

# Technical Notes

## National Tuberculosis Surveillance System

Reporting areas (i.e., the 50 states, the District of Columbia (DC), New York City, Puerto Rico, and other U.S. jurisdictions in the Pacific Ocean and Caribbean Sea) provide information regarding tuberculosis (TB) cases to CDC's National TB Surveillance System (NTSS) by using a standard case report form, Report of Verified Case of Tuberculosis (RVCT). TB cases are verified according to the Tuberculosis Case Definition for Public Health Surveillance (Appendix A). TB cases are reported and counted according to the Recommendations for Reporting and Counting Tuberculosis Cases (Appendix B).

## TB Case Definition

In 2009, the TB case definition was modified. TB cases are verified according to the following specified laboratory and clinical criteria (see Appendix A).

## Laboratory Criteria for Diagnosis

A TB case may be verified by the laboratory case definition with at least one of the following criteria: (1) isolation of *Mycobacterium tuberculosis* complex from a clinical specimen; **or** (2) demonstration of *M. tuberculosis* complex from a clinical specimen by nucleic acid amplification test (NAAT), **or** (3) demonstration of acid-fast bacilli (AFB) in a clinical specimen when a culture has not been or cannot be obtained or is falsely negative or contaminated.

## Clinical Case Criteria

A TB case may be verified by the clinical case definition in the presence of **all** of the following clinical criteria: (1) a positive tuberculin skin test (TST) result or positive interferon gamma release assay (IGRA) result for *M. tuberculosis*; **and** (2) other signs and symptoms compatible with TB (e.g., abnormal chest radiograph, abnormal chest computerized tomography [CT] scan, or other chest imaging study or clinical evidence of current disease); **and** (3) treatment with two or more anti-TB drugs; **and** (4) a completed diagnostic evaluation.

## Provider Diagnosis

Provider diagnosis is not a component of the case definition for TB as described in Appendix A. However, when cases of TB are diagnosed but do not meet either the clinical or laboratory case definition, reporting areas have the option of verifying TB cases on the basis of provider diagnosis as described in Appendix B. Through 2008, the RVCT did not collect information regarding IGRA results. If an IGRA was performed in lieu of TST, the RVCT would have indicated that TST was not performed. Thus, culture- and smear-negative cases without a TST that were diagnosed by a positive IGRA result before 2008 were considered to have been confirmed by provider diagnosis. Starting in 2009, positive results for an IGRA have been included as part of the clinical case definition for TB confirmation. Anergic patients with a clinical presentation consistent with TB but without laboratory evidence of *M. tuberculosis* complex would also be an example of provider diagnosis and one that has not changed over time.

## TB Case Verification Criteria Calculation

The software for TB surveillance developed by CDC includes a calculated variable for TB case verification called "Vercrit," which was modified in 2009. The new variables, Nucleic Acid Amplification Test (NAAT) Result, Interferon Gamma Release Assay (IGRA) for *Mycobacterium tuberculosis* at Diagnosis, and Initial Chest CT Scan or Other Chest Imaging Study were added in the Vercrit calculation.

Vercrit is calculated by using the following criteria in hierarchical order:

1. Positive culture.
2. Positive NAAT.
3. Positive AFB.
4. Clinical case confirmation.
5. Provider diagnosis.

## Reporting and Counting of TB Cases

In 2009, the recommendations for reporting and counting of TB cases (Appendix B) were modi-

fied. TB cases that are verified but not countable for morbidity statistics are now reported to CDC as a measure of programmatic and case management burden. However, data for noncountable TB cases are incomplete and therefore are not included in this report.

The recommendations for counting TB cases among immigrants, refugees, and foreign visitors were revised on the basis of the 2007 recommendations in the *Technical Instructions for Tuberculosis Screening and Treatment for Panel Physicians*.<sup>1</sup> Regardless of panel physician classification or citizenship status, immigrants and refugees examined after arriving in the United States and receiving a diagnosis of clinically active TB requiring anti-TB medications should be reported and counted by the locality of their residence at the time of diagnosis. Foreign visitors with diagnosed TB receiving anti-TB therapy and planning to remain in the United States for  $\geq 90$  days should be reported and counted by the locality of current residence.

### RVCT Variables

Data regarding demographic characteristics, clinical or laboratory diagnosis, initial treatment, and treatment outcomes are collected through the following three RVCT data collection reports:

1. **Report of Verified Case of Tuberculosis** — used for all patients with a verified TB case.
2. **Initial Drug Susceptibility Report (Follow-Up Report 1)** — used for all patients who had a culture that was positive for *M. tuberculosis* complex.
3. **Case Completion Report (Follow-Up Report 2)** — used for all patients who were alive when TB was diagnosed.

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<sup>1</sup>CDC. Immigration Requirements: Technical Instructions for Tuberculosis Screening and Treatment 2009. Atlanta: CDC, Division of Global Migration and Quarantine, revised October, 2009; <http://www.cdc.gov/immigrantrefugeehealth/pdf/tuberculosis-ti-2009.pdf>.

The instructions for completing the RVCT forms and the definitions for all data items are available in Centers for Disease Control and Prevention (CDC). Report of Verified Case of Tuberculosis (RVCT) Instruction Manual. Atlanta, GA: U.S. Department of Health and Human Services, CDC; 2009. Available at: <http://www.cdc.gov/tb/programs/rvct/InstructionManual.pdf>.

### Tabulation and Presentation of TB Data

This report presents summary data for TB cases counted by reporting areas through the end of 2016. TB cases are tabulated by year in which the reporting area verified that the patient had TB and included the patient in its official annual TB case count. Since 2004, the published report has reflected updated information regarding the numbers of cases of confirmed TB for each year from 1993 onward. Totals for the United States include data from the 50 states and DC.

Trend data are presented in Tables 1–15. Age group tabulations are based on the patient's age during the month and year the patient was reported to the health department as having a suspected TB case. State or metropolitan area data tabulations are based on the patient's residence at the time of TB diagnosis.

### Rates

Rates are expressed as the number of cases reported each calendar year per 100,000 persons. Population denominators used in calculating TB rates were based on official census and mid-year postcensal estimates from the U.S. Census Bureau. In Tables 1, 29, and 30, the U.S. total populations for 1990–1999 were taken from the Bridged-Race Intercensal Population Estimates for July 1, 1990–July 1, 1999 ([ftp://ftp.cdc.gov/pub/health\\_statistics/nchs/datasets/nvss/bridge-pop/documentationbridgedintercensal.doc](ftp://ftp.cdc.gov/pub/health_statistics/nchs/datasets/nvss/bridge-pop/documentationbridgedintercensal.doc)); populations for 2000–2009 were taken from the U.S. Census Intercensal Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico for April 1, 2000–July 1, 2010 (<https://www.census.gov/data/tables/time-series/demo/pepest/intercensal-2000-2010-state>).

[html](#)); and populations for 2010–2016 were taken from the U.S. Census Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2016 (<https://www2.census.gov/programs-surveys/popest/tables/2010-2016/state/totals/nst-est2016-01.xlsx>). Beginning in 2004, unrounded numbers were applied to calculate the annual percentage change in the TB case rate.

During 2003, two modifications were made to the RVCT form: (1) entries for multiple race (two or more races reported for a person) were allowed, and (2) the previous category of “Asian/Pacific Islander” was divided into “Asian” and “Native Hawaiian/Other Pacific Islander.” To calculate rates for Tables 2 and 4, denominators for 1993–1999 were obtained from the U.S. Census Monthly Postcensal Resident Population, by single year of age, sex, race, and Hispanic origin (<https://www.census.gov/data/datasets/time-series/demo/popest/1990s-national.html>); denominators for 2000–2009 were obtained from U.S. Census Intercensal Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States: April 1, 2000 to July 1, 2010 (<https://www.census.gov/data/datasets/time-series/demo/popest/intercensal-2000-2010-state.html>); and denominators for 2010–2016 were obtained from the U.S. Census Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin: April 1, 2010 to July 1, 2016 (<https://www.census.gov/data/tables/2016/demo/popest/nation-detail.html>).

The population source for nativity is the Current Population Survey, which is used to calculate case rates for U.S.- and non-U.S.-born persons with diagnosed TB. U.S.-born populations includes persons born in the 50 states and DC, those born abroad to U.S. parents, and those born in U.S. territories. In Table 5, the populations for U.S.- and non-U.S.-born persons for 1993 were obtained from Quarterly Estimates of the United States Foreign-born and Native Resident Populations: April 1, 1990–July 1, 1999 (<http://www.census.gov/population/estimates/nation/nativity/>

[fbtab001.txt](#)). Denominators for computing the 1994–2016 rates were based on extrapolations from the U.S. Census Current Population Survey (accessed July 2016) through DataFerrett at: <http://dataferrett.census.gov/>). Denominators for computing 2016 rates in Table 17 were obtained from U.S. Census Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin: April 1, 2010 to July 1, 2016 (<https://www.census.gov/data/tables/2016/demo/popest/nation-detail.html>).

### **Mortality Data**

The annual mortality rate is calculated as the number of deaths caused by TB in that year, divided by the estimated population for the year, multiplied by 100,000 (Table 1). The number of deaths was obtained from the CDC’s National Center for Health Statistics, Multiple Cause of Death Files, 1999–2015, available from CDC’s WONDER online database and released in 2017. Data were compiled from the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Finalized numbers of TB-related deaths for 2016 were unavailable at the time of this publication.

### **Drug Resistance**

Drug-resistance patterns are displayed in separate tables with drug-resistance trend data by previous TB status and origin of birth. Isoniazid resistance and multidrug resistance are displayed in Tables 8 and 9, respectively.

### **Completion of Tuberculosis Therapy**

Tables 10, 57, 58, and 59 present percentages of completion of TB therapy (COT). Data collected by RVCT Follow Up Report-2 forms regarding date and reason therapy was stopped (e.g., the patient completed the therapy or the patient died) were used to calculate COT percentages. Cases were stratified by the indicated length of therapy, based on American Thoracic Society, CDC, and Infectious Diseases Society of America treatment guidelines in effect during the period covered

and the patient's initial drug-susceptibility test results, age, and disease site.<sup>2</sup>

In Table 58, the first column lists the total number of cases reported during 2014. The remaining columns are grouped under two headings: therapy of  $\leq 1$  year indicated and therapy of  $> 1$  year indicated. Patients eligible to complete therapy in  $\leq 1$  year had to have been alive at time of diagnosis and initiated therapy with  $\geq 1$  drug. Eligible patients did not have rifampin resistance; did not die in  $\leq 1$  year after initiating therapy; did not move out of the country in  $\leq 1$  year after initiating therapy; and did not have meningeal TB, bone or joint TB, or TB of the central nervous system, regardless of age. Additionally, TB patients aged 0–14 years were ineligible to complete therapy in  $\leq 1$  year if they had disseminated disease (defined as miliary TB, a positive TB blood culture, or a positive NAAT on a blood specimen). Patients with culture-negative disease, those with an unknown culture status, and those with culture-positive disease but unknown initial drug-susceptibility test results were included under the category of therapy of  $\leq 1$  year indicated.

For the group with an indicated length of therapy of  $\leq 1$  year, percentages are displayed for both COT in  $\leq 1$  year and for COT regardless of duration (i.e., duration of therapy  $\leq 1$  year or  $> 1$  year). For COT  $\leq 1$  year, the numerator included only those patients completing therapy in  $\leq 366$  days (based on the dates therapy was started and stopped). Patients with missing dates were classified as “treatment not completed” for this calculation.

COT percentages, regardless of duration, were calculated by dividing the number of patients reported as having completed therapy by the number of total eligible patients. Patients with an outcome other than completed therapy (i.e.,

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<sup>2</sup>CDC. Treatment of Tuberculosis, American Thoracic Society, CDC, and the Infectious Diseases Society of America. [MMWR](#) 2003; 52 (No. RR-11): 1–77.

moved, lost to follow-up, refused treatment, or other) were classified as “treatment not completed.” Patients with an unknown outcome were also classified as “treatment not completed.” For the group of indicated therapy length  $> 1$  year, only COT percentages regardless of duration, are presented. Table 10 provides percentages for COT  $\leq 1$  year and for COT regardless of duration for the group with an indicated therapy of  $\leq 1$  year only. Table 57 presents COT percentages by ethnicity and non-Hispanic race and by state for those among whom therapy  $\leq 1$  year was indicated.

### **TB Disease Site**

Miliary disease should be reported as a pulmonary form of TB (Tables 7, 37, and 38). Beginning in 2009, miliary disease could not be classified as a TB disease site because it is a clinical or a radiologic finding and should be recorded under Initial Chest Radiograph, Initial Chest CT Scan, or Other Chest Imaging Study. During 1997–2008, miliary disease was classified as both an extrapulmonary and a pulmonary form of TB. In publications before 1997, miliary disease was classified as extrapulmonary TB unless pulmonary disease was reported as the major TB disease site.

### **Reporting of HIV Status**

Information regarding human immunodeficiency virus (HIV) status for persons with TB is displayed in Tables 11 and 50 for those persons not dead at diagnosis; Table 11 also lists trend data for persons aged 25–44 years. Reporting completeness for HIV status has significantly improved to 95% of TB patients tested among persons aged 25–44 years during 2016; however, this variable is still underreported across jurisdictions. Data regarding the HIV-infection status of persons reported with TB should be interpreted with caution because these data are not representative of all TB patients with HIV infection. HIV testing is performed after a patient receives counseling and gives informed consent. TB patients who are tested anonymously might choose not to share HIV testing results with their

health care provider. TB patients managed in the private sector can receive confidential HIV testing, but results might not be reported to the health department's TB program. Additionally, certain factors can influence HIV testing among TB patients, including the extent to which testing is targeted or routinely offered to specific groups (e.g., males aged 25–44 years, injection-drug users, or homeless persons) and the availability of and access to HIV testing services. These data might overrepresent or underrepresent the proportion of TB patients known to be HIV-infected in a reporting area.

### **Primary Occupation for the Past Year**

Table 47 reflects the modified 2009 RVCT variable, Primary Occupation Within the Past Year, which replaces the Occupation Within Past 24 Months of TB Diagnosis in previous reports. After the 2009 RVCT revision, Multiple Occupation was removed and the Retired and Not Seeking Employment categories were added.

### **Reason Therapy Was Stopped**

Tables 12 and 55 now include a patient's adverse reaction to anti-TB drug therapy as an option for the reason therapy was stopped. The 2009 RVCT revision removed the option of Moved as a valid response to the variable Reason Therapy Stopped, and this option is therefore not reported after 2009. Those cases entered as Moved as reason therapy was stopped after 2009 are now included in the Unknown category.

### **Metropolitan Statistical Areas**

Tables 60 through 64 present data by metropolitan statistical areas (MSAs) having an estimated 2016 population of  $\geq 500,000$  persons. MSAs are defined by the White House Office of Management and Budget (OMB), and the definitions were based on the application of the 2010 OMB standards for delineating MSAs to Census Bureau population estimates for 2012–2013 announced as of July 2015 (<https://www.bls.gov/lau/lausmsa.htm>).

The MSA definitions apply to all areas except the six New England states; for those states, the New England County Metropolitan Areas (NECMAs) are used. MSAs are named for a central city in the MSA or NECMA, can include multiple cities and counties, and can cross state boundaries. For example, the TB cases and case rates presented for DC in Table 29 include only persons residing within DC's geographic boundaries. However, the TB cases and case rates for the Washington, DC-MSA (Table 60) include persons residing within the multiple counties in the metropolitan area, including counties in Maryland, Virginia, and West Virginia. Cities or MSAs with incomplete or unavailable data were not included in the tables, and certain cities' or MSAs' total numbers might be underreported because of missing information.

### **National Tuberculosis Genotyping Service**

National Tuberculosis Genotyping Service laboratories primarily use two genotyping methods: spoligotyping and MIRU–VNTR (mycobacterial interspersed repetitive units–variable number of tandem repeats). Both methods require only a minor amount of culture material, provide digital results, and are relatively quick. Retrospective 24-locus MIRU–VNTR for older isolates can be performed, if requested, and can help in further differentiating genotype clusters. All isolates are prepared for long-term storage at genotyping laboratories or CDC.

### **Tuberculosis Genotyping Information Management System**

In March 2010, the Tuberculosis Genotyping Information Management System (TB GIMS) was launched by CDC as a secure Internet-based system to support ongoing use of TB genotyping data in TB control activities. TB GIMS facilitates systematic data collection of TB genotyping results, and it integrates genotyping results with epidemiologic data collected by NTSS to form a national and centralized database. Primary users of TB GIMS include TB laboratories that submit isolates for genotyping, national CDC-contracted genotyping laboratories, state and local TB con-

trol programs, and CDC programs that apply this information for TB control activities.

Genotyping results from the national genotyping laboratories or CDC are uploaded into TB GIMS as they become available. Line-listed data from the NTSS are also uploaded into TB GIMS weekly. After genotyping results have been linked to individual patient surveillance data in TB GIMS, the record is considered complete. These complete records are essential for the majority of the applications of TB genotyping, including all reports and maps as well as for using the outbreak detection system to identify potential chains of transmission and outbreaks. Twenty-four system updates have occurred for adding new reports, data management functions, and other tools since TB GIMS was released in March 2010. As of July 2017, a total of 579 local, state, and federal users have accessed the system.

### Genotype Clustering

A genotype cluster comprises two or more cases in a jurisdiction during a specified period having *M. tuberculosis* isolates that share matching genotypes. The jurisdiction and period used vary on the basis of the specific application. Cases that are part of the same genotype cluster are likely to be related by TB transmission in some way; however, the cases might not be directly related (i.e., one person did not necessarily give TB to another person in the cluster) or recently related (i.e., both persons might have contracted TB from the same person, but the exposure might have happened years ago). In TB GIMS, clustering is defined as  $\geq 2$  cases with matching genotypes (spoligotype and 24-locus MIRU-VN-TR) in a single county within a 3-year period.

### *Mycobacterium bovis*

For culture-confirmed TB cases that have been genotyped, *Mycobacterium bovis* can be defined primarily on the basis of spoligotyping results. The genotype-based definition for *M. bovis* required either (1) the absence of spoligotyping spacers 3, 9, 16, and 39–43; the presence of  $\geq 1$

of the spacers 29–32; and the presence of  $\geq 1$  of the spacers 33–36; or (2) the absence of spacers 3, 9, 16, and 39–43 and  $\geq 2$  copies of the repeated sequence at MIRU locus 24; or (3) determination based on microbiologic expertise. Data reported for 2004–2016 exclude cases of bacillus Calmette-Guérin *M. bovis*, which were defined as spoligotype 67677377777600 with x, y, or z in the second MIRU position. Although cases of bacillus Calmette-Guérin *M. bovis* (defined as spoligotype 67677377777600 with x, y, or z in the second MIRU position) were reported during 2004–2016, they are excluded from this report.

### Recent Transmission

Estimates are based on a plausible-source case method that is described in detail elsewhere.<sup>3</sup> Briefly, a given case is designated as attributed to recent transmission if a plausible source case with the following five characteristics can be identified in the national surveillance data: the same *M. tuberculosis* GENType, an infectious form of TB disease, patient's residential location within 10 miles, patient's age  $\geq 10$  years, and a diagnosis within the 2 years before the given case. These criteria were field-validated using local epidemiologic assessments of whether 1,188 cases in three states were actually due to recent transmission that was attributed to source cases reported during 1996–2000. Any given case with a plausible source case identified is included regardless of cluster size. Among cases attributed to overall recent transmission, a given case can also be attributed to extensive recent transmission if at least five other cases could be identified in a plausible transmission chain within 3 years prior to the given case.

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<sup>3</sup>France AM, Grant J, Kammerer JS, Navin TR. A field-validated approach using surveillance and genotyping data to estimate tuberculosis attributable to recent transmission in the United States. [Am J Epidemiol](#) 2015; 182: 799-807.