

# Evaluation of a School-Based Tuberculosis-Screening Program and Associate Investigation Targeting Recently Immigrated Children in a Low-Burden Country

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## ABSTRACT

**CONTEXT.** In countries with a low incidence of tuberculosis (TB), screening programs targeting recent immigrants from TB-endemic countries have been shown to be effective in further reducing TB incidence; however, evaluative data on some aspects of these programs remain sparse.

**OBJECTIVE.** We sought to retrospectively evaluate a school-based screening program targeting children at high risk for TB infection in Montreal, Canada, as well as subsequently investigate family and household associates of the schoolchildren with latent TB infection (LTBI), based on adherence to LTBI therapy and cost-benefit analysis.

**DESIGN, SETTING, AND PARTICIPANTS.** Newly arrived immigrant children (aged 4–18 years) in selected schools were screened for LTBI by using the tuberculin skin test (TST). The TST was defined as positive at an induration of  $\geq 10$  mm. Each child who tested positive on the TST was referred for medical evaluation. Family and household associates of the TST-positive child also were screened for LTBI. Classroom attendance sheets and medical charts were reviewed for 16 elementary and secondary schools that comprised the school-screening program of the Montreal Children's Hospital from 1998 to 2003. Medical charts of the child associates (<18 years old) who were screened were reviewed also.

**MAIN OUTCOME MEASURES.** The main outcome measures were TST-positivity rate, rate of adherence to LTBI therapy, estimation of factors associated with adherence, and net cost/benefit of the school-screening and associate-investigation programs, both respectively and as a combined program, compared with the cost of passive treatment of TB disease.

**RESULTS.** Of 2524 immigrant children screened, 542 (21%) were TST-positive. Of 342 children started on therapy, 316 (92%) demonstrated adequate adherence.

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### Key Words

tuberculosis, children, targeted screening, associates, cost-effectiveness

### Abbreviations

TB—tuberculosis  
LTBI—latent tuberculosis infection  
MCH—Montreal Children's Hospital  
TST—tuberculin skin test  
INH—isoniazid

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The only predictor of adherence among the schoolchildren was having  $\geq 2$  family members brought in for TB screening (adjusted odds ratio: 2.0; 95% confidence interval: 1.3–3.3). There were 599 associates investigated from the 484 TST-positive schoolchildren seen at the TB clinic. Of 555 associates with TST results, 211 (38%) were found to be TST-positive. Of 136 TST-positive child associates, 131 were seen at the Montreal Children's Hospital TB clinic and had their chart reviewed. Of these, 108 (82%) were started on LTBI therapy, and 78 (79%) of 99 of those children with information complied adequately with their therapy. We found net benefits from both school-based screening and associate investigation, both as stand-alone programs and as 1 coordinated, targeted TB-screening program.

**CONCLUSION.** We demonstrated the effectiveness, including cost-effectiveness, of a targeted, school-based screening program in a low-burden country and the extra benefit given by adding associates to such a program.

**I**MMIGRANTS AND FOREIGN-BORN Canadians account for more than half of all active tuberculosis (TB) cases in Canada,<sup>1</sup> and in Montreal their overall risk for developing active disease is 10 times higher than the non-foreign-born population (37.5 and 3.3 cases per 100 000, respectively).<sup>2</sup> TB disease rates are at their highest during the first few years of arrival to Canada.<sup>1</sup> Furthermore, the TB case rate among foreign-born children has been found to be relatively high when compared with Canadian-born non-Aboriginal children.<sup>1</sup> In Canada, there is no systematic screening for latent TB infection (LTBI) among newly arrived children. Children aged 11 years and older are required to undergo a chest radiograph and must either complete a course of treatment before entry to Canada if they are found to have active TB or be placed under medical surveillance as a condition of entry if they are found to have inactive TB.<sup>3</sup>

In low-burden countries, screening programs that target recently immigrated populations, including children, may be particularly effective in reducing the burden of TB.<sup>4–6</sup> Another strategy for targeted tuberculin skin testing is that of the associate investigation, in which family members and other close contacts of children who are diagnosed with LTBI are persuaded to receive TB screening and treatment as necessary.<sup>7</sup> To maintain TB-prevention programming among foreign-born children in a low-incidence area, it is necessary to assess the potential effectiveness of such a program in terms of successful screening, drug-therapy treatment, adherence to treatment, and cost-effectiveness. Furthermore, determining which factors are associated with adherence to treatment allows for an assessment of strengths and opportunities for improvement in a particular targeted screening program.

Previous studies evaluating school-based screening studies<sup>8–15</sup> have not included any details of related associate investigations, nor have they determined factors associated with adherence to TB drug therapy. Of the few studies that have evaluated associate investigations in children,<sup>16–19</sup> only 1 included children  $> 8$  years of age, none were explicitly related to another targeted screening-program strategy, and none included a cost-benefit analysis. We evaluated a school-based screening program that targeted children at high risk for TB infection in Montreal, as well as subsequent investigation of family and household associates of the schoolchildren with LTBI. This evaluation was a retrospective review of available data and was based on screening, treatment, and adherence rates, as well as on cost-effectiveness of the program. A comparison was also made between the net cost/benefit of the school-based screening alone and that of the school screening with associate investigation. The results of this study were presented in part elsewhere.<sup>20</sup>

## METHODS

Each school year, the TB clinic at the Montreal Children's Hospital (MCH) performs TB-screening clinics at welcoming classes for newly arrived immigrant children (aged 4–18 years) in a selected number of elementary and secondary schools. These welcoming classes are provided to help integrate the child into the school and the new society, as well as to offer language-learning assistance to children whose first language is not French. Schools were chosen primarily from multiethnic neighborhoods in which a large proportion of the families were most likely to have immigrated to Canada from a highly endemic TB country and in which students attending welcoming classes are more closely followed and supported. A school also may have been visited by the TB clinic because of a special request from the school board or by notification from the Montreal health board if cases of active disease had been reported in specific schools over the previous years. Schools that were included in the screening program on a 1-time basis for the sole purpose of investigation of contacts of an active TB case within that school were excluded from our study. For each school visited, a specific grade was usually targeted. In elementary schools, that target was primarily grade 6.

The TB-screening program was conducted in connection with the local community health clinic. Each local community health clinic provided the child with a written consent form to bring home to his or her family along with information on TB infection, disease, and the importance of screening. Children who were not present in class at the time of the TB clinic were given an appointment for screening at the MCH, provided their parents had already signed the consent form.

The tuberculin skin test (TST) was performed by

trained nurses from the TB clinic of the MCH according to Canadian tuberculosis standards.<sup>21</sup> The TST was performed by using the Mantoux technique and injection of 0.1 mL or 5 TU of purified protein derivative-T, which is bioequivalent to purified protein derivative-S (Connaught-Merieux Laboratories, Willowdale, Ontario, Canada). A positive TST was defined as an induration of  $\geq 10$  mm in diameter at the site of injection 48 to 72 hours after administration. Children with a TST result between 5 and 9 mm (inclusive) were also referred to the MCH for medical evaluation if symptoms characteristic of TB were observed by the TB nurse. Children whose parents reported prior skin testing were retested unless documentation of the results was provided. Each child who tested positive on the TST was given an appointment sheet for the TB clinic, which gives instructions for the visit in French, English, Spanish, Russian, and Chinese. At the appointment, the accompanying parent(s) was asked about the family's knowledge, beliefs, and personal experience with TB and the child's history with respect to immigration and TB treatment. Bacille Calmette-Guérin (BCG) vaccination status was assessed through report by the child's parent or guardian and was verified by any existing medical documentation, vaccination records, and scarring at common sites. Associates of the child were also given a date for TB screening at this time. Associates were defined as those family members and any other individual demonstrating close, sustained contact with the child, primarily through cohabitation or recent long-term visits to the child's household. Overlap between school screenings and investigation of siblings was prevented largely by the targeting of 1 particular grade in each school, as mentioned previously.

The medical evaluation was conducted by the TB clinic physician and followed Canadian Thoracic Society guidelines for TB control.<sup>22</sup> Previous BCG vaccination was ignored in the interpretation of the TST results.<sup>21</sup> All patients received a physical examination and posterior-anterior and lateral chest radiograph; gastric lavage, sputum smear, and cultures were performed when active TB disease was suspected. For children started on isoniazid (INH) therapy, follow-up visits were planned for the second, fourth, and eighth month of treatment. Adherence to therapy was assessed by the clinic nurses through pill counts, patient self-report, verification with pharmacies, and general attendance to the scheduled medical visits. Adherence to the LTBI regimen was considered adequate if patients took  $>80\%$  of the total prescribed doses within 43 weeks of initiating therapy, whereas the remainder were considered to have poor adherence. Techniques such as availability of interpretation services at each appointment and, according to the parents' baseline level of knowledge, teaching and provision of information for better comprehension of the LTBI-treatment regimen were used to improve adher-

ence. Children who were diagnosed with active pulmonary TB were seen on a monthly basis by the respirologist.

Records from these visits collected over a period of 5 school years (1998–2003, inclusive) were reviewed by using classroom attendance sheets used by the MCH TB nurse as well as medical charts of those children who presented at the TB clinic for evaluation. For each child diagnosed with LTBI, a record of family members who also were screened was entered in the medical chart. Schoolchildren and associates who were screened and treated at the MCH TB clinic had their medical chart reviewed for information on initiation of treatment and adherence to treatment. Associates  $\geq 18$  years of age were not seen at the MCH and were not assessed for treatment information in this study.

From the classroom attendance sheets, the proportion of TST-positive children was determined, whereas the medical charts of both the schoolchildren and their child associates were evaluated to assess the proportion of TST-positive children who had presented at the clinic, been initiated on INH treatment, and completed treatment with adequate adherence. For schoolchildren only, these values were also stratified by school year to view any trends in how the program was being administered. Among schoolchildren and associates with a positive TST, the following demographic and treatment-factor proportions were calculated: gender, age at test date, years since immigration to Canada, region of origin, self-reported BCG vaccination status, self-reported previous TST, chest radiograph results, treatment adverse effects, and number of family members screened. Among TST-positive schoolchildren, these factors were assessed for potential associations with LTBI-treatment adherence by using univariate and multivariate analyses. A comparison was also made between those who were lost to follow-up during LTBI treatment and those who were not based on these same demographic and treatment factors. The  $\chi^2$  test was used to determine the statistical significance of categorical variables, and analysis of variance was used for continuous variables. Analyses were conducted by using the SAS 8 software system (SAS Institute, Inc, Cary, NC). A *P* value of  $<.05$  was considered statistically significant. Multivariate analyses were assessed by using a backward-selection procedure with *P* = .2 assigned as the cutoff for selection.

The cost-benefit comparisons were made by first calculating the total material and labor costs associated with the school-screening program and the associate investigations, respectively. All associates investigated, including adults, were included in this calculation. This figure was compared with the cost of managing 1 case of active TB through passive case finding as well as the investigation of contacts of the active case and treatment of contacts with LTBI, which then was multiplied by the estimated number of active TB cases that were prevented

among the TST-positive children and adults who were screened and treated through the school-based program and subsequent associate investigation. The values for the cost of treating 1 active TB case as well as contact investigation and treatment of contacts were derived from a recent cost-benefit analysis of treatment of TB in Montreal.<sup>23</sup> All reported figures for cost are in Canadian dollars. The number of contacts per case of pediatric TB disease was estimated by interpolating the average number of contacts investigated per case of pulmonary TB among the  $\leq 18$ -year-old age group and the immigrant group based on observed data from an evaluation of contacts of active cases seen in Quebec.<sup>24</sup> The estimated number of TB cases prevented was based on the total number of subjects in the current study who successfully adhered to therapy, as well as on estimates that 10% of all LTBI will become active cases later on in life,<sup>25</sup> that all children were HIV-negative, that sensitivity and specificity for the TST were 90%,<sup>26</sup> and that adherence to INH therapy was 90% effective in preventing TB.<sup>23</sup> Rates of INH-therapy adherence observed in this study were also used. For adult associates seen at the other clinic, we used the overall adherence rate of 70% that was reported for LTBI treatment in the recent-immigrant population.<sup>23</sup>

The sensitivity of the results to different cost assumptions was tested by varying the rate of hospitalization for the treatment of active pediatric TB cases. In addition, cases prevented were discounted at 3% annually over a 20-year period in both the original (76%) and the reduced-rate-of-hospitalization (50%) scenarios. Finally, all of the above-mentioned scenarios were repeated by substituting a 5% probability of lifetime risk of developing TB for those TST-positive subjects who had lived  $> 2$  years in Canada at the time of original screening<sup>27</sup> and, separately, a 95% sensitivity and specificity for the skin test.

## RESULTS

From September 1998 to August 2003, a total of 3710 immigrant children were listed as available for TST testing in the 16 elementary and secondary schools that were chosen for screening, of whom 2524 (68%) were tested. Of these, 542 (21%) had a TST result of  $\geq 10$  mm, and 484 (89%) of them presented at the MCH TB clinic.

The number of children started on LTBI treatment was 375 (77% of those without active TB disease who presented at the clinic), of whom 316 of 342 with information on this factor (92%) completed therapy with adequate adherence. The proportions for each of these figures remained relatively stable throughout the 5-year time period (see Table 1), although a significant decrease was observed over this period in the proportion of referred children who presented at the TB clinic for treatment. There were also 99 children with TST results between 5 and 9 mm who presented at the clinic, of whom 9 (9%) were started on LTBI treatment. Three of those children were treated because of the presence of abnormalities on the chest radiographs, which were compatible with inactive disease, whereas the other 6 had many family members who had already tested TST-positive. INH was the drug used for treating LTBI in all but 2 children. Two active cases of TB were detected during this 5-year period: 1 15-year-old girl with pulmonary TB and a 12-year-old boy with pleural TB.

Descriptive characteristics of schoolchildren who were TST-positive and attended the clinic at MCH ( $n = 484$ ) are detailed in Table 2. Abnormal chest radiographs related to TB were primarily the result of the presence of calcified granulomas, whereas peribronchial thickening was present in the remaining abnormal chest radiographs that were not related to TB. The most common symptoms recorded during treatment were abdominal pain (45%) and associated minor weight loss (14%).

Loss to follow-up occurred in 78 (21%) cases. Those who were lost to follow-up were found to be, on average, older at the time of testing (13.0 vs 12.1 year old;  $P < .05$ ) and had been in Canada longer (15.8 vs 11.3 months;  $P < .05$ ) compared with those who had completed LTBI treatment. Multivariate analysis demonstrated that, among screened schoolchildren, having  $\geq 2$  family members who were brought in for TB screening was positively associated with adherence to treatment (Table 3).

There were 599 associates investigated from the 484 TST-positive schoolchildren who were seen at the TB clinic. The mean age of all associates was 24.9 years (SD: 15.8) and 314 (52.4%) were male. Of 555 associates with TST results, 211 (38%) were found to be TST-positive. Of the 136 TST-positive children associates

**TABLE 1** Yearly Totals for TB School-Screening Program

School Year	No. Tested (% High School)	TST $\geq 10$ mm and Referred, $n$ (% Tested)	TST $\geq 10$ mm and Presented at TB Clinic, $n$ (% TST <sup>+</sup> and Referred)	No. Started on Therapy at TB Clinic (% Presented at TB Clinic)	No. Complied to Treatment (% Started on Therapy at TB Clinic)
1998–1999	759 (22)	157 (21)	140 (89)	107 (76)	64 (60)
1999–2000	465 (31)	113 (24)	109 (96)	94 (86)	59 (63)
2000–2001	469 (46)	117 (25)	105 (90)	84 (80)	52 (62)
2001–2002	525 (49)	97 (19)	83 (86)	56 (67)	36 (64)
2002–2003	306 (79)	58 (19)	47 (81)	36 (76)	23 (64)
Total	2524	542 (21)	484 (89)	377 (78)	234 (62)

**TABLE 2** Characteristics of TST-Positive ( $\geq 10$  mm) Schoolchildren and Their Child Associates Presenting at the TB Clinic

Variable	Schoolchildren ( <i>n</i> = 484)	Associates ( <i>n</i> = 131) <sup>a</sup>
Gender, <i>n</i> (%)		
Male	257 (53.1)	70 (53.4)
Age, y		
Mean	12.4	11.6
Range	5.0–18.4	1.2–17.8
Region of origin, <i>n</i> (%)		
East/Southeast Asia	121 (25.0)	19 (14.6)
Eastern Europe	102 (21.1)	24 (18.5)
Central Asia	67 (13.8)	21 (16.2)
South Asia	67 (13.8)	32 (24.6)
South/Central America	39 (8.1)	11 (8.5)
North Africa/Middle East	28 (5.8)	7 (5.3)
Caribbean	22 (4.5)	8 (6.1)
Sub-Saharan Africa	20 (4.1)	4 (3.0)
North America/Western Europe	18 (3.7)	4 (3.0)
Years since immigration to Canada, <i>n</i> (%)		
<1	156 (32.2)	52 (39.7)
1–2	242 (50.0)	63 (48.1)
$\geq 2$	86 (17.8)	16 (12.2)
Vaccinated (BCG), <i>n</i> (%) <sup>b</sup>		
Yes	407 (84.1)	104 (79.4)
No	22 (4.5)	4 (3.1)
Unknown	55 (11.4)	23 (17.6)
Previous TST, <i>n</i> (%) <sup>b</sup>		
Yes	127 (26.2)	27 (20.6)
No	221 (45.6)	59 (45.0)
Unknown	136 (28.1)	45 (34.4)
Chest radiograph results, <i>n</i> (%)		
Normal	413 (85.3)	113 (86.3)
Abnormal, not TB	39 (8.1)	5 (3.8)
Abnormal, TB	21 (4.3)	0 (0.0)
Missing	11 (2.3)	13 (9.9)
Started on drug treatment, <i>n</i> (%)		
Yes	377 (77.9)	108 (82.4)
No	66 (13.6)	10 (7.7)
Refused	36 (7.4)	12 (9.2)
Unknown	5 (1.0)	1 (0.8)
Type of drug treatment given, <i>n</i> (%) <sup>c,d</sup>		
INH	370 (98.1)	106 (98.1)
Rifampin	2 (0.5)	1 (0.9)
Other	0 (0)	0 (0.0)
Unknown	5 (1.3)	1 (0.9)
Duration of treatment, <i>n</i> (%) <sup>c,d</sup>		
$\leq 6$ mo	7 (1.9)	3 (2.8)
9 mo	365 (96.8)	103 (95.4)
12 mo	1 (0.3)	0 (0)
Unknown	4 (1.1)	2 (1.9)
Adherence to treatment, <i>n</i> (%) <sup>c,d</sup>		
Good	316 (83.8)	94 (87.0)
Poor	26 (6.9)	5 (4.6)
Unknown	35 (9.3)	9 (8.3)
Treatment adverse effects, <i>n</i> (%) <sup>c,d</sup>		
Yes <sup>e</sup>	22 (5.8)	6 (5.6)
No	314 (83.3)	81 (75.0)
Unknown	41 (10.9)	21 (19.4)
Loss to follow-up, <i>n</i> (%) <sup>c,d</sup>		
None	278 (73.7)	91 (84.3)
Moved	23 (6.1)	2 (1.9)
Dropped out	55 (14.6)	7 (6.5)
Unknown	21 (5.6)	8 (7.4)
Family members screened, <i>n</i> (%)		
0	139 (28.7)	NA
1–3	226 (46.7)	NA
$\geq 4$	45 (9.3)	NA
Unknown	74 (15.3)	NA

NA indicates not applicable.

<sup>a</sup> Children aged <18 years.

<sup>b</sup> Self-reported.

<sup>c</sup> Among those who had been started on treatment (*n* = 377).

<sup>d</sup> For associates: only among children started on treatment at MCH (*n* = 108).

<sup>e</sup> The most common adverse effects for schoolchildren were abdominal pain (*n* = 9), weight loss (*n* = 3), and headache (*n* = 2).



**TABLE 3 Adherence to LTBI Treatment and Associated Factors Among Schoolchildren (Among Those Started on LTBI Treatment [n = 377])**

Variable	OR	Adjusted OR <sup>a</sup>	Adjusted OR 95% CI
Gender, male	0.72	0.76	0.47–1.23
Age, >12 y old	0.82	0.88	0.54–1.43
Region of origin			
North America/Western Europe	1.00 (reference)	1.00 (reference)	—
Developing countries/countries of former Soviet bloc	1.02	0.81	0.27–2.50
Time since arrival in Canada			
<2 y	1.00 (reference)	1.00 (reference)	—
≥2 y	1.07	1.16	0.58–2.31
BCG vaccination	1.24	NA	—
Previous TST	1.04	NA	—
Abnormal chest radiograph	1.73	1.51	0.73–3.14
Adverse effects from treatment	1.19	1.19	0.44–3.20
No. of family members screened			
0–1	1.00 (reference)	1.00 (reference)	—
≥2	2.20 <sup>b</sup>	2.04	1.26–3.30

OR indicates odds ratio; CI, confidence interval; NA, not applicable.

<sup>a</sup> Adjusted for age, gender, region of origin, time in country, chest radiograph status, treatment adverse effects, and number of family members screened.

<sup>b</sup>  $P > .01$ .

(<18 years of age), we reported on the 131 who presented at the MCH TB clinic with a positive TST result (Table 2). Of 130 associates with information, 108 (83%) started on drug therapy. Of 99 child associates who had started therapy and had information, 94 complied adequately with therapy (95%). One active case of TB was detected directly through screening of both child and adult associates: a 65-year-old woman with sputum-smear-positive pulmonary TB.

The cost-benefit analysis (see Table 4) demonstrated that during the 5-year period, an estimated 36.1 cases of active TB were prevented by the school-screening program and the subsequent associate investigation. The costs of the program totaled \$193 461. Comparatively, treating 36.1 active cases would yield a cost of \$557 384, giving the school-screening program approach a net savings of \$363 923 (\$72 785 per year). The associate investigation alone contributed \$95 530 of savings (\$19 106 per year). When the hospitalization rate of active pediatric TB cases was reduced from 76% to 50%, the annual net savings of the combined school screening and associate investigation was reduced to \$45 992. Furthermore, when discounting of the number of cases prevented was applied to the 76% and 50% hospitalization rate, the results were an annual net savings of \$23 068 and an annual net cost of \$8224, respectively. When the scenarios above are recalculated with a lifetime risk of 5% for developing active TB for those diagnosed with LTBI and have lived in Canada for >2 years, the same pattern of reduction in savings was observed, with only slightly lower values. Conversely, when a sensitivity and specificity of 95% were used for the skin test, this pattern was observed again but with slightly higher savings values than in the original scenario.

## DISCUSSION

The prevalence of TST-positive children found in the present study was considerably higher than the 2.4% of Canadian-born Montreal schoolchildren<sup>28</sup> and still higher than that which was reported in another young population at high risk for TB in Canada (Aboriginal peoples<sup>29</sup>). However, the proportion of children who were TST-positive in this study was similar to that found in other studies of school-based screening programs for immigrant children both in Canada<sup>8–10</sup> and other low-burden countries.<sup>11,15</sup> Similarly, the proportion of associates who were TST-positive in this study (38%) was comparable to that of the existing studies on household associates of infected schoolchildren, which had TST positivity ranging from 30% to 43%.<sup>16–19</sup> The active-case-finding rate in this study was somewhat lower than that found in 2 previous studies of school-based TB-screening programs that targeted high-risk populations<sup>8,11</sup> but was higher than that of another evaluated program in which no cases were found<sup>10</sup> and was slightly higher than that of a study of a screening program based in schools with mixed Canadian-born and foreign-born populations.<sup>15</sup> It should be noted that the number of cases found in all of the studies mentioned above did not exceed 2, which may account for the variability in results.

Because the present study was conducted on a retrospective basis and the screening process observed was not set up to be systematically evaluated, there was a resultant inconsistency of data available for all schoolchildren and child associates not available for TST testing, as well as those who were non-TST reactors. However, future evaluations will profit from the recent introduction at the MCH TB clinic of a computer data-

**TABLE 4 Cost-Benefit Analysis of School Screening and Associate Investigation Versus Passive Case Finding: 1998–2003**

	Cost of School Screening	Cost of Associate Investigation
Program costs for screening and treatment for schoolchildren and associates of schoolchildren, \$ <sup>a</sup>		
TST testing, wages, and materials <sup>b</sup>	9518	7983
TB clinic appointments <sup>c</sup>	102 445	51 086
Chest radiographs <sup>d</sup>	12 645	5199
Interpreters <sup>e</sup>	2263	2322
Total	126 871	66 590
Grand total		193 461
Benefits from screening program and associate investigation		
No. of TB cases prevented with school screening		25.6
No. of TB cases prevented with associate investigation		10.5
No. of TB cases prevented, total		36.1
Treatment costs, passively diagnosed active TB case, \$		
Hospitalized proportion of case <sup>f</sup>		10 848
Directly observed therapy <sup>g</sup>		1228
Total cost per case		12 076
Contact investigation (per index case) <sup>h</sup>		694
Treatment of all contacts (per index case) <sup>i</sup>		2670
Total cost for 1 active case		15 440
Treatment costs based on screening and associate benefits, \$		
Treatment of TB cases prevented, school		395 264
Treatment of TB cases prevented, associates		162 120
Treatment of TB cases prevented, total		557 384
Total net cost (savings) from school-screening program and associate investigation		(363 923)
Total net cost (savings) from school-screening program without associate investigation		(268 393)
Total net cost (savings) from associate investigation		(95 530)

All costs are expressed in Canadian dollars (\$1 Canadian = \$0.66 US).

<sup>a</sup> Average wages used: \$26.40/hour for nurses; \$16.00/hour for clerical staff; and \$15.50/hour for interpreters.

<sup>b</sup> Based on 6-hour work day for nurses and 3 hours for clerical staff, during which 100 children were screened; another 6 hours for reading results. Materials include syringes, swabs, and printed educational materials.

<sup>c</sup> Includes costs of opening chart, pretreatment consultation, initial physician consultation (\$32.60; \$47.60 if <5 years old), and 6 follow-up visits.

<sup>d</sup> Chest radiograph cost is \$32.49 (for immigrants with papers).

<sup>e</sup> Based on estimated need for interpreter for 1 of 8 patients and billing for 2-hour session.

<sup>f</sup> Includes initial work-up costs (\$391), average of 19 days of hospitalization (\$13 141), and outpatient-therapy costs (\$742), based on 76% hospitalization rate.<sup>23</sup>

<sup>g</sup> Based on 0.75-hour visit with daily visit for first 14 days, followed by twice-weekly visits for a duration of 6 months of therapy: 62 visits.

<sup>h</sup> Based on a local published study.<sup>23</sup>

<sup>i</sup> Based on a local published study<sup>23</sup>; 10 contacts per immigrant pediatric active TB case, based on interpolation of data on average number of contacts among ≤18-year-olds and immigrant subgroups in local assessment.<sup>24</sup>

base program developed specifically to track the school- and associate-screening process.

The proportion of schoolchildren targeted by the screening program who received a skin test was comparable with that of other studies in this population,<sup>8–11</sup> although their results were highly variable (43–79%). However, this proportion demonstrates the difficulty of securing participation in a voluntary, community-based, preventive medicine initiative. Efforts were made to include children in the screening through such activities as distributing culturally appropriate information materials translated into many of the mother tongues of the children's parents, as well as engaging in thorough follow-up on children who were not in class during the visit. Additional efforts may need to be made to further increase the participation at this first step of the TB-prevention process.

A high number of those with LTBI also presented at the TB clinic and were started on treatment. The decline over the course of the study period in referred children who presented for treatment may have been caused by

the increased proportion of high school students screened over this period who may have had less parental supervision in attending TB clinic appointments. Although the proportion of schoolchildren who finished their treatment with adequate adherence was found to be comparable or even higher than rates found in similar studies (range: 82–90%<sup>8–11</sup>), it only represented 58% of those who were initially eligible (ie, with a positive TST: 316 of 542). Those children with a positive TST who were not started on treatment often had parents who indicated a history of previous LTBI treatment in the child's country of origin.

To our knowledge, this is the first study to report LTBI-treatment adherence in associates in relation to a school-based TB-screening program. The adherence rate observed in these children are comparable to those of successful screening programs and, together with favorable adherence from the initial school based screening, implies that this targeted approach to screening is an effective way of preventing TB in a low-incidence country. We also showed a significant independent associa-

tion between adherence and number of family members screened. This finding reinforces the importance of using associate investigation in conjunction with school-based screening.

The average number of associates screened per child screened at school was lower than that found in other studies on associate investigations of TST-positive children. The majority of these studies<sup>17–19</sup> reported a much higher proportion of non-foreign-born and naturalized associates than the current study, which might account for the relatively lower proportion of associates in the current study if these more recently immigrated children had a greater number of family members who were still waiting to be sponsored for immigration to Canada. A more systematic data-collection system may help to answer this question.

The school-based TB-screening program that we evaluated was found to be cost-effective. Other studies evaluating school-based screening that included a cost-benefit analysis were split between those reporting a substantial net benefit<sup>11,14</sup>; 1 study only reported the costs of the screening program but stated that their costs were comparable to TB disease-treatment costs cited in the existing literature,<sup>10</sup> and 1 study reported a substantial net cost.<sup>8</sup> However, the latter study evaluated a screening program with poor prescription and participation rates and found a negligible net cost when more ideal program conditions were substituted in the analysis. We found a net benefit from the investigation of associates of schoolchildren with LTBI, both as a stand-alone program and as an addition to the targeted TB-screening program. To our knowledge, this is the first study to examine the cost-effectiveness of associate investigations. Our investigation of different scenarios in the determination of cost and benefit demonstrated that our original estimate is sensitive to hospitalization rates of active TB cases, especially when discounting is used. The hospitalization rate used for this study was based on a recent local assessment of TB-treatment costs and was comparable to the rate found in a cost-benefit analysis of school-based TB screening.<sup>14</sup> However, communities that are served by hospitals that emphasize outpatient treatment for their active cases may experience lower savings from targeted screening.

## CONCLUSIONS

We demonstrated the cost-effectiveness of a targeted school-based screening program in a low-burden country and the extra benefit given by adding associates to such a program. The challenge is to scale up such community initiatives so that they cover all schools with a large newly arrived immigrant population. A successful school-screening program directed toward newly arrived immigrants has to be built primarily on the initial relationship and trust that develops between the treating team (mainly the nurses), the children, and their asso-

ciates. This is an important aspect that is difficult to quantify in any cost analysis but remains, in our minds, the basis of success for any program that deals with issues related to continuity of care.

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