Outbreak of Tuberculosis in a Church*

Asim K. Dutt, MD, FCCP; Jay B. Mehta, MD, FCCP; Betty J. Whitaker, RN; and Harriet Westmoreland, RN

A 48-year-old white man (index case) with an abnormal chest radiograph remained undiagnosed for tuberculosis for 4 years. Investigation by purified protein derivative (PPD) tuberculin test revealed positive tuberculin reactions (≥10 mm induration) in seven of eight (88%) initial close contacts, and in 12 of 46 (26%) coworkers. On the suspicion that transmission had also occurred among members of the index case’s church congregation, a PPD tuberculin test survey of 184 of 200 of the members revealed 77 (42%) positive reactors. Thirty percent of the members under the age of 35 years were infected, suggesting transmission of infection. Eight cases of active tuberculosis (including the index case) were detected, yielding a high case rate (4.3%) among the parishioners. Three of the cases were confirmed recent PPD converters. Although bacteriologic findings were available in only three of the eight cases, two cases had phage typing of organism identical to the index case; the third had recrudescent tuberculous disease. Of the remaining five cases without bacteriologic confirmation, two had pleural tuberculosis, one child had progressive primary tuberculosis, and two persons had localized pulmonary nodules suggestive of primary infection progressing to disease. Because transmission of tuberculous infection may occur in any closed environment, including a church, physicians must be conversant with tuberculosis control measures and preventive therapy guidelines to preclude unforeseen transmission of disease. *(Chest 1995; 107:447-52)*

**Key words:** contact investigation; mini-epidemic; tuberculosis transmission

TBuberculosis is transmitted via the inhalation of airborne droplets generated by an infected person. Prolonged exposure to an active tuberculosis case in a closed environment substantially increases risk of infection. Reports of such transmission and subsequent tuberculosis epidemics with drug-sensitive or drug-resistant organisms have originated in schools, jails, day care centers, nursing homes, and various other closed environments. However, religious groups have seldom been identified for this form of transmission. Herein we report an outbreak involving exposure of a large church congregation to an infectious case. Our experience is rare, reflecting a difficult, but important, contact investigation.

**MATERIALS AND METHODS**

The study presented herein was conducted at the Upper Cumberland Regional Office of the Tennessee Department of Health tuberculosis control program. This regional chest clinic serves a population of 264,000 in 14 counties of the state and covers 5,093 square miles. The region’s tuberculosis case rate for 1988 was 20.7 as compared with 12.5 for the state of Tennessee and 9.5 nationwide.

In Tennessee, most patients with tuberculosis are treated by private physicians. Tuberculosis contact screening (tuberculin testing and radiologic examination) and preventive therapy are provided at the clinic by public health nurses under guidance of a consultant physician. The clinic uses the Mantoux method of skin testing with purified protein derivative (PPD) in which induration of ≥10 mm is considered a positive reaction. Radiologic examination is performed on all infected contacts. Symptomatic persons and close contacts receive chest radiograph and sputum examination even in cases with negative tuberculin test. The clinic also provides preventive therapy when appropriate.

**Index Case**

In April 1986, a 48-year-old white man was referred to our clinic with symptoms of cough and weight loss. The patient had positive PPD and an abnormal chest radiograph in 1982 (Fig 1). In 1985, a bronchoscopy was performed to evaluate chest symptoms and worsening abnormal chest radiograph (Fig 2). Flexible bronchoscopy showed no evidence of endobronchial lesion or laryngeal tuberculosis. Isoniazid (INH) therapy was initiated, but it was discontinued after 3 months when sputum and bronchoscopic washing cultures were reported negative for *Mycobacterium tuberculosis*. Progressive cavitary disease was noted in the right apex (Fig 3). Sputum examination revealed acid-fast bacilli (AFB) that were subsequently identified as *M tuberculosis* in the cultures. Phage typing was type 2 (7, 9, 12, 13). Antituberculosis treatment with INH, rifampin (RIF), pyrazinamide (PZA), and ethambutol (EMB) was initiated in 1986, when the sputum smear showed AFB.

**Examination of Close Contacts**

On contact investigation, seven of eight household contacts were found to be positive tuberculin reactors, indicating high infectiousness of the index case. However, chest radiographs were normal for all but one 70-year-old woman whose radiograph showed minimal apical scarring. She refused prophylactic treatment. The remaining six positive reactors completed the full

---

*From the Upper Cumberland Chest Clinic, Tennessee Department of Health, Cookeville, Tenn.
Manuscript received November 1, 1993; revision accepted July 14, 1994.
course of INH preventive therapy.

The investigation was extended to the index case’s workplace, a garment factory, due to the large number of positive reactors among household contacts. Twelve of the 46 (26%) coworkers on his shift had positive reactions; nine were recommended INH preventive therapy. This high percentage prompted investigation of the other shift. Eight of the 56 (14%) employees on the other shift proved to be positive reactors, four of whom received INH preventive therapy. No active disease was found among their contacts.

Suspicion of Transmission in the Church

In November 1986, a 32-year-old woman and her 6-year-old son arrived at our clinic for tuberculosis checkups following rumors of tuberculosis circulating among members of their church. The woman had heard of the tuberculosis disease in our index case, in another adult, and in a 6-year-old girl attending the same church. We recalled that the church minister’s 19-year-old daughter had a positive skin reaction but normal chest radiograph during a precollege admission examination in September 1986. The woman and her son were found to be positive reactors with normal findings on the chest radiographs and received INH preventive therapy. These findings aroused suspicion of transmission of infection, and initiated review of the records of verified cases within the church.

Review of Notified Tuberculosis Cases Within the Church

Case 1: In July 1986, a 63-year-old man was treated at a Veterans Administration Medical Center with INH and EMB for pleural tuberculosis (Table 1). The patient was a positive skin reactor with no record of previous skin testing, hence, diagnosis was made solely on a clinical basis. Screening of contacts was negative.

Case 2: Also in July 1986, a 6-year-old girl was treated for pleural disease at a local hospital. Granulomatous pleuritis with AFB was noted on the biopsy specimen, but mycobacterial culture of the tissue was not performed. The child was a negative reactor in 1985, but tested positive in 1986. Her mother was a known negative reactor in 1985 who tested positive in 1986 and received INH therapy. The girl’s father and two siblings were all negative reactors.

In December 1986, a decision was made to screen members of the index case’s church for tuberculosis, and the minister was contacted for a membership listing. In February 1987, the minister reluctantly provided us with a partial list of members and the contact investigation was finally begun.

New Tuberculosis Cases in the Church

Case 3: Among the first group of church members tested were a mother and her 2-year-old daughter, (case 3) who both had positive reactions to the skin test (Table 1). Chest radiograph of the child, who had tested tuberculin negative in July 1986, showed hilar adenopathy with segmental collapse of right upper lobe. No bacteriologic study was performed and she was treated with INH and RIF. Despite substantial efforts, a complete list of church members could not be acquired due to lack of cooperation. Eventually, however, a member provided a 1984 church directory. After seeking legal advice, a survey questionnaire was mailed to the members with advice for tuberculin testing at either the health department or their family physician’s office.

Case 4: In February 1987, a 23-year-old woman who had been a negative reactor 2 years earlier was found to be positive. Chest radiograph revealed left upper zone infiltration, and sputum culture was positive for M. tuberculosis. Phage typing of the organism was identical to that of the index case (type 2 [7, 9, 12, 13]). The patient was treated with INH and RIF.

Case 5: In May 1987, a 71-year-old woman was determined to be a positive reactor after her chest radiograph revealed a pulmonary nodule. Subsequent open lung biopsy specimen showed “granuloma with positive stains for AFB,” but the tissue was not cultured. The patient was treated with INH and RIF.

Case 6: A 43-year-old man had a positive PPD test in April 1987 and a normal chest radiograph. In March 1988, he became symptomatic at the same time the chest radiograph revealed infiltration in the right upper zone with sputum culture positive for M. tuberculosis. Phage typing showed the organism to be type 1 (13).

Case 7: A 67-year-old man was found to be a positive reactor in March 1987. He, too, had a normal chest radiograph. In June
1988, a repeated chest radiograph prior to initiation of preventive therapy revealed a new pulmonary nodule, 1.5×1.5 cm, in the right upper zone of the lung. The nodule was resected due to the patient's strong history of smoking and negative sputum smears for AFB. The resected nodule revealed “granuloma with AFB,” but the tissue was not cultured. The patient was treated with INH and RIF.

Epidemiologic Survey of the Church

In conjunction with the Centers for Disease Control (CDC, Atlanta), an epidemiologic study was done in the church. Located on the same site since August 1980, the church had an estimated membership of 200 persons, including children. A class of about 35 children was held on Sunday mornings and Wednesday evenings. Adult classes met in the auditorium at the same times. Worship services were conducted on Sunday mornings, Sunday evenings, and Wednesday evenings, with attendances of about 150, 110, and 100, respectively. Fellowship dinners, held one Sunday a month, were usually attended by about 40 couples. No activities were scheduled for preschoolers or high school age students.

The church auditorium, located in the center of the building, contained 15 pews on the left and right sides separated by a middle aisle. Air was recirculated via intake vents located near the floor at the front of the room. Heat and air conditioning were provided by heat pumps on the left and right sides of the auditorium.

RESULTS

By December 1988, 184 persons had been contacted by the health department. Eighty-four of 184 (45.6%) church members were men; mean age of the group was 38.6 years (median 37.5 years). Of the 184 contacted, 77 (42%) had positive skin reactions (Table 2), including 7 secondary cases, which is quite high compared with the 15 to 20% usually observed among close contacts. Twelve of the 77 positive reactors were already known to be so.

Mean age of those infected was higher (39.7 years) than that of the noninfected persons (29.4 years) (p=0.017, unpaired Student’s t test). Among those ≤19 years old, 12 of the 49 tested (24.4%) were positive reactors. Thirty-nine of 100 (39%) female subjects were infected compared with 38 of 84 (45%) male subjects. These rates did not differ significantly. All 77 persons who tested positive had a follow-up chest radiograph and 50 (65%) were prescribed INH preventive therapy. Eight active cases (4.3%) of tuberculosis were diagnosed among 184 church members.

Based on self-reports of seating in the auditorium, infected persons were evenly distributed throughout the room. Rates of infection varied little in any area of the auditorium except the front right section, ranging between 40.0% to 45.5%. The presumed index case, who was not a member of the church choir, sat in the front right section where 8 of 11 persons infected reported sitting. However, it is likely that many were members of the index case’s extended family, household transmission may have occurred. Using attendance self-reports, we determined that infected persons spent slightly more time in the auditorium each week than uninfected persons (14 h vs 12 h per month), although this difference was not statistically significant (p=0.22, unpaired Student’s t test).

DISCUSSION

Our investigation of tuberculosis transmission in the church indicated high infectivity of the index case. Seven of the eight (88%) household contacts had positive skin reactions, a much higher number than the 25 to 30% expected.11 Twenty-six percent of the employees working on the index case’s shift at the garment factory also tested positive.

In 1982, the index case exhibited radiographic abnormalities and a positive tuberculin reaction, but preventive therapy was not prescribed. Apparently, the disease was active, but remained unconfirmed until 1986. It was during this prolonged period that many of the contacts became infected.12,13 Had preventive therapy been prescribed in 1982, as recommended by the CDC,13 transmission of infection might have been averted. Sputum and bronchoscopy washings were collected for M *tuberculosis* to evaluate the index case’s deteriorating chest radiograph in 1985, but appropriate therapy still was not given due to negative culture reports. Ironically, as little as 4 months of INH/RIF preventive therapy might have eradicated the disease in the individual with negative smears and cultures had he been suspected of harboring active tuberculosis.14

During the course of study, eight cases of active

![Figure 3. Chest radiograph showing cavitation in right apex (April 7, 1986).](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21708/)
Table 1—Active Tuberculosis Cases Identified Among Church Members

<table>
<thead>
<tr>
<th>Case No./Age, y/</th>
<th>Race/Sex</th>
<th>Date</th>
<th>Presentation</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index case/48/W/M</td>
<td></td>
<td>4/86</td>
<td>Pulmonary infiltration</td>
<td>Sputum smear and culture positive, positive, PPD</td>
</tr>
<tr>
<td>1/63/W/F</td>
<td></td>
<td>7/86</td>
<td>Pleural</td>
<td>Clinical, positive PPD, previous PPD unknown but likely primary</td>
</tr>
<tr>
<td>2/6/W/F</td>
<td></td>
<td>7/86</td>
<td>Pleural</td>
<td>Pleural biopsy and positive AFB, not cultured, PPD conversion</td>
</tr>
<tr>
<td>3/2/W/F</td>
<td></td>
<td>2/87</td>
<td>Hilar adenopathy and pulmonary segmental collapse</td>
<td>Clinical, positive PPD, PPD conversion</td>
</tr>
<tr>
<td>4*/23/W/F</td>
<td></td>
<td>2/87</td>
<td>Pulmonary infiltration</td>
<td>Sputum smear and culture positive, PPD conversion, phage typing identical to index case</td>
</tr>
<tr>
<td>5/71/W/F</td>
<td></td>
<td>5/87</td>
<td>Pulmonary nodule</td>
<td>Excision biopsy, positive AFB, not cultured, positive PPD, previous PPD unknown but likely primary</td>
</tr>
<tr>
<td>61/43/W/M</td>
<td></td>
<td>3/88</td>
<td>Pulmonary infiltration</td>
<td>Sputum smear and culture positive, positive PPD, previous PPD unknown, phage typing unlike index case, recrudescence disease</td>
</tr>
<tr>
<td>7/67/W/M</td>
<td></td>
<td>6/88</td>
<td>Pulmonary nodule</td>
<td>Excision biopsy, positive AFB, not cultured, positive PPD, previous PPD unknown but likely primary</td>
</tr>
</tbody>
</table>

*Index case and case 4: phage type 2 (7, 9, 12, 13).
†Case 6: phage type 1 (13).

Tuberculosis, including the index case, were diagnosed among 184 church members screened (Table 1), presenting a very high case rate (4,348/100,000). Three patients were recent converters. Although bacteriologic confirmation was not available in all cases, two of the bacteriologically proven cases had identical phage typing of the organisms, confirming likely transmission from the same source. Of the first five active cases, two had pleural tuberculosis, one child had primary tuberculosis, and two persons had localized "pulmonary nodules." All these manifestations are suggestive of primary infection with tubercle bacilli.

Several epidemics of tuberculosis have been reported in institutions with closed environment. High infection rates have been described in prisons, jails, nursing homes, homeless shelters, and day care homes.7-10,15 Until now, however, religious institutions have not been implicated in the transmission of tuberculosis. Generally, a detailed inquiry of home environment and workplace is made during contact investigation, but churches and other meeting places are usually not included. Hence, despite high infection rates among contacts at the home and workplace, further workup of church members was not undertaken initially. Suspicion of tuberculosis transmission in the church arose only when a member indirectly brought the possibility to our attention. A review of

Table 2—Final Results of Tuberculin Testing and Preventive Therapy in the Church, 1986 to 1988

<table>
<thead>
<tr>
<th>Age Group yr</th>
<th>Total</th>
<th>Radiograph</th>
<th>Negative</th>
<th>Positive</th>
<th>Recom*</th>
<th>Started</th>
<th>Completed</th>
<th>SGOT**</th>
<th>SX†</th>
<th>Yield Active‡ Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 4</td>
<td>11</td>
<td></td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5 to 9</td>
<td>13</td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10 to 14</td>
<td>15</td>
<td>1</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>15 to 19</td>
<td>10</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 to 34</td>
<td>32</td>
<td>15</td>
<td>20</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>35 to 49</td>
<td>31</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>11</td>
<td>11</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>50 to 64</td>
<td>48</td>
<td>31</td>
<td>23</td>
<td>25</td>
<td>17</td>
<td>16</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>65+</td>
<td>24</td>
<td>16</td>
<td>11</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>184</td>
<td>88</td>
<td>107</td>
<td>77</td>
<td>52</td>
<td>50</td>
<td>40</td>
<td>6</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

*Rcom=recommended.
†SX=symptoms.
‡Index case not included.
**SGOT=serum glutamate oxaloacetate transaminase.
active tuberculosis cases in our region added weight to our conviction of transmission by this means.

Our request for investigation among members of the church raised emotional issues that led to resistance from church leaders. We sought legal advice from the state Attorney General’s office to ensure that church members’ legal rights would in no way be violated while we performed our duty as public health workers to prevent tuberculosis transmission due to the sensitive nature of such investigation. Although the process was slow and required concerted efforts, most of the members were eventually screened. Of the 184 parishioners who cooperated in the tuberculosis testing efforts, 77 (42%) were positive reactors. Differentiation between newly infected and previously infected persons was difficult without knowledge of prior skin test results; however, presence of infection in 30% of the members under age 35 years signified transmission of new infection. Pleural effusion is generally a presentation of primary infection, as are postobstructive infiltrates located in the anterior segment of the upper lobe. These manifestations were exhibited in the cases of this report. That primary infection in tuberculosis-negative elderly persons may progress to active disease is well documented in nursing homes. These facts further substantiate that transmission of tuberculosis infection occurred in the church. Inadequate ventilation of recirculated air in the church may have played a role in this transmission.

The incidence of tuberculous disease has been declining for several decades at the rate of 6% per annum. Except in metropolitan areas, most primary care physicians see very few cases of active tuberculosis per year. In a study by Byrd et al., treatment of tuberculosis by nonpulmonary physicians was found to be inappropriate in 73 of 130 patients. In the present study, there has been a paucity of tuberculosis cultures of sputum and tissues obtained by private physicians, even in the patients undergoing surgery. If the treatment of this disease is to remain in the mainstream of medical practice, increased educational efforts in the epidemiology, diagnosis, and treatment of tuberculosis are essential at all levels of medical training.

Many persons with positive PPD tests and abnormal chest radiographs but negative sputum cultures will eventually develop tuberculosis if they do not receive treatment. Grzybowski et al. found a reactivation rate of about 5% per annum for the first year, with additional reactivation of 0.5 to 1.0% annually for as long as 20 years. In a study among 173 Chinese patients, 41% developed culture positive disease and another 16% showed radiologic deterioration during 5 years.

The CDC and the American Thoracic Society have established national guidelines for the administration of INH preventive therapy in appropriate high-risk groups. A study by Mehta et al. however, revealed that enthusiasm for prevention is declining. This study noted that although 59.5% of those meeting the criteria for preventive therapy were given INH therapy in 1979, the percentage had declined to 32.1% in 1985, indicating reduced efforts for INH preventive therapy.

With the decline in tuberculosis have come drastic cuts in funding for tuberculosis programs in state health departments. The resultant lack of resources and trained personnel has had a negative impact on surveillance and control of the disease. Since 1985, there has been a resurgence of tuberculosis in the United States. The weakness of tuberculosis control programs has been more acutely exposed due to the growing number of persons with human immunodeficiency virus infection and their increased vulnerability to tuberculosis. Numerous recent outbreaks of tuberculosis with sensitive or drug-resistant organisms exemplify our now critical need for a total overhaul of existing tuberculosis control programs.

CONCLUSIONS

Our experience with this small, but virulent, tuberculosis epidemic shows that religious and social congregations should be considered when conducting contact investigations. Although 6 years of observation may not be long enough, it may be concluded that the tuberculosis control measures taken in the church have been effective in managing this disease outbreak.

It is hoped that awareness of such an unrecognized, but noteworthy, experience with a tuberculosis outbreak will encourage community physicians and other healthcare providers in their continued vigilance in conducting thorough contact investigations. Prompt and complete investigation is an essential step in controlling the transmission of tuberculosis and effecting appropriate treatment for infected contacts.

ACKNOWLEDGMENTS: The authors thank the following: Melinda Wharton, MD, Epidemiology Intelligence Service, CDC, for her assistance with the epidemiologic survey of the church; Wilber D. Jones, Jr., PhD, Mycobacteriology Laboratory, CDC, for phage typing of organisms; Mr. Sterling Bentley, Tuberculosis Advisor, Tuberculosis Program, Tennessee Department of Health, for his direction in screening the church members; and Ms. Taris Tipton and Ms. Debbie Turner for manuscript preparation.

REFERENCES

7 King L, Geis G. Tuberculosis transmission in a large urban jail. JAMA 1977; 237:791-92
15 Stead WW. Undetected tuberculosis in prison: source of infection for community at large. JAMA 1978; 240:2544-47
18 Nardell EA. Tuberculosis in homeless, residential care facilities, prisons, nursing homes, and other close communities. Semin Respir Infect 1989; 4:206-15
24 Centers for Disease Control. Tuberculosis and human immunodeficiency virus infection: recommendations of the Advisory Committee for the Elimination of Tuberculosis. MMWR 1989; 38:236-50

4TH European Congress of Extracorporeal Life Support
May 10 - 12, 1995; Bergamo, Italy

Contact: Mr. Matteo Salvi, ECMO Conference, Centro Congressi Giovanni XXIII, Viale Papa Giovanni XXIII, 106, 24121 Bergamo, Italy. Tel: 39 35-236435; Fax: 39 35-236474.