 cases per year being related to foreign-born individuals (60% to 70% of cases per year). The results show

that 17% of total TB hospitalizations occurred among new immigrants, despite new immigrants who landed between 2000 and 2013 accounting for only 7% of the population. The data did not include hospitalizations from Quebec and the territories, or from Manitoba before 2004. Because of this, hospital use reported in this study is an underestimate of the true national figure.

A large majority of immigrants with TB hospitalizations were from countries with high risk of TB, as identified by IRCC's designated country list. Specifically, findings from this study identified the top source countries for TB, including India and the Philippines (in terms of cases), as well as Ethiopia and Somalia (in terms of rates).[31] The CTBRS reported that approximately 60% of active TB cases occurring among foreign-born individuals occurred among people from the Philippines, India, China,

Viet Nam and Pakistan, but Ethiopia and Somalia were not identified. Known migration trends and the domestic TB rates in the home countries of migrants can inform immigration policies and in-Canada TB control programs.

An unanticipated advantage of this linkage is the ability to derive information on the timing of TB-related hospitalization in relation to landing date rather than arrival date, which can inform screening practices. Approximately 1 in 10 TB-related hospitalizations occurred prior to landing in Canada. These cases represent newcomers who acquired the legal right to "land" (permanently) as immigrants as per IRCC requirements only after their original arrival in Canada. They include in-Canada asylum seekers and some temporary residents (students, visitors and temporary workers). Hospitalization in this group likely occurred among individuals diagnosed through activities related to public health (e.g., contact tracing of active TB index cases, and review of clients referred by IRCC) after seeking medical attention for abnormal findings or symptoms, or as part of a new in-Canada immigration medical examination (IME). The IME is used by IRCC to screen for active pulmonary TB and identify clients with latent TB infection. Some individuals would not have had an IME before originally entering Canada (e.g., asylum seekers in Canada). These pre-landing results can inform immigration policy and TB screening procedures based on sociodemographic TB risk factors.[32,33] Recent papers have identified sociodemographic predictors of active TB in migrants (not restricted to hospitalization) and provide complementary evidence to inform immigration policy.[34]

Hospitalizations that occurred within 12 months of landing could represent immigrants whose active TB was either missed during IME procedures or whose infection was acquired after the IME but before arrival in Canada. In contrast, cases that were identified as occurring after one year of landing more likely represent a reactivation of more distant latent TB infection. Since most cases occurred after one year, this suggests

that the reactivation of latent TB infection accounts for a significant proportion of hospital admissions for TB among new arrivals to Canada.[35,36,37] WHO recommendations for countries with low incidence of TB, such as Canada, indicate that screening for latent TB infection in TB contacts and selected high-risk groups should be a priority action.[5] As a result, this analysis provides insight that can help develop strategies to decrease the reservoir of infected individuals and eliminate TB.[38,39]

In this study, the mean length of hospital stay was 17 days, while the median length was 11 days (Table 6) among the immigrant landing cohort. This is less than the mean length of 22 days and median length of 14 days for TB patients nationwide, and less than the 20.6 days reported previously.[29] It is possible that recent immigrants are younger or have less advanced disease at the time of admission, resulting in a shorter mean or median length of hospital stay. The burden of hospital care for TB among the landing cohort aged 65 and older (mean 22 days, median 16 days) could be explained by previous findings. Previous findings show that this age group had statistically significant factors prolonging the length of stay.[40,41] In addition, this age group most likely represented more complex TB cases, a higher incidence of significant co-morbidities, and more disease severity with associated delays in TB diagnosis and mortality.[42,43] According to immigration category (economic, family and refugee), the economic category had the shortest length of hospital stay, while the refugee category had the longest. The shorter hospital stays for the immigrant cohort might also reflect an increased index of suspicion as a result of IME for TB in this group, leading to earlier diagnosis and shorter hospitalization.

This study found that certain provinces, such as British Columbia, had longer TB hospital days. It is beyond the scope of this paper to interpret the differences of hospital stay between provinces, but appropriate interpretation would likely involve factors such as age, co-morbidities, index of suspicion, differing patterns of practice and alternate care options.[30,32,34,40-43] These interrelated factors may partially explain why some provinces have longer hospital stays.

Limitations

This study has certain limitations. The hospital use reported is an underestimate of the national figure for recent immigrants because it does not include Manitoba before April 2004 or Quebec. The study also does not include hospitalization for processes that were not identified initially as TB-related, but ultimately proven to be TB-related after discharge. Prelanding data may also be underestimated if there were issues related to one's ability to pay for hospitalization. This could lead to an outpatient management for conditions usually managed in hospital. It is assumed that landed immigrants are covered by provincial insurance, except for any health care waiting period that is required by new immigrants. A group of in-Canada residents that are not identified in this study includes temporary residents (e.g., students, workers, visitors) who either did not apply for permanent resident status or did apply and were unsuccessful.

When appropriate, TB can be treated in an ambulatory setting, including measures such as home isolation. TB cases treated using strictly ambulatory management or cases where the ICD codes for TB were not entered in the hospital discharge summary are not reflected in this study. Despite this, linkages in this study

can provide insight into epidemiological patterns of TB-related hospitalization in Canada (e.g., immigration category and countries of concern with high risk of TB) and associated costs (related to lengths of hospital stays for TB).

Conclusion

This study provides new insights into aspects of TB-related hospitalization occurring among new immigrants to Canada using linked administrative immigration and hospital data. With the increasing number of immigrants to Canada, this linked dataset provides a timely contribution to developing immigrant health surveillance systems and monitoring the health and health service use of immigrants, by immigration category, as well as to contribute to the commitment by the Government of Canada to end TB.[44] It can also provide policy makers with information to help develop approaches for managing a disease that, in Canada, is relatively uncommon among the non-Indigenous Canadian-born population, but more prevalent among the immigrant population.

Acknowledgements

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Appendix

Appendix 1
Immigration, Refugees and Citizenship Canada designated country/territory list for tuberculosis (TB) and World Health Organization high TB-burden country list

Immigration, Refugees and Citizenship Canada (IRCC) designated country/territory list, 2017 (n=124)†	World Health Organization (WHO) high TB-burden country (n=48)	IRCC-specific country/territory (n=76)†
Afghanistan		✓
Algeria		✓
Angola	✓	
Armenia		✓
Azerbaijan	✓	
Bangladesh	✓	
Belarus	✓	
Benin		✓
Bhutan		✓
Bolivia		✓
Bosnia and Herzegovina		✓
Botswana	✓	
Brazil	✓	
Brunei Darussalam		✓
Burkina Faso		✓
Burundi		✓
Cambodia	✓	
Cameroon	✓	
Cape (Cabo) Verde, including Maio		✓
Central African Republic	✓	
Chad	✓	
China (Hong Kong Special Administrative Region)		✓
China, People's Republic of	✓	
Comoros, Union of		✓
Congo, Democratic Republic of the (Kinshasa)	✓	
Congo, Republic of the (Brazzaville)	✓	
Côte d'Ivoire		✓
Djibouti		✓
Dominican Republic		✓
Ecuador		✓
El Salvador		✓
Equatorial Guinea		✓
Eritrea		✓
Ethiopia	✓	
Fiji		✓
Gabon		✓
Gambia		✓
Georgia		✓
Ghana	✓	
Greenland		✓
Guam		✓
Guatemala		✓
Guinea, Republic of		✓
Guinea-Bissau	✓	
Guyana		✓
Haiti		✓
Honduras		✓
India	✓	
Indonesia	✓	
Iraq		✓
Kazakhstan	✓	
Kenya	✓	
Kiribati		✓
Korea, Democratic People's Republic of	✓	
Korea, Republic of		✓
Kosovo, United Nations Administered		✓
Kyrgyz Republic (Kyrgyzstan)	✓	

Appendix 1

Immigration, Refugees and Citizenship Canada designated country/territory list for tuberculosis (TB) and World Health Organization high TB-burden country list

Immigration, Refugees and Citizenship Canada (IRCC) designated country/territory list, 2017 (n=124)†	World Health Organization (WHO) high TB-burden country (n=48)	IRCC-specific country/territory (n=76)†
Lao People's Democratic Republic		✓
Latvia		✓
Lesotho	✓	
Liberia	✓	
Libya		✓
Lithuania		✓
Macao, Special Administrative Region of China		✓
Macedonia, Republic of		✓
Madagascar		✓
Malawi	✓	
Malaysia (Peninsular and East)		✓
Maldives		✓
Mali, Republic of		✓
Marshall Islands, Republic of the		✓
Mauritania		✓
Micronesia, Federated States of (including Truk, Yap, Kosrae/Kusaie, Chuuk, Pohnpei/Ponape)		✓
Moldova, Republic of	✓	
Mongolia		✓
Morocco		✓
Mozambique	✓	
Myanmar (Burma)	✓	
Namibia	✓	
Nauru, Republic of		✓
Nepal		✓
Nicaragua		✓
Niger		✓
Nigeria	✓	
Northern Mariana Islands, Commonwealth of the USA		✓
Pakistan	✓	
Palau (Belau), Republic of		✓
Panama		✓
Papua New Guinea, including Admiralty (Manus) Islands and New Britain	✓	
Paraguay		✓
Peru	✓	
Philippines	✓	
Qatar		✓
Romania		✓
Russian Federation	✓	
Rwanda		✓
Sao Tome and Principe		✓
Senegal		✓
Sierra Leone	✓	
Singapore		✓
Solomon Islands		✓
Somalia	✓	
South Africa, Republic of	✓	
South Sudan, Republic of		✓
Sri Lanka		✓
Sudan		✓
Swaziland	✓	
Taiwan		✓
Tajikistan	✓	
Tanzania	✓	
Thailand	✓	
Timor-Leste		✓
Togo		✓
Tunisia		✓
Turkmenistan		✓
Tuvalu		✓
Uganda	✓	

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Immigration, Refugees and Citizenship Canada designated country/territory list for tuberculosis (TB) and World Health Organization high TB-burden country list

Immigration, Refugees and Citizenship Canada (IRCC) designated country/territory list, 2017 *(n=124)†*	World Health Organization (WHO) high TB-burden country *(n=48)*	IRCC-specific country/territory *(n=76)†*
Ukraine	✓	
Uzbekistan	✓	
Vanuatu		✓
Viet Nam	✓	
Yemen		✓
Zambia	✓	
Zimbabwe	✓	

† The IRCC designated country/territory list includes all high TB-burden countries identified by the WHO for 2016 to 2020. The People's Republic of China is listed three times (Hong Kong, China and Macao).
‡ IRCC-specific countries are countries listed on the IRCC list of designated countries/territories for TB that are not found on the WHO list. Two territories on this list are American (Guam and the Northern Mariana Islands).