Evaluation of Investigations Conducted to Detect and Prevent Transmission of Tuberculosis

Mary R. Reichler, MD
Randall Reves, MD, MSc
Sarah Bur, RN, MPH
Virginia Thompson, RN
Bonita T. Mangura, MD
Josie Ford, RN
Sarah E. Valway, DMD, MPH
Ida M. Onorato, MD
for the Contact Investigation Study Group

CONTACTS OF PATIENTS WITH infectious tuberculosis (TB) are at increased risk of Mycobacterium tuberculosis infection and disease. Therefore, contact investigations are recommended for all patients with suspected or confirmed active pulmonary TB reported in the United States.1-3 The main goal of contact investigations is to identify secondary cases of active TB and latent TB infection among contacts so that they can begin therapy.1-4

Contact investigations are complex and involve many steps.4,5 Patients with suspected or confirmed TB are identified by clinicians and reported to the health department. Case patients are then interviewed by health department staff to obtain information about persons they may have had contact with when potentially infectious. Following a process known as the concentric circle approach, contacts are prioritized for in-

See also pp 996 and 1040.
vestigation based on their amount of exposure to the case patient. Persons judged to have had the most contact are evaluated first, and the investigation is expanded to include contacts with less exposure if infection rates in the highest priority group are greater than the expected background rate in the community (generally >15%-20%). Health department staff notify contacts that they have been exposed to TB and the contact is scheduled for a tuberculin skin test (TST). A follow-up test is recommended 3 months subsequent to last exposure, since TST conversion may occur up to 10 weeks following exposure.

Chest radiograph examinations are performed for all contacts with positive TST results and for young children and immunocompromised contacts with negative TST results to determine whether they have active TB.

Most health departments in the United States conduct contact investigations for all patients with infectious TB as a routine part of their TB control programs, but little is known about the actual procedures followed or the results of those investigations. To address this knowledge gap, we conducted a retrospective study of contact investigations performed in 1996 in 5 US states. Our study had the following objectives: (1) to determine which data are currently being collected during contact investigations, (2) to describe contact investigation procedures, and (3) to evaluate contact investigation results. Results of initiation and completion of treatment of latent TB infection for these contacts has already been described.

Study Design
Data were abstracted from existing health department records for 360 patients aged 15 years or older with culture-positive pulmonary TB reported to the Centers for Disease Control and Prevention national surveillance system during 1996 (all patients at 4 sites and a random sample at 1 site), and for all identified contacts of these patients. A list of contacts identified for each patient was made by reviewing health department records. Investigations with only tabular summary data recorded and those lacking individual contact listings or records were excluded. The project was exempted from institutional review board review because it involved the use of existing records.

Study Definitions
Close Contact. Definitions for contact closeness differed between study areas, and closeness was not recorded in written records for many contacts. For this study, we defined contacts as “close” if they were members, visitors, or workers in the case household (n=699), or were friends (n=145) or relatives (n=325) of the case; “not close” if they were not household contacts, friends, or relatives; and “unknown” if type and place of contact were not specified in the record.

Dates. The “date of last exposure” was defined as the approximate date of a contact’s last exposure to a patient, determined using the start date of the patient’s treatment (or date of collection of the first culture-positive specimen in instances where the former was not available). The “date of clinical evaluation” was defined as the date of collection of the first culture-positive specimen from the patient.

Skin Test Converter. Defined as a contact with a negative TST at the time of initial evaluation (or within the 2-year period prior to screening, if documented in health department records) and a subsequent positive TST (≥5 mm induration and an increase of ≥5 mm compared with the initial test).

Methods
Study Areas
We solicited applications from health departments in the United States that met 3 standards in 1996: (1) had a policy to conduct contact investigations for all infectious TB patients, (2) maintained written records for all TB patient and contact investigations, and (3) annually reported 50 or more patients with TB. From 11 eligible health departments that applied for the study, 5 with the perceived best contact investigation programs and the best-organized records were selected. Three study sites were large metropolitan areas, 1 comprised a large metropolitan area and 5 surrounding counties, and 1 comprised 10 counties containing small- or medium-size cities and surrounding rural areas.

Data Analysis
Statistically significant differences (P<.05) in risk variable responses were assessed with Mantel-Haenszel χ² tests and χ² tests for trend using Epi Info 6.04d (Centers for Disease Control and Prevention, Atlanta, Ga).

Results
Cases and Identified Contacts
A total of 3824 contacts were identified for 360 patients with active pulmonary TB. No contact investigation results were available for 11 (3%) patients and these patients were excluded from analysis. For the remaining 349 patients, the median number of contacts identified per patient was 5 (range by study area, 3-14). The median number of contacts identified was higher for patients who had both a positive smear and cavitary disease on chest radiograph (8 vs 4 for other cases; P<.001). Forty-five (13%) patients with contact investigations done had no contacts identified (range by study area, 2%-19%), and an additional 38 (11%) had no close contacts identified (range by study area, 11%-37%). The number of contacts identified per patient ranged from 0 to 274 (interquartile range, 2-10). Of 5 investigations involving more than 100 contacts, 1 was conducted in a school, 2 in homeless shelters, 1 in a large workplace, and 1 in an apartment complex.

Patients with no contacts identified were more likely to reside in a homeless shelter (13% [6/45] vs 2% [6/304] of patients with contacts identified; P<.001). Only 6 (50%) of 12 patients residing in homeless shelters had con-
The proportion of contacts with a positive TST result or TB disease, chest radiograph results were available for 598 (88%). The proportion of contacts with radiograph results was higher for close contacts (95% vs 84% for non-close contacts; P<.001).

Of 678 contacts with a positive TST result or TB disease, chest radiograph results were available for 598 (88%). The proportion of contacts with radiograph results was higher for close contacts (95% vs 84% for non-close contacts; P<.001).

**Table 2. Tuberculosis infection (ie, initial TST positive or skin test converter) or disease was more likely for close contacts (43% vs 32% for non-close contacts [P<.001] vs 17% for contacts of unknown closeness [P<.001]). Close contacts exposed to patients with both a positive smear and cavitary disease diagnosed by chest radiograph (62%) were more likely to have TB infection or disease than those with 1 or neither characteristic (33% with positive smear only; 44% with cavitary disease diagnosed by radiograph only; and 37% with neither; P<.001).**

Of 678 contacts with a positive TST result or TB disease, chest radiograph results were available for 598 (88%). The proportion of contacts with radiograph results was higher for close contacts (95% vs 84% for non-close contacts; P<.001).

**Data Collected During Contact Investigations**

The figure displays the overall frequency with which a number of factors known to be associated with patient infectiousness, contact exposure, contact susceptibility to TB infection, and contact risk of progression to TB disease were recorded in written contact records.

**COMMENT**

No contacts were identified for 13% of the patients with culture-positive pulmonary TB reported from our study areas. The number of persons potentially exposed to a patient with TB varies considerably from patient to patient and is dependent on the individual's household, work, and social environments. Establishing a standard minimum number of contacts to be identified per patient would not be useful, but nearly every case should have at least 1 contact, with most having more than 1.

Ninety-three percent of patients in our study with no identified contacts were alive at the time of diagnosis, and only half were known to have been interviewed. Interviewing the patient to elicit contacts is the best (and often the only) means of identifying potentially exposed persons, and it is essential that all patients (or a suitable proxy for patients who are dead at the time of diagnosis) be interviewed. The quality of TB case interviews is dependent on a number of factors, including interviewer skill, interviewer understanding of the patient's social setting, and the patient's ability...
ity and willingness to share information. This is well illustrated by several recent outbreaks in which initial patient interviews failed to identify contacts in certain social networks that investigators were not initially aware of, but whose presence was later established. The 2-week median interval from patient evaluation to report observed for patients in our study who had no contacts identified may have decreased the number of cases who could be located for an interview and may also have resulted in lower interview quality. That patients with no identified contacts were less likely to have a usual place of residence, or a safe home, in which to be interviewed. Further studies are needed to determine whether conducting structured interviews, more than 1 interview, or at least 1 interview in the patient household (rather than in the clinic or hospital) would minimize the number of patients for whom no contacts are identified.

We found that only 50% of patients with TB who resided in homeless shelters had contacts identified. Previous studies have noted the limited usefulness of traditional approaches to identifying contacts when the patient with TB is homeless. Location-based approaches, special efforts to establish trust, and improvements in the interview technique have been suggested as ways to improve contact investigation in this population. Social network techniques for contact investigations involving homeless populations may be another useful approach.

Fewer than two thirds of identified contacts in our study completed TST screening. The majority of incompletely screened and unscreened contacts appear to have been in a priority group for screening. Since our study was retrospective, we could not determine why some contacts were never screened or why some initiated screening but did not complete it. Reasons could include failure to locate certain contacts, failure of located contacts to respond to requests for follow-up, or determination by health department staff that a named contact was not a true contact. The large number of those incompletely screened needs further exploration. One problem may be that health departments lack “ticker” systems to remind personnel about the need to pursue contacts for a
follow-up test. There also may be problems motivating contacts to be screened a second time.

The number of secondary infections that can be expected to arise from patients with infectious TB in the United States today remains unknown. Our study identified an average of 1.9 infected contacts per patient (2.6 per smear-positive patient and 1.2 per smear-negative patient). Since complete TST screening results were not available for many identified contacts, it is likely that the actual number of infected contacts in the study areas is higher than described herein.

Factors critical to optimal contact investigation, such as those associated with case infectiousness, contact susceptibility to infection, type and amount of contact exposure to the case, contact risk for progression to active TB (including human immunodeficiency virus status), and contact history of prior TB infection, were not recorded in written records for many or most contacts in this study. These findings highlight the importance of written documentation of key patient and contact characteristics, particularly those that are needed to assess TB transmission risk and to establish priority in contact investigations.

A limitation of our study is that it was based on retrospective chart review conducted at sites that had different procedures, definitions, and data collection and management practices. However, we selected study sites that were, in our opinion, among the best organized TB control programs in the United States; thus, our data may underestimate the need for improvement in the contact investigation process nationally.

A standard approach to TB contact investigation has the potential to improve outcomes. To accomplish this, it will be necessary to (1) determine the data that should be routinely collected during contact investigations; (2) develop standard definitions for “contact” and “close contact”; (3) define the duration, time period, and frequency of contact in various environments that constitute exposure; (4) develop standard criteria for expanding contact investigations; (5) define the extent of investigation needed in various epidemiologic settings; and (6) develop effective data management systems for contact investigations. A prospective study that attempts to provide the data needed to improve contact investigation in these 6 ways is in progress in study areas in 4 US states. Further studies should help define the ideal background and training of staff who conduct contact investigations, determine the contact investigation model (ie, outreach vs clinic-based) that works best in various settings, and determine how to better motivate patients to comply with TST screening procedures.

Our results also highlight the need for greater awareness on the part of the general medical community of the importance of promptly reporting patients with suspected TB to facilitate contact identification and tracing. Greater familiarity with the contact investigation process by physicians outside the public health arena may also facilitate contact compliance with screening and completion of treatment of latent TB infection—essential steps toward interrupting TB transmission in the United States.

Author Contributions: Study concept and design: Reichler, Reves, Bur, Valway, Onorato. Acquisition of data: Reves, Bur, Thompson, Mangura, Ford. Analysis and interpretation of data: Reichler, Reves, Bur, Mangura, Valway, Onorato. Drafting of the manuscript: Reichler, Mangura, Ford. Critical revision of the manuscript for important intellectual content: Reichler, Reves, Bur, Thompson, Mangura, Valway, Onorato. Statistical expertise: Reichler. Obtained funding: Reves, Bur, Mangura. Administrative, technical, or material support: Reves, Mangura, Ford, Valway. Study supervision: Ford, Valway, Onorato.

Contact Investigation Study Group Members: Denver Public Health Department and Colorado Department of Health and Environment: Patty Calixto, Mohammed Malakouti, Bessy Naterano Garcia, Juanita Diaz, Maryland Department of Health and Mental Hygiene: Nancy Baruch, Deirdre Thompson; Massachusetts Department of Public Health: Janice Boutotte, Denise O’Connor, Sue Elkind, Margaret Harding; Mississippi State Department of Health: J. M. Holcombe; New Jersey Department of Health and Senior Services: Ken Shilkret, Janet de Graaf; New Jersey Medical School National Tuberculosis Center: Mark Wolman.

Funding/Support: Funding for this project was provided through a supplement to the Centers for Disease Control and Prevention Tuberculosis Cooperative Agreement.

Previous Presentation: Preliminary data from this study were presented at the International Union Against Tuberculosis and Lung Disease Annual Meeting, Bangkok, Thailand, November 1998; the Infectious Diseases Society of America Annual Meeting, Denver, Colo, November 1998; the International Union Against Tuberculosis and Lung Disease Annual Meeting, Madrid, Spain, September 1999; the Infectious Diseases Society of America 37th Annual Meeting, Philadelphia, Pa, November 1999; and the American Thoracic Society Conference, Toronto, Ontario, Canada, 2000.

Acknowledgment: We thank Elsa Villarino, MD, MPH, Rick O’Brien, MD, and Peter Bing, MD, for their helpful comments on the manuscript.

REFERENCES