Community-Based Tuberculin Screening in Montreal: A Cost–Outcome Description

ABSTRACT

Objectives. This study describes the costs and outcomes of community-based tuberculin screening programs conducted between 1987 and 1991 in Montreal, Quebec, Canada.

Methods. Follow-up information was abstracted from hospital records of all reactors detected in tuberculin screening of students in grades 6 and 10, of first-year health professional students, and of workers aged 18 to 25 in a number of workforces. Screening costs were estimated directly from survey records, and follow-up costs were estimated from the annual financial report of the Montreal Chest Hospital for 1989/90.

Results. Of 7669 persons tested, 782 (10.2%) had positive results and 757 (9.9%) were referred to a clinic. Of those, 525 (6.8% of the original 7669) reported, 293 (3.8%) were prescribed therapy, and 154 (2.0%) were compliant. In Canadian dollars, screening cost $5.70 per person tested and $56 per tuberculin reactor detected, but follow-up of reactors accounted for 73% of the total program cost of $13 455 to $18 753 per case of tuberculosis prevented.

Conclusions. Because of high rates of patient and provider noncompliance, a tuberculin screening program was much less cost-effective than anticipated. Screening costs must be targeted to the highest risk populations, and compliance with recommendations for preventive therapy must be maximized. (*Am J Public Health.* 1995;85:786–790)

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Introduction

The recent resurgence of tuberculosis in the United States[1] and in several European countries,[2] coupled with the emergence of multidrug resistant strains, has reawakened interest in the control of tuberculosis. Tuberculin screening to detect infected persons and begin treatment with isoniazid before disease emerges has been recommended for all health care workers, residents of mental and correctional facilities, medically underserved populations, and immigrants upon entry to the United States.[3–5] These recommendations are supported by several risk–benefit[6–8] and cost-effectiveness[9–11] studies demonstrating the individual and societal benefits of preventive therapy in these groups.

Implementation of these recommendations would require massive screening programs; for example, each year, there are more than 1 million immigrants to the United States and Canada. The benefits of such screening programs may be less than anticipated because persons may not undergo the screening tests,[12–14] those identified as tuberculin reactors may fail to report for further evaluation,[15,16] and physicians[12,17,18] or patients[19,20] may fail to comply with treatment recommendations.

We have recently completed community-based tuberculin surveys of more than 7500 persons.[21–23] All those with reactions of 10+ mm were referred for further evaluation to the outpatient departments of two university hospitals. This enabled us to obtain detailed information regarding costs and outcomes of tuberculin screening in a large population sample under program rather than study conditions.

Methods

Study Population

Between 1987 and 1991, community-based tuberculin screening surveys were conducted in four population groups:

1. All grade 6 students attending public schools in central Montreal territories of the Departments of Community Health of Verdun, Montreal General, and St-Luc Hospitals
2. All grade 10 students in the same area
3. Students entering their first year of health professional training programs at Dawson, Vanier, John Abbott, and Edouard Montpetit Colleges, as well as at McGill University and Université de Montréal
4. Adult workers (aged 18 to 25) in unionized factories, nonunionized garment factories, and offices located in central Montreal

These groups included persons born in Canada and immigrants, the majority of whom were born in Asia, Haiti, Central America, and the Caribbean. Objectives of these surveys were to determine factors associated with the prevalence of initial and two-step tuberculin reactions. These surveys and the follow-up study were approved by an ethics committee of the Montreal Chest Hospital.

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Data Collection

The names and dates of birth of all those referred to each hospital were checked against the hospitals' medical records and x-ray departments' master files to identify those who reported for evaluation. Additionally, the following data were abstracted from hospital records: prescription of therapy or reasons for nonprescription, x-rays, blood tests (liver function), urine tests (isoniazid metabolites), pills prescribed, punctuality of follow-up visits, occurrence of side effects, months of therapy completed, and any breaks in therapy of more than 1 week.

Outcome Definitions

Patients who reported for evaluation were those whose name appeared in the hospital, medical, or x-ray departments' master files of the two hospitals. Patients who were evaluated but were not prescribed therapy when it appeared indicated according to American Thoracic Society guidelines[24] were accounted for under "physician noncompliance."

Patient compliance was determined qualitatively as follows:

- Good: No break in treatment, no visit more than 1 week late, and positive results on more than 75% of urine tests
- Fair: No break in treatment, clinic visits possibly as much as 2 weeks late, and positive results on 50% to 74% of urine tests
- Poor: Break in therapy judged by delay in clinic visit beyond supply of pills, or positive results on fewer than 50% of urine tests. A note in the chart that patient *stated* that he or she had not taken therapy for a period of more than 1 week was used to define poor compliance for 6 of 293 patients.

A therapy effectiveness score, equivalent to the degree of risk reduction for tuberculosis, was calculated for each patient who was prescribed therapy. This score was determined as follows[25]:

- 0 = Duration of less than 6 months or duration for 6 to 9 months and compliance rated fair or poor
- 0.4 = Duration for 10 to 12 months and compliance rated fair or poor
- 0.75 = Duration for 6 to 9 months and compliance rated good
- 0.93 = Duration for 10 to 12 months and compliance rated good

TABLE 1—Summary of Community-Based Tuberculin Surveys, Montreal, 1987 through 1991

Population	No. Eligible for Testing	No. Tested (% of Eligible)	No. Positive (% of Tested)	No. Referred to Clinic[a] (% of Tested)	No. Reported to Clinic (% of Referred)	No. Eligible for Therapy (% of Tested)[b]
Grade 6 students	2959	2422 (82%)	122 (5.0%)	118 (4.9%)	85 (72%)	95 (3.9%)
Grade 10 students	1956	1163 (59%)	127 (10.9%)	127 (10.9%)	72 (57%)	98 (8.5%)
Health-professional students	2399	2120 (88%)	235 (11.1%)	216 (10.2%)	173 (80%)	142 (6.7%)
Young adult workers	2926	1964 (67%)	298 (15.2%)	296 (15.1%)	195 (66%)	247 (12.6%)
Total	10 240	7669 (75%)	782 (10.2%)	757 (9.9%)	525 (69%)	583 (7.6%)

[a]Those with known prior therapy were not referred.
[b]Excludes those who had prior treatment or who reported for evaluation, had a normal chest x-ray, and were (1) older than 35 or (2) BCG vaccinated.

TABLE 2—Patients' Compliance with Therapy

Population	No. Prescribed Therapy (% of Reported and Eligible)[a]	No. Completing Therapy			No. Completing Therapy with Good Compliance	Therapy Effectiveness Score[b]
		6–8 mo of Therapy	9–10 mo of Therapy	11–12 mo of Therapy		
Grade 6 students	51 (73%)	6	18	17	32	27.6
Grade 10 students	52 (93%)	6	22	9	29	24.3
Health professional students	68 (62%)	17	12	19	34	28.5
Young adult workers	122 (72%)	20	14	20	45	38.9
Total	293 (73%)	49	66	75	140	119.4

[a]Percentage of all those who reported and met American Thoracic Society (ATS) criteria for preventive therapy (ATS 1990).
[b]Sum of therapy effectiveness scores for all patients prescribed therapy. (See the Methods section for description of how this score was calculated.)

For each group, the sum of all individuals' scores was calculated and interpreted as the number of persons in whom tuberculosis was completely prevented.

Costs for screening were taken from invoices for supplies and records of personnel time spent on all aspects of the screening program. Costs for physicians were taken from the 1989/90 specialists' fee schedule of the Régie de l'Assurance-Maladie du Québec. Costs for tests, clinic visits, and pharmacist labor, including costs of personnel, supplies, administration, heating, security, and maintenance,[26] were taken from the annual report of the Montreal Chest Hospital[27] representing the middle years of the survey. Drug costs were taken from charges by suppliers of isoniazid. All costs are expressed in Canadian dollars ($1.00 = US $0.80 in 1990).

Results

As shown in Table 1, the total eligible population was 10 240, of whom 7669 (75%) were tuberculin tested. Of those tested, 782 (10%) had significant tuberculin reactions, 25 had prior therapy, and 757 were referred for further evaluation. Of 525 who reported to the clinic and were evaluated, 121 (23%) were judged

TABLE 3—Costs of Tuberculin Screening and Follow-Up Cost, Canadian $

Screening costs per 100 persons	
Materials[a]	
Questionnaire	21.50
Syringes and swabs	61.60
Tuberculin testing material	128.30
Staff time[b]	
Project organization	128.60
Travel and field time	191.25
Data entry and management	38.75
Subtotal	570.00
Subtotal per person screened	5.70
Follow-up costs per person	
Clinic costs[c]	
Opening dossier and initial visit	114.70
Follow-up visit	32.63
Physician costs[d]	
Principal exam	27.00
Follow-up visit	13.00
Radiology costs[c]: chest x-ray (posteroanterior and lateral) and reading	23.67
Tests[c]	
Liver function blood test	3.58
Isoniazid urine test	5.38
Prescription costs,[e] per 100 tablets	
Pharmacist labor	2.55
Isoniazid, 300 mg	3.00

Sources:
[a]From purchase invoices, 1989–1990.
[b]From personnel records of tuberculin surveys.
[c]From average costs at Montreal Chest Hospital, 1989–1990.
[d]From fees paid to specialists by RAMQ, 1989–1990.
[e]From pharmacy costs at Montreal Chest Hospital, 1989–1990.

TABLE 4—Total Costs (Canadian $) of Tuberculin Screening and Follow-Up

Population	Sum of Scores[a]	Total Screening Cost, $	Total Follow-Up Cost, $	Total Cost, $	Cost per Patient in which TB was Fully Prevented,[b] $	Cost per Case of Active TB Prevented,[c] $
Grade 6 students	27.5	13 805	23 605	37 410	1360	13 603
Grade 10 students	24.3	6630	20 931	27 561	1134	11 342
Health-professional students	28.7	12 084	29 843	41 927	1461	14 609
Young adult workers	38.9	11 195	42 581	53 775	1382	13 823
Total	119.42	43 714	116 960	160 674	1345	13 455

[a]The sum of individuals' therapy effectiveness scores is considered to be the number of persons in whom TB was totally prevented. (See the Methods section for a description of how this score was calculated.)
[b]Total cost divided by sum of therapy effectiveness scores.
[c]Assumes a 10% lifetime cumulative risk of tuberculosis (TB) (see text).

TABLE 5—Total Costs (Canadian $) per Patient in Whom Tuberculosis Was Totally Prevented

	Total Cost for All Patients	Total Cost for Canadian Born	Total Cost for Foreign Born	Total Cost for Those With Good Compliance with Therapy	
				Canadian Born	Foreign Born
Grade 6 students	1360	1997	911	862	566
Grade 10 students	1134	1183	1035	678	492
Health-professional students	1461	1673	1322	718	482
Young adult workers	1382	1720	1090	586	444
Total	1345	1639	1100	658	490

not to be candidates for preventive therapy because they either had documented prior bacillus Calmette-Guérin vaccination (97 cases), were over age 35 (19 cases), or were discovered to have had prior therapy (5 cases). Of the 525 who reported and were evaluated, 404 (77%) met American Thoracic Society criteria for preventive therapy. If the same proportion of those who did not report had also been eligible for preventive therapy then 583 persons would have been eligible for preventive therapy (Table 1). To assess the nonresponders to referral, 43 health professional students who did not report were recontacted by telephone and/or letter. Of these, 16 (37%) had received an x-ray and/or medical evaluation elsewhere, but none had been placed on isoniazid preventive therapy.

Of the 404 who reported, were evaluated, and met American Thoracic Society guidelines for preventive therapy, only 293 (73%) were prescribed therapy by their physicians and only 140 (35%) completed at least 6 months of therapy with good compliance (Table 2). As a result, tuberculosis could be considered totally prevented in 119 (20%) of the 583 eligible persons in whom tuberculosis might have been prevented, and in only 1.6% of those persons who were originally tested.

The costs for each aspect of the program are shown in Table 3. Screening costs were considered equivalent for Canadian and foreign-born participants and for the different age groups because all participants were tested together. Also, testing, reading, and travel time were similar, given that the same methods were used in all age groups and all study sites were located within a defined geographic area. Nonparticipants were not considered in costs per person screened because the proportion of personnel time spent planning and preparing for tuberculin screening was much less than that spent in actual screening activities. The cost to detect each Canadian-born tuberculin reactor averaged $101 (range: $58 for workers to $250 for grade 6 students), compared with an average cost of $18 per foreign-born reactor detected (range: $16 for workers to $25 for grade 6 students). Compared with the costs per tuberculin reactor detected, the cost to detect persons eligible for isoniazid therapy was 35% higher among Canadian-born persons but only 10% higher among foreign-born persons. This difference occurred because many Canadian-born but few foreign-born individuals had documented bacillus Calmette-Guérin vaccination.

Tuberculosis could be considered totally prevented in 119 persons at a cost of $1345 per person (Table 4). Assuming that the cumulative lifetime risk of tuberculosis is between 7.2%[7,11] and 10%[28] for a 20-year-old living to 80 years, then 8.6 to 11.9 cases of tuberculosis were prevented at an average cost of $13 455 to $18 753 per case prevented. The major components of evaluation and follow-up costs were clinic visits (65%), physician charges (17%), radiology (11%), urine and blood tests (3%), and medications including pharmacist labor (4%). Total program costs were divided among screening (27%), initial evaluation (46%), and follow-up of those treated (26%).

Serious adverse effects requiring change in therapy were uncommon, occurring in none of the grade 6 students, in only 1 (2%) of the adolescents, and in 13 (7%) of the young adults. Two persons, aged 20 and 29, developed hepatitis that was not severe enough to require hospitalization; three developed a rash; and the remainder had intolerance that was severe enough to discontinue isoniazid therapy. Follow-up of these 14 patients with major side effects, for an average of 2.8 months, cost $362 per patient, or $129 per patient-month. On the other hand, follow-up of the 90 persons with minor side effects cost $355 per patient, and of the 189 with no side effects, the cost was $46 per patient-month.

Evaluation and follow-up cost $242 per patient completing 0 to 5 months (mean = 1.5 months) of therapy, $374 per patient completing 6 to 9 months (mean = 7.9 months), and $398 per patient completing at least 10 months (mean = 12.0 months) of therapy. Of those who completed 10 months or more of therapy, the average cost per patient-month was $52 in the first 6 months and only $8 in the second 6 months.

Follow-up costs were similar for foreign-born and Canadian-born persons, but because it cost more to detect each reactor, costs to prevent tuberculosis were higher among Canadian-born subjects. The effect of physician and patient noncompliance on costs per case of tuberculosis prevented was relatively more important because more than half of all follow-up costs were expended for patients who were evaluated but not prescribed, or who were prescribed but did not take therapy. As shown in Table 5, among the 73 Canadian-born and 80 foreign-born subjects with good compliance, fully preventing tuberculosis cost only $658 and $490, respectively, or 40% and 45% of average costs for the two populations.

Discussion

A community-based tuberculin prevalence survey detected 782 tuberculin reactors among 7669 persons screened, at a cost of $56 per reactor. However, effectiveness was reduced and follow-up costs were substantial. As a result, the program cost $1345 for each person in whom tuberculosis could be considered completely prevented.

Strengths of the study included the screening of a large population of varying ages, ethnicities, and socioeconomic status. Costs included expenses from initial screening to final follow-up visits and were based on actual interventions and outcomes under program, (not study) conditions. The compliance of patients and physicians, which may be artificially higher in a prospective study,[17,20,25,29] was not affected by this retrospective review. Therefore, the costs and benefits should be more realistic and generalizable to other settings where tuberculin screening may be planned.

Limitations of this survey included potential misclassification of treatment because a large proportion of reactors detected did not report for evaluation and perhaps were treated elsewhere. Information was available for health professional students, of whom fewer than one third indicated that they were evaluated elsewhere and none was treated. Information was not systematically available for other groups, but it might be expected that health-seeking behavior would have been lower since the rates of those participating in the survey and reporting to a clinic were highest among health professional students.

Misclassification of compliance with therapy may have occurred because this behavior is difficult to measure accurately,[30] although the 48% who were judged to have been compliant was within the previously reported range of 43% to 58% under program conditions.[19,20] The precision of estimation should have been improved by using both clinic punctuality and urine isoniazid testing[30]; self-reported interruption of therapy was a factor in only 2% of all patients treated. Punctuality of clinic visits, although not necessarily equivalent to pill taking, is objective and easily verified, and was consistently recorded in both clinics, an important consideration in a retrospective survey. On average, each patient treated had two urine tests for isoniazid metabolites, and 82% had at least one such test.

The generalizability of this study may be limited because costs at other institutions, particularly those in the United States, may differ from those at the two hospitals studied. The use of local costs is valid to compare the relative contribution of factors affecting costs. Similarly, the actual interventions are tabulated to allow recalculation of probable costs for a similar screening program at other institutions. The cost of $5.70 per person screened falls within the range of previously reported costs of US $2.40[15] or US $6 to $11.[16]

More than 30% of tuberculin reactors detected did not report for evaluation despite the involvement of nurses from the two institutions at the time of the tuberculosis test reading to facilitate referral by providing written instructions, including date and time of appointments for all reactors. Problems of similar or greater magnitude have been experienced in screening surveys in the community,[15,31] among health care workers in hospitals,[14,16] and among physicians.[12]

Physician noncompliance with recommended guidelines for preventive therapy,[24] as well as their variation in evaluation and management, was surprisingly common even though all physicians were board-certified pulmonary specialists working in university teaching hospitals. Physician noncompliance in following guidelines has been previously recognized.[12,14,17,18] This finding underscores the need for close collaboration and agreement between those screening and those managing tuberculin reactors regarding the need for preventive therapy.

Snider and colleagues' calculated that 6 months of isoniazid is significantly more cost-effective than 12 months, provided that costs remain the same throughout follow-up.[9] However, in this study, all major side effects, more than 90% of x-rays and lab tests, and 75% of visits occurred in the first 6 months, so costs were substantially higher in the first 6 months compared with the second 6 months. This finding might alter the relative cost-effectiveness in favor of the longer duration of therapy.

Prior cost-benefit analyses[9–11] have assumed patient compliance of 68% to 80% and have failed to account for costs associated with the detection of reactors or the evaluation of those who are not prescribed therapy. Fitzgerald and Gafni estimated that it would cost $645 to complete 1 year of isoniazid preventive

therapy and $8586 to prevent a case of tuberculosis in a 20-year-old (assuming a cumulative lifetime risk of 7.2%).[11] In our study, it cost $634 to treat a Canadian patient who was fully compliant with therapy, meaning that Fitzgerald and Gafni's estimates of costs were quite reasonable *for patients who take therapy.* However, because we included screening costs and because patient and physician noncompliance was higher, we estimated that for the same risk, it would cost $18 753 to prevent one case of tuberculosis.

Tuberculin screening with isoniazid prophylaxis for reactors remains one of the most cost-effective preventive strategies.[3,32] However, this study serves to emphasize that, before implementing tuberculin screening, program planning must include subsequent evaluation and follow-up. To maximize the cost-effectiveness of tuberculin screening, programs should be targeted to populations with increased prevalence of tuberculin reactions, and patient and provider compliance in the referral, evaluation, treatment, and follow-up of those found positive should be assured. □

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