Tuberculosis Outbreak in a Long-term Care Facility

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ABSTRACT

OBJECTIVES: Tuberculosis (TB) was a major cause of morbidity and mortality in Canada early in the 20th century. Elderly populations in Canada remain at high risk for TB disease. Elderly patients may present atypically, with the result that many active cases can remain undiagnosed. We present an outbreak of TB that occurred in a Residential and Long-Term Care (LTC) facility in Ontario.

METHODS: Case finding was carried out through the conventional concentric circle approach. Three rounds of tuberculin skin testing were conducted at 8-12 week intervals. Laboratory analysis was conducted at the Public Health Ontario Laboratories. An indoor air quality assessment was conducted to determine whether inadequate engineering controls were a transmission risk factor.

RESULTS: A case of active pulmonary TB was confirmed in May 2010 in a staff member at the facility. By January 2011, 3 additional active cases and 24 latent tuberculosis infections among residents and staff had been identified. Genotyping methods confirmed that the 4 active cases were infected by an identical strain. Nine of 15 locations tested in the facility had air exchange rates below published guidelines.

CONCLUSION: Prompt reporting of the initial case allowed for a quick initiation of the epidemiologic investigation. Given the epidemiology of TB in elderly populations, outbreaks should remain a concern for LTC facilities and physicians, even in jurisdictions of low TB incidence. Baseline and annual TB screening for residents and staff, early diagnosis of active TB, and adequate ventilation are important to reduce the incidence of disease.

KEY WORDS: Epidemiology; outbreaks; tuberculosis; long-term care

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

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Tuberculosis (TB), caused by *Mycobacterium tuberculosis* infection, is spread through airborne, aerosolized droplet nuclei produced by persons with pulmonary TB during forceful expiration (e.g., coughing, sneezing).¹ TB disease most commonly affects the lungs but can involve almost any organ of the body and was a major cause of morbidity and mortality in Canada throughout the first half of the 20th century.

Since then, the Canadian incidence rate of new cases has steadily declined to approximately 4.7 per 100,000 population per year.² The highest rates of TB disease occur in three groups: Aboriginal (28/100,000),² foreign-born (13/100,000)² and the elderly. In the elderly, incidence rates increase with age, from 5.4 (65-74 years) to 8.5 (≥75 years) per 100,000.² Classic symptoms of active pulmonary disease are cough, fatigue, weight loss, fever and night sweats. However, elderly patients may present atypically (unexplained weight loss, anorexia, weakness, or change in cognitive status), such that many active cases may be undiagnosed.³

In 1956, 75% of persons living in large cities in Ontario had latent TB infection (LTBI) by the age of 60.⁴ In 2007, 20-30% of those aged 65 or older in long-term care (LTC) facilities may be infected.⁵ Because persons with LTBI remain at risk for reactivation and post-primary TB disease, health care professionals caring for institutionalized elderly must be aware of the risks of TB in the elderly in order to manage this diagnosis.

A 1992 survey of 29 nursing homes and 26 homes for the aged in metropolitan Toronto found that 20% of respondent institutions reported at least one case of active TB in the previous five years.⁶ Outbreaks reported in nursing homes in the United States demon-

strate that TB transmission is very efficient within closed environments.⁷⁻⁹ In Arkansas, unrecognized TB in a resident led to infection of 49 other residents, including 8 cases of active TB disease and 1 death.⁷ A second outbreak in the state led to infection of 52 employees, 23 residents and 1 visitor.⁹ Spread from a nursing home into the community was also reported in a Washington outbreak involving 6 residents, 1 employee and 1 visitor.⁸

To our knowledge, there have been no published reports of TB outbreaks in long-term care facilities in Canada. We present an outbreak of TB that occurred in a Residential and Long-Term Care (LTC) facility in Ontario among staff members and residents from May 2010 to January 2011.

METHODS

Following diagnosis of the index case, case finding was carried out by the local public health unit through the conventional concentric circle approach described in the Canadian Tuberculosis Standards (i.e., casual and community contacts are tested only if close

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Table 1. Characteristics by Case Definition, May 1, 2010 to January 31, 2011, Ontario (n=28)

Characteristic	Case Definition		
	Confirmed Active TB (n=4)	New LTBI (n=24)	All (n=28)
Number of persons	4	24	28 (100.0%)
Number of deaths	3	0	3 (10.7%)
Number of hospitalizations	3	0	3 (10.7%)
Sex			
Female	3	19	22 (78.6%)
Male	1	5	6 (21.4%)
Age			
Range	40 to 92 years	22 to 94 years	22 to 94 years
Mean	76 years	65 years	66 years
Median	86 years	72 years	77.5 years
Designation			
LTC residents	3	10	13 (46.4%)
Residential residents	0	5	5 (17.9%)
Staff members	1	9	10 (35.7%)

contacts have a high rate of infection).¹⁰ For the purpose of this investigation, all facility staff, volunteers and residents were considered close household contacts (shared airspace on a daily basis and/or >4 hours/week), and visitors and family members were considered close non-household contacts if they shared airspace 2-4 hours/week. Tuberculin skin testing (TST) was conducted for identified contacts at 8-12 week intervals, based on experimental and epidemiologic evidence indicating that TST conversion occurs within 8 weeks of exposure and infection.¹⁰ Induration of 5 mm or greater was considered a positive result. Persons found to have a positive TST received a chest x-ray and a physician assessment to rule out active disease. All suspicious chest x-rays were followed by a chest computerized tomography (CT) scan and sputum samples for culture. One resident was referred for bronchoscopy after attempts to collect sputum were unsuccessful and sputum induction was not available.

Cases defined as confirmed active cases had a positive culture for *M. tuberculosis* complex with or without symptoms of TB disease, a positive TST or findings indicative of TB infection on x-ray or CT. Cases defined as new latent TB infection (LTBI) had a positive TST preceded by a documented negative TST prior to January 1, 2010 and no symptoms or findings suggestive of active TB disease.

Laboratory analysis of sputum and other samples was conducted at the Public Health Laboratories, Public Health Ontario (PHOL). Standard protocols for restriction fragment-length-polymorphism (RFLP),⁶ spoligotyping,^{11,12} and mycobacterial interspersed repetitive unit-variable number tandem repeats (MIRU-VNTR)^{13,14} methods were used.

An external contractor completed an assessment of the heating, ventilation and air conditioning (HVAC) airflow in December 2010. Air flow measurements were taken in 15 locations within the Facility using an Accubalance 8371. Data-logging measurements of carbon monoxide (CO), carbon dioxide (CO₂), temperature and relative humidity were collected in six locations using a TSI QTrak Monitor. Measurements of CO, CO₂, temperature and relative humidity were recorded at five-minute intervals for three days in duration at each location. The number of air changes per hour (ACH) was calculated: $ACH = [\text{Air Supply (cfm)} \times 60 \text{ minutes/hour}] / [\text{Volume of the Room (cf)}]$

RESULTS

A case of active pulmonary TB was diagnosed in May 2010 in a staff member at a 121-bed combined retirement residence and LTC facil-

Table 2. Results From Environmental Testing

Location	ASHRAE Total ACH Guideline	Air Changes per Hour	Meets ASHRAE Guideline
Dining Room A	4	0.8	N
Dining Room C	4	5	Y
Common Area B	4	3.4	N
Common Area E	4	4.4	Y
Staff Meeting (Mtg) Area	4	6.1	Y
Room 27	4	4	Y
Room 31	4	3.4	N
Room 30	4	4.0	Y
Room 19	4	3.3	N
Room 14	4	3.3	N
Room 7	4	3.8	N
Room 37	4	3.2	N
Room 34	4	3.1	N
Room 22	4	2.4	N
Common Area D	10	25	Y

ity that includes private and shared accommodations (two beds per room). The building is separated into two distinct sides: Long-Term Care and Residential. The LTC side has only one floor whereas the Residential side has two floors. Residents typically eat in separate dining rooms; however crossover between facility sides may occur for social activities. The index case presented with classic symptoms of TB disease, including cough, fever, night sweats and pleuritic chest pain in April 2010. Individual risk factors included immigration to Canada in 2004 from a high TB incidence country (Philippines). A 1-step baseline TST was documented as negative in 2007. A chart review did not identify a past history of TB disease or conditions that might have led to a false-negative TST reaction.

Following identification of the index case, primary care physicians attending to facility residents were alert to subtle changes in patient condition and identified additional cases (one in July and two in October 2010). The LTC residents diagnosed with active disease primarily presented with weight loss and worsening chronic cough. By January 2011, a total of 3 laboratory-confirmed active cases and 24 newly identified LTBI among residents and staff had been identified (see Table 1).

The attack rate among staff members was 0.8% (1/121) for active cases and 7.4% (9/121) for new LTBI. For residents (LTC and Residential), attack rates were 2% (3/146) for active cases and 10.3% (15/146) for new LTBI. By January 2011, 24% (10/42) of the identified family members and visitors of active cases had received a TST. None were positive.

In this outbreak, 96.5% (54/56) of LTC residents had a documented 2-step TST at the time of admission to the facility. Although the *Canadian Tuberculosis Standards* recommend that all employees have a 2-step TST at the time of hiring, documented baseline TST results were available for only 40% (48/121) of staff members.

Laboratory testing

All three genotyping methods confirmed that the four active cases were infected by an identical strain that was unique in the TB genotype database in Ontario and in Canada (Public Health Ontario Laboratory, Toronto, ON and National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, MB). The outbreak spoligotyping pattern was spoligo-international type (SIT) #167 belonging to the T1-lineage of TB strains, a EuroAmerican strain. At least 42 SIT #167 isolates from several countries worldwide have been reported to the international spoligotyping database curated at L'Institut Pasteur de la Guadeloupe.¹⁵

Environmental testing

Nine of the 15 locations tested had air exchange rates below the American Society of Heating, Ventilating and Air-Conditioning Engineers (ASHRAE) guidelines, which set a range between 2 (e.g., in corridors) and 10 (e.g., in washrooms, sterilizing, diagnostic and treatment areas) total air exchanges per hour (ACH).¹⁶ Resident rooms, dining rooms and common areas require 4 ACH. Carbon dioxide levels (a surrogate measure of fresh air addition) exceeded the 1000 ppm guideline in the staff meeting area and common area E (although ACH was adequate), indicating that occupancy within the affected rooms was higher than that for which the rooms were designed (see Table 2).

Figure 1 shows the room locations of the active TB and LTBI cases, as well as air flow measurement results within the facility.

Treatment and outcomes

The strain was sensitive to all first-line drugs used to treat TB in Canada: isoniazid (INH), rifampin, ethambutol and pyrazinamide. The index case completed a six-month course of treatment including all four medications without incident. The three residents with active TB disease initiated treatment with isoniazid, rifampin and ethambutol. One also received pyrazinamide. One resident died due to treatment complications (INH hepatitis). The two other residents died during treatment, with TB identified as a contributing factor. The primary causes of death were pulmonary embolism and renal carcinoma.

Fifteen residents were offered treatment for LTBI. Three completed the standard regime (5 mg/kg of INH daily for nine months). One died of unrelated causes while on treatment, two were discontinued secondary to treatment complications and nine residents either refused or had an underlying medical condition that precluded treatment.

Nine staff members with new LTBI were offered treatment. Six completed the standard regime, two refused and one deferred treatment until after pregnancy.

Control measures

Control measures implemented by the facility with assistance of the local public health unit included contact tracing and case follow-up as described above and closing the facility to admissions and resident transfers unless authorized by the public health unit.

DISCUSSION

The facility and local public health unit were concerned with identifying the source of the outbreak and transmission links between the cases. A chart review provided some evidence that one of the residents diagnosed in October 2010 may have been symptomatic as far back as December 2009. The molecular genotyping showed that the four active cases were infected by an identical strain unique in Canada. Since all cases were linked by person, place and time, this outbreak was identified to be an isolated cluster. Close living conditions and prolonged exposure due to delayed diagnosis of active disease were potential factors in the transmission of TB among residents and staff.¹⁷

In particular, barriers to access of diagnostic services may have delayed diagnosis of some active cases. Many residents were unable to expectorate sufficient amounts of sputum on demand; therefore, samples for microscopic and microbiologic testing were collected

opportunistically or via invasive bronchoscopy. Had sputum induction facilities been available in the public health unit, it is possible that suspected cases of active TB might have been identified earlier.

Virtually all patients will produce sputum samples using induction techniques, and a single induced sputum sample has better sensitivity than bronchoscopy for the diagnosis of TB.² Sputum induction requires a small, negative pressure room with at least 12 ACH. Air should be exhausted through a dedicated exhaust or HEPA filtered (reference TB guidelines). While a separate sputum induction room may not be practical in all hospitals, complete or partially enclosed booths could be used as an alternative. Complete enclosed booths range in cost from approximately \$3000 for a fully enclosed portable tent to \$7500 or greater for a booth.¹⁸

Other factors related to the outbreak setting and population presented challenges to this investigation. The TST "booster effect" was first described in elderly persons in whom it was thought to demonstrate LTBI acquired remotely, with subsequent waning of immunity. However, research suggests that the recommended 2-step test may be insufficient to fully elicit the booster phenomenon in the elderly.¹⁷ Among the LTC residents, most had a documented 2-step TST at the time of admission to the facility. Given that only 7.3% of residents had a positive baseline TST when the true prevalence of LTBI for residents ≥ 65 years of age in long-term care facilities in Canada may approach 20-30%,² it is possible that some of the LTBI cases identified among residents were not new infections.

The TST booster effect has also been described in persons with sensitivity to non-tuberculous mycobacterial antigens or prior BCG vaccination. In this investigation, most (7 of 10) staff members who were identified with active TB or new LTBI were born outside of Canada. Depending on TB epidemiology and vaccination recommendations in their country of origin, these persons may have been previously infected with TB or other mycobacteria in their country of origin and/or vaccinated with BCG. Documented baseline TST results were available for only 40% of staff members, although the *Canadian Tuberculosis Standards* recommend that all employees have a 2-step TST at the time of hiring.

Following primary infection, the estimated lifetime risk for the development of TB disease is 10%, although certain factors increase personal risk. For example, HIV infection increases risk to 10% annually, 50-110 times higher than persons without known risk factors.¹⁰ Frail elderly adults residing in long-term care settings have been reported to have 5-50 times greater risk of active disease compared with community-dwelling elderly of a similar age.¹⁷

Poor adherence has been cited as the most important reason for the failure of treatment to prevent TB disease,² but treatment in the elderly is associated with significant morbidity. Of the 18 residents offered treatment for active TB disease or LTBI, 9 initiated treatment and only 3 completed treatment successfully. The mortality rate for residents with active TB disease was 100%.

CONCLUSION

This outbreak investigation attempted to determine the source of the outbreak and transmission links among cases. All cases were linked via epidemiology and molecular diagnostics, but a source case could not be identified conclusively. Given the epidemiology of TB in elderly populations and the high mortality rate associated

Figure 1. Room locations of residents with confirmed active cases and LTBI and air flow measurement results, May 1, 2010 to January 31, 2011 (n=28)

with treatment, outbreaks should remain an issue of concern for LTC facilities and physicians. With this in mind, some recommendations are provided:

- Baseline 2-step TST, or 1-step in select circumstances at hire or placement for staff and regular volunteers;
- Annual TST for staff and regular volunteers if the annual TST conversion rate in such facilities is 0.5% or higher;
- Baseline posterior-anterior and lateral chest X-ray for new residents;
- Baseline 2-step TST for new residents if required by public health authorities or if the past incidence of active TB in the population served by the institution is elevated;
- Consult as needed with a TB expert regarding management of positive TST results and treatment of active TB cases;
- Suspect active TB in any resident with fever, cough for more than 3 weeks, unexplained weight loss, hemoptysis, loss of appetite or night sweats;
- Proactively secure access to a diagnostic sputum induction service which can be used by residents with suspect disease. It is more sensitive and causes fewer adverse effects than bronchoscopy;
- Prepare written policies and procedures to facilitate the timely transportation of residents and/or laboratory specimens to diagnostic services;
- Check ventilation rates in all rooms regularly used by patients/residents and staff. To minimize the risk of transmission, modify (or upgrade) the system to meet ASHRAE guidelines for each room type. According to Canadian accreditation standards, facilities must be aware of and follow evidence-based international, federal, and provincial or territorial infection control guidelines.

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RÉSUMÉ

OBJECTIFS : La tuberculose était l'une des grandes causes de morbidité et de mortalité au Canada au début du 20^e siècle. Les populations âgées du Canada présentent encore un risque élevé de contracter la tuberculose-maladie. Ses manifestations peuvent être atypiques chez les patients âgés; de nombreux cas actifs peuvent donc rester non diagnostiqués. Nous présentons une écloison de tuberculose survenue dans une maison de soins infirmiers en Ontario.

MÉTHODE : Nous avons procédé à la recherche des cas selon l'approche classique des cercles concentriques. Trois cycles de tests cutanés à la tuberculine ont été menés à intervalles de 8 à 12 semaines. L'analyse a été faite dans les laboratoires de Santé publique Ontario. Une évaluation de la qualité de l'air à l'intérieur a permis de déterminer si des mesures d'ingénierie inadéquates étaient un facteur de risque dans la transmission de la maladie.

RÉSULTATS : Un cas de tuberculose pulmonaire active a été confirmé en mai 2010 chez un membre du personnel de l'établissement. En janvier 2011, 3 autres cas actifs et 24 infections latentes à la tuberculose avaient été détectés parmi les résidents et le personnel. Des méthodes de génotypage ont confirmé que les quatre cas actifs étaient infectés par une souche identique. Neuf des 15 endroits testés dans l'établissement avaient des taux d'échange d'air inférieurs aux lignes directrices publiées.

CONCLUSION : La déclaration rapide du cas initial a permis d'amorcer rapidement l'enquête épidémiologique. Étant donné l'épidémiologie de la tuberculose dans les populations âgées, les maisons de soins infirmiers et les médecins doivent rester à l'affût des écloisions, même dans les provinces et les territoires où l'incidence de la tuberculose est faible. Le dépistage initial, puis annuel de la tuberculose chez les résidents et le personnel, le diagnostic précoce de la tuberculose active et une ventilation adéquate sont d'importants facteurs pour réduire l'incidence de cette maladie.

MOTS CLÉS : épidémiologie; flambées épidémiques; tuberculose; soins longue durée