A Shelter-associated Tuberculosis Outbreak: A Novel Strain Introduced Through Foreign-born Populations

Danusia Moreau, BScN, RN,¹ Jennifer Gratrix, MSc, RN,² Dennis Kunimoto, MD,^{3,4} Avril Beckon, BScN, RN,⁴ Evelina Der, BScN, RN,¹ Elisabeth Hansen, BScN, RN,⁴ Linda Chui, PhD,^{5,6} Rabia Ahmed, MD^{3,4}

ABSTRACT

Objective: An outbreak of tuberculosis (TB) in a large urban apartment building and three homeless shelters within a one-block radius in Edmonton, Alberta occurred between 2008 and 2009. The purpose of this report is to describe the transmission dynamics of this multiethnic, multicentre inner-city TB outbreak.

Methods: A retrospective chart review was conducted through the Integrated Public Health Information Systems (iPHIS) to extract demographic, clinical and treatment data as well as data for contacts for all 19 cases involved in the outbreak. TB isolates were genotyped using molecular IS6110 restriction fragment-length polymorphism (RFLP). Categorical variables were compared using Fisher's exact test and continuous variables were analyzed using the Kruskal Wallis test.

Results: Two groups were identified through genotyping. One group consisted of 9 cases with a newly identified TB genotype circulating in Alberta. All of the cases in this group were among males and two thirds were among individuals from northeast Africa, with subsequent transmission into Canadian-born populations through exposure during shelter stays. The second group (n=3) identified were infected by a previously circulating strain of TB in Alberta and consisted of Canadian-born Aboriginal people.

Conclusion: This study demonstrates the transmission of a novel TB strain from foreign-born populations to Canadian-born populations through location-based settings serving vulnerable populations. This study highlights the changing demographic and emerging health concerns for under-housed populations in Canada.

Key words: Homeless persons; *Mycobacterium tuberculosis*; Canada; foreign-born; shelter; outbreak

La traduction du résumé se trouve à la fin de l'article.

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In low TB incidence countries such as Canada, TB disease remains concentrated in urban settings with outbreaks involving homeless and under-housed populations that continue to challenge TB control programs. While the incidence of TB in Canada declined to 4.7/100,000 in 2009, the burden of TB cases continues to be diagnosed among foreign-born (FB) individuals.¹ In Alberta, the rate of TB among the FB is 17.7/100,000, compared to the Canadian-born (CB) population at 1.7/100,000.¹ Other descriptions of homeless and under-housed populations in Canadian urban centres have reported that disease remains concentrated among CB-Aboriginal (CB-AB) populations,² though the rise in the proportion of FB cases among homeless populations has been noted.³ Although cases of TB in the FB represent the majority of cases in Alberta, there had previously been little documented transmission to other FB or to CB individuals.⁴ The objective of this study is to describe the transmission of TB from FB populations to CB populations through shelter-based locations in the inner city of Edmonton, Alberta.

METHODS

Study population

Edmonton is a northern Canadian city with a population of 1,024,820; 18.5% of the population are immigrants.⁵ The homeless population is estimated to be 3,079 and is concentrated in the inner city of Edmonton.⁶ All cases of TB in the province are centrally reported to TB Services. Between May 2008 and December 2009,

103 cases of active TB were reported within Edmonton (mean annual rate for 2008 and 2009 was 7.9/100,000); 19 cases were linked to three locations (one apartment building and three homeless shelters) within a one-block area of the inner city.

Demographic and clinical characteristics

A retrospective review of these 19 cases was completed by extracting demographic, clinical, treatment and contact tracing data from iPHIS. All TB cases were culture-confirmed at the Provincial Laboratory for Public Health (Edmonton, Alberta).

Contacts were identified through social networking interviews and through resident lists of shared communal-living locations. Contact investigation was limited to chest x-ray (CXR), sputum for acid-fast bacilli (AFB) analysis and symptom inquiry.

Author Affiliations

1. Central TB Services, Alberta Health Services, Edmonton, AB
2. Communicable Disease Control, Alberta Health Services, Edmonton, AB
3. Department of Medicine, University of Alberta, Edmonton, AB
4. Edmonton TB Clinic, Alberta Health Services, Edmonton, AB
5. Laboratory Medicine and Pathology, University of Alberta, Edmonton, AB
6. Provincial Laboratory for Public Health, Edmonton, AB

Correspondence: Danusia Moreau, Alberta Health Services, 3062A 10216 124 Street, Edmonton, AB T5K 1P7, Tel: 780-735-3461, Fax: 780-735-3442, E-mail: danusia.moreau@albertahealthservices.ca

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Conflict of Interest: None to declare.

Table 1. Characteristics of Groups Associated With Inner-city Outbreak in Edmonton, Canada, May 2008-December 2009

Characteristics	Group 1 (n=9) n (%)	Group 2 (n=3) n (%)	Group 3 (n=7) n (%)	Total (N=19) n (%)	p-value
Demographic					
Male	9 (100)	1 (33.3)	7 (100)	17 (89.5)	0.02
Ethnicity					
Canadian-born Aboriginal (CB-AB)	2 (22.2)	3 (100)	1 (14.3)	6 (31.6)	0.05
Canadian-born non-Aboriginal (CB-NA)	1 (11.1)	0	0	1 (5.3)	
Foreign-born (FB)	6 (66.7)	0	6 (85.7)	12 (63.2)	
Age (median years, IQR)	40 (38-42)	50 (40-50)	35 (26-45)	40 (36-46)	0.18
Homeless	4 (44.4)	3 (100)	3 (42.9)	10 (52.6)	0.27
History of contact to TB					
In the inner city	7 (77.8)	2 (66.7)	2 (28.6)	11 (57.9)	0.03
Outside of inner city	0	1 (33.3)	0	1 (5.3)	
History TST+	4 (44.4)	2 (66.7)	1 (14.3)	7 (36.8)	0.27
HIV+	1 (11.1)	2 (66.7)	1 (14.3)	4 (21.1)	0.17
HCV+	2 (22.2)	3 (100)	0	5 (26.3)	0.01
Lifestyle					
Smoking	8 (88.9)	3 (100)	3 (42.9)	14 (73.7)	0.22
Alcohol use	7 (77.8)	3 (100)	3 (42.9)	13 (68.4)	0.39
Non-prescription drug use	3 (33.3)	1 (33.3)	0	4 (21.1)	0.54
Symptoms (self-reported)					
Cough >2 weeks	8 (88.9)	2 (66.7)	6 (85.7)	16 (84.2)	0.74
Night sweats	6 (66.7)	0	1 (14.3)	7 (36.8)	0.60
Weight loss	6 (66.7)	1 (33.3)	3 (42.9)	10 (52.6)	0.57
Fever	7 (77.8)	1 (33.3)	2 (28.6)	10 (52.6)	0.11
Clinical					
Pulmonary TB	8 (88.9)	3 (100)	7 (100)	18 (94.7)	1.00
Sputum smear positive	6 (66.7)	1 (33.3)	5 (71.4)	12 (63.2)	0.67
Chest X-ray					
Cavitary	5 (55.6)	0	4 (57.1)	9 (47.4)	0.31
Infiltrate	1 (11.1)	2 (66.7)	2 (28.6)	5 (26.3)	
Hospital utilization					
Emergency room visit	7 (77.8)	1 (33.3)	4 (57.1)	12 (63.2)	0.46
Admitted to hospital	8 (88.9)	2 (66.7)	7 (100)	17 (89.5)	0.42
If admitted, median days in hospital (IQR)	41 (14-54)	23 (16-30)	22 (13-31)	22 (14-49)	0.59
Treatment completed	8 (88.9)	3 (100)	7 (100)	18 (94.7)	1.00

TST = Tuberculin skin test.

Genotyping of *M. tuberculosis* isolates

Genotyping was completed utilizing molecular IS6110 restriction fragment-length polymorphism (RFLP).⁶ Clustered cases were assumed to be linked by one or more transmission events.

Data analysis

A diagram was constructed to illustrate case-place and case-case linkages. Cases were plotted on a timeline based on their date of diagnosis (i.e., date of smear or culture positivity) to demonstrate the movement of the outbreak with time. Lines were drawn to connect cases to places as well as to named contacts. Categorical variables were compared using Fisher's exact test and continuous variables were analyzed using the Kruskal Wallis test. Analyses were completed using STATA version 10 (Stata Corp., College Station, TX, USA). Approval for this study was obtained from the University of Alberta Health Ethics Research Board.

RESULTS

Using genotyping, three groups were identified among the 19 cases: group 1 (n=9) RFLP pattern 0.1462, a newly identified strain circulating in Alberta; group 2 (n=3) RFLP pattern 0.0728, a previously identified strain circulating in the inner city; and group 3 (n=7), cases with unique RFLP patterns. Table 1 compares demographic and clinical characteristics of the cases in the three groups. All cases were males except in group 2 where two thirds of the cases were females (n=2). The majority of cases in groups 1 and 3 were among FB individuals while all cases in group 2 were among Canadian-born Aboriginals. In addition, all of the cases in group 2 reported a history of contact with TB. Otherwise, cases in the three groups were similar in terms of age, lifestyle variables, clinical symptoms and hospital utilization.

Figure 1 displays the case-case and case-place linkages of group 1. A single case in the apartment building was linked socially to two other cases who did not reside in the apartment building but visited often. One of these cases was the link to the shelter system and the subsequent transmission to Canadian-born individuals.

Contact tracing was completed at the four locations identified. A total of 1,825 contacts were identified, 89.8% (n=1639) of the contacts were identified through the shelters. Contacts were more likely to be assessed if they were identified through the apartment building (47.3%; n=88) than through the shelters (27.5%; n=451, p<0.001). Contacts assessed from the shelters were more likely to require follow-up for abnormal x-rays (19.3%; n=87) than contacts assessed from the apartment building (5.7%; 87, p=0.001).

DISCUSSION

We believe this is the first account of a TB outbreak in Canada that began with a novel TB strain among FB individuals, with transmission into CB populations through shelters within a one-block radius. We hypothesize that this outbreak of TB began with a highly infectious case of advanced pulmonary TB in a FB individual that spread via the ventilation system and via casual contact in the apartment building. Through social connections with an under-housed FB individual, the outbreak spread into homeless shelters where further transmission occurred via the ventilation system and via casual contact among occupants. While spread was predominantly linked to location, it is likely the apartment building and shelter locations were linked by an under-housed FB individual who moved between the sites.

Although TB in Canada is primarily a disease of FB populations,⁷ this finding has not been documented in other Canadian TB out-

Figure 1. Timeline showing outbreak TB cases (Group 1, n=9) by ethnicity and location type with case-place links and case-case links

Date of diagnosis is indicated inside the circles followed (in parentheses) by the number of days until contact investigation was initiated. Solid lines connect patients to places and dotted lines connect patients to social contacts.

breaks involving homeless populations, where CB-AB populations continue to be most affected.^{2,3,8,9} TB in the FB is usually the result of reactivation of latent tuberculosis infection (LTBI), as compared to in the CB where disease reactivation likely reflects urban risk factors such as HIV co-infection, substance abuse and homelessness.⁴ Strategies to improve TB control in the FB require expanded in-country LTBI prevention activity targeting those persons most likely to develop reactivation TB, including those with high-risk medical conditions, refugees, and those who have recently arrived from Africa and Asia.¹⁰ However, geographic information systems (GIS) analysis suggests that in low-incidence countries, the socioeconomic deprivation of certain ethnicities, rather than high-prevalence immigration background, is an important factor in TB disease rates.^{11,12} Our finding emphasizes the impact of the changing ethnic profile of homeless and under-housed populations in Canada and the new transmission paths for infections, such as drug-resistant TB, not seen previously in these communities.

Homeless TB patients tend to seek care when disease is advanced and highly contagious, creating delays in diagnosis and the potential to expose large numbers of other vulnerable populations to the disease. Factors associated with diagnostic delay include HIV seropositivity, history of immigration, poverty, alcohol and substance abuse, which are also known risk factors for TB in low-incidence countries.¹³

Previous reports describe difficulties with identifying contacts of homeless and under-housed persons and the importance of site-based contact investigations.^{9,14,15} Less than one third of contacts in our outbreak were assessed. Challenges faced in this outbreak are similar to those highlighted in other reports involving this population, including identifying, locating and screening contacts as

well as early treatment of those diagnosed with active or LTBI. Specific challenges in this outbreak included the delayed recognition of the outbreak itself. The initial two cases occurred in the urban apartment building approximately one year prior to the peak of the outbreak. Thus, site-based contact investigation at the urban apartment building was delayed, and due to the transient nature of the residents, many had since relocated and could not be found. Second, by the time the outbreak was recognized, it had already spread into the shelters and a large number of contacts had been generated, which overwhelmed limited staff resources. Additional TB control measures within shelters that may have improved outcomes included spot sputum samples upon entry, mobile chest x-ray units, ultraviolet germicidal lighting irradiation (UVGI) and improved ventilation within the shelter.^{16,17}

A previous TB outbreak in the inner city of Edmonton occurred in 2001 and involved eight cases, of which five were FB with the same *M. tuberculosis* genotype. As a result, the local TB program assembled a team of seven public health staff to assess the 502 contacts who were identified. The majority (88.2%; n=443) were screened and approximately one third (31%; n=138) were determined to have latent TB infection based on a tuberculin skin reaction of 10 mm or more of induration. Factors associated with increased contact assessments included additional staffing, site-based screening^{14,15} and offering additional blood-borne pathogen testing.¹⁸

Effective contact investigations are crucial to the control of TB in high-risk communities in low TB prevalence countries. Conventional contact-tracing strategies can fail as they focus on the individual alone and ignore the role that locations and casual contacts play in transmission. New strategies for meeting the challenges

posed by identifying contacts of homeless and under-housed persons include GIS, genomics, and social network analysis (SNA).¹⁴ GIS has been used in contact tracing to examine the geographical distribution of cases, risk factors for disease, and to identify “hot spots” for increased targeted testing. Genomics is the study of the complete genome of an organism. Conventionally, identical genetic fingerprints coupled with epidemiological links have been used to identify clonal TB clusters. However, with complete *M. tuberculosis* genomic sequencing, isolates can be better characterized and may be more divergent than previously identified through molecular epidemiology.¹⁹ SNA has been used in TB contact investigation to identify high-risk behaviours (often illicit drug or alcohol use), common locations, and persons not specifically captured in traditional contact tracing. SNA highlights the importance of common locations and casual contact in sustaining transmission in outbreaks.¹⁹ The importance of these innovative modalities in contact investigation is illustrated by the failure of conventional genotyping and contact tracing to capture the true dynamics of an outbreak in British Columbia.²⁰ Instead, the combination of large-scale bacterial whole-genome sequencing and SNA were used to link cases and determine the origins of the outbreak.

Our outbreak would have benefitted from a more in-depth social networking analysis at the time of diagnosis of our two index cases. This could have been used early in the outbreak to improve identification of contacts of the index case in the urban apartment building and might have prevented further spread into the shelter systems. If site-based contact investigation and SNA had been initiated at the onset of the outbreak, secondary cases might have been diagnosed at an earlier stage of infection or might have been prevented.

Moreover, endeavours to support and promote education within the Edmonton inner-city community must be undertaken. TB education programs utilizing laypersons from TB-affected FB and CB-AB ethnic groups can be effective in: promoting a more optimal understanding due to decreased language barriers; addressing the stigma associated with TB by increasing sense of support from within their community; and improving the ability to target the needs or deficiencies of the community. These benefits alone may yield a more sustainable TB prevention program.²¹

Although our study is of clinical and epidemiologic interest, several limitations exist. First, our sample size made it difficult to compare transmission characteristics between groups. Second, this outbreak occurred in a homeless population that may be uncharacteristic of the population in other Canadian cities, which may not have as many foreign-born residents. Finally, our retrospective study used public health surveillance data, making our analyses subject to limitations in terms of how the data were collected and recorded. However, our study highlights the ongoing transmission of TB within homeless and under-housed populations and the potential for the introduction of drug-resistant infections into the shelter system. Therefore, further study of innovative health-care and contact-tracing interventions within this at-risk population is warranted.

CONCLUSION

This outbreak illustrates the changing demographics and subsequent emerging health concerns for under-housed populations in Canada. This group presents considerable challenges with delayed diagnosis and treatment as well as exposure to large numbers of

vulnerable populations. There is a need for improved strategies to promote contact screening, latent TB preventive treatment initiation and completion, and early case detection, including raising awareness and improving both access to services and active case-finding measures.

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RÉSUMÉ

Objectif : Une écloison de tuberculose s'est produite entre 2008 et 2009 dans un grand immeuble d'appartements et trois maisons d'hébergement pour sans-abri situés dans le même pâté de maisons à

TUBERCULOSIS OUTBREAK

Edmonton, en Alberta. Nous décrivons la dynamique de transmission de cette éclosion multiethnique et multicentrique de tuberculose dans un quartier déshérité du centre-ville.

Méthode : Nous avons mené un examen rétrospectif des dossiers médicaux par le biais du Système intégré d'information sur la santé publique (SIISP) pour en extraire les données démographiques, cliniques et de traitement, ainsi que les noms des contacts des 19 cas impliqués dans l'éclosion. Les isolats de la tuberculose ont été génotypés à l'aide du polymorphisme de restriction (RFLP) de la séquence d'insertion IS6110. Les variables catégorielles ont été comparées selon la méthode exacte de Fisher, et les variables continues ont été analysées à l'aide du test de Kruskal-Wallis.

Résultats : Le génotypage a permis d'identifier deux groupes. Le premier comprenait 9 cas présentant un génotype de la tuberculose nouvellement identifié circulant en Alberta. Tous les cas de ce groupe étaient des hommes, et les deux tiers étaient d'origine nord-africaine; la transmission de la maladie dans la population née au Canada s'est faite lors de séjours dans des maisons d'hébergement pour sans-abri. Les membres du second groupe identifié (n=3), des Autochtones nés au Canada, avaient été infectés par une souche de la tuberculose ayant déjà circulé en Alberta.

Conclusion : Cette étude montre la transmission d'une nouvelle souche de la tuberculose d'une population née à l'étranger dans une population née au Canada, ceci dans un milieu au service de populations vulnérables. L'étude fait ressortir les changements démographiques dans la population des personnes mal logées au Canada et soulève de nouvelles préoccupations relatives à leur santé.

Mots clés : personnes sans domicile fixe; *Mycobacterium tuberculosis*; Canada; personnes nées à l'étranger; maisons d'hébergement; flambées épidémiques