Tuberculosis Transmission in a High School Choir

Rita Washko, Errol Robinson, Laura J. Fehrs, Thomas R. Frieden

In July 1994, the New York City Dept. of Health was notified that a recently graduated student of a New York City high school had infectious (sputum sample was positive for acid-fast bacillus), cavitary, drug-susceptible pulmonary TB. The student had been symptomatic with cough, weight loss of 30 pounds, and fatigue during the last six months of the school year.

In September 1994, tuberculin skin testing (TST) was offered to all staff and students, including June 1994 graduates. Testing was performed using five tuberculin units of purified protein derivative (PPD) tuberculin by the Mantoux method; results were read by trained staff 48-72 hours later. Persons with positive results were referred to the local chest clinic for further evaluation.

Following the initial screening, additional screenings were conducted because: 1) evidence existed of TB transmission among the choir; 2) approximately one-third of participants did not return for a TST reading; and 3) few persons exposed to the index patient had participated. A community meeting was held and letters sent to parents of students who had shared a classroom with the index patient, urging students to participate. Presumed transmission of TB, based on epidemiologic findings, was described in the setting of singing activities such as choir.[1]

The second school screening, in November 1994, targeted choir members from the 1993-94 school year. Choir members unable to participate were tested at their homes by health department workers. Subsequently, active TB was diagnosed in a student who had declined TB screening at the school. During the 1993-94 school year, this student had class in the choir classroom immediately following the index patient's choir class ("class after choir"). Because of this additional secondary TB case, a third school screening was held in May 1995 at which time screening of students from the "class after choir" who were still at this school was mandatory.

Rita Washko, MD, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Respiratory Disease Studies, Clinical Investigations Branch, 1095 Willowdale Road, Room H-009, Morgantown, WV 26505 or RMW8@CDC.GOV; Errol Robinson, Bureau of Tuberculosis Control, New York City Dept. of Health, New York, NY 10013; Laura J. Fehrs, MD, MPH, Epidemiology Program Office, Division of Field Epidemiology, Centers for Disease Control and Prevention, Atlanta, GA 30333; and Thomas R. Frieden, MD, MPH, Division of Tuberculosis Elimination, National Center for Prevention Services, Centers for Disease Control and Prevention, Atlanta, GA 30333. *This article was submitted October 6, 1997, and revised and accepted for publication February 17, 1998.*

To identify other secondary TB cases linked to the index patient who may have presented elsewhere for evaluation, rosters of students and staff from the 1993-94 and 1994-95 school years were matched with the New York City TB Registry.

PROCEDURES

For this epidemiologic investigation, a positive TST was defined as ≥10mm of induration. For clinical decision making, a positive TST was ≥5mm of induration among close contacts[2] (classmate, choirmate, or member of the "class after choir") of the index patient and ≥10mm among all others. Active TB was defined as clinically-confirmed disease[3] or culture-confirmed *Mycobacterium tuberculosis*. A secondary case of TB was defined as active TB in a person who had an epidemiologic link to the source patient.

Self-administered questionnaires were used to collect the following information: age; gender; current year in school; country of birth; race/ethnicity; BCG vaccination; and prior TST results and treatment for TB infection or disease.

Persons with a documented history of positive TST results or active TB were excluded. Because results of prior TSTs were not consistently recorded in school medical records, investigators analyzed rates of positive TSTs rather than TST conversion rates. The risk for a positive TST by categorical variables was analyzed by chi-square or Fishers' Exact tests using Epi-Info.[4] DNA fingerprint analysis of *Mycobacterium tuberculosis* isolates was performed to determine genetic relatedness (ie, whether infection from a common source existed).[5]

RESULTS

The school, constructed in the 1930s, did not have a general ventilation system. Approximately 2,200 students attended the school during 1993-94, 700 of whom were seniors. The index patient attended choir and six other classes, all of which met daily. There were 108 other students in choir (included all grades) and 173 other students in the remaining six classes (mostly seniors). Fifty-one members from the 1993-94 choir were students at the school during the screenings.

A total of 890 students had a TST placed. The return rate for the first screening was 66% (274/414); after intensive educational efforts, the return rate increased to 92% (329/357) and 94% (112/119) for the second and third screenings, respectively. Of 890 students tested,

715 (80%) had the tests read. Fifty-eight percent were female, and 54% were born in the United States. The country of birth was unknown for 59 (8%) of 715 students. Race was identified by 413 (58%) students: 36% identified themselves as Asian, 23% as Black, 24% as White, 15% as Hispanic, and 2% as "other." Participants' responses to a question of BCG vaccination were unreliable.

Of the 108 choir members, 101 (94%), including all current members, were screened. Three (3%) choir members who had graduated declined testing, two (2%) could not be located, and two (2%) were tested elsewhere but did not release their results.

Six of eight teachers who shared a classroom with the index patient participated. Teachers who shared a classroom with this student were somewhat more likely to have a positive TST result than were the 123 other staff participants (2/6 [33.3%] versus 12/123 [9.8%]; relative risk [RR]=3.4; 95% confidence limits [CL]=1.0, 12.0). However, this difference was not statistically significant. None of the teachers or staff had active TB.

The overall prevalence of a positive TST was 10% (74/715). Foreign-born and Asian students were approximately three times as likely to have a positive TST than were US-born and nonAsian students, respectively (Table 1). Rates of positive TSTs were somewhat higher for choir members and for students in the "class after choir" compared to other students, however this finding was not statistically significant.

Additional analysis, performed separately for US-born and foreign-born students, revealed that among the 389 US-born students, choir participation was a risk factor for having a positive TST (Table 2). Choir members were almost three times as likely to have a positive TST as those not in choir. US-born students from the "class after choir" were more likely to have a positive TST than those not in this class, but this difference was not statistically significant.

The other six classes. Of 173 students in the other six classes with the index patient, 52 (30%) participated. Of these, 28 students were exposed only in nonchoir classes; three (11%) had positive TST results.

Twenty-four students were potentially exposed to the index patient in both choir and at least one other class. Sharing both choir and one or more classes with the index patient did not substantially increase the risk for TB infection beyond that resulting from choir exposure alone (3/24 [12.5%] students in both choir and one or more other classes versus 11/76 [14.5%] students in choir only had positive TSTs; RR=0.9; CL=0.1, 3.6).

TST results by classroom exposures. Analysis of positive TST results by mutually exclusive categories of classroom exposures revealed that students who attended only choir (11/76 [14.5%]) with the index patient had positive TST rates similar to those students who attended only the "class after choir" (8/54 (14.8%]). US-born students who shared no classrooms with the index patient had a positive TST rate of 3.2% (9/284).

Secondary TB cases. Six students had active TB; three were identified through screening activities. The remaining three students did not participate in the school screenings and were diagnosed by private physicians. Three (50%) had culture-confirmed TB. Four students were in choir, one was in the "class after choir," and one

Table 1
Risk of A Positive Tuberculin Skin Test Among Student Participants, Tuberculosis Transmission in a High School Choir, New York City, 1994-1995

Characteristic	Tuberculin Skin Test Positive	Tuberculin Skin Test Negative	Relative Risk	Confidence Limits
Foreign-born [a]				
Yes	48	219	3.5	2.1, 5.7
No	21	368		
Asian Race [b]				
Yes	24	123	3.1	1.7, 5.8
No	14	252		
Class After Choir				
Yes	8	47	1.5	0.7, 2.9
No	66	594		
Choir				
Yes	14	87	1.4	0.8, 2.4
No	60	554		
Gender				
Female	46	367	1.2	0.8, 1.9
Male	28	273		

[a] Students whose country of birth was unknown (N = 59) were excluded.
[b] Race was known for 413 students.

shared two other classes with the index patient. Choir participants were >12 times as likely to have active TB than were students not in choir (4/101 [4%] versus 2/614 [0.3%]; RR=12.2; CL=2.3, 65.6).

All six students had abnormal chest radiographs; none had cavitation. Two were asymptomatic at the time of diagnosis and were identified at the school screenings. Two had negative TST results but had culture-confirmed TB. Isolates from two of the three culture-confirmed patients were available for DNA fingerprint analysis; both isolates had patterns identical to that of the index case.

Rosters of students and staff from the 1993-94 and 1994-95 school years were matched with the New York City TB Registry. No additional TB cases were identified.

DISCUSSION

This investigation identified 74 students with positive TSTs and six students with active TB. For those with active TB, identification was early — all were asymptomatic or symptomatic for only a short period prior to diagnosis and treatment, and none had positive smears. Thus, they were unlikely to further transmit TB. Some positive TST results among foreign-born students could have represented previously acquired infection or, alternatively, been due to BCG vaccination. A positive TST due to BCG vaccination is, however, unlikely in high school students, most of whom were vaccinated as infants or young children.

Among students born in the United States, choir participation was associated with both positive TSTs and active TB. Previous studies[6-8] among school students, including those in a chorus or choir, have documented TB transmission. In one investigation, a TST conversion rate of 60% was documented among choir members compared with a conversion rate of only 20% among all school members.[8] A few years later, Loudon and Roberts[9] published a classic paper documenting singing as a strong risk factor for the spread of TB. The sizes of droplets expelled during singing were noted to be very effective at penetrating the lungs and investigators found that more than one-third of these droplets were still airborne after 30 minutes. This investigation also documents singing as an effective means of spreading TB and, unlike the others, provides additional support in the form of molecular technology (DNA fingerprinting).

Data from this investigation also provided a general estimate of background rates for positive TSTs for this school's students. Approximately 3% of US-born students who did not share a class with the index case had positive TSTs. In the United States, approximately 4-6% of the population have positive TSTs.[10] However, this estimate includes all age groups, and TST positivity rates vary by age group. For school-aged persons, positive TST rates similar to those in this study have been documented in other large metropolitan areas.[11,12]

This investigation had several limitations. Staff did not have baseline TST results, so conversion rates could not be determined. In addition, information on students' country of birth and race was not consistently recorded and was unavailable from school records. Finally, less than one-third of students who were in one of the six nonchoir classes with the index patient were screened for TB despite repeated encouragement by the health department and the school. Consequently, the possibility of additional TB infections or disease among this group cannot be excluded.

IMPLICATIONS FOR SCHOOLS

Results from this investigation support some important public health messages. First, TST screening should be accompanied by intensive educational efforts and active follow-up. Second, BCG-vaccinated persons can become infected with *M.tuberculosis* and develop active

Table 2
Risk of A Positive Tuberculin Skin Test Among US-born Student Participants Only, Tuberculosis Transmission in a High School Choir, New York City, 1994-1995

Characteristic	Tuberculin Skin Test Positive	Tuberculin Skin Test Negative	Relative Risk	Confidence Limits
Choir				
Yes	7	50	2.9	1.2, 6.9
No	14	318		
Class After Choir				
Yes	3	27	2.0	0.6, 6.4
No	18	341		
Gender				
Female	11	203	0.9	0.4, 2.1
Male	10	165		
Asian Race				
Yes	1	31	0.6	0.1, 4.6
No	10	184		

TB. Both the index patient and one of the secondary cases had received BCG vaccination. In addition, case-finding and contact investigations are central to effective TB control efforts and should assume precedence over mass screening policies.

The most effective public health strategies are those targeted toward high-risk groups[13,14] and thus, TST screening of high-risk groups before school entry should be considered. In situations where an efficient means for spread of TB infection and disease exists, such as described in this report, more aggressive screening efforts may initially be necessary so that the target group is effectively evaluated. The success of such activities ultimately rests with effective collaboration between schools and public health TB control programs. ■

References

1. Horton R, Champlin RD, Rogers EFH, Korns RF. Epidemic of tuberculosis in a high school. *JAMA*. 1952;149:331-333.

2. Centers for Disease Control and Prevention. Prevention and control of tuberculosis in facilities providing long-term care to the elderly. *MMWR*. 1990;39 (No. RR-10).

3. Centers for Disease Control and Prevention. Case definitions for public health surveillance. *MMWR*. 1990;39 (No. RR-13).

4. Dean AG, Dean JA, Burton AH, et al. *Epi Info, Version 5: A Word Processing, Database, and Statistics Program for Epidemiology on Microcomputers*. Atlanta, Ga: Centers for Disease Control; 1990.

5. Hermans PWM, van Soolingen D, Dale JW, et al. Insertion element IS986 from *Mycobacterium tuberculosis:* a useful tool for diagnosis and epidemiology of tuberculosis. *J Clin Microbiol*. 1990;28:2051-2058.

6. Sacks JJ, Brenner ER, Breeden DC, Anders HM, Parker RL. Epidemiology of a tuberculosis outbreak in a South Carolina junior high school. *Am J Pub Health*. 1985;75:30-38.

7. Bredin CP, Godfrey M, McKiernan J. A school microepidemic of tuberculosis. *Thorax*. 1991;46:922-923.

8. Bates JH, Potts WE, Lewis M. Epidemiology of primary tuberculosis in an industrial school. *N Engl J Med*. 1965;272:714-717.

9. Loudon RG, Roberts RM. Singing and the dissemination of tuberculosis. *Am Rev Respir Dis*. 1968;98:297-300.

10. American Thoracic Society. Diagnostic standards and classification of tuberculosis. *Am Rev Respir Dis*. 1990;142:725-735.

11. Davidson PT, Ashkar B, Salem N. Tuberculosis testing of children entering school in Los Angeles County, California [Abstract]. *Am Rev Respir Dis*. 1990;141(suppl):A336.

12. Starke JR, Taylor KT, Martindill CA, et al. Extremely high rates of tuberculin reactivity among young schoolchildren in Houston [Abstract]. *Am Rev Respir Dis*. 1988;137(suppl):22.

13. Centers for Disease Control and Prevention. Tuberculosis among foreign-born persons entering the United States. Recommendations for the screening, prevention, and control of tuberculosis among foreign-born persons after arrival in the United States. *MMWR*. 1990;39 (No. RR-18).

14. Mohle-Boetani JC, Miller B, Halpern M, et al. School-based screening for tuberculosis infection: a cost benefit analysis. *JAMA*. 1995;274:613-619.

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