



Centers for Disease Control
and Prevention (CDC)
Atlanta GA 30333

April 5, 2012

Richard Hopkins, MD, MSPH
Acting State Epidemiologist
Florida Department of Health

Dear Dr. Hopkins:

Thank you for inviting us to assist with the tuberculosis (TB) investigation in Duval County. This outbreak represents one of the most extensive TB outbreaks that CDC has been invited to assist with since the early 1990s, both in terms of its size and rapid growth.

The enclosed report summarizes the methods and results of the Epi-Aid. Additionally, we have provided recommendations based on these results, which we hope will provide guidelines for the control and prevention of TB transmission in the future.

We could not have completed this investigation without the dedication and hard work of the Duval County Health Department and Florida Department of Health. Ongoing, assertive, and collaborative action will be critical over the next few years to respond to this outbreak.

If you have any questions regarding this report, please feel free to contact me at 404-639-8426 or via e-mail (rluo@cdc.gov).

Sincerely,

Robert Luo, MD, MPH
Epidemic Intelligence Service Officer
Surveillance, Epidemiology, and Outbreak Investigations Branch
Division of Tuberculosis Elimination
National Center for HIV/AIDS, Viral Hepatitis, STD, and Tuberculosis Prevention
Office of Infectious Diseases

CC: Madsen Beau de Rochars
Max Salfinger
Jimmy Keller
Gail Burns-Grant
Dan Ruggiero



Centers for Disease Control
and Prevention (CDC)
Atlanta GA 30333

Date: April 5, 2012

From: Robert Luo, MD, MPH
Epidemic Intelligence Service (EIS) Officer
Outbreak Investigations Team (OIT)
Surveillance, Epidemiology, and Outbreak Investigations Branch (SEOIB)
Division of Tuberculosis Elimination (DTBE)
National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention
(NCHHSTP)
Centers for Disease Control and Prevention (CDC)

Subject: Tuberculosis outbreak investigation associated with homelessness — Duval
County, Florida, 2004–2012 (Epi-Aid 2012-031)

To: Douglas H. Hamilton, MD, PhD
Director, EIS Program
Scientific Education and Professional Development Program Office (SEPDPO)
CDC

Through: KM Kiren Mitruka, Medical Officer, NCHHSTP/DTBE/SEOIB/OIT
MBH Maryam Haddad, Team Lead, NCHHSTP/DTBE/SEOIB/OIT
TN Thomas R. Navin, Chief, NCHHSTP/DTBE/SEOIB
KGC Kenneth G. Castro, Director, NCHHSTP/DTBE

BACKGROUND

In June 2009, the Duval County Health Department (DCHD) and Florida Department of Health (FDOH) requested assistance from CDC to investigate an outbreak of tuberculosis (TB) cases in an assisted living facility for adults with mental illness in Duval County, Florida. The investigation (Epi-Aid 2009-061) identified 18 epidemiologically linked cases, nine of which were culture-confirmed and caused by *Mycobacterium tuberculosis* complex strains belonging to the PCR00160 genotype cluster (spoligotype: 777776777760601, 12-locus MIRU-VNTR: 224325143323). Fifteen of the cases were in residents of the facility, and two of the three non-residents had documented exposure to the index patient, a resident of the assisted living facility. However, the full scope of the outbreak outside the facility could not be determined because of limited genotyping (approximately 25%) of culture-positive cases in Florida at the time and the lack of available records and reliable interviews of outbreak patients with mental illness that documented their whereabouts (e.g., homeless shelters).

Although the total number of TB cases in Duval County declined from 89 cases in 2009 to 72 cases in 2010 and 71 cases in 2011, the number of cases belonging to the PCR00160 genotype cluster increased, with 10 cases identified in 2010 and 30 cases in 2011; of note, the county's genotyping coverage had improved to 96% of all culture-confirmed cases in both years, above the national average of 89% in 2010 (National TB Genotyping Service). While no additional TB cases were found at the assisted living facility at the center of the 2009 investigation, DCHD noticed increasing numbers of cases with the PCR00160 genotype at several local homeless shelters and other sites providing services to persons experiencing homelessness. One case was also diagnosed in a local jail. Furthermore, higher proportions of alcohol and drug use were observed among persons with cases belonging to the PCR00160 genotype cluster compared to other TB cases in Duval County. This apparent shift in epidemiology involving increasing numbers of persons affected by homelessness and other social TB risk factors raised concern for ongoing transmission in hard to reach populations, prompting FDOH and DCHD to request on-site epidemiologic assistance from CDC on February 2, 2012.

On February 14, 2012, Dr. Robert Luo (EIS Officer, DTBE/SEOIB), Dr. Raymund Dantes (EIS Officer, Division of Healthcare Quality Promotion), Dr. Kiren Mitruka (Medical Officer, DTBE/SEOIB), and Emma Johns (CDC Experience Fellow, DTBE/SEOIB) traveled to Jacksonville, Florida, to assist FDOH and DCHD with the investigation. They were joined by Dr. Madsen Beau de Rochars (EIS Officer, OSELS/SEPDPDPO/EIS Field Assignments Branch) on February 15, 2012, and by Dr. Tracie Gardner (Epidemiologist, DTBE) on February 26, 2012. In addition to the support of the entire DCHD TB program, further on-site assistance was provided by Vincy Samuels (Florida EIS Fellow) and Kateesha McConnell, Sherrie Arnwine, Debra Spike, and Jose Zabala from FDOH.

EPI-AID OBJECTIVES

- 1) Describe the epidemiology of the outbreak
- 2) Determine chains of transmission
- 3) Provide recommendations for TB control and prevention, including prioritization of TB contacts

EXPANDED BACKGROUND

PCR00160 TB Cases in Duval County. Although the first TB case documented as having the PCR00160 genotype in Duval County, Florida, was diagnosed in 2004, over half of the total PCR00160 cases in Duval County were diagnosed after 2009. However, genotyping coverage in Duval County was notably lower before 2010. Coverage has improved from 25% of culture-confirmed cases during 2004–2008, to 64% in 2009, and to 96% in both 2010 and 2011. All PCR00160 cases in Duval County also shared the same MIRU2 results (244234423337) for all MIRU2 loci with available data. Compared with other TB cases having genotyping results in Duval County reported during January 1, 2004–February 29, 2012, PCR00160 TB cases were more often associated with homelessness and substance abuse (**Table 1**).

Table 1. PCR00160 TB cases compared with other TB cases with genotyping results — Duval County, Florida, January 1, 2004–February 29, 2012 (Source: National TB Genotyping Service, CDC, using genotyping results reported as of February 29, 2012)

Characteristic (within 1 year of diagnosis unless specified)	PCR00160 TB cases (N=70) n (%)	All other TB cases with genotyping results (N=173) n (%)
Homelessness	19 (27)	15 (9)
Injection drug use	3 (4)	3 (2)
Non-injection drug use	10 (14)	16 (9)
Excess alcohol use	25 (36)	31 (18)
Incarceration at diagnosis	1 (2)	5 (3)

National Distribution of PCR00160. PCR00160 is a relatively uncommon genotype in the United States. During January 1, 2004–February 29, 2012, of 225 cases with PCR00160 genotype results reported nationally, 88 had been reported in Florida, with 70 of these in Duval County. The 70 cases in Duval County accounted for the highest genotype cluster alert level in the country in 2012, measured by county log-likelihood ratio, a statistical test that compares the geographic concentration of a genotype in a county to the rest of the country during the preceding 3 years.

DCHD Efforts in Response to PCR00160 cases. DCHD conducted contact investigations of named contacts of each PCR00160 case since 2004. As part of the 2009 outbreak investigation, active case finding was conducted at the assisted living facility. In response to increasing number of cases among homeless persons during 2010–2011, DCHD conducted a total of 22 TB screenings at homeless shelters and other sites suspected of having potential TB transmission, including one active case finding activity at a homeless shelter. DCHD increased educational outreach to local homeless providers and shelter staff and convened a forum on TB and homelessness involving stakeholders in 2011.

Homelessness in Duval County. In 2010, a point-in-time count estimated 4,105 persons experiencing homelessness in Duval County (1), representing a 20% increase from 2009. The mean age of persons with homelessness was 43 years, approximately half of the persons were

male, and over three quarters were black. Additionally, over three quarters had been in Duval County for more than 1 year. Over half had been homeless for over a year.

METHODS

Outbreak Case Definitions:

- **Confirmed case:** TB disease caused by an *M. tuberculosis* complex strain belonging to the PCR00160 genotype cluster in a Duval County resident since 2004 (Given the rare occurrence of this genotype outside of Duval County, an epidemiologic link was not required to be a confirmed case.)
- **Probable case:** TB disease without an isolate available for genotyping (i.e., clinical disease, or culture-confirmed disease awaiting genotyping results) in a Duval County resident since 2004 with an epidemiologic link to a confirmed case.
- **Suspected case:** TB disease without an isolate available for genotyping (i.e., clinical disease, or culture-confirmed disease awaiting genotyping results) in a Duval County resident since 2004 who was identified by DCHD as having a potential epidemiologic link to a confirmed case and had risk factors similar to those in the genotype cluster (i.e., a history of homelessness, incarceration, or substance abuse within 1 year of TB diagnosis).

Definition of Epidemiologic Links:

- **Location-based epidemiologic link:** Being present at the same location as a person having a confirmed case during that case's infectious period
- **Name-based epidemiologic link:** Having known social ties with a person having a confirmed case

Case Reviews. The Epi-Aid team used a standardized abstraction form (**Appendix A**) to review each outbreak case. Priorities of these reviews were to determine patient characteristics, including their infectious periods according to CDC's contact investigation guidelines (2); identify potential sites of transmission based on known location of patients during their infectious periods; and ascertain epidemiologic links among patients, with an emphasis on likely exposure periods and locations. Exposure period was defined for this investigation as the 2 years preceding the start of that person's infectious period. Data sources for case reviews included TB clinic records, inpatient records if the patient had been hospitalized, radiographic and bacteriologic reports, discussions with DCHD staff, and interviews of patients using a standardized interview form (**Appendix B**). Data on HIV status and mental illness were obtained from patients' medical records. Patients who agreed to be interviewed were offered a \$5 McDonalds voucher. Proxy interviews with family members or close associates were attempted for patients unavailable for interview.

Site Visits. The Epi-Aid team visited sites where DCHD staff had found recent outbreak cases and other potential sites of transmission. At each site, the team met with staff members to review TB screening and testing policies and to discuss existing administrative, respiratory, and engineering controls. The Epi-Aid team also requested stay logs for all clients from ServicePoint,

an electronic information management system used by all homeless shelters and other homeless service providers in Duval County. Additional logs were requested from sites that either did not use ServicePoint or had only been using ServicePoint for less than 1 year. Dates of stay for all cases at a local jail were ascertained through a publically accessible website.

Social Network Analysis. An electronic cross-match between outbreak cases and site records of client stays determined whether TB patients had been present at that site during their likely exposure period, overlapping with another case during that case's infectious period. Such location-based epidemiologic links and the name-based links ascertained from chart reviews and interviews were visualized using the software program R (University of Auckland, New Zealand). Sites were prioritized for future TB screening based on the large magnitude of recent (during 2010–2011) transmission, as evidenced by the number of recent epidemiologic links associated with a site and the number of exposed cases these links represented.

Contact Investigation Review. The Epi-Aid team reviewed the results of name-based contact investigations for all outbreak cases since 2004 and the 22 location-based screenings conducted at select sites by DCHD since 2009, noting the number of cases identified, the number of persons evaluated, the number of persons diagnosed with latent TB infection (LTBI), and the number of persons with LTBI who initiated and completed treatment of LTBI. A line list of persons with incomplete evaluations or treatment was then provided to DCHD.

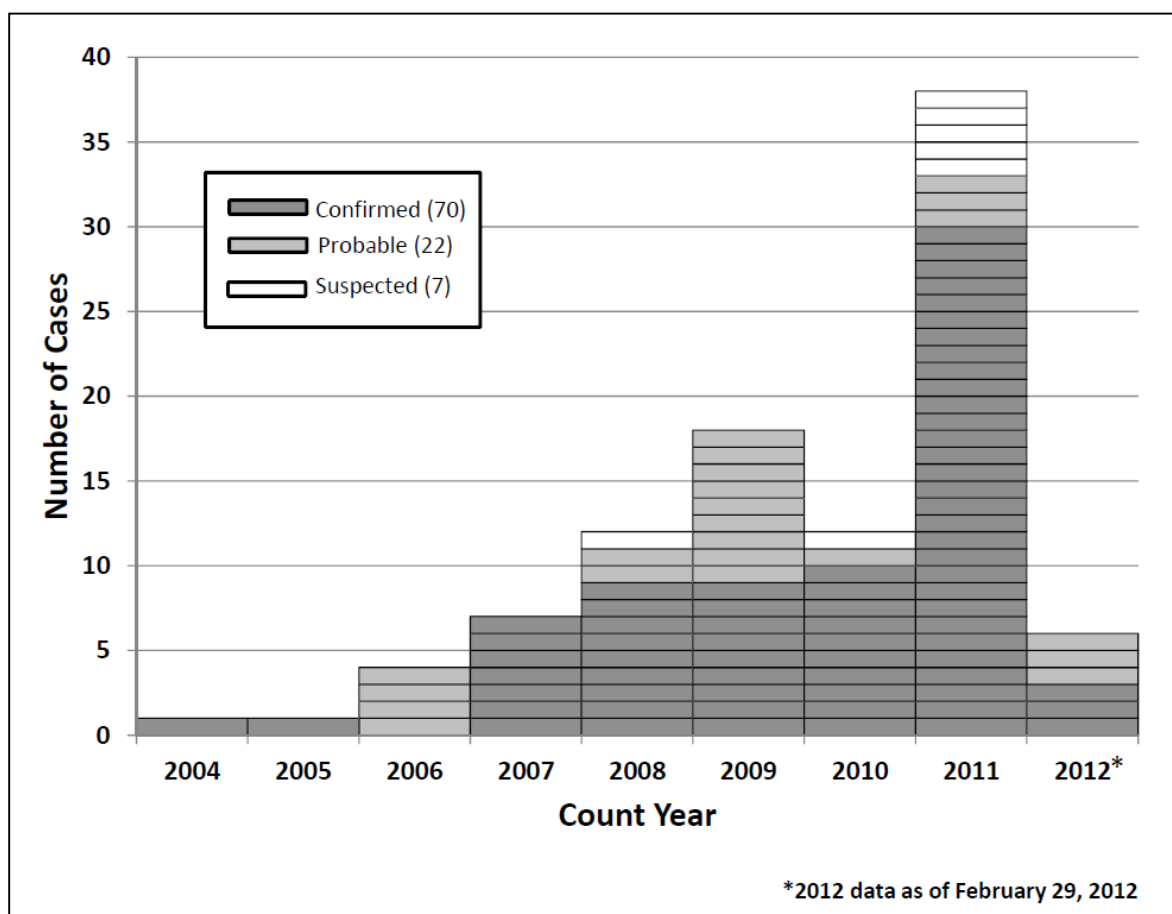
Prioritization of Additional Contacts at Sites with Evidence of Recent TB Transmission. The Epi-Aid team reviewed all available stay logs at sites determined to be high priority for TB screening to identify 2010–2011 contacts of TB patients present at sites during their infectious periods. Contacts who had not yet undergone evaluation were prioritized for TB screening based on CDC guidelines (2). Because of the large number of high-priority contacts, these were further prioritized for screening based on the site of exposure and duration of stay. A line list was provided to DCHD of additional contacts requiring evaluation.

Collaboration with Partners. The Epi-Aid team participated in meetings with partners providing services to the homeless community to identify areas for enhanced collaboration with DCHD in TB screening and management of persons affected by homelessness.

RESULTS

Case Reviews. After reviewing the records for 105 patients, 99 outbreak cases were identified, including 70 confirmed cases, 22 probable cases, and seven suspected cases (**Figure 1**). Although 56 patients could not be contacted, the team was able to reach and interview 33 (77%) of the 43 remaining cases. Sixty-two cases were detected because of symptoms, 27 were identified through health department contact investigation and screening efforts, and five were identified during routine healthcare provider screening. Information on case detection was not available for five cases.

Figure 1. Epidemic curve of outbreak cases — Duval County, Florida, January 1, 2004–February 29, 2012 (N=99)



While the highest number of cases was in 2011, the six cases identified in 2012 represented only the first two months of 2012. This rate of three cases per month was similar to that seen in 2011. The majority of cases occurred among persons who were male, black, and U.S.-born (**Table 2**). Six of the cases occurred in children, five of whom had name-based epidemiologic links to other confirmed cases (**Appendix C**). Documentation of HIV status was available for 81 cases; of these, 20 (25%) had HIV infection. One third of cases were among persons with a history of mental illness. Eighty-seven cases were pulmonary, with 61 smear-positive cases and 37 cases with evidence of cavitory disease on chest radiograph. Most cases (78) were culture confirmed. Of these, 75 (96%) were pansusceptible to all first-line TB drugs (isoniazid [INH], rifampin, pyrazinamide, and ethambutol), two were resistant to isoniazid, and two had unknown drug susceptibilities. One of the INH-resistant cases (counted in 2008) became resistant during treatment after nonadherence. The other case (counted in 2012) had INH resistance at the time of diagnosis and reported a history of INH treatment for 90 days in 2001 for LTBI. An epidemiologic link was not identified between the two INH-resistant cases, although both patients did stay at homeless shelters in Duval County.

Five cases did not have documented treatment completion for their active TB disease because the patients were lost to follow-up. Fourteen cases had a history of prior LTBI infection; however, documentation of treatment completion was only available for three of them.

Table 2. Demographics and clinical characteristics of outbreak patients — Duval County, Florida, January 1, 2004–February 29, 2012 (N=99)

Characteristics	n
<u>Demographics</u>	
Male	78
Race/Ethnicity	
Black non-Hispanic	76
White non-Hispanic	16
Hispanic (any race)	5
Asian non-Hispanic	1
Native Hawaiian non-Hispanic	1
U.S.-born	96
Adult cases	93
Median age (range)	46 (18-86) years
Pediatric cases	6
Median age (range)	8 (2-16) years
<u>Clinical Characteristics</u>	
Known HIV infection	20
Mental illness ¹	33
Diabetes	9
Pulmonary TB disease	87
Sputum or BAL ² AFB ³ smear-positive	61
Cavitary disease	37
Cavitary disease and smear-positive	34
Culture confirmed	78
Pansusceptible	74
INH resistance	2
Unknown susceptibility	2
Treatment completion unknown	5
Died	13

¹Mental illness defined as an Axis I disorder other than substance abuse. ²BAL=bronchoalveolar lavage. ³AFB= acid-fast bacilli.

Notably, 13 of the patients in this outbreak had died by the time of the investigation, with two deaths before, eight during, and three after treatment (**Appendix D**). The two patients who died before treatment represented possible delayed diagnosis of TB. One person had been treated for possible bacterial pneumonia 7 months before his death, with worsening chest radiograph findings despite antibiotic treatment. The other person, identified as a recent contact of an outbreak case, had begun LTBI treatment 2 months before death, but was found to have pulmonary TB on autopsy, despite a negative bronchoscopy shortly before death. Of the eight patients who died during TB treatment, four died within 2 weeks of starting treatment, while the other four died within the first 2 months. Half had cavitory disease on chest radiograph upon diagnosis and half were HIV-infected. Of the three patients who died after completing TB treatment, two had intermittent nonadherence during treatment, and all three died within the year following treatment completion; whether their deaths were related to TB is unknown.

Histories of homelessness, incarceration, and substance abuse were common among outbreak patients (**Table 3**). Nearly half had stayed in homeless shelters in Duval County, and nearly half had been homeless within 1 year of TB diagnosis. Additionally, based on ServicePoint, half of the outbreak patients from the 2009 Epi-Aid were found to have used a shelter in Duval County (data on shelter stays had been incomplete during the 2009 investigation). Approximately two thirds of all patients had a history of incarceration, with a quarter having been incarcerated within 1 year of TB diagnosis. Ten of the 18 previous Epi-Aid patients had a history of incarceration in Duval County. Tobacco smoking was common among patients (63%), followed by excess alcohol use (52%) and injection or non-injection drug use (23%) within 1 year of diagnosis.

Table 3. Social risk factors of outbreak patients — Duval County, Florida, January 1, 2004–February 29, 2012 (N=99)

Risk Factor	n
Homeless ever	60
Shelter use in Duval County	42
Homeless within 1 year of diagnosis	43
Incarceration ever	61
Incarceration within 1 year of diagnosis	26
Excess alcohol use within 1 year of diagnosis	51
Tobacco smoking within 1 year of diagnosis	62
Drug use ¹ within 1 year of diagnosis	23
≥1 of the above social risk factors	82
≥1 of the above social risk factors, excluding smoking	78

¹Drug use includes injection and non-injection drug use.

The proportion of cases with histories of homelessness ever increased from 50% in 2008 to 61% in 2009 and to 69% in 2010, and then decreased to 62% in 2011. The proportion of cases with

histories of incarceration ever increased from 58% in 2008 and 56% in 2009 to 62% in 2010 and 70% in 2011. Documented alcohol and drug use had increases of even greater magnitude over the last several years. The proportion of cases with a history of excess alcohol use within 1 year of diagnosis increased from 25% and 33% in 2008 and 2009, respectively, to 62% and 65% in 2010 and 2011. Similarly, the proportion of cases with a history of non-injection drug use within 1 year of diagnosis increased from 0% and 11% in 2008 and 2009, respectively, to 38% and 35% in 2010 and 2011. Of note, while the team was able to interview approximately half of 2010–2011 cases, fewer than 10% of cases counted before 2010 were available to interview.

The overall proportion of cases with social risk factors was higher than what had been previously reported in the Report of Verified Case of Tuberculosis (RVCT) standard surveillance form. The Epi-Aid team found that 43% of cases had a history of homelessness within 1 year of TB diagnosis, compared to a documentation of homelessness within 1 year for 25% of cases in RVCT data. Similarly, the proportion of cases with excess alcohol use within 1 year of diagnosis was 51%, compared to 30% in RVCT. For non-injection drug use within 1 year of diagnosis, the proportion of cases in this investigation was found to be 23%, compared to 12% in RVCT.

Site Visits. See **Appendix E** for site names and **Appendix F** for descriptions of individual sites. The Epi-Aid team visited nine sites identified by DCHD as locations where health department staff had found to be associated with outbreak cases during the past 2 years. The sites consisted of five homeless shelters (sites A–D, with site A consisting of two separate shelters), a jail (site E), a food program for the homeless (site F), an outpatient mental health facility that provides services to the homeless community (site G), and a transitional housing facility (site K). Additional outdoor locations where persons experiencing homelessness were known to congregate were also visited.

Because of the variability in timing of when ServicePoint use began among shelters, completeness of available data on stays differed by shelter: the most complete data in ServicePoint were available for sites A, C, and F (time period: 2004–2012). Data were available for site B during 2011–2012, for site D during 2005–2012, and for site K during 2008–2012. However, additional data on stays were obtained directly from sites for site B (all client stays during 2001–2011) and sites E, G, and K (TB patient stays during 2004–2012, but other client stays were unavailable). Records on stays of patients during 2004–2012 were also obtained from three additional mental health facilities that were part of the 2009 Epi-Aid (sites H, I, and J), although these sites were not visited due to their lack of recent outbreak cases.

Although homeless shelter directors did report an increased number of clients staying in overflow areas during the coldest nights of the winter, they also stated that full censuses were typical throughout the year regardless of the weather. In terms of TB infection control, each site had different policies and procedures regarding administrative, respiratory, and engineering controls (**Table 4**). None of the sites had ongoing, formal TB education programs to ensure that all new staff and clients received TB education on a routine basis. Additionally, symptoms screening and tuberculin skin test (TST) use was voluntary for clients at sites involved in TB screenings conducting through the health department. Only two sites had policies in place to test all staff and residents on a routine basis.

Table 4. TB control measures identified at site visits, TB outbreak investigation — Duval County, Florida, February–March 2012 (N=9)

Category	Specific Measures	Sites
TB education	• Informal, one-time sessions among staff/residents	8
	• No ongoing, regular programs	9
Symptom screening of residents	• Voluntary, regular health department screenings	6
	• Done for all long-term residents	4
	• Done for all overnight residents	0
TST testing of residents	• Voluntary, regular health department screenings	5
	• Completed on all residents	2
Staff screening and testing	• Voluntary, done along with residents	4
	• Mandatory upon hiring and yearly thereafter	2
Respiratory protection	• Informal cough etiquette or monitoring	6
	• No formal monitoring	9
Engineering controls	• HEPA ¹ filters	1
	• Pleated filters	2
	• UV ² lamps	1
	• Isolation areas	1

¹HEPA=high efficiency particulate air. ²UV=ultraviolet.

Social Network Analysis. Social network analysis was conducted by mapping out and quantifying epidemiologic links among cases. Epidemiologic links were identified for 48 (69%) of 70 confirmed cases. Twenty-four cases had location-based links only, 12 had name-based links only, and 12 had both location- and name-based links. Of the 29 cases without a genotyped isolate, 22 (76%) had epidemiologic links to a confirmed case and were classified as probable cases. Ten had location-based links only, nine had name-based links only, and three had both location- and name-based links. The remaining seven cases had no known epidemiologic links, but did have social risk factors for TB, making them suspected cases. Thus epidemiologic links were identified for 70 (71%) of the 99 cases.

Average daily client volume at each site and the total number of location-based epidemiologic links by year are provided in **Table 5**. No location-based epidemiologic links were found during 2004–2006 or in 2012 for any site with available data on stays. Additionally, no location-based epidemiologic links were found for sites J and K during 2004–2012. Sites A, E, and F had the highest number of location-based epidemiologic links. While clients at sites A and E shared sleeping quarters, clients at site F only shared one meal together each day for approximately 20–30 minutes. Although site G did not have a high total number of location-based epidemiologic links, it had the second highest number (after site A) of links in 2011, suggesting recent TB transmission. Clients at site G spent several hours to the entire day together in daytime programs in a classroom setting.

Table 5. Daily client volume and number of location-based epidemiologic links at investigation sites — Duval County, Florida, 2007–2011

Site	Clients per Day ¹	2007	2008	2009	2010	2011	Total
Shelters							
Site A	175	-	-	-	27	5	32
Site B	200	-	-	-	1	2	3
Site C	300	-	-	4	-	-	4
Site D	150	-	-	5	7	1	13
Site E	3,000	3	4	-	22	3	32
Site F	450	-	-	25	44	20	89
Site G	160	-	-	1	-	9	10
Site H	25	-	-	3	-	-	3
Site I	60	-	5	-	1	-	6

¹Numbers are approximate and include only clients who slept at least one night at these sites for all sites except sites F and G, where the numbers reflect daytime clients only.

Figure 2 illustrates all location-based epidemiologic links by three categories of sites: homeless shelters (sites A–D), a jail (site E), and sites providing services to persons affected by homelessness (sites F–I). The highest density of location-based links was seen around homeless shelters.

Figure 2. Social network diagram of all location-based epidemiologic links — Duval County, Florida, 2007–2011

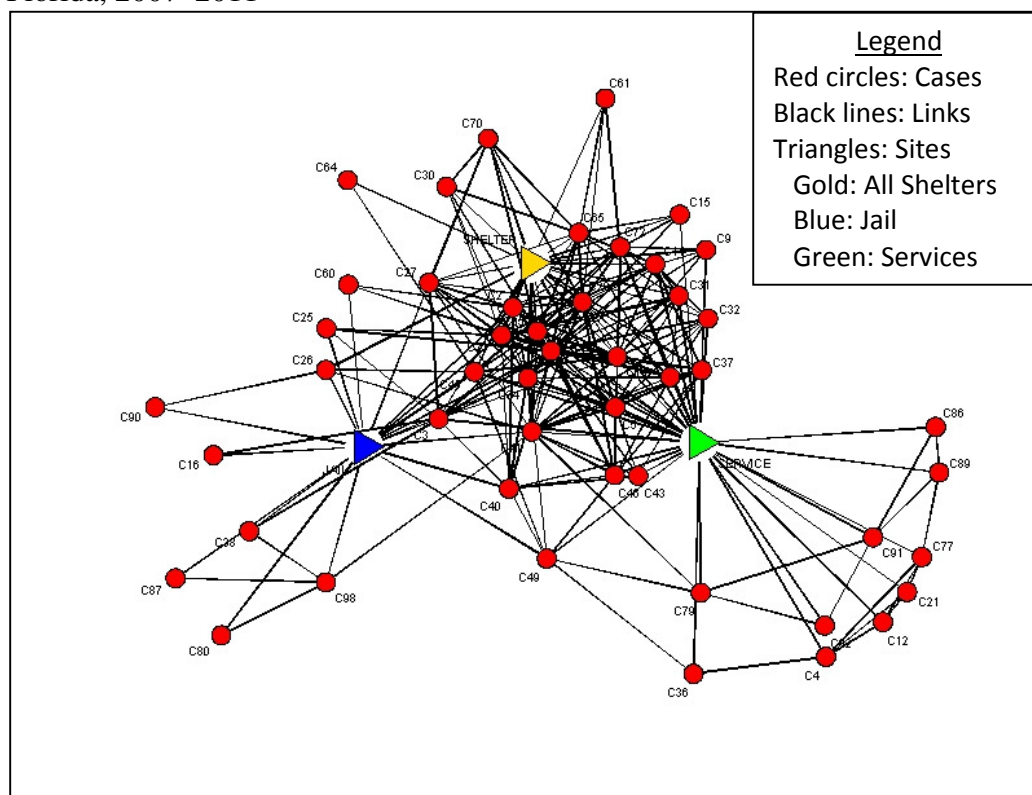


Figure 3 shows location-based links only for sites A–E, where clients share sleeping quarters and consequently have the most amount of exposure to each other. Name-based links are also included to show the relationships between name- and location-based links. Without consideration of links associated with services for the homeless, the highest density of location-based links remained around homeless shelters versus the jail. Five pairs of cases and one cluster of three cases with name-based links did not have any known location-based epidemiologic links.

Figure 3. Social network diagram of all name-based epidemiologic links and location-based epidemiologic links involving homeless shelters (Sites A–D) and Site E — Duval County, Florida, 2007–2011

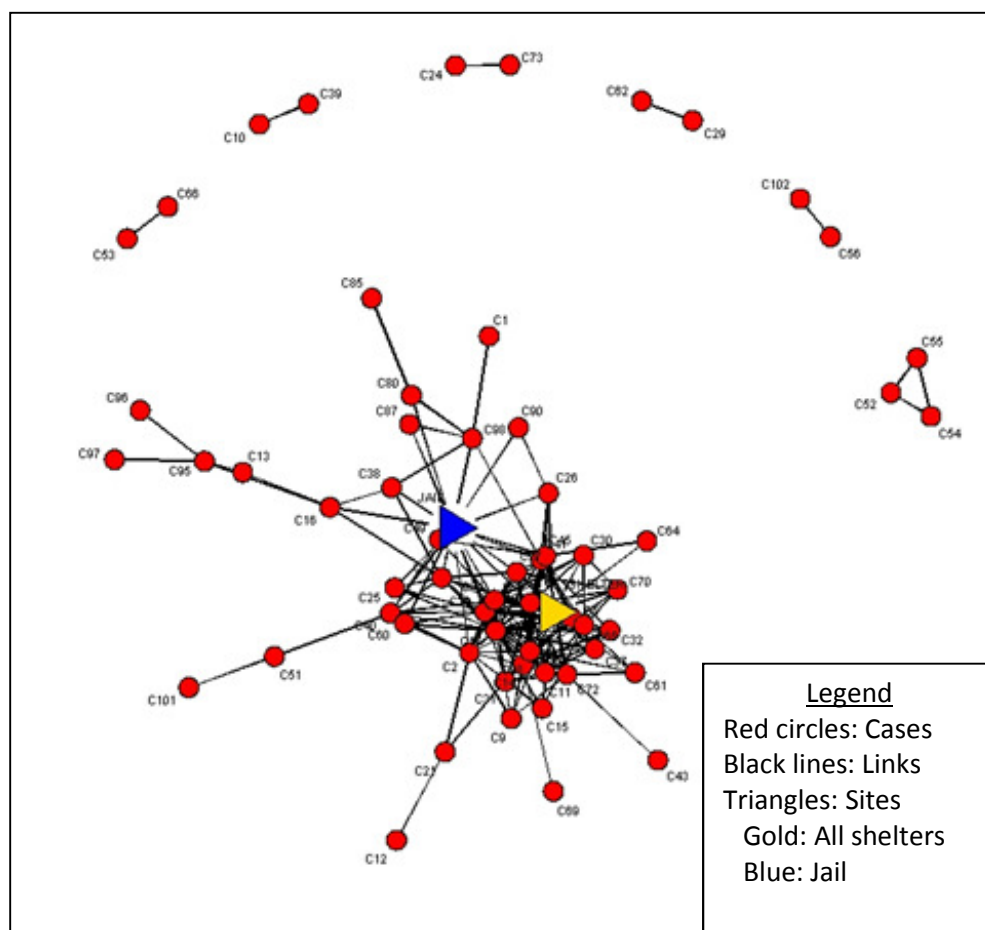


Figure 4. Social network diagram of location-based epidemiologic links at (A) Site A and (B) all other homeless shelters (Sites B–D) — Duval County, Florida, 2007–2011

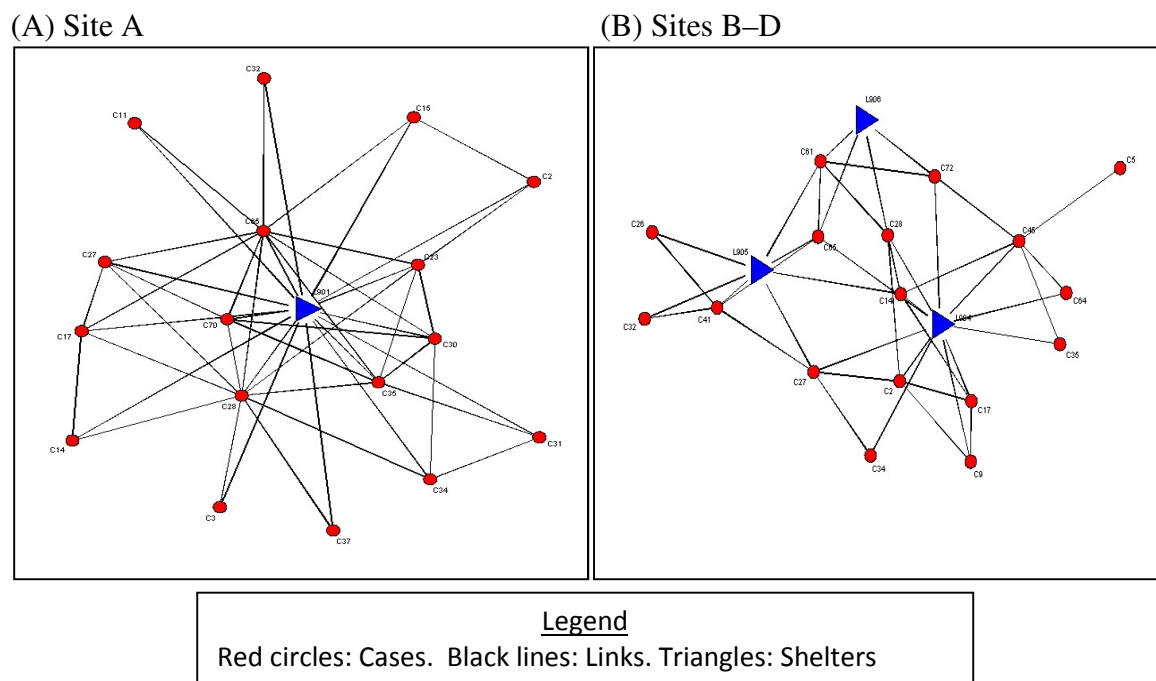
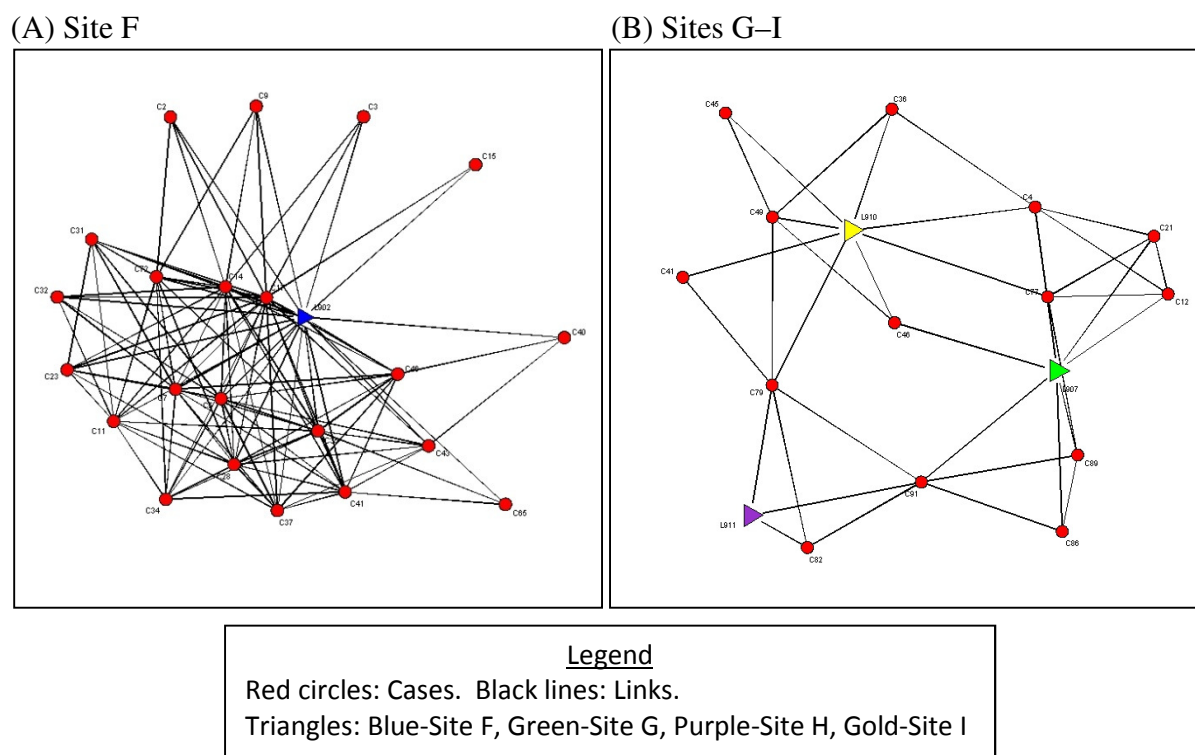


Figure 5. Social network diagram of location-based epidemiologic links at (A) Site F and (B) mental health facilities (Sites G–I) — Duval County, Florida, 2007–2011



Since many cases had epidemiologic links to multiple locations and cases, the Epi-Aid team also quantified the number of cases with TB exposure at a single site or single type of site (e.g., shelter) based on having a location-based epidemiologic link with another case during that case's infectious period (**Table 6**). Since no other location-based links could be identified for these cases, these sites were considered likely sites of TB exposure.

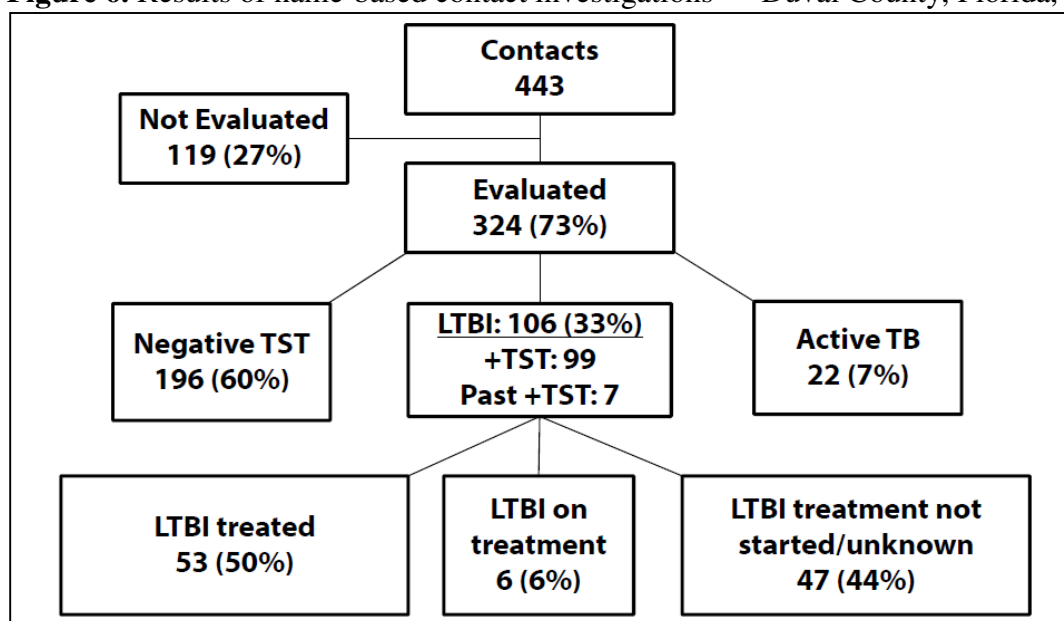
Homeless shelters (sites A–D) represented the only site of TB exposure for seven cases, of which 5 were among persons who had a TB exposure in 2010, including four who were exposed exclusively at site A. Despite the high number of location-based epidemiologic links at site F, the site was only exclusively linked to two cases in 2010 and none in 2011. Site G was linked to five cases — four in 2011 alone — that had no other known location-based links to explain TB exposures. Thus, based both on the number of epidemiologic links and the number of cases exposed exclusively at particular sites, sites A–D (particularly A) and G, with evidence of recent transmission, were determined to be priority sites for TB screening.

Table 6. Likely TB exposure sites of cases with location-based epidemiologic links at investigation sites — Duval County, Florida, 2007–2011 (N=38)

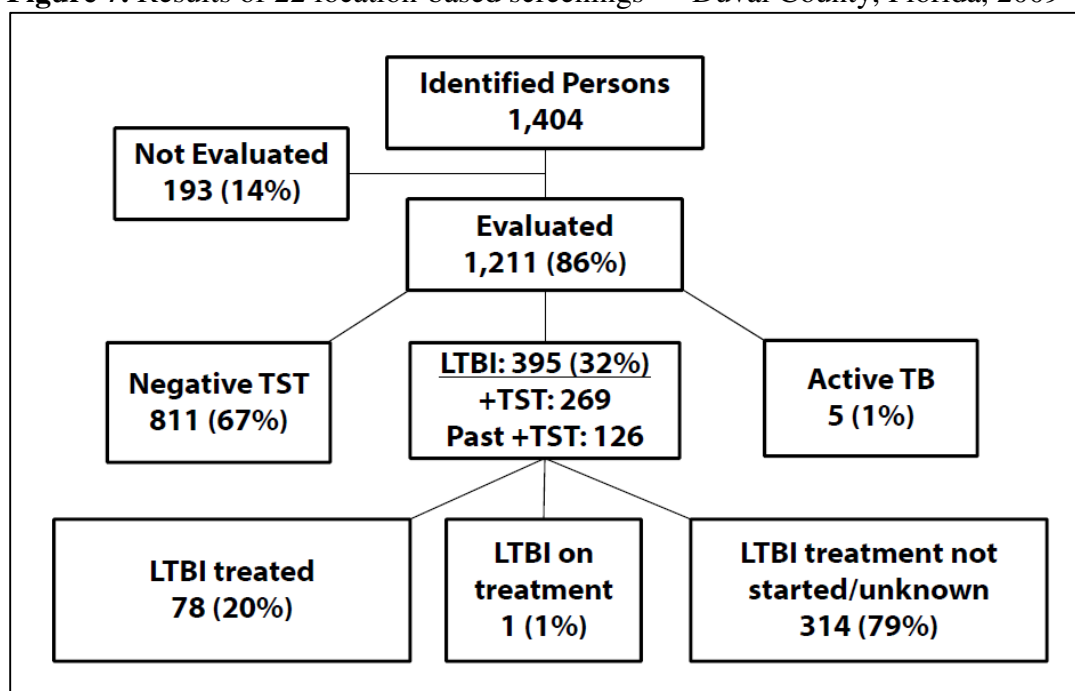
Site	2007–2009	2010	2011	Total ¹
Sites A–D only ²	2	5	0	7
Site E only	3	0	0	3
Site F only	2	2	0	4
Site G only	1	0	4	5
Site I only	4	0	0	4

¹The 15 cases not shown were exposed at multiple types of sites (homeless shelters [sites A–D], jail (site E), and homeless services [sites F–I]). One was exposed at shelters and jail, two were exposed at jail and services, seven were exposed at shelters and services, and five were exposed at all three types of sites. ²Sites A–D are grouped together as homeless shelters, as persons often went to more than one shelter.

Contact Investigation Review. The Epi-Aid team also reviewed the results of name-based contact investigations and location-based screenings performed by DCHD in response to outbreak cases. Over 400 contacts were identified through name-based contact investigations during 2004–2012, although approximately one quarter of them could not be evaluated, either because they could not be located or because they were lost to follow up before completing evaluation (**Figure 6**). Of 324 contacts who were evaluated, one third had a positive TST result, and of those, over half have received LTBI treatment. Documentation was not available regarding treatment for 44% of contacts with LTBI. Full names and dates of birth of contacts with incomplete TB screening or LTBI treatment were provided to DCHD if available.

Figure 6. Results of name-based contact investigations — Duval County, Florida, 2004–2012

DCHD completed 22 location-based screenings starting in 2009 in response to the rising number of PCR00160 cases. Over 1,400 persons were identified through location-based screenings, although 193 persons were lost to follow up before completing evaluation. Over 1,200 persons had been evaluated at the time of the Epi-Aid, with approximately one third having TST-positive results (**Figure 7**); of these persons, one fifth received LTBI treatment and LTBI treatment status was not known for the remaining 79%. Full names and dates of birth of persons with incomplete TB screening or LTBI treatment were provided to DCHD if available.

Figure 7. Results of 22 location-based screenings — Duval County, Florida, 2009–2011

Of all sites with more than 10 persons evaluated, sites A and G had the highest proportion of persons with positive TST results (**Table 7**). Excluding persons with a known positive TST results in the past, the odds of LTBI among persons screened at site A were 3.6 times (95% confidence interval 2.7–4.8) the odds of those at other sites. Site C conducted its own regular screening of staff and clients: during 2010–2012, of total 898 clients evaluated, 40 (5%) were known to have past positive TST results. Of the remaining 858 clients without a known baseline TST result, only 21 (2%) had a positive TST result. TB screening of 281 staff members during 2005–2012 revealed no positive TST results. Complete screening results were not available for the other sites, including site E.

Table 7. Results of 22 location-based screenings by site — Duval County, Florida, 2009–2011

Site	Number of Screenings	Number Evaluated	Past Positive TST	Positive TST ¹
Site A	6	381	52	140 (43%)
Site B	2	70	10	6 (10%)
Site C ²	N/A	N/A	N/A	N/A
Site D	1	3	0	0 (0%)
Site E	1	15	0	0 (0%)
Site F	1	8	0	0 (0%)
Site G	2	390	35	82 (23%)
Site H	0	-	-	-
Site I	1	3	0	1 (33%)
Site J	0	-	-	-
Site K	1	31	0	6 (19%)
Other Sites	7	310	29	34 (12%)
Total	22	1,211	126	269 (25%)

¹Percentages calculated excluding persons with a known past positive TST from the number evaluated; baseline TST status rarely available (i.e., whether previous negative test).

²Site C conducts its own regular screening of staff and clients. N/A=not applicable.

In total, as of the start of the 2012 Epi-Aid, 1,847 persons had been identified through name-based contact investigations and location-based screenings done by DCHD. Of those, 119 (6%) name-based contacts and 193 (10%) persons identified through location-based screenings were not fully evaluated. Of the 361 persons who did complete evaluation and had a positive TST result, LTBI treatment status was not known for 47 (13%) name-based contacts and 314 (87%) location-based persons. The Epi-Aid team provided the full names of 214 of these persons to the DCHD for follow-up to determine whether treatment needed to be offered to these individuals. Names for the remaining 147 persons were either incomplete or not documented, as only aggregate results or partial logs were available for several of the location-based screenings.

Prioritization of Additional Contacts Requiring Evaluation at Sites with Evidence of Recent Transmission. Names and duration of stay of 3,222 recent contacts to infectious cases at homeless shelters (sites A–D) were identified by cross-matching the infectious periods of outbreak cases with the ServicePoint database and individual shelter logs during 2010–2012. Of these contacts, 253 (8%) had already been evaluated by the DCHD during name-based contact

investigations or location-based screenings (although not all evaluations had documentation of completion), leaving 2,969 exposed persons who had yet to be evaluated. The Epi-Aid team prioritized these 2,969 contacts into 2,488 (84%) high-priority and 481 (16%) medium-priority contacts based on sputum smear status of the infectious case and exposure in a congregate setting (2).

Given the large number of high-priority contacts, further prioritization for TB screening was done for high-priority contacts based on the site and duration of exposure (**Table 8**). No infectious cases were present at site C during 2010–2011. Site A was given highest priority because of its high number of epidemiologic links, evidence of cases with recent TB exposure only at site A, and the high proportion (43%) of persons evaluated at site A with a positive TST result detected during DCHD location-based screenings. Cut-points for the duration of exposure were based on the frequency distribution of stay durations of all persons who were contacts and dividing these durations into roughly equal categories. In addition, these cut-offs were consistent with categories of clients stays at most shelters. A line list of available names, date of birth, TB evaluation status, and priority ranking for TB screening of all contacts was provided to the DCHD for follow-up. No contacts of INH-resistant cases were identified at sites A–D. A list of contacts at site G, which also had evidence of recent transmission, could not be generated because data on all client stays were not available.

Table 8. Additional location-based contacts needing evaluation from sites A–D — Duval County, Florida, 2010–2012

Priority	Criteria	Number
High	Exposure to smear-positive case in congregate setting	2,488
Priority 1	Site A contacts staying ≥ 10 days	566 (23%)
Priority 2	Site A contacts staying 2–9 days, or Site B or D contacts staying ≥ 10 days	954 (38%)
Priority 3	Site A contacts staying 1 day, or Site B or D contacts staying < 10 days	968 (39%)
Medium	Exposure to smear-negative case in congregate setting	481

Collaboration with Additional Partners. The Epi-Aid team met with the Homeless Coalition of Jacksonville, which identified ServicePoint as a possible mechanism for flagging clients who required evaluation for TB. This could be done through a generic “health department alert” in ServicePoint when a client checked in at a site, informing staff at the site to contact the health department; the specific the reason for the referral would not be available to protect individual privacy. Additional information about TB history, including screening results, could also be included, but further discussions among the health department, sites, and homeless coalition were to be had to develop appropriate protocols. The Epi-Aid team also spoke with the national leadership of Healthcare for the Homeless, which offered to provide onsite technical assistance of other shelters outside Florida that have implemented TB programs for persons experiencing homelessness. In the past, DCHD participated in a TB coalition with homeless providers. DCHD had held a TB forum for homeless providers in 2011 and planned to continue these efforts in 2012.

DISCUSSION

This investigation examined the largest TB outbreak in the United States that CDC has been invited to assist with the investigation in approximately 20 years. During 2004–2012, a total of 99 outbreak cases were identified in Duval County, Florida. The majority of cases were in U.S.-born black men, and 78 had a history of homeless, incarceration, or substance abuse. If the number of cases per month seen thus far in 2012 remains the same for the rest of the year, the total number of 2012 cases will rival the high number of 2011 cases, suggesting that this outbreak has yet to show signs of abating.

The improvements Florida has made in genotyping coverage and the availability of new systems in Duval County documenting stays at homeless shelters, use of homeless services, and incarceration greatly helped this investigation and are important tools for the interventions that will be necessary to get this outbreak under control. Nine of the 18 cases from the 2009 Epi-Aid were found to have used homeless shelters and services, and ten of them had been incarcerated in a Duval County jail. The added value of these new systems underscores the difficulty of eliciting social risk factors through traditional interview and chart review techniques, which was also evident in the underreporting of these risk factors to the national TB surveillance system through RVCT data. These information sources provide new opportunities for DCHD to identify locations where TB patients stayed during their infectious periods, thus enabling more complete contact investigations that can focus on congregate setting contacts with the highest risk exposures. Additionally, connecting 2009 cases to homeless shelters and services, and the jail enabled a better understanding of the possible role these risk factors played in the TB outbreak centered around the assisted living facility for adults with mental illness (3).

The current investigation identified one homeless shelter (site A), a jail (site E), and an outpatient mental health facility that serves the homeless community (site G) as the most concerning sites for TB transmission. Sites A and G appear particularly worrisome for transmission during the last 2 years, given the number of recent epidemiologic links connecting cases to these sites. However, all sites with cases from this outbreak can benefit from stronger efforts around TB control, including regular education of staff and clients regarding TB, mandatory TB screening (i.e., symptom screening and TB skin testing), cough monitoring, and systematic referral of persons with possible TB to DCHD. Explosive outbreaks of TB have been well-documented in homeless communities outside of Florida, and controlling these outbreaks have required intensive efforts, including the development and implementation of standard guidelines for TB infection control and mandatory TB screening and testing at shelters (4–10).

Thirteen deaths in this outbreak, with ten deaths occurring either before treatment or within the first 2 months of treatment, suggests that many of these deaths may have occurred in the context of advanced disease, although available information on the deaths was limited. Regardless of the cause, the high number of deaths in this outbreak emphasizes the need for vigilant active case finding, improved education about TB, and ongoing screening at all sites with outbreak cases.

Two major factors likely contributed to the size and complexity of the outbreak. The first is the lack of formal TB guidelines and programs at sites. Although DCHD has done a tremendous amount of work over the last few years, identifying over one quarter of outbreak cases through

contact investigations and location-based screenings, robust education, screening, and referral guidelines are still needed at all sites to respond to the outbreak. The second major factor is the large number of contacts who have not yet been evaluated, despite the continued dedication of DCHD to performing name-based contact investigations and location-based screenings. Only 253 of 3,222 recent contacts to infectious cases identified at homeless shelters during 2010–2012 have been evaluated through these screenings, raising the possibility that the 1,200 persons evaluated at location-based screenings might not have been contacts with the highest risk TB exposure if they were present at the site on the day of screening but did not come into contact with an infectious case for a prolonged period of time. With the nearly 3,000 contacts at homeless shelters over the last 2 years that this investigation identified as still needing evaluation, location-based screenings may not be practical to evaluate all contacts. Combining location-based efforts in this high-risk population with a more targeted approach to identifying, prioritizing, and evaluating contacts may provide the best use of resources to prevent future cases of TB.

Limitations of this investigation included incomplete data on stays and bed locations of clients at all sites during 2004–2012. Without more complete data on clients, the number of cases at sites during their infectious or exposure periods may have been underestimated. Contact prioritization could not be done for sites E and G, as information on all contacts was not available. Furthermore, prioritization could not be done based on medical risk factors of the contacts, as this information was also not available. The team was not able to interview all cases, and consequently, social risk factors and epidemiologic links may have been underestimated. The lack of known epidemiologic links for nearly one third of outbreak cases suggests that additional cases or sites may have also contributed to TB transmission.

This outbreak demonstrates the magnitude of TB transmission that can occur among difficult to reach populations and highlights the usefulness of combining genotyping and social network analysis to identify sites of likely TB transmission. Implementation of more aggressive and comprehensive TB guidelines will be required from DCHD and CDC to address the outbreak. Successful implementation of these guidelines will rely on strengthening collaborations among public health, homeless providers, and the local jail (11). Despite a strong public health response involving multiple sites, intense *M. tuberculosis* transmission has continued in Duval County. Emphasizing the top two priorities of TB control — finding and treating active cases and diagnosing and treating LTBI (12) — in continued collaboration with all sites will be critical to managing this outbreak.

RECOMMENDATIONS

- 1) **Active case finding** at sites A and G every 8–10 weeks until no new cases are found.
 - a. Screen all staff and clients with symptom screening, TST or IGRA testing, and a chest radiograph and/or sputum testing.
 - b. Consider sputum testing in all HIV-infected persons and all symptomatic persons regardless of HIV status.

- c. Continue on-site directly observed therapy (DOT) with incentives and enablers.
 - d. Ensure documentation of treatment completion.
- 2) **Periodic TB screening** at all sites, including sites A and G, after active case finding is complete.
- a. Mandatory TB symptom screening and TST or IGRA testing every 3 months. Once there are no more new infections being identified at that site, this frequency can be scaled back to every 6–12 months.
 - b. Refer all persons who are symptomatic or who have a positive TST or IGRA result for chest radiograph and immediate evaluation. For HIV-infected persons with known contact to a TB case, chest radiograph should be performed regardless of symptoms or TST or IGRA results.
 - i. Educate staff and volunteers at each site on how to identify and refer persons with suspected TB.
 - ii. Strengthen collaborations with existing healthcare providers to assist the health department with screening and evaluating clients. Improving coordination will ensure that efforts are not unnecessarily duplicated.
 - c. Systematically document TB screening results and review data on an ongoing basis to assess evidence for TB transmission.
 - d. Provide documentation to all staff members and clients with their screening results (e.g. through a TB card or clearance letter).
- 3) **Evaluate and prioritize contacts for LTBI treatment** according to risk of progression to TB disease after TB infection exposure to an infectious case.
- a. Focus initial efforts on highest priority group (566 contacts with ≥ 10 days of exposure to infectious cases at site A) from the 2,488 high priority contacts identified in this investigation as needing evaluation. Most of these persons will need evaluation to exclude TB disease before initiating treatment. High-priority persons for LTBI treatment include:
 - i. Persons with recent infection, as suggested by a change from a negative to positive TST or IGRA result
 - ii. Persons with HIV infection (as identified through self-report or an HIV registry match)
 - iii. Persons with diabetes

- iv. Children aged <5 years
 - v. Persons with known contact to an infectious case
 - b. Currently, the preferred regimen to treat LTBI in the United States is 9 months of isoniazid (13). However, adherence has been reported as low as 60% even in populations with stable housing. To improve adherence and completion:
 - i. Consider on-site DOT for LTBI, similar to DOT for active TB cases, particularly at sites with high numbers of persons with LTBI.
 - ii. Consider acceptable, alternative short-course regimens such as 4 months of daily rifampin or 12 weeks of weekly INH and rifapentine (4,14).
 - c. Provide incentives and enablers to promote adherence with the LTBI medical evaluation and treatment. For example, provide incentives and enablers for getting the chest radiograph in a timely manner, keeping appointments, and for each dose of a 12-dose INH-rifapentine regimen, or each month of a 4-month rifampin or 9-month INH regimen.
 - d. Provide education about the risks and benefits of treatment.
- 4) Implement a **formal TB infection control program with standard operating procedures at all sites**, building upon existing efforts by DCHD.
- a. Develop standard operating procedures at all sites for periodic TB screening and ongoing symptom monitoring as well as respiratory hygiene measures. With health department guidance, sites would tailor these operating procedures based on their capacity, needs, and the number of TB cases recently associated with that site. Guidelines from other cities are available online and can be used as examples (7–10).
 - b. Through a coalition of TB providers and sites, develop a seamless TB/LTBI referral and tracking process. All sites should understand how to refer cases and contacts to the health department, and the health department would be expecting such persons in order to track their TB/LTBI evaluation and management.
 - c. Encourage all sites to follow **best practices** for infection control.
 - i. Administrative controls
 - 1. Ensure all staff and clients receive education about TB symptoms within 30 days of starting.

2. Maintain as much space as possible between beds and position beds “head to toe.”
3. Maintain bed maps and track bed assignments.
4. Refer staff and clients needing evaluation to the health department.
5. Require proof of TB screening for all staff and clients after a certain duration of stay (e.g. after staying one day, three days, or even one week) and thereafter on a regular basis, decided upon by each site in consultation with DCHD. A shared tracking system agreed upon by all sites will prevent duplication of work and enable clients to access all sites once they have been cleared.

ii. Respiratory protection

1. Encourage all staff and clients to cover cough with tissue or masks. Ensure that both are available.
2. Post signs on cough awareness and hygiene.
3. Educate all staff on cough monitoring. Consider using a cough log to document which staff and clients are coughing, particularly at night, so that they can be referred for medical evaluation.
4. Separate those coughing until medically evaluated by within 1 day.

iii. Engineering controls

1. Keep windows and doors open as often as possible.
2. Replace ventilation filters monthly and keep records.
3. Prioritize areas where transmission is more likely.
4. Assess ability to promote realistic, cost-effective engineering controls. For crowded areas, consider UV lamps or pleated or HEPA filters as resources permit.

- d. Dedicate a staff member as a liaison to all sites over the next 12–24 months to lead the implementation of this TB program and oversee all activities outlined above (points a–c). Initial efforts would be focused on sites A, E, and G. Consider training and education for the liaison, if necessary, to complete the following responsibilities:

- i. Conducting regular staff and client education at sites, including jails.

- ii. Collecting, managing, and monitoring data on screening and testing results over time.
 - iii. Networking with homeless shelter and services, and jail to enhance TB control.
- 5) Continue to **improve management of all cases and contacts at DCHD.**
- a. Systematically document in a single location (e.g. patient chart) each new patient's infectious periods and locations visiting during the infectious period.
 - i. In addition to information from patient interviews and chart review, search ServicePoint and the jail website for shelter use and incarceration history.
 - ii. Collaborate with sites (especially the jail) via a health department liaison to conduct contact investigations where patients were infectious.
 - b. Develop one system (e.g., Excel spreadsheet) that tracks named-based and location-based contact investigation results done at all sites, including shelters, mental health facilities, and the jail.
 - c. Consider using a system to flag suspect cases and contacts needing evaluation at DCHD that would be used at all sites.
 - d. Document start and completion of all TB and LTBI evaluation and treatment.

REFERENCES

- 1) Northeast Florida Center for Community Initiatives. 2010 report on the homeless populations in Duval, Clay, Nassau, and Baker Counties [online]. 2011. [cited 2012 Mar 27]. Available from URL:
<http://www.unf.edu/uploadedFiles/aa/coas/cci/projects/2010%20Homeless%20Report.pdf>.
- 2) CDC. Guidelines for the investigation of contacts of persons with infectious tuberculosis: recommendations from the National Tuberculosis Association and CDC. MMWR 2005;54(RR-15):1–47.
- 3) Cavanaugh JS, Powell KM, Renwick OJ, David KL, Hilliard A, Benjamin C, et al. An outbreak of tuberculosis among adults with mental illness. Am J Psychiatry. In press 2012.
- 4) CDC. Public health dispatch: tuberculosis outbreak in a homeless population—Portland, Maine, 2002–2003. MMWR 2003;52:1184–5.
- 5) CDC. Tuberculosis outbreak associated with a homeless shelter — Kane County, Illinois, 2007–2011. MMWR 2012;61:186–9.

- 6) Lofy KH, McElroy PD, Lake L, Cowan LS, Diem LA, Goldberg SV, et al. Outbreak of tuberculosis in a homeless population involving multiple sites of transmission. *Int J Tuberc Lung Dis* 2006;10(6):683–9.
- 7) Maine Department of Health and Human Services. Tuberculosis prevention and control recommendations for homeless shelters in Maine [online]. 2005. [cited 2012 Mar 27]. Available from URL: <http://www.umdnj.edu/ntbc/audioarchives/documents/METBToolkitforShelters.doc>.
- 8) Public Health—Seattle and King County. Tuberculosis prevention and control guidelines for homeless service agencies in Seattle-King County, Washington [online]. 2010. [cited 2012 Mar 27]. Available from URL: http://www.kingcounty.gov/healthservices/health/personal/HCHN/~media/health/publichealth/documents/hchn/recommended_shelter.ashx
- 9) San Francisco Department of Public Health. Tuberculosis infection control guidelines for homeless shelters [online]. 2005. [cited 2012 Mar 27]. Available from URL: <http://www.sfdph.org/dph/files/TBdocs/TBControl4HomelessShelters01272005.pdf>.
- 10) Curry International TB Center. Shelters and TB: what staff need to know, second edition [online]. 2011. [cited 2012 Mar 27]. Available from URL: <http://www.currytbcenter.ucsf.edu/sheltertb/index.cfm>.
- 11) CDC. Forging partnerships to eliminate tuberculosis [online]. 2007. [cited 2012 Mar 27]. Available from URL: <http://www.cdc.gov/tb/publications/guidestoolkits/forged/default.htm>.
- 12) CDC. Controlling tuberculosis in the United States: recommendations from the American Thoracic Society, CDC, and the Infectious Disease Society of America. *MMWR* 2005;54(No. RR-12):1–81.
- 13) American Thoracic Society, Centers for Disease Control and Prevention. Targeted tuberculin testing and treatment of latent tuberculosis infection. *Am J Respir Crit Care Med* 2000; 161(4):S221–S247.
- 14) CDC. Recommendations for use of an isoniazid-rifapentine regimen with direct observation to treat latent *Mycobacterium tuberculosis* infection. *MMWR* 2011;60:1650–3.