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# Contact investigations in congregate settings, New York City

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**SUMMARY**

**SETTING: Large urban tuberculosis control program.**

**OBJECTIVE: To evaluate results of procedures implemented for systematic investigation of tuberculosis exposures in congregate settings.**

**DESIGN: Between October 1995 and December 2000, a unit consisting of epidemiologists, health educators and tuberculin screening staff investigated exposures in sites with >15 persons. Transmission at the site was defined as likely, possible, unlikely or unknown.**

**RESULTS: Among 100 investigations, 12 were tuberculosis case clusters, five were source case investigations, and 83 were exposures to single infectious cases. Transmission was likely in 24 (21%), possible in eight (8%), unlikely in 62 (62%), and could not be assessed in four (4%). Among the 83 exposures to single infectious cases, 2740 contacts were tested; 502 (18%) were infected. Among 1202 close contacts, 996 (82%) were tested, 197 (20%) were infected and started treatment of latent tuberculosis infection (LTBI) and 102/197 (52%) completed treatment. Sites with likely transmission had index patients with longer duration of cough (13 vs. 6 weeks, $P = 0.01$) and cavitary lesions (84% vs. 44%, $P = 0.01$) compared to sites with unlikely transmission.**

**CONCLUSION: A systematic approach for conducting contact investigations in congregate settings is useful for assessing transmission. As such investigations are resource intensive and transmission is not common, performing tuberculin skin testing after most persons would have converted should be considered in low-risk groups. Additional efforts are needed to increase completion of treatment for LTBI in contacts identified in these settings.**

**KEY WORDS:** tuberculosis; contact investigations; exposure; congregate settings

CONTACT INVESTIGATIONS are an essential component of tuberculosis control programs as a means of finding and preventing cases among recently infected persons.[1,2] The priority, speed, and extent of a contact investigation should be influenced by the likelihood of transmission and consequences of infection.[2] However, to our knowledge the yield of investigating exposures in congregate settings has not been described. Tuberculosis exposures in congregate settings require different skills and procedures for identifying and testing contacts than those required in household or clinic settings.[3] They generally involve a greater number of contacts, preparation, staff resources, coordination of communication, and data management to assess results. In addition, fear of disease transmission is often amplified in settings with greater number of contacts and requires rapid, effective interventions to provide accurate information of risk. In October 1995, we implemented procedures for systematically conducting such investigations in a tuberculosis control program setting. In this paper we describe our approach to such investigations and the results obtained since implementation.

## METHODS

In the New York City Tuberculosis Control Program, all suspected or confirmed tuberculosis patients are interviewed by outreach or clinic staff using a standard questionnaire to obtain case information and to elicit contacts. Contact investigations are performed for all those with respiratory specimen that are acid-fast bacilli (AFB) positive on microscopic examination or had *Mycobacterium tuberculosis* isolated from a pulmonary source. Each contact located by outreach staff is offered testing at a location convenient to the contact. Infected contacts are referred to a Department of Health chest clinic or private provider for medical evaluation and treatment of latent tuberculosis infection (LTBI).

### *Conducting contact investigations in congregate settings*

All cases in which there was a potential exposure in a congregate setting, such as a school or workplace, were referred by field or clinic staff to an epidemiologist who evaluated the need for testing at the congregate setting (Figure).

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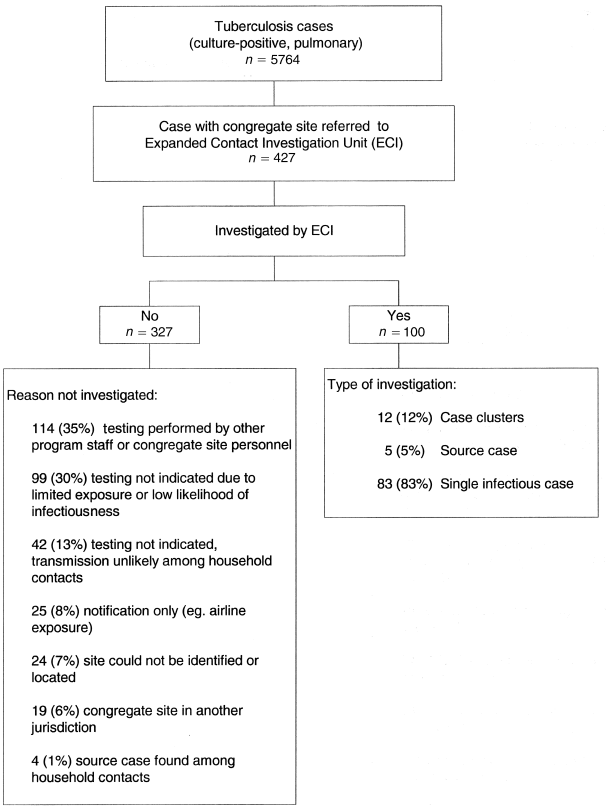


**Figure** Disposition of cases referred for Expanded Contact Investigation (ECI) evaluation.

Sites with fewer than 15 persons were usually investigated by outreach staff, and sites with 15 or more persons were investigated by an Expanded Contact Investigation (ECI) Unit. Most investigations were initiated as a result of an exposure to a single potentially infectious case. In these situations, the determination to perform testing at a congregate setting was based on: 1) infectiousness of the index case and the results of testing of closest contacts (often household contacts), 2) characteristics of the congregate setting environment, such as size, crowding and windows, and 3) characteristics of contacts at the congregate setting such as age and immune status. The timing of tuberculin testing in a congregate setting depended on the risk of developing disease given infection. In settings with young children or immune suppressed persons, testing was offered as soon as possible after the index case was diagnosed, and again 10–12 weeks after the last exposure. In settings that did not include such high-risk groups, testing was performed only once, 10–12 weeks after the last exposure.

Alternative criteria for initiating an investigation in congregate settings were case clusters detected by surveillance of address of residence, reporting facility and patient characteristics. In the presence of a cluster of tuberculosis cases at a congregate setting, an investigation was conducted independent of the characteristics of the suspected source case. Finally, for young children (<6 years) with active disease in whom a source case was not found among household contacts, investigations to identify a source case were conducted at congregate sites such as day care centers. Sites that had medical or infection control staff, such as hospitals, nursing homes, or employee health clinics, were notified of exposures in those settings and contact testing was performed by those staff with consultation and assistance from the ECI Unit.

The ECI team included epidemiology, screening, and education and training staff. An ECI coordinator was responsible for the overall coordination and supervision of ECIs. The coordinator was the central point person for all communications related to the investigation including notification of appropriate program and department staff and outside agency staff such as school principals, management and union officials, and supervision of the epidemiologist conducting the investigation.

An epidemiologist was assigned to lead each investigation. A brief summary of the case and need for investigation was prepared and distributed to key department staff. The epidemiologist was responsible for obtaining personnel lists or school rosters from site staff and classifying persons according to exposure status, including persons no longer at the site. Written protocols outlined the steps for conducting work site and school investigations. Dates for on-site education and testing were scheduled. Standard checklists, letters and site-specific questionnaires were tailored for each investigation. Contacts were generally notified in writing of the exposure, and plans for education and testing and printed educational materials were included in the mailing. Letters informing unexposed persons at the site and educational materials were hand-delivered on-site. In school investigations, reminder telephone calls were made to increase the participation of closest contacts and to obtain telephone consent from parents. The screening staff performed tuberculin skin tests (TSTs), ensured the availability of testing supplies, referred all symptomatic or infected persons for medical evaluation at a health department chest clinic, and obtained chest radiograph results and plans for treatment. Close communication was maintained with Board of Education and School Health representatives to coordinate investigations of tuberculosis exposures in schools.

A health educator was also assigned to each ECI on a rotating basis to conduct on-site group educational sessions on tuberculosis. Before the initial meeting with the site managers, the educator and epidemiologist developed a strategy for protecting patient confidentiality and anticipating potential questions and problems related to the investigation. Tuberculin testing was performed by a screening unit that has dedicated staff. A written report of each investigation, including an assessment of transmission and recommendations, was written.

*Definitions*

Transmission at each congregate site was classified as likely, possible, unlikely, or unknown based on the following criteria: 1) likely transmission—the proportion TST-positive in the exposed group was statistically significantly higher than in a comparison group, or there were documented TST conversions in persons not vaccinated with bacille Calmette-Guérin (BCG), or secondary cases with epidemiologic or molecular linkage[4] to the index case; 2) possible transmission—the proportion TST-positive was significantly greater than in a comparison group but the proportion of identified contacts tested was less than 50%; 3) unlikely transmission—the above conditions were not met; 4) unknown transmission—fewer than 50% of potential contacts were tested and the proportion TST-positive among those tested was not greater than expected, and there were no TST conversions or secondary cases.

Comparison groups included non-exposed persons (i.e., self-referred persons) of similar birth-country and age tested at the same site, or other unexposed groups in New York City such as new school entrants.

Transmission to household contacts was assessed using the same criteria for assessing transmission as described above. When the number of household contacts was four or less and there were no converters or TST reactors who were not born in tuberculosis-endemic countries, transmission in the household was classified as unknown. The size of the exposure site was measured in $ft^3$ using hand-held digital distance estimators, or estimated based on site dimensions when possible. Potential hours of exposure were defined as the estimated number of hours per week the source case was at the site during the 3-month period before the last date of exposure at the site. Close contacts were defined as persons who lived or spent significant amount of time with the index case (generally, more than 8 h per week). Other-than-close contacts had 8 h or less exposure to the index case.

A positive TST in contacts was defined as a reaction of $\geq$5 mm induration to 5 tuberculin units (TU) of purified protein derivative (PPD) tuberculin administered by the Mantoux technique. Among self-referred individuals who were not exposed, a positive TST was defined as a reaction of $\geq$10 mm to 5 TU PPD. For epidemiologic comparison of exposed and unexposed groups, $\geq$10 mm induration was considered positive. A TST conversion was defined as a documented increase of $\geq$10 mm in the previous 2 years. In this paper, being tuberculin tested means having had at least one TST 10–12 weeks after the last exposure to the index case. Data on completion of treatment for contacts identified and tested by field staff were routinely entered in the case registry for the entire study period. However, contacts identified in ECIs were not entered into the case registry, nor were they counted in the contact index until January 1998, when all close contacts identified in ECIs and their results were entered prospectively into the case registry database and information on ECI contacts was given to the case managers for ensuring completion of treatment for latent tuberculosis infection. Data on completion of treatment were not available for ECI contacts identified before 1998.

*Data analysis*

In these analyses, we described the type, number and assessment of transmission for investigations performed by the ECI unit. Investigations were grouped according to criteria for initiating the investigation (i.e., single infectious case vs. cluster). For investigations of single infectious cases, we compared case patient characteristics assessed at the time anti-tuberculosis treatment was started by likelihood of transmission at the congregate site. Case characteristics included sputum bacteriology, cavitation on chest radiograph, presence and duration of cough, drug susceptibility of the *M. tuberculosis* isolate, and human immunodeficiency virus (HIV) infection. Treatment of infected contacts at these sites was also described. Data were analyzed using Epi Info 6.04 statistical software[5] and SAS Version 7-1 (SAS Institute Inc., Cary, NC). Categorical variables were compared using the $\chi^2$ or Fisher's exact test. Continuous variables were compared using analysis of variance (ANOVA) or the Kruskall-Wallis test. Odds ratios and 95% confidence intervals were used to assess the association between variables.

## RESULTS

Between 1 October 1995 and 31 December 2000, 5764 new culture-positive pulmonary tuberculosis cases were diagnosed; 427 cases were referred to the ECI Unit for review and 100 investigations were performed by the ECI Unit. Of the 327 cases who were referred but not investigated, reasons for closure are shown in the Figure.

On average, 17 investigations were performed by the ECI Unit each year (range 13–24). The criteria for investigation and assessment of transmission for these investigations were as follows: 12 were investigations of case clusters, five were source case investigations and 83 were exposures to a single infectious case. Tuberculosis transmission was likely ($n$ = 19) or possible ($n$ = 6) in 25 (25%) investigations. Among the five source case investigations of disease in children, a source case was not identified in any of these investigations.

Eighty-three (83%) of the 100 exposures were to a single infectious case. The median age of patients was 39 years (range 12–67). Seventy-four (88%) patients had sputum that was AFB smear-positive, and 42 of 68 patients with smear grade information available had smear grade >3+. Forty-three (51%) had cavitary lesions. Among the 79 (94%) who reported a

cough, the median duration of cough for the 71 with this information available was 6 weeks (range 1–130). Among 59 patients with HIV results available, 22% were HIV-seropositive. Thirty-eight (45%) were conducted at work sites and 33 (39%) at schools; the remaining 12 were conducted in drug treatment centers, single-room-occupancy hotels and other locations. Transmission was likely in 13 (16%), possible in six (7%), unlikely in 60 (72%) and could not be assessed in four (5%) due to the low proportion of contacts tested.

In these 83 investigations, 2740 contacts were tested and 502 (18%) were infected. One secondary case was identified among these ECI contacts. In addition, 2769 unexposed persons were tested, of whom 267 (10%) were infected. Depicted in Table 1 are the TST results by exposure, birth-country and assessment of transmission at the site for exposure to a single infectious case. As expected, the proportion TST-positive was higher in non-US-born compared to US-born contacts in each type of congregate setting as well as by likelihood of transmission. Data on the completion of treatment were available for close ECI contacts beginning in 1998. During this period, 1202 close contacts were identified; 996 (83%) were tested, 197 (20%) were infected and started treatment for latent tuberculosis infection; 102 (52%) of 197 completed treatment for latent tuberculosis infection.

Case patient and site characteristics of the investigations in which transmission could be assessed ($n = 79$) is shown in Table 2. Sites with likely transmission compared to those with unlikely transmission had index cases with longer duration of cough (median 13 vs. 6 weeks, $P = 0.01$), cavitary lesions (84% vs. 44%, $P = 0.01$) for chest radiography and multidrug resistance (23% vs. 3%, $P = 0.01$). However, multidrug resistance was not independently associated with likelihood of transmission after adjusting for the effect of cavitary lesions and duration of cough (data not shown).

## DISCUSSION

Using a systematic approach to investigate tuberculosis exposures in congregate settings, 100 such investigations were conducted over a 5-year period, and the likelihood of transmission could be assessed in all but 6%. While widespread transmission of tuberculosis outside the household has been described,[6–14] our investigation suggests that this is probably an unusual occurrence. Despite characteristics of high potential for infectiousness in the index cases, tuberculosis transmission in our congregate settings was not common. Excluding the cluster investigations, transmission occurred at only 22% of the sites investigated as a result of a single infectious case.

Tuberculin testing in congregate settings will likely be needed to meet the goal of tuberculosis elimination as well as to address community concerns when tuberculosis exposures in large settings are known to the public. However, such investigations are clearly resource-intensive, as many sites are investigated for each one in which transmission is identified. Excluding the cluster investigations, over 5000 TSTs were performed, with nearly equal numbers of exposed and self-referred persons tested and only one secondary case identified. Assuming the same proportion completed treatment for latent infection as did close contacts after 1998, at most 400 contacts would have been treated. Given the low yield, utilization of program resources for such an activity should be minimized.

**Table 1** Investigations of tuberculosis exposures to a single infectious case in congregate settings, New York City, October 1995–December 2000 ($n = 83$)

| | Exposed | | | | Self-referred | | | |
|---|---|---|---|---|---|---|---|---|
| | US-born | | Non-US-born | | US-born | | Non-US born | |
| Likelihood of transmission/site | Tested *n* | TST+ *n* (%) | Tested *n* | TST+ *n* (%) | Tested *n* | TST+ *n* (%) | Tested *n* | TST+ *n* (%) |
| Unlikely ($n = 60$) | | | | | | | | |
| School ($n = 23$) | 552 | 8 (1) | 274 | 64 (23) | 619 | 18 (3) | 188 | 30 (16) |
| Worksite ($n = 29$) | 510 | 36 (7) | 521 | 181 (35) | 521 | 27 (5) | 222 | 87 (39) |
| Other ($n = 8$) | 112 | 12 (11) | 33 | 12 (36) | 90 | 11 (12) | 20 | 8 (40) |
| Possible ($n = 6$) | | | | | | | | |
| School ($n = 3$) | 37 | 7 (19) | 60 | 15 (25) | 167 | 1 (0.6) | 73 | 7 (10) |
| Worksite ($n = 3$) | 19 | 7 (37) | 42 | 22 (52) | 2 | 0 (0) | 10 | 5 (50) |
| Likely ($n = 13$) | | | | | | | | |
| School ($n = 4$) | 96 | 9 (9) | 49 | 11 (22) | 318 | 4 (1) | 33 | 6 (18) |
| Worksite ($n = 6$) | 176 | 42 (24) | 103 | 48 (47) | 109 | 8 (7) | 61 | 16 (26) |
| Other ($n = 3$) | 53 | 16 (30) | 9 | 6 (67) | 77 | 4 (5) | 8 | 0 (0) |
| Cannot assess ($n = 4$) | | | | | | | | |
| School ($n = 3$) | 59 | 1 (2) | 17 | 2 (12) | 143 | 7 (5) | 70 | 16 (23) |
| Other ($n = 1$) | 17 | 2 (12) | 1 | 1 (100) | 32 | 9 (28) | 6 | 3 (50) |
| Total ($n = 83$) | 1631 | 140 (9) | 1109 | 362 (33) | 2078 | 89 (4) | 691 | 178 (26) |

TST = tuberculin skin test; + = positive.

**Table 2** Investigations of exposure to single infectious cases in congregate settings, by TB patient and exposure site characteristics ($n = 79$)

| | Assessment of transmission | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Likely ($n = 13$) | | Possible ($n = 6$) | | Unlikely ($n = 60$) | | Total ($n = 79$) | |
| Characteristic | *n* (%) | Median (Range) | *n* (%) | Median (Range) | *n* (%) | Median (Range) | *n* (%) | Median (Range) |
| Age years | | 44 (12–59) | | 31 (17–46) | | 36 (13–67) | | 37 (12–67) |
| Birthplace | | | | | | | | |
| US-born | 6 (46) | | 0 (0) | | 26 (43) | | 32 (41) | |
| Foreign-born | 7 (54) | | 6 (100) | | 34 (57) | | 47 (49) | |
| Sputum smear | | | | | | | | |
| AFB− | 0 (0) | | 1 (17) | | 9 (15) | | 10 (13) | |
| AFB+ | 13 (100) | | 5 (83) | | 51 (85) | | 69 (87) | |
| Grade* | | 3 (1–4) | | 3 (1–3) | | 3 (0–4) | | 3 (0–4) |
| Sputum culture | | | | | | | | |
| Negative | 0 (0) | | 0 (0) | | 2 (3) | | 2 (3) | |
| Positive | 13 (100) | | 6 (100) | | 58 (97) | | 77 (97) | |
| Cough | | | | | | | | |
| No | 0 (0) | | 0 (0) | | 5 (8) | | 5 (6) | |
| Yes | 13 (100) | | 6 (100) | | 55 (92) | | 74 (94) | |
| Cough duration | | | | | | | | |
| <2 weeks | 0 (0) | | 0 (0) | | 3 (5) | | 3 (4) | |
| ⩾2 weeks | 12 (92) | | 6 (100) | | 47 (85) | | 65 (88) | |
| Unknown | 1 (8) | | 0 (0) | | 5 (9) | | 6 (8) | |
| Duration (weeks)† | | 12 (2–130) | | 3.5 ( 2–13) | | 5 (0–30) | | 6 ( 0–67) |
| Chest radiograph | | | | | | | | |
| Cavitary† | 11 (85) | | 3 (50) | | 26 (43) | | 40 (51) | |
| Non-cavitary | 2 (15) | | 3 (50) | | 34 (57) | | 39 (49) | |
| MDR-TB | | | | | | | | |
| Yes | 4 (31) | | 0 (0) | | 2 (3) | | 6 (8) | |
| No | 9 (69) | | 6 (6) | | 58 (97) | | 73 (92) | |
| HIV infection | | | | | | | | |
| No | 7 (54) | | 3 (50) | | 39 (56) | | 44 (56) | |
| Yes | 1 (8) | | 2 (33) | | 10 (17) | | 13 (16) | |
| Not tested | 5 (38) | | 1 (17) | | 16 (27) | | 22 (28) | |
| Exposure site type | | | | | | | | |
| Worksite | 6 (46) | | 3 (50) | | 29 (48) | | 38 (48) | |
| School | 4 (31) | | 3 (50) | | 23 (38) | | 30 (38) | |
| Other | 3 (22) | | 0 (0) | | 8 (14) | | 11 (14) | |
| Exposure duration (hours/week)‡ | | 30 (7.5–40) | | 35 (10–40) | | 30 (3.5–60) | | 32 (3.5–60) |
| Exposure site size ($ft^3$)§ | | 13 200 (720–311 520) | | 6718 (2023–26 213) | | 9000 (140–3 000 000) | | 8500 (140–3 000 000) |

* 6 = Unknown smear grade.
† $P < 0.05$, comparing sites with likely vs. unlikely transmission.
‡ 18 = unknown exposure duration.
§ 24 = unknown site size.
AFB = acid-fast bacilli; MDR-TB = multidrug-resistant tuberculosis; HIV = human immunodeficiency virus.

There are a number of lessons that may be drawn from our experience. First, consideration should be given to reducing the number of TSTs performed in an ECI. Whenever possible, tuberculin testing should be performed only once, after most contacts would have had a tuberculin conversion. This would have the benefit of reducing: 1) the number of TSTs performed, 2) the number of positive TSTs due to boosting, and 3) the number of initially negative persons who refuse retesting. The appropriate timing for testing ECI contacts is of central consideration in this regard. The time from tuberculosis infection to tuberculin conversion is generally considered to be 10–12 weeks.[1,15] However, there is evidence that 8 weeks would be sufficient to detect conversion in low-risk casual contacts, and this period coincides with the amount of time it generally takes to obtain culture confirmation of *M. tuberculosis*.[16,17] In actual practice, obtaining culture confirmation, evaluating household contacts, contacting the site and scheduling testing, and getting lists of exposed persons often takes 8 weeks. Performing a single TST after 8 weeks can also avoid the difficulties of distinguishing TST boosting as a result of prior BCG from conversion.[16] In settings with large numbers of non-US-born contacts, boosting as a result of prior BCG can result in persons receiving unnecessary treatment as well as a drain on resources. Thus, the likelihood of transmission can be assessed more easily in non-US-born contacts by determining the prevalence of infection with one TST at a time when most contacts would have had a conversion, thus avoiding the additional noise from boosting.

In January 2001, the Bureau of Tuberculosis Control program began using 8 weeks from the date of last exposure as the time period for retesting contacts who are initially TST-negative in field contact investigations as well as in congregate settings.

In addition to reducing the number of TSTs performed, tuberculosis control programs may prioritize investigations using known predictors of transmission such as duration of cough and presence of cavitary lesions on chest radiograph.[18,19] Finally, in order to reduce the number of unnecessary tests such as among unexposed persons at congregate sites, more effective health education approaches are needed to communicate the risk of exposure. Assigning primary responsibility to a core staff allowed staff to develop the skills and efficiency necessary to manage complex investigations. Such staff are often called upon to balance public demand for broad screening with clear, accurate messages of risk so that resources are directed appropriately. This is often difficult, however, in settings with a great deal of publicity and fear. Strategies from the field of risk communication may be useful and applicable to managing tuberculosis exposures as well. Staff who develop such skills are a valuable resource for educating (and reassuring) site administrators and managers on investigation procedures and the extent of testing needed. Excellent organizational and communication skills are essential, as well as a strong knowledge of tuberculosis transmission and the ability to manage and interpret testing results.

Regardless of success in previous steps, however, treatment of infected contacts identified in congregate settings is also essential.[1] In our program, the proportion of close contacts who were tested and completed treatment was comparable to that seen in contact investigations performed in the New York City Bureau of Tuberculosis Control overall (NYC Department of Health and Mental Hygiene, unpublished data). Treatment completion rates among infected contacts must be improved, however, in order to meet the program and national goal set by the Centers for Disease Control and Prevention of 85%.

Our data are limited by a number of factors. First, we do not have information about all potential congregate sites where persons with culture-positive pulmonary tuberculosis may have spent significant time during the study period. We are therefore likely to have underestimated the number of exposures in congregate settings. Second, as exposures in sites with fewer than 15 persons were not included in these analyses, our findings cannot be generalized to smaller settings. Third, there was selection in the cases referred for evaluation by the ECI Unit; these were more likely to be infectious cases or cases with potential for outside attention or fear among contacts at the site. Exposures investigated by hospitals or other service agencies that had medical facilities and the expertise to identify and test contacts were also not included in our analyses. In these situations, the ECI Unit provided consultation and assistance to staff who performed the investigations at those sites. Despite these limitations, however, the investigations presented in this analysis are likely to reflect the experience in a program setting.

In summary, a systematic approach for conducting tuberculosis contact investigations in congregate settings is useful for assessing transmission. As such investigations are resource intensive and transmission is not common, performing one TST after most persons would have converted should be considered in low-risk groups. Additional efforts are needed to increase completion of treatment for latent tuberculosis infection in contacts identified in these settings.

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