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Tuberculosis in the US Kidney Failure Population

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Abstract

Background: People with chronic kidney disease (CKD) have a higher risk for progression to tuberculosis disease following infection with *Mycobacterium tuberculosis*. We produced a nationwide incidence estimate and description of tuberculosis among people with kidney failure.

Methods: We completed a cross-sectional descriptive analysis of people with a reported case of tuberculosis in the United States between 2010 and 2021. We stratified all people with tuberculosis by reported kidney failure status. The primary outcome was tuberculosis incidence among people with kidney failure. We also compared characteristics of people with tuberculosis by reported kidney failure status.

Results: Approximately 3% of people (2,892 of 111,155) diagnosed with tuberculosis between 2010 and 2021 also had kidney failure. Annual tuberculosis incidence ranged from 26.1 to 45.4 per 100,000 people with kidney failure and 2.1 to 3.5 per 100,000 people without kidney failure. Among people with kidney failure, 924 (32%) had extrapulmonary tuberculosis only, and nearly 40% died: 286 were diagnosed with tuberculosis after death, and 792 died during treatment. People with tuberculosis and kidney failure had approximately twice the prevalence of a false-negative tuberculin skin test result (39%) compared to people with tuberculosis alone (20%).

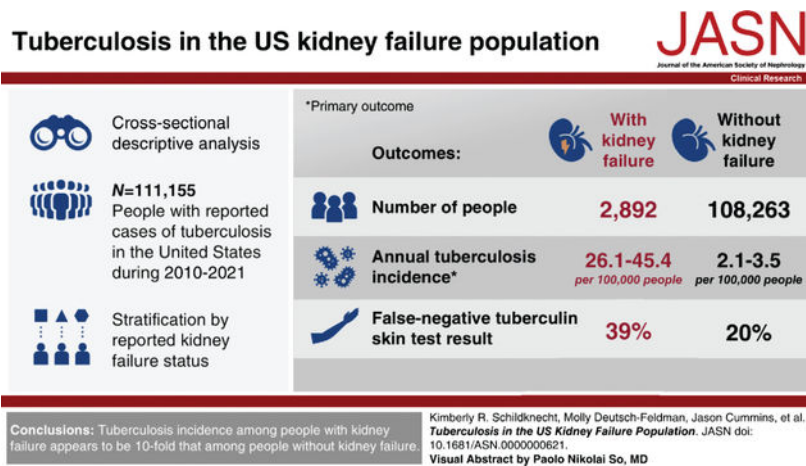
Conclusions: Tuberculosis incidence among people with kidney failure between 2010 and 2021 in the United States was 10-fold that among people without kidney failure.

Graphical Abstract:

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Disclosures:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Tennessee Department of Health.



Introduction

Kidney failure is the fifth and final stage of chronic kidney disease (CKD). Approximately 800,000 people in the United States currently undergo dialysis or have received a kidney transplant for treatment of kidney failure,¹ resulting in >\$37 billion in annual Medicare expenditures.²

CKD disrupts T-cell function, which increases the risk for infections, including infection with *Mycobacterium tuberculosis*.³ Following *M. tuberculosis* infection, many people develop lifelong latent infection; relatively few progress to tuberculosis disease. However, CKD confers a higher risk for progression.⁴⁻⁷ Disrupted T-cell function likely contributes to this higher risk for progression and atypical clinical presentations of disease.⁶

A study based in South Korea found that kidney failure was associated with a 4.39-fold higher risk of tuberculosis disease compared with people without kidney failure.⁵ California and New Jersey have been the locations of previous studies of tuberculosis and kidney failure,^{8,9} but tuberculosis disease in the US kidney failure population was, to our knowledge, last examined between 1995 and 2000.¹⁰

Since that time, the prevalence of kidney failure has increased.¹ Both tuberculosis and kidney failure disproportionately affect socioeconomically disadvantaged people in the United States,⁴ and understanding the relationship between these two diseases could inform interventions to prevent tuberculosis disease and associated morbidity. Identifying characteristics of tuberculosis specific to people with kidney failure may also help clinicians working with people with kidney failure recognize and diagnose tuberculosis more easily.

To improve our understanding of kidney failure as a risk for progression to tuberculosis in the United States, we produced nationwide estimates of kidney failure-associated tuberculosis incidence and mortality. We also described characteristics of people with tuberculosis by reported kidney failure status.

Methods

National Tuberculosis Surveillance System (NTSS)

Latent tuberculosis infection (i.e., a positive test for *M. tuberculosis* infection in the absence of tuberculosis disease) is not nationally reportable. However, the 50 U.S. states and the District of Columbia mandate reporting of each new case of tuberculosis disease, which is defined according to established laboratory and clinical criteria. Cases not classified as laboratory-confirmed can also be verified by clinical criteria if a clinician decides to start treatment for tuberculosis disease (e.g., if the patient has a positive test for *M. tuberculosis* infection and diagnostic findings compatible with tuberculosis disease).¹¹

Numerators for Incidence of Tuberculosis Disease

We conducted a cross-sectional descriptive analysis of incident tuberculosis cases reported to the NTSS using the standardized Report of a Verified Case of Tuberculosis during January 1, 2010, to December 31, 2021. We stratified all people with tuberculosis by reported kidney failure status. Kidney failure was added as a surveillance system variable (“end-stage renal disease”) in 2009.¹¹

Denominators for Calculating Tuberculosis Incidence Among People With Kidney Failure

The United States Renal Data System (USRDS) captures the prevalence of all people in the United States with kidney failure, regardless of age or insurance status, provided they receive medical treatment for the condition.¹² The USRDS annual report (i.e., deidentified and publicly available aggregate data) provided the denominators that we used for each year between 2010 and 2021 to estimate the annual incidence of tuberculosis per 100,000 people with kidney failure.¹

Denominators for Calculating Tuberculosis Incidence Among People Without Kidney Failure

For context, we calculated the incidence of tuberculosis among people without kidney failure. Our denominators were the general population counts from the U.S. Census American Community Survey, which we modified by subtracting out the annual prevalent number of people with kidney failure provided by the USRDS. We reported the annual incidence of tuberculosis per 100,000 people without kidney failure.

Demographic and Clinical Characteristics

We used demographic and clinical characteristics reported to NTSS to compare people with tuberculosis, stratified on the basis of their reported kidney failure status (i.e., the outcome of interest). The demographic exposures of interest were age categories (0–14, 15–24, 25–44, 45–64, 65+ years); self-reported race/ethnicity (American Indian/Alaska Native, Asian, Black, Hispanic, Native Hawaiian/Pacific Islander, White, multiple, unknown);¹³ nativity (U.S.-born, non-U.S.-born); and sex at birth (female, male). The clinical exposures of interest were comorbid conditions (diabetes, HIV, organ transplantation); death (before diagnosis or during treatment); *Mycobacterium tuberculosis* infection test results by test type (interferon-gamma assay test, tuberculin skin test); tuberculosis

disease diagnosis (laboratory-confirmed, clinical or provider diagnosis); site of tuberculosis disease (pulmonary, extrapulmonary, both); extrapulmonary site of disease (pleural, cervical lymphatic, bone/joints, peritoneal, genitourinary, meningeal); reason evaluated for tuberculosis (symptoms, abnormal chest radiograph, incidental diagnosis, targeted testing, contact investigation, immigration, occupational screening); and type of healthcare provider for tuberculosis treatment (health department, private/other, both).

Data Analysis

We used SAS 9.4 (SAS Institute, Cary NC) for our analyses. We used Poisson regression to calculate the 95% confidence limits for the annual incidence of tuberculosis per 100,000 people with and without kidney failure. Given that this descriptive analysis was not hypothesis-testing, and the size of the dataset rendered all *P* values to be statistically significant, no *P* values for statistical difference and no measures of association are presented. NTSS data are collected for public health surveillance purposes and are protected by an Assurance of Confidentiality, a formal confidentiality protection authorized under Section 308(d) of the Public Health Service Act. This analysis based on previously collected and deidentified NTSS data did not require institutional review board approval.

Surveillance Variable Evaluation

The NTSS variable for kidney failure is intended to capture the most advanced stage of CKD (i.e., stage V only), not earlier stages. NTSS does not capture the timing of the kidney failure diagnosis relative to the tuberculosis diagnosis. To examine the accuracy of this checkbox variable, one state health department re-reviewed the medical records of all 35 people reported as having both conditions between 2010 and 2021.

Results

Among the 111,155 persons diagnosed with tuberculosis disease in the United States between 2010 and 2021, 2,892 (3%) were reported as also having kidney failure. Annual tuberculosis incidence ranged from 26.1 to 45.4 per 100,000 people of all ages with kidney failure and from 2.1 to 3.5 per 100,000 people of all ages without kidney failure, with a general downward trend in both groups (Figure 1). Overall, annual tuberculosis incidence rates among people with reported kidney failure were 9.6 to 13.8 times the rates in people without kidney failure. This difference in incidence persisted after stratifying by the potential confounder of age among people with kidney failure. People aged 18–44 years with kidney failure had annual tuberculosis incidence rates of 5.0 to 10.4 times higher than tuberculosis incidence among people in the same age group without kidney failure. The corresponding annual relative ratios in incidence rates between 2010 and 2021 were 7.2 to 10.3 for ages 45 to 64 years, 6.5 to 11.4 for ages 65 to 74 years, and 7.0 to 10.1 for ages ≥75 years.

Among people with tuberculosis and kidney failure, the median age was 65 years; it was 47 years for people with tuberculosis alone (interquartile age ranges were 55–75 and 30–63, respectively). Table 1 shows demographic and clinical characteristics (i.e., exposures of interest) of people with and without kidney failure. Diabetes was reported in 1,490 (52%)

people with tuberculosis and kidney failure, compared with 19,085 (18%) people with tuberculosis alone. Being an organ transplant recipient was reported in 177 (6%) people with tuberculosis and kidney failure, compared with 486 (0.4%) to people with tuberculosis alone.

A tuberculosis diagnosis following death (e.g., *M. tuberculosis* culture was still pending at time of death) occurred in 286 (10%) of people with kidney failure, compared with 2,278 (2%) of people without kidney failure. Among people alive at tuberculosis diagnosis, 792 (30%) people with kidney failure died during tuberculosis treatment, compared with 6,493 (6%) people without kidney failure. These higher proportions persisted even after accounting for the older age distribution of people with both tuberculosis and kidney failure. That is, comparing people with and without kidney failure within the age strata of 25–44, 45–64, and ≥65 years, death before tuberculosis diagnosis or before treatment completion occurred for a higher proportion of those with kidney failure (Table 1).

Among people with tuberculosis and kidney failure, 39% had a false-negative tuberculin skin test result (i.e., 258 of 657 tested), approximately twice as many as the 20% without kidney failure (i.e., 7,665 of 37,677 tested). False-negative results were less prevalent with the interferon-gamma release assay test, occurring for 17% of people with tuberculosis and kidney failure (i.e., 275 of 1,659 tested) and 15% with tuberculosis alone (i.e., 8,507 of 58,581 tested) (Table 1).

Among people with kidney failure, 924 (32%) had only extrapulmonary sites of tuberculosis, compared with 22,073 (20%) people without kidney failure. Among people with exclusively extrapulmonary sites of tuberculosis, the five most common sites in people with kidney failure were pleural (20%), cervical lymphatic (17%), peritoneal (15%), bone/joint (15%), and genitourinary (14%). Regardless of kidney failure status, symptoms of tuberculosis disease led to the tuberculosis diagnosis for approximately half of people; it was an incidental diagnosis for 18% of people with kidney failure. Targeted testing for tuberculosis led to the tuberculosis diagnosis in only 2% with kidney failure, compared to 4% without kidney failure. Private providers treated tuberculosis in 981 (40%) of people with kidney failure, compared with 23,796 (24%) of people without kidney failure (Table 1).

In our convenience sample of 35 people in one state reported as having both tuberculosis and kidney failure, re-review of medical records in one state confirmed that 30 (86%) had kidney failure, but 5 (14%) had earlier CKD stages I–IV. All 35 had CKD.

Discussion

We found that tuberculosis incidence was consistently 10 times higher among people also reported as having kidney failure compared with among those without kidney failure, and nearly 40% of people with both tuberculosis and kidney failure during 2010–2021 died. Our finding is consistent with studies finding higher incidence and relative risk of tuberculosis, and higher risk of tuberculosis-related death, among people with kidney failure.^{5–10,14} The nationwide dip in tuberculosis incidence during the onset of the COVID-19 pandemic in 2020¹⁵ did not appear to have a corresponding dip in tuberculosis incidence among

people with kidney failure (Figure 1). Subsequently, the decades-long downward trend in tuberculosis incidence halted, with tuberculosis increases in 2022 and 2023.^{15,16} Our findings also reinforce CDC's national guidelines to screen all people with kidney failure for latent tuberculosis infection and tuberculosis disease.¹⁷ However, our results also underscore the possibility of false-negative tests for tuberculosis infection and atypical presentations of tuberculosis disease.

In the United States, people with tuberculosis with and without kidney failure were similar in reported race/ethnicity, nativity, and sex at birth. Although people with tuberculosis and kidney failure were older on average than people without kidney failure, a greater proportion of people with both diagnoses died before their tuberculosis diagnosis or before they were able to complete tuberculosis therapy, and this higher mortality also occurred among people with kidney failure aged 25–64 years. Although nearly 40% of the persons with both tuberculosis and kidney failure in this study died (i.e., 1,078 of the total 2,892), we were unable to calculate the excess mortality attributable to tuberculosis. All-cause annual mortality in the U.S. kidney failure population ranged 16%–19% during our study period.¹

About half of the people with tuberculosis and kidney failure also had diabetes, which corresponds with diabetes being the leading cause of kidney failure.¹ More people with kidney failure reported being an organ transplant recipient. Although NTSS does not specify the organ, it presumably refers primarily to kidney transplants for people with both kidney failure and tuberculosis.

In the United States, the national tuberculosis elimination strategy includes identifying people at higher risk for developing tuberculosis disease who would benefit from treatment of latent tuberculosis infection; this strategy is termed targeted testing.¹⁷ Our finding of targeted testing as a reason for tuberculosis evaluation was surprisingly low for people with kidney failure, given that many people with kidney failure are receiving dialysis multiple times a week, have frequent interactions with healthcare providers, and are a group for whom targeted testing is recommended.^{17–19}

In addition to prompt tuberculosis disease diagnoses and regular screenings for *M. tuberculosis* infection, treatment of latent infection is important to prevent progression to tuberculosis disease, a risk that is higher with older age and develops additional medical conditions that weaken the immune system.^{17–19} Treatment of latent tuberculosis infection also involves fewer medications and can typically be achieved in a shorter timeframe than previously.¹⁹ However, this analysis found that people with tuberculosis disease and kidney failure had a higher proportion of false-negative test results for *M. tuberculosis* infection, especially with the tuberculin skin test. Whether this apparent lower sensitivity of the tuberculin skin test, as compared to the interferon-gamma release assay test, would generalize to the larger population of people with kidney failure but not tuberculosis disease is unknown since both tests rely on T-cell mediated immune responses to tuberculosis antigens.

For all people, either with or without kidney failure, symptoms of tuberculosis disease were the most common reason for the evaluation that led to the tuberculosis diagnosis.

Previous studies have reported that the presentation of tuberculosis in people with kidney failure is often atypical due to symptoms consistent with uremia and that up to 60%–80% of people with kidney failure who present with tuberculosis have extrapulmonary tuberculosis.⁴ We also found that tuberculosis was exclusively extrapulmonary more often in people with kidney failure. Extrapulmonary tuberculosis can be more difficult to diagnose; our analysis suggests that when evaluating people with kidney failure, clinicians should consider the most common extrapulmonary tuberculosis disease sites (pleural, cervical lymphatic, peritoneal, bone/joint, and genitourinary). A proper tuberculosis evaluation includes consideration of the individual patient history, clinical findings (which might be nonspecific), test results (which are imperfect), the presence of social and medical risk factors, and epidemiology of tuberculosis in the community.

Tuberculosis treatment through a private provider was reported more frequently for people with kidney failure. Perhaps this finding represents necessary coordination of antituberculosis treatment with dialysis or transplant providers to attain therapeutic levels of antituberculosis therapy and post-transplant immunosuppressants.^{20,21} Another possible explanation is that most people with kidney failure have established relationships with nephrologist and Medicare coverage, making them less dependent on health departments to manage tuberculosis care.

Our study has limitations. First, a small number of people with kidney failure who chose not to seek medical treatment (e.g., opting instead for comfort care due to advanced age or other comorbidities) would not be represented in the USRDS. Second, 14% of the patients in our convenience sample of 35 people were reported as having both tuberculosis and kidney failure but had less advanced forms of CKD; the kidney failure variable might similarly be misclassified in the NTSS. Nonetheless, it is unlikely that misclassification explains the 10-fold higher tuberculosis incidence than among people without kidney failure. Third, we know that this cohort of people diagnosed with incident tuberculosis between 2010 and 2021 had kidney failure at the time of tuberculosis diagnosis, but we do not know the date of onset for kidney failure, making this a cross-sectional analysis that cannot draw conclusions regarding causality. Finally, among the 399 people with both tuberculosis and kidney failure who also had a positive tuberculin test, the amount of induration (recorded in mm units) was unavailable for 102 (26%), making it difficult to verify whether appropriate cutoff values were used (i.e., ≥ 5 mm for recent tuberculosis contacts, people living with HIV or with organ transplants, and generally otherwise ≥ 10 mm for people with kidney failure).¹⁷ However, for those 297 with both quantitative indurations recorded and a positive interpretation of the result, all except 16 had tuberculin skin test readings of ≥ 10 mm, suggesting that recommended cutoff values were used for most people with kidney failure. More information regarding performance characteristics of tests for tuberculosis infection could be used to optimize efforts to prevent tuberculosis disease and associated morbidity among people with kidney failure.

In conclusion, we found higher tuberculosis incidence, higher percentage of false-negative results of tests for *M. tuberculosis* infection, and atypical tuberculosis disease presentations, underscoring the recommendations^{17–19} that all people with kidney failure receive regular screening for tuberculosis disease, especially at extrapulmonary sites, and regular

testing and treatment for tuberculosis infection. Clinicians should have a low threshold for comprehensive diagnostic testing for tuberculosis disease, including extrapulmonary specimen collection, and not exclude tuberculosis as a diagnostic possibility in people with kidney failure, even if the results of tests for infection appear negative.

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Data Sharing Statement:

The National Tuberculosis Surveillance System operates under an Assurance of Confidentiality issued by CDC under Sections 306 and 308(d) of the Public Health Service Act (42 USC 242k and 242m(d)). Health departments voluntarily reported the data used in this report on a case report form called the Report of Verified Case of Tuberculosis (OMB No. 0920-0026). The Assurance of Confidentiality prevents disclosure of any information that could be used to identify patients either directly or indirectly. For more information, see the CDC/ATSDR Policy on Releasing and Sharing Data (at https://www.cdc.gov/os/docs/final-cdc-public-access-plan-jan-2015_508-compliant.pdf). A limited dataset is available at <https://wonder.cdc.gov/tb.html>. Researchers may apply to analyze additional data by contacting TBInfo@cdc.gov.

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Key Points:

- Chronic kidney disease (CKD) is associated with a higher risk of tuberculosis.
- We produced nationwide estimates of tuberculosis incidence and mortality associated with kidney failure.
- Tuberculosis incidence ranged from 26.1 to 45.4 per 100,000 people with kidney failure, and nearly 40% died before diagnosis or during treatment.

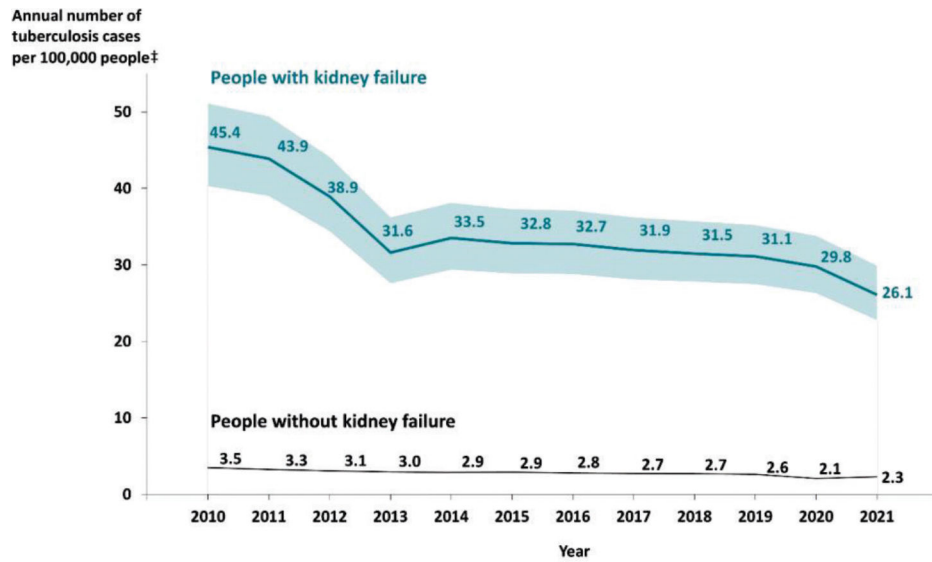


Figure 1. Tuberculosis incidence in people with kidney failure* vs. in people without kidney failure†, 2010–2021

* The United States Renal Data System (USRDS) provided the population denominators that were used for each year during 2010–2021 to estimate the annual incidence of tuberculosis among people with kidney failure.

† The U.S. Census American Community Survey provided the denominators for each year during 2010–2021 to estimate the annual incidence of tuberculosis among people without kidney failure, which were modified by subtracting out the annual prevalent number of people with kidney failure provided by the USRDS.

‡ 95% confidence intervals shown as shaded bands but barely visible for people without kidney failure (precision caused by larger numbers).

Table 1.

Characteristics of people with tuberculosis based on reported kidney failure status, U.S. National Tuberculosis Surveillance System, 2010–2021

	Kidney failure reported	
	Yes N=2,892 No. (%) [*]	No N=108,263 No. (%) [*]
Age group, years (y)		
0–14	2 (0.1)	5,258 (5)
15–24	25 (0.9)	10,935 (10)
25–44	288 (10)	33,759 (31)
45–64	1,088 (38)	33,148 (31)
≥65	1,489 (51)	25,159 (23)
Diagnosis following death	286 (10)	2,278 (2)
Age 0–14 y	0 (0) [†]	21 (0.4) [†]
Age 15–24 y	0 (0) [†]	33 (0.3) [†]
Age 25–44 y	15 (5) [†]	264 (1) [†]
Age 45–64 y	95 (9) [†]	681 (2) [†]
Age ≥65 y	176 (12) [†]	1,279 (5) [†]
Race/ethnicity [‡]		
American Indian/Alaska Native	43 (1)	1,309 (1)
Asian	1,096 (38)	35,999 (33)
Black	610 (21)	23,043 (21)
Hispanic	813 (28)	31,319 (29)
Native Hawaiian/Pacific Islander	51 (2)	1,078 (1)
White	255 (9)	14,532 (13)
Multiple	14 (0.5)	675 (1)
Unknown	10 (0.3)	308 (0.3)
U.S.–born	890 (31)	35,368 (33)
Male sex at birth	1,811 (63)	65,898 (61)
HIV co-infection	110 (4)	5,655 (5)
Diabetes	1,490 (52)	19,085 (18)
Organ transplant recipient	177 (6)	486 (0.4)
Interferon-gamma assay results		
Positive	1,213 (73) [§]	47,415 (81) [§]
Indeterminate	171 (10) [§]	2,659 (5) [§]
Negative	275 (17) [§]	8,507 (15) [§]
Tuberculin skin test results		
Positive	399 (61)	30,012 (80)

	Kidney failure reported	
	Yes N=2,892 No. (%) [*]	No N=108,263 No. (%) [*]
Negative	258 (39) ^{//}	7,665 (20) ^{//}
Tuberculosis diagnosis		
Laboratory-confirmed	2,456 (86) ^{//}	75,942 (82) ^{//}
Clinical or provider diagnosis	409 (14) ^{//}	16,124 (18) ^{//}
Disease site		
Pulmonary only	1,426 (49)	74,885 (69)
Extrapulmonary only	924 (32)	22,073 (20)
Both	541 (19)	11,262 (10)
Unknown	1 (0.03)	43 (0.04)
Extrapulmonary only disease sites		
Pleural	186 (20) ^{**}	3,460 (16) ^{**}
Cervical lymphatic	156 (17) ^{**}	5,725 (26) ^{**}
Peritoneal	142 (15) ^{**}	1,329 (6) ^{**}
Bone/joint	141 (15) ^{**}	2,369 (11) ^{**}
Genitourinary	130 (14) ^{**}	1,717 (8) ^{**}
Meningeal	29 (3) ^{**}	1,174 (5) ^{**}
Other sites	140 (15) ^{**}	6,299 (29) ^{**}
Reason for tuberculosis evaluation		
Tuberculosis symptoms	1,574 (56) ^{††}	59,751 (58) ^{††}
Incidental diagnosis	490 (18) ^{††}	10,872 (10) ^{††}
Targeted testing for tuberculosis	56 (2) ^{††}	4,028 (4) ^{††}
Tuberculosis treatment provider		
Private provider/other	981 (40) ^{‡‡}	23,796 (24) ^{‡‡}
Health department	1,208 (49) ^{‡‡}	65,490 (66) ^{‡‡}
Both	286 (12) ^{‡‡}	10,421 (10) ^{‡‡}
Death during treatment	792 (30) ^{§§}	6,493 (6) ^{§§}
Age 0–14 y	0 (0) ^{§§}	22 (0.4) ^{§§}
Age 15–24 y	1 (4) ^{§§}	73 (0.7) ^{§§}
Age 25–44 y	38 (14) ^{§§}	536 (2) ^{§§}
Age 45–64 y	267 (27) ^{§§}	1,852 (6) ^{§§}
Age ≥65 y	486 (37) ^{§§}	4,005 (17) ^{§§}

* Percentages may not add to 100% due to rounding. The small number of persons with missing age (n=4 without kidney failure), nativity (n=5 with kidney failure, n=218 without kidney failure), and sex (n=12 without kidney failure) are excluded from the numerators but not the denominators.

[†] Percentages calculated using the denominator of people in that age group. Diagnosis following death was via laboratory confirmation (e.g., specimen collected just before death later grew *M. tuberculosis* on culture) for 286 people with kidney failure and 2,278 people without kidney failure.

[‡] Self-reported by participants; responses were categorized by investigators following federal government standards (13). Ethnicity was non-Hispanic unless otherwise noted.

[§] Percentages calculated using total number of people with an interferon-gamma assay test result (i.e., 1,659 with kidney failure, 58,581 without kidney failure).

// Percentages calculated using total number of people with a tuberculin skin test result (i.e., 657 with kidney failure, 37,677 without kidney failure).

[¶] Numbers and percentages based on subset of the 2,865 persons aged ≥25 years with kidney failure and the 92,066 aged ≥25 years without kidney failure because pediatric tuberculosis is usually culture-negative.

*** Percentages calculated using total number of people with extrapulmonary disease site only (i.e., 924 with kidney failure, 22,073 without kidney failure). The sites shown in the table are the six that were most prevalent among persons with kidney failure and tuberculosis.

^{††} Percentages calculated using total number of people with reason evaluated for tuberculosis listed (i.e., 2,791 with kidney failure, 103,684 without kidney failure).

^{‡‡} Percentages calculated using total number of people with tuberculosis treatment provider listed (i.e., 2,475 with kidney failure, 99,707 without kidney failure).

^{§§} Percentages calculated using people alive at diagnosis as the denominator (i.e., 2,606 with kidney failure, including 2 aged 0–14 y, 25 aged 15–24 y, 273 aged 25–44 y, 993 aged 45–64 y, 1,313 aged ≥65 y; and 105,981 without kidney failure, including 5,237 aged 0–14 y, 10,902 aged 15–24 y, 33,495 aged 25–44 y, 32,467 aged 45–64 y, 23,880 aged ≥65 y).