Tuberculosis in Indigenous Persons — United States, 2009–2019

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Abstract

Background—Populations of indigenous persons are frequently associated with pronounced disparities in rates of tuberculosis (TB) disease compared to co-occurring nonindigenous populations.

Methods—Using data from the National Tuberculosis Surveillance System on TB cases in U.S.-born patients reported in the United States during 2009–2019, we calculated incidence rate ratios and risk ratios for TB risk factors to compare cases in American Indian or Alaska Native (AIAN) and Native Hawaiian or other Pacific Islander (NHPI) TB patients to cases in White TB patients.

Results—Annual TB incidence rates among AIAN and NHPI TB patients were on average 10 times higher than among White TB patients. Compared to White TB patients, AIAN and NHPI TB patients were 1.91 (95% confidence interval (CI): 1.35–2.71) and 3.39 (CI: 1.44–5.74) times more likely to have renal disease or failure, 1.33 (CI: 1.16–1.53) and 1.63 (CI: 1.20–2.20) times more likely to have diabetes mellitus, and 0.66 (CI: 0.44–0.99) and 0.19 (CI: 0–0.59) times less likely to be HIV positive, respectively. AIAN TB patients were 1.84 (CI: 1.69–2.00) and 1.48 (CI: 1.27–1.71) times more likely to report using excess alcohol and experiencing homelessness, respectively.

Conclusion—TB among U.S. indigenous persons is associated with persistent and concerning health disparities.

Keywords

American Indian or Alaska Native (AIAN) persons; Health disparities; Native Hawaiian or other Pacific Islander (NHPI) persons; Tuberculosis

Introduction

Globally, in both developing and industrialized nations, populations of indigenous persons are often associated with large disparities in rates of tuberculosis (TB) disease compared to

co-occurring nonindigenous populations [1]. In the United States, persons who self-identify as being solely or partially American Indian or Alaska Native (AIAN) or Native Hawaiian or other Pacific Islander (NHPI) constitute the majority of U.S. indigenous persons [2, 3]; in 2019 they represented 2.2% (~7 million people) of the U.S. population [4]. While the absolute burden of TB disease among U.S indigenous persons has been slowly declining since at least the mid-1990s [5, 6], TB incidence rates among non-Hispanic AIAN persons (3.4 cases per 100,000 persons) and non-Hispanic NHPI persons (17.6 per 100,000) in the United States in 2019 were 6.8 and 35.2 times larger than those among non-Hispanic White persons (0.5 per 100,000), respectively [7]. In addition to persistent disparities in incidence [5, 6], other TB-related health disparities among U.S. indigenous persons have been documented. An investigation of mortality attributed to any of 10 infectious diseases (or categories thereof) during 1999–2009 found that AIAN persons had an overall death rate twice that of White persons [8]; the disparity in TB-associated mortality, 13 times larger for AIAN persons compared to White persons, was greatest. Another investigation during 1990–2009 found that in Alaska, AIAN persons had a TB death rate 48 times that of White persons; the magnitude of this disparity had increased from the previous 9-year period when the death rate for AIAN persons had been 14 times higher [9]. Other studies found that TB-related hospitalization and death rates among AIAN persons were twice the national rate [10] or the rate among Asian persons [11], respectively. Beyond raising significant concern from the perspectives of public health promotion and health equity, these disparities are particularly disheartening given the central roles played by U.S. indigenous persons in epidemiologic studies to assess the efficacy of vaccines and pharmacological therapies [12]. Notably, AIAN persons constituted the study population in trials and follow-up studies of the Bacille Calmette-Guérin (BCG) vaccine [13, 14] and isoniazid for treating and preventing TB disease [15, 16].

To quantify TB-related health disparities, identify factors and mechanisms that contribute to them, and inform the development of strategies to promote health equity, we describe demographic, clinical, and sociobehavioral characteristics of TB cases reported in the United States during 2009–2019, with analyses stratified by patient race/ethnicity and focused on U.S. indigenous persons who self-identified as AIAN or NHPI. We also characterize annual TB case rates and rate disparities by race/ethnicity over this period. Finally, by applying molecular surveillance methods [17], we evaluate the contribution of recent transmission to TB incidence. Our investigation is modeled on two published studies describing TB cases in the United States by race/ethnicity during 1993–2002 [5] and 2003–2008 [6], extending previous work on TB among U.S. indigenous persons.

Methods

We analyzed incident TB disease case report data from the U.S. Centers for Disease Control and Prevention's (CDC) National Tuberculosis Surveillance System (NTSS). Health departments in all 50 states, the District of Columbia (DC), and multiple U.S.-affiliated jurisdictions in the Pacific Ocean and Caribbean Sea submit information on TB cases that meet a national surveillance case definition [7] to NTSS using a standardized form (Report of Verified Case of Tuberculosis (RVCT)), which includes fields for demographic, clinical, case management, outcome, and laboratory data [18]. Results from CDC's

National Tuberculosis Genotyping Service, which conducts genotyping for at least one *Mycobacterium tuberculosis* isolate from each culture-confirmed TB case in the United States, are linked to NTSS records using the TB Genotyping Information Management System (TB GIMS) for molecular surveillance [19].

Our analyses included all incident TB cases reported to NTSS that met the case definition during January 1, 2009–December 31, 2019, were counted within any of the 50 states or DC, and occurred in a U.S.-born patient (i.e., born in the United States or outside the United States to at least one parent with U.S. citizenship). Within NTSS, patient self-reported race/ethnicity data are used to assign cases to one of eight race/ethnicity groups: non-Hispanic patients who are AIAN, NHPI, Asian, Black, or White alone, or multiple race; Hispanic patients; or unknown race/ethnicity. To restrict analyses to U.S. indigenous persons, cases in the AIAN group in patients who reported a country/location of birth other than the United States (or blank/not reported) were excluded. Similarly, cases in the NHPI group were excluded unless patients met one of the following criteria: (a) reported any of six RVCT NHPI subrace groups (Guamanian, Chamorro, Guamanian or Chamorro, Mariana Islander, Native Hawaiian, Saipanese) that are associated with U.S. indigenous populations; (b) did not self-report a subrace group and reported the United States (or blank/not reported) as country/location of birth; (c) reported a combination of any of four subrace groups (Polynesian, Samoan, Other Pacific Islander, blank/not reported) and the United States, American Samoa, Guam, Northern Mariana Islands, U.S. Minor Outlying Islands, or U.S. Miscellaneous Pacific Islands as country/location of birth. For reference, the U.S. Census Bureau defines AIAN persons as "having origins in any of the original peoples of North and South America (including Central America) and who maintains tribal affiliation or community attachment" [3] and NHPI persons as "having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands" [2]. Cases in the multiple and unknown groups were combined.

Following two previous publications [5, 6], we enumerated frequencies of TB patient characteristics by race/ethnicity group. We calculated race/ethnicity-specific crude and age-adjusted annual TB case rates (per 100,000 persons) using the U.S. Census Bureau's American Community Survey (ACS) 5-year population estimates (Appendix 1); age-adjusted rates were calculated using direct standardization to the 2010 U.S. population [20]. For different subsets of TB patient characteristics, we compared bivariate relationships between each race/ethnicity group and the White group (reference) by calculating risk ratios (RRs) and associated 95% confidence intervals (CIs) or using chi-square tests. Annual TB case rates were similarly compared using incidence rate ratios (IRRs) and CIs. We calculated CIs using the normal approximation (Wald) method if the numerator for the non-reference group in the RR or IRR calculations was >10 and otherwise using a bootstrap method with 10,000 replicates. We defined statistical significance as $P<0.05$. Data for nonindigenous race/ethnicity groups (Asian, Black, Hispanic, Multiple/unknown) are provided for reference. We used the plausible source-case method [17] to identify TB cases attributed to recent transmission during 2011–2019; we only considered cases in patients aged 15 years because *M. tuberculosis* isolates from sputum cultures needed for genotyping cannot be obtained consistently from younger patients. Characteristics of cases

attributed to recent transmission were not examined for the NHPI group due to the small sample size (*N*=12 during 2009–2019).

Results

A total of 113,151 incident TB cases were reported to NTSS during 2009–2019, including 36,663 (32.4%) counted within the 50 states or DC and in a U.S.-born patient; 36,509 (99.6%) were included in our analyses after applying our AIAN and NHPI case definitions (Appendix 2).

Characteristics of AIAN TB Patients

When compared to White TB patients, a significantly higher percentage of AIAN TB patients were female (31.4% vs 41.3%), aged <15 years (2.7% vs 9.6%), resided in the Pacific-northwest (3.5% vs 42.8%) or Central-mountain (1.5% vs 10.3%) Standard Federal Regions [21], or were diagnosed based on positive culture (78.2% vs 83.3%) (all comparisons: χ^2 18.20; *P*<.0001) (Table 1). AIAN TB patients were significantly more likely than White TB patients to have experienced TB disease previously (RR=1.97, CI: 1.60–2.43), have a positive sputum culture recorded for their current TB episode (RR=1.19, CI: 1.14–1.24), and have received treatment for their current episode partially or completely as directly observed therapy (RR=1.06, CI: 1.05–1.07) (Table 1). At the time of TB diagnosis, AIAN TB patients were also significantly more likely than White TB patients to have been diagnosed with end-stage renal disease or chronic renal failure (RR=1.91, CI: 1.35–2.71) or type 1 or type 2 diabetes mellitus (RR=1.33, CI: 1.16–1.53); conversely, they were less likely to have been HIV positive (RR=0.66, CI: 0.44–0.99) or immunosuppressed because of a condition other than HIV/AIDS or a medication (RR=0.32, CI: 0.24–0.43).

Among TB patients 15 years of age, AIAN patients were significantly more likely to have their current episode of TB disease attributed to recent transmission (RR=2.34, CI: 2.10–2.61) and to have had infectious TB (i.e., sputum acid fast bacilli smear positivity, cavitary disease on chest radiograph or chest computerized tomography scan, or both) (RR=1.07, CI:1.01—1.12) compared to White patients (Table 2); AIAN patients were also significantly more likely to have reported using excess alcohol (RR=1.84, CI: 1.69–2.00) or noninjection drugs (RR=1.54, CI: 1.36–1.75) as well as experienced homelessness (RR=1.48, CI: 1.27–1.71) or been primarily unemployed (RR=1.48, CI: 1.37–1.61) during the 12 months prior to TB diagnosis.

Characteristics of NHPI TB Patients

When compared to White TB patients, a significantly higher percentage of NHPI TB patients were female (31.4% vs 42.3%), aged <15 years (2.7% vs 30.4%), resided in the Pacific-southwest (12.4% vs 37.1%) or Pacific-northwest (3.5% vs 21.1%) regions, or were not diagnosed based on positive culture (21.8% vs 38.7%) (all comparisons: χ^2 10.39; *P*<.001) (Table 1). NHPI TB patients were significantly more likely to have been diagnosed with end-stage renal disease or chronic renal failure (RR=3.39, CI: 1.44–5.74) or type 1 or type 2 diabetes mellitus (RR=1.63, CI: 1.20–2.20) at the time of TB diagnosis; conversely, they were less likely to have been HIV positive (RR=0.19, CI: 0–0.59) or

immunosuppressed because of a condition other than HIV/AIDS or a medication (RR=0.37, CI: 0.11–0.65).

NHPI TB patients were significantly less likely than White TB patients to have had any pulmonary disease (RR=0.89, CI: 0.82–0.96), a positive sputum culture recorded for their current TB episode (RR=0.64, CI: 0.53–0.77), sputum-smear positivity (RR=0.59, CI: 0.46–0.77), and cavitary disease (RR=0.43, CI: 0.29–0.66), but more likely to have completed treatment for their TB disease (RR=1.08, CI: 1.03–1.12) (Table 1). Among TB patients 15 years of age, NHPI patients were significantly less likely to have reported using excess alcohol during the 12 months prior to TB diagnosis (RR=0.59, CI: 0.37–0.93) compared to White patients (Table 2).

Annual TB Case Rates and Incidence Rate Ratios

Crude annual TB case rates for the AIAN group ranged from 7.46 cases per 100,000 persons in 2010 to 3.72 cases per 100,000 persons in 2019 (Figure 1, Online Resource 1). Relative to the White group, crude annual IRRs for the AIAN group ranged from 6.48 (CI: 5.28–7.95) in 2009 to 13.48 (CI: 11.32–16.06) in 2015; values did not differ statistically between 2009 and 2019 (IRR=9.26, CI: 7.35–11.68). Age-adjusted annual TB case rates for the AIAN group ranged from 8.55 cases per 100,000 persons in 2010 to 3.84 cases per 100,000 persons in 2019 (Online Resource 2, Online Resource 3). Compared to the White group, age-adjusted annual IRRs for the AIAN group ranged from 8.31 in 2009 to 16.14 in 2015.

Crude annual TB case rates for the NHPI group ranged from 1.21 cases per 100,000 persons in 2013 to 8.40 cases per 100,000 persons in 2017 (Figure 1, Online Resource 1). Relative to the White group, crude annual IRRs for the NHPI group ranged from 2.11 (CI: 0.51–4.36) in 2013 to 20.05 (CI: 13.93–28.87) in 2017; values did not differ statistically between 2009 (IRR=9.05, CI: 5.75–14.23) and 2019 (IRR=11.78, CI: 7.28–19.04). Age-adjusted annual TB case rates for the NHPI group ranged from 1.57 cases per 100,000 persons in 2013 to 8.90 cases per 100,000 persons in 2010 (Online Resource 2, Online Resource 3). Compared to the White group, age-adjusted annual IRRs for the NHPI ranged from 3.02 in 2013 to 21.70 in 2018.

Characteristics of AIAN TB Patients with Cases Attributed to Recent Transmission

When compared to White TB patients aged 15 years with cases counted during 2011–2019 and attributed to recent transmission, a significantly higher percentage of AIAN TB patients were female (28.0% vs. 36.7%), aged 15–24 years (4.9% vs. 17.5%), or resided in the Pacific-northwest region (4.9% vs 67.8%) (all comparisons: χ^2 7.97; *P*<.005) (Online Resource 4). The annual percentage of cases attributed to recent transmission among AIAN TB patients ranged from 28.6% in 2011 to 43.6% in 2013 (Figure 2, Online Resource 5). Relative to the White group, crude annual IRRs for the AIAN group ranged from 2.01 (CI: 1.41–2.85) in 2011 to 2.84 in 2013 (CI: 2.14–3.76); values did not differ statistically between 2011 and 2019 (IRR=2.83, CI: 1.96–4.08).

Discussion

Like previous studies of TB in the United States that examined racial/ethnic variation in disease epidemiology [5, 6], we found evidence of persistent disparities in both incidence and the proportion of TB patients with clinical and sociobehavioral risk factors, with a disproportionate burden of disease associated with indigenous AIAN and NHPI persons. Despite collectively representing 4% of the TB cases reported during 2009–2019, either the AIAN or the NHPI group had the highest crude and age-adjusted annual TB case rates among U.S.-born persons in every year of the 11-year investigation period. When averaged across this period, crude and age-adjusted annual case rates for both the AIAN and NHPI groups were 10 times higher than rates for the White group. Given the persistence of TB disease as a significant, endemic public health problem facing U.S. indigenous persons, intensified, culturally sensitive efforts are needed to reduce disparities by strengthening TB prevention and control measures focused on AIAN and NHPI communities. Compared to other race/ethnicity groups, TB case rates among AIAN and NHPI persons should in theory be highly amenable to reduction owing to their relatively high magnitude and the small population sizes of these U.S. indigenous groups.

Our analyses documented pronounced racial/ethnic disparities in the frequencies of clinical and sociobehavioral characteristics known to be associated with an increased burden of TB disease. AIAN and NHPI TB patients were significantly more likely than White TB patients to have also been diagnosed with end-stage renal disease or chronic renal failure or with type 1 or type 2 diabetes mellitus. TB patients with end-stage renal disease are at higher risk for TB-related mortality [22, 23]; diabetes is associated with more severe TB symptoms, delayed sputum conversion, and increased probabilities of TB treatment failure, recurrent disease, and death during TB treatment [24-26]. Consistent with two previous studies [5, 6], AIAN TB patients aged 15 years were significantly more likely than White TB patients to have reported excess alcohol and noninjection drug use as well as unemployment and experiencing homelessness. Substance misuse has been associated with more severe symptoms and adverse outcomes of TB disease, findings likely attributable to reductions in immunocompetence and organ function (especially liver and lungs) [27-29]. These four sociobehavioral characteristics are among a constellation of TB risk factors linked to increased rates of exposure and infection, more severe and prolonged symptoms (partly because of delayed TB diagnosis), and higher probabilities of treatment failure and death [30-32]. These findings are consistent with U.S. indigenous persons being at increased risk of adverse outcomes associated with TB disease. Further, they support the need for and provide high-level insights into ways in which the effectiveness of TB control programs could be enhanced by tailoring interventions to meet the unique needs, resiliencies, and vulnerabilities of individual U.S. indigenous populations. For example, TB-specific public health activities focused on reducing rates of transmission or increasing rates of testing and treatment could be undertaken concurrently with interventions to detect and treat specific clinical comorbidities, promote particular aspects of behavioral health, and stabilize and improve employment and housing conditions.

Comparison of demographic characteristics of TB patients by race/ethnicity group identified a number of conspicuous differences. The age distributions of AIAN and especially NHPI

TB patients were strongly right-skewed; 18% of AIAN and 45% of NHPI TB patients were aged <25 years compared to 6% of White TB patients. This suggests that TB was diagnosed at a relatively earlier age among AIAN and NHPI TB patients, likely as a result of population age structure and perhaps because of higher clinical suspicion for TB among patients in these groups. This may help to explain the findings that NHPI TB patients were significantly less likely than White TB patients to have had any pulmonary disease, a positive sputum culture recorded for their current TB episode, sputum-smear positivity, cavitary disease, or reported using excess alcohol. TB diagnoses among relatively young AIAN and NHPI TB patients may require pediatric infectious disease specialty care. Additionally, we observed geographic clustering of AIAN and NHPI TB cases; approximately 60% of both AIAN and NHPI TB patients resided in the Pacific-northwest and Pacific-southwest regions compared to 16% of White TB patients. These demographic and geographic attributes could be leveraged to reduce disease burden in AIAN and NHPI populations by informing tailored TB control activities.

Using the plausible source-case method [17] and molecular surveillance data, we demonstrated that TB cases in AIAN patients aged 15 years were significantly more likely than cases in White counterparts to be attributed to recent transmission. Among these AIAN TB patients, the observed age distribution is consistent with recent transmission occurring disproportionately among persons aged <65 years (91.3%) and TB disease in persons aged 65 years (8.7%) being more likely to be attributed to reactivation of longstanding latent TB infection. Yet AIAN and White TB patients aged 15 years did not differ significantly in their likelihood of having infectious TB. These results suggest that racial/ ethnic variation in factors related to exposure or susceptibility might be important drivers of recent transmission among U.S. indigenous persons. Susceptibility-related disparities could result from variation in clinical and sociobehavioral risk factors described above as well as other mechanisms contributing directly or indirectly to poor health. In terms of exposure, AIAN TB patients may be more likely than White TB patients to spend time in close proximity to others or in locations with reduced ventilation. During 2013–2015, 15.9% of AIAN households in tribal areas were categorized as overcrowded (>1 person per room) compared to 2.2% of total households in the United States (2013 estimate) [33]. During the same periods, 12% of AIAN households in tribal areas were categorized as having heating problems (uncomfortably cold during the past winter for prolonged periods because of broken down heating equipment) compared to 0.1% of total households in the United States [33]; low household temperatures could lead occupants to crowd together or reduce ventilation in an attempt to conserve warmth. Racial/ethnic variation in exposure would also be consistent with our and previous findings [6] that AIAN TB patients were significantly more likely than White TB patients to have experienced TB disease previously.

Our investigation had several limitations. We may have misclassified TB cases because we based our analyses on patient self-reported race/ethnicity and focused on patients who reported only a single race/ethnicity. In the 2010 census, 44% and 56% of the U.S. AIAN and NHPI populations, respectively, reported more than one race; a majority of persons in both groups self-identified with two races, with White as the other race [34, 35]. Of the 318 TB cases combined into the multiple/unknown race/ethnicity group in our analyses, 86 were in patients who reported AIAN and one or more other races; 32 cases were in patients who

reported NHPI and one or more other races (Appendix 2). Including these cases in the AIAN and NHPI groups in our analyses would have increased the counts of those groups by 6.7% and 16.5%, respectively, and could have altered our findings. Related to this, we applied relatively narrow AIAN and NHPI case definitions that included only TB patients who reported one of a small number of countries/locations of birth and subraces (for the NHPI group). As a result, we excluded cases in patients who might be classified as AIAN or NHPI in other investigations involving analyses stratified by race/ethnicity. This was particularly true for the NHPI group. For example, we excluded 41 cases in patients who self-identified as NHPI but reported a subrace of Marshallese or Micronesian and a country of birth of the Republic of the Marshall Islands or the Federated States of Micronesia. While these patients are Pacific Islanders, the Marshall Islands and the Federated States of Micronesia are sovereign nations with U.S. affiliation through Compacts of Free Association; thus, we did not consider these patients to be indigenous to the United States. Use of these restrictive case definitions and the resulting exclusion of cases could complicate comparison of our findings with those of other investigations of racial/ethnic health disparities involving U.S. indigenous persons. Our analyses of clinical and sociobehavioral characteristics did not control for the effects of underlying racial/ethnic variation in the frequency of those characteristics. For example, while AIAN and NHPI TB patients were significantly more likely than White TB patients to have also been diagnosed with diabetes mellitus, rates of diabetes mellitus among AIAN and NHPI persons in general are high relative to other race/ethnicity groups [36, 37]. The small number of NHPI cases likely contributed to fluctuations in annual rate estimates. Finally, we restricted our analysis of recent transmission to cases in patients aged 15 years. Because pediatric TB cases are generally assumed to result from recent transmission, but genotype evidence is often missing from younger patients who cannot reliably produce sputum for culture, our analyses may have underestimated the frequency of recent transmission in AIAN and NHPI groups, particularly given their relatively young age distributions.

Recent advances in TB diagnostic and therapeutic methods are understandably cause for excitement among those working to eliminate TB [38]. Yet our findings of persistent and pronounced racial/ethnic disparities in rates of TB disease among U.S. indigenous persons suggest that additional work may be needed to better understand the interplay between the various clinical, cultural, environmental, and socioeconomic factors underlying health inequities. It might be possible to achieve substantial reductions in disease burdens associated with AIAN and NHPI populations in the United States by tailoring existing TB control methods to the needs of these groups. Evidence of persistent health disparities serves as a reminder of the ethical imperative to pursue health equity through intentionally prioritized, adequately resourced, and effectively implemented health promotion efforts focused on disproportionately affected populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Disclaimer

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

Appendix 1

Population data for rate calculations were obtained from the U.S. Census Bureau's American Community Survey (ACS) through queries of the Census Bureau website (data.census.gov/mdat) on January 14, 2021. These data are provided in Online Resources 6, 7 and 8 for reference.

Crude annual TB case rate calculations:

To calculate crude annual TB case rates (per 100,000 persons) by patient race/ethnicity group, we obtained annual population estimates from the public use microdata sample (PUMS), 5-year population estimates using queries involving the RAC1P, RAC2P, RAC2P12, RAC3P, HISP, and NATIVITY variables and person-weight weighting as follows:

A. For the AIAN, Asian, Black, and White groups, we obtained annual population estimates using queries involving the RAC1P, HISP, and NATIVITY variables (e.g., https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2019&cv=NATIVITY(1),HISP(01)&rv=RAC1P&wt=PWGTP). For the HISP and NATIVITY variables, we only included counts associated with the "Not Spanish/Hispanic/Latino" and "Native" categories, respectively. For the AIAN group, we summed counts associated with three RAC1P categories ("American Indian alone," "Alaska Native alone," and "American Indian and Alaska Native tribes specified; or American Indian or Alaska Native, not specified and no other race") to generate the population estimate for each year.

B. For the Hispanic group, we obtained annual population estimates using queries involving the HISP and NATIVITY variables (e.g., https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2019&cv=NATIVITY(1)&rv=HISP(02,03,04,05,06,07,08,09,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24)&wt=PWGTP). For the HISP variable, we included counts associated with all categories except "Not Spanish/Hispanic/Latino." For the NATIVITY variable, we only included counts in the "Native" category. We summed counts associated with all 23 HISP categories to generate the population estimate for each year.

C. For the NHPI group, we obtained annual population estimates using queries involving the RAC1P, RAC2P, RAC2P12, RAC3P, HISP, and NATIVITY variables. We did this as follows to obtain estimates as consistent as possible with our NHPI TB case definition, which excluded some NHPI subraces:

    i. For years 2016–2019, we first obtained annual population estimates using queries involving the RAC2P, HISP, and NATIVITY variables (e.g., https://data.census.gov/mdat/#/search? ds=ACSPUMS5Y2019&cv=NATIVITY(1),HISP(01)&rv=RAC2P(60,61,62,63,64,65,66)&wt=PWGTP). For the RAC2P variable, we included counts associated with all seven NHPI-related categories (i.e., NHPI subraces): "Native Hawaiian alone," "Samoan alone," "Tongan alone," "Guamanian or Chamorro alone," "Marshallese alone," "Fijian alone," and "Other Native Hawaiian and Other Pacific Islander." For the HISP and NATIVITY variables, we only included counts associated with the "Not Spanish/Hispanic/Latino" and "Native" categories, respectively. Next, we compared these annual population estimates to those obtained for the "Native Hawaiian and Other Pacific Islander alone" category using the queries involving the RAC1P, HISP, and NATIVITY variables (described above in section 1A). The population estimates generated using the RAC2P queries and the RAC1P queries were the same in each of the four years during 2016–2019. Given this concordance, we summed the counts associated with the three RAC2P categories that we sought to exclude from our NHPI population estimates ("Tongan alone," "Marshallese alone," "Fijian alone") in each year during 2016–2019 and subtracted that sum from the population estimate obtained using the RAC1P query for that year.

    ii. For years 2012–2015, we first obtained annual population estimates using queries involving the RAC2P12, HISP, and NATIVITY variables (e.g., https://data.census.gov/mdat/#/search? ds=ACSPUMS5Y2015&cv=NATIVITY(1),HISP(01)&rv=RAC2P12(60,61,62,63,64,65,66)&wt=PWGTP). For the RAC2P12 variable, we included counts associated with all seven NHPI-related categories (i.e., NHPI subraces): "Native Hawaiian alone," "Samoan alone," "Tongan alone," "Guamanian or Chamorro alone," "Marshallese alone," "Fijian alone", and "Other Native Hawaiian and Other Pacific Islander." For the HISP and NATIVITY variables, we only included counts associated with the "Not Spanish/Hispanic/Latino" and "Native" categories, respectively. Next, we compared these annual population estimates to those obtained for the "Native Hawaiian and Other Pacific Islander alone" category using the queries involving the RAC1P, HISP, and NATIVITY variables (described above in section 1A). The population estimates generated using the RAC2P12 queries and the RAC1P queries were different in each year during 2012–2015. Given this discordance, we summed the counts associated with the three RAC2P12 (or RAC2P)

categories that we sought to exclude from our NHPI population estimates ("Tongan alone," "Marshallese alone," "Fijian alone") in each year during 2012–2019 and quantified the percent of the total population estimate obtained using the RAC2P12 (or RAC2P) query that this sum represented. For each of the three categories that we sought to exclude, these percentages were highly consistent across the seven years (mean±stdev: "Tongan alone" = 5.77%±0.37%, "Marshallese alone" = 2.48%±0.42%, "Fijian alone" = 2.76%±0.19%). Given this consistency we summed the counts associated with the three RAC2P12 categories that we sought to exclude in each year during 2012–2015, calculated the percent of the total population estimated using the RAC2P12 query that this represented, and then reduced the population estimate obtained using the RAC1P query for that year proportionally.

iii. For years 2009–2011, we first obtained annual population estimates using queries involving the RAC3P, HISP, and NATIVITY variables (e.g., https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2011&cv=NATIVITY(1),HISP(01)&rv=RAC3P(02,03,04,05,06)&wt=PWGTP). For the RAC3P variable, we included counts associated with all five NHPI-related categories (i.e., NHPI subraces): "Native Hawaiian alone," "Samoan alone," "Guamanian or Chamorro alone," "Other Pacific Islander alone," and "Native Hawaiian and Other Pacific Islander groups only." For the HISP and NATIVITY variables, we only included counts associated with the "Not Spanish/Hispanic/Latino" and "Native" categories, respectively. Next, we compared these annual population estimates to those obtained for the "Native Hawaiian and Other Pacific Islander alone" category using the queries involving the RAC1P, HISP, and NATIVITY variables (described above in section 1A). The population estimates generated using the RAC3P queries and the RAC1P queries were the same in each year during 2009–2011, but counts for the three NHPI subrace categories that we sought to exclude from our NHPI population estimates ("Tongan alone," "Marshallese alone," "Fijian alone") were not reported separately. Given the aforementioned interannual consistency in the percent of the annual total population estimate associated with counts for these three NHPI subrace categories during 2012–2019, we summed the three percentages in each year during 2012–2019 (range= 10.4–11.4%), averaged these sums across years (mean±stdev: 11.02%±0.003%), rounded this average to the nearest whole percent (11%), and reduced the population estimate obtained using the RAC1P query for each year during 2009–2011 by that proportion.

Age-adjusted annual TB case rate calculations:

To calculate age-adjusted annual TB case rates (per 100,000 persons) by patient race/ethnicity group, we used the direct method, the 2010 U.S. Standard population, and age-stratified annual population estimates from the U.S. Census Bureau's American Community Survey (ACS). We applied the six-level age categorization scheme used in NTSS: <5 years, 5–14 years, 15–24 years, 25–44 years, 45–64 years, and 65 years.

The 2010 U.S. standard population (308,745,538 persons), as estimated using 2010 decennial census data from the U.S. Census Bureau, was partitioned into the six NTSS age categories based on published age-stratified counts [20] as follows: <5 years=20,201,362 persons; 5–14 years=41,025,851 persons; 15–24 years=43,626,342 persons; 25–44 years=82,134,554 persons; 45–64 years=81,489,445 persons; 65 years=40,267,984 persons.

We obtained age-stratified annual population estimates from the public use microdata sample (PUMS), 5-year population estimates using queries involving the RAC1P, HISP, NATIVITY, and AGEP variables and person-weight weighting as follows:

A. For the AIAN, NHPI, Asian, Black, and White groups, we obtained age-stratified annual population estimates using queries involving the RACE1P, HISP, NATIVITY, and AGEP variables (e.g., https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2019&cv=NATIVITY(1),HISP(01),RAC1P&rv=AGEP&wt=PWGTP). For the HISP and NATIVITY variables, we only included counts associated with the "Not Spanish/Hispanic/Latino" and "Native" categories, respectively. For the AIAN group, we summed counts associated with three RAC1P categories ("American Indian alone," "Alaska Native alone," and "American Indian and Alaska Native tribes specified; or American Indian or Alaska Native, not specified and no other race") to generate the population estimate for each year.

B. For the Hispanic group, we obtained age-stratified annual population estimates using queries involving the HISP, NATIVITY, and AGEP variables (e.g., https://data.census.gov/mdat/#/search?ds=ACSPUMS5Y2019&cv=NATIVITY(1),HISP(02,03,04,05,06,07,08,09,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24) &rv=AGEP&wt=PWGTP). For the HISP variable, we included counts associated with all categories except "Not Spanish/Hispanic/Latino." For the NATIVITY variable we only included counts in the "Native" category. We summed counts associated with all 23 HISP categories to generate the population estimate for each year.

C. For the NHPI group, age-stratified counts were not available for the annual population estimates obtained using the queries involving the RAC1P, RAC2P, RAC2P12, RAC3P, HISP, and NATIVITY variables (described above in section 1C). To approximate these, we obtained age-stratified annual population estimates for the "Native Hawaiian and Other Pacific Islander alone" category using queries involving the RACE1P, HISP, NATIVITY, and AGEP variables

(described above in section 2A) and used these to determine the percent of the total population associated with each of the 6 NTSS age categories. We then calculated the products of these percentages and the annual population estimates obtained using the queries involving the RAC1P, RAC2P, RAC2P12, RAC3P, HISP, and NATIVITY variables to complete the age-stratified approximations.

Appendix 2

Among incident TB cases with a count date during January 1, 2009–December 31, 2019, counted within any of the 50 states or DC, and in a patient classified as being U.S.-born and who reported their race/ethnicity as AIAN, NHPI (or both), 332 were not classified into either the AIAN or the NHPI patient race/ethnicity group because they met one of the follow criteria:

A. A total of 106 cases were classified into the Multiple/unknown patient race/ethnicity group because they were in patients who reported their race as AIAN or NHPI (or both) and one or more other races (i.e., multiple race/ethnicity). Of these, 76 were in patients who reported their race as AIAN and another race other than NHPI (the most common other races reported by these patients were White (57) and Black (21)), 28 were inpatients who reported their race as NHPI and another race other than AIAN (the most common other races reported by these patients were White (16) and Asian (11)), and 2 were in patients who reported their race as AIAN and NHPI.

B. A total of 9 cases were classified into the Multiple/unknown patient race/ethnicity group because they were in patients who did not self-report their ethnicity (i.e., unknown race/ethnicity). Of these, 7 reported their race as AIAN, 1 reported their race as NHPI, and 1 reported their race as both AIAN and NHPI.

C. A total of 63 cases were classified into the Hispanic patient race/ethnicity group because they were in patients who reported their ethnicity as Hispanic. Of these, 58 were in patients who reported their race as AIAN, 4 were in patients who reported their race as NHPI, and 1 was in a patient who reported their race as both AIAN and NHPI.

A total of 154 cases were excluded from the analysis entirely because they were in patients who reported a country of birth or an NHPI subrace (or both) not included in our AIAN and NHPI case definitions. Of these, 2 were in patients who reported their race as AIAN and their country of birth as France or India (these patients were likely misreported as AIAN); the remaining 152 were in patients who reported their race as NHPI. These 152 cases were in patients who reported their NHPI subrace and country of birth as follows: 52 Micronesian (of which 23 and 20 reported their country of birth as the United States or the Federated States of Micronesia, respectively), 47 Marshallese (of which 26 and 18 reported their country of birth as the United States or the Marshall Islands, respectively), 19 Chuukese (of which 10 reported their country of birth as the United States), 16 Tongan (of which 15 reported their country of birth as the United States), 4 Samoan, 1 Carolinian, 1 Fijian, 1 Solomon Islander, and 11 cases in patients who did not self-report an NHPI subrace

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(of which 8, 2, and 1 reported their country of birth as the Marshall Islands, Federated States of Micronesia, or Palau, respectively).
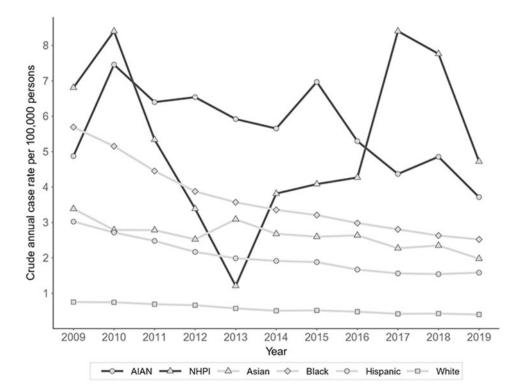
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Fig. 1.
Crude annual tuberculosis (TB) case rates (per 100,000 persons) by race/ethnicity among U.S.-born persons: United States, 2009–2019. AIAN, American Indian or Alaska Native; NHPI, Native Hawaiian or other Pacific Islander
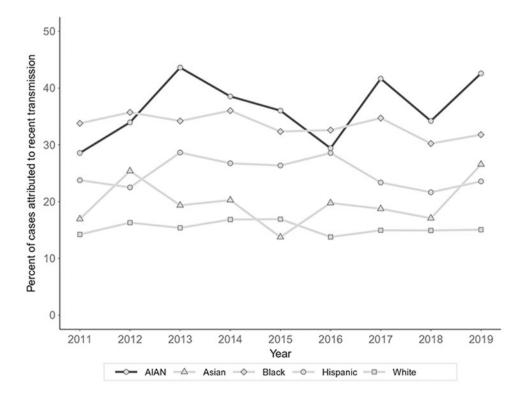
Fig. 2.
Annual percentage of tuberculosis (TB) cases in patients aged 15 years attributed to recent transmission, by race/ethnicity among U.S.-born persons: United States, 2011–2019. AIAN, American Indian or Alaska Native; Native Hawaiian or other Pacific Islander (NHPI) group excluded due to low sample size

Table 1

Characteristics of tuberculosis (TB) cases by race/ethnicity among U.S.-born persons: United States, 2009–2019

Characteristic	Non-Hispanic, N (%)					Hispanic, N (%)	Multiple/unknown, N (%)
	AIAN	NHPI	Asian	Black	White		
Total number of cases	1277 (3.5)	194 (0.5)	1483 (4.1)	14075 (38.6)	11709 (32.1)	7453 (20.4)	318 (0.9)
Sex							
Male	748 (58.6)	112 (57.7)	799 (53.9)	9184 (65.3)	8026 (68.5)	4437 (59.5)	196 (61.6)
Female	528 (41.3)	82 (42.3)	684 (46.1)	4891 (34.7)	3679 (31.4)	3016 (40.5)	122 (38.4)
Unknown/not reported	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.0)	0 (0.0)	0 (0.0)
Age (years)							
<5	57 (4.5)	39 (20.1)	350 (23.6)	597 (4.2)	218 (1.9)	1316 (17.7)	46 (14.5)
5–14	65 (5.1)	20 (10.3)	153 (10.3)	358 (2.5)	96 (0.8)	660 (8.9)	16 (5.0)
15–24	114 (8.9)	28 (14.4)	394 (26.6)	985 (7.0)	396 (3.4)	1350 (18.1)	30 (9.4)
25–44	277 (21.7)	40 (20.6)	347 (23.4)	3466 (24.6)	1939 (16.6)	1780 (23.9)	76 (23.9)
45–64	475 (37.2)	38 (19.6)	103 (6.9)	5864 (41.7)	4858 (41.5)	1439 (19.3)	102 (32.1)
65	289 (22.6)	29 (14.9)	136 (9.2)	2803 (19.9)	4201 (35.9)	908 (12.2)	48 (15.1)
Unknown/not reported	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)
Standard Federal Region[a]							
1 (Upper northeast)	1 (0.1)	0 (0.0)	49 (3.3)	154 (1.1)	320 (2.7)	135 (1.8)	5 (1.6)
2 (Lower northeast)	3 (0.2)	2 (1.0)	137 (9.2)	1039 (7.4)	659 (5.6)	627 (8.4)	35 (11.0)
3 (Mid-Atlantic)	2 (0.2)	2 (1.0)	84 (5.7)	1146 (8.1)	840 (7.2)	191 (2.6)	13 (4.1)
4 (Southeast)	112 (8.8)	13 (6.7)	142 (9.6)	5925 (42.1)	3680 (31.4)	674 (9.0)	53 (16.7)
5 (Upper Midwest)	46 (3.6)	4 (2.1)	130 (8.8)	1646 (11.7)	1441 (12.3)	354 (4.7)	14 (4.4)
6 (Southcentral)	208 (16.3)	49 (25.3)	169 (11.4)	2842 (20.2)	2337 (20.0)	2684 (36.0)	85 (26.7)
7 (Midwest)	7 (0.5)	7 (3.6)	17 (1.1)	228 (1.6)	403 (3.4)	69 (0.9)	9 (2.8)
8 (Central-mountain)	131 (10.3)	4 (2.1)	8 (0.5)	39 (0.3)	173 (1.5)	94 (1.3)	32 (10.1)
9 (Pacific-southwest)	220 (17.2)	72 (37.1)	676 (45.6)	974 (6.9)	1452 (12.4)	2514 (33.7)	58 (18.2)
10 (Pacific-northwest)	547 (42.8)	41 (21.1)	71 (4.8)	82 (0.6)	404 (3.5)	111 (1.5)	14 (4.4)
Case verification criteria[b]							
Positive culture	1064 (83.3)	119 (61.3)	953 (64.3)	10728 (76.2)	9153 (78.2)	5071 (68.0)	231 (72.6)

Characteristic		Non-Hispanic, N (%)					Hispanic, N (%)	Multiple/ unknown, N (%)
		AIAN	NHPI	Asian	Black	White		
	Nucleic acid amplification test	27 (2.1)	2 (1.0)	23 (1.6)	181 (1.3)	243 (2.1)	96 (1.3)	5 (1.6)
	Smear positive (in absence of culture)	2 (0.2)	0 (0.0)	1 (0.1)	73 (0.5)	70 (0.6)	50 (0.7)	1 (0.3)
	Clinical case definition	130 (10.2)	62 (32.0)	395 (26.6)	2199 (15.6)	1348 (11.5)	1683 (22.6)	54 (17.0)
	Provider diagnosis	54 (4.2)	11 (5.7)	111 (7.5)	894 (6.4)	895 (7.6)	553 (7.4)	27 (8.5)
Site of disease								
	Pulmonary only	968 (75.8)	119 (61.3)	1022 (68.9)	10091 (71.7)	9269 (79.2)	5243 (70.3)	233 (73.3)
	Extrapulmonary only	187 (14.6)	46 (23.7)	279 (18.8)	2624 (18.6)	1644 (14.0)	1413 (19.0)	54 (17.0)
	Both	121 (9.5)	28 (14.4)	181 (12.2)	1352 (9.6)	791 (6.8)	796 (10.7)	30 (9.4)
	Unknown/not reported	1 (0.1)	1 (0.5)	1 (0.1)	8 (0.1)	5 (0.0)	1 (0.0)	1 (0.3)
	RR (95% CI)[c]	0.99 (0.97, 1.02)	0.89 (0.82, 0.96)*	0.94 (0.92, 0.97)*	0.95 (0.94, 0.96)*	Ref	0.94 (0.93, 0.96)*	0.97 (0.92, 1.02)
Pulmonary cavity[d]								
	Yes	296 (27.2)	19 (12.9)	203 (16.9)	3492 (30.5)	2832 (28.2)	1431 (23.7)	74 (28.1)
	No	621 (57.0)	116 (78.9)	920 (76.5)	6606 (57.7)	5917 (58.8)	4054 (67.1)	153 (58.2)
	Unknown/not reported	172 (15.8)	12 (8.2)	80 (6.7)	1345 (11.8)	1311 (13.0)	553 (9.2)	36 (13.7)
	RR (95% CI)[e]	1 (0.90, 1.10)	0.43 (0.29, 0.66)*	0.56 (0.49, 0.63)*	1.07 (1.03, 1.11)*	Ref	0.81 (0.76, 0.85)*	1.01 (0.83, 1.22)
Sputum smear for acid-fast bacilli								
	Positive	540 (42.3)	46 (23.7)	374 (25.2)	5505 (39.1)	4687 (40.0)	2423 (32.5)	128 (40.3)
	Negative	540 (42.3)	79 (40.7)	609 (41.1)	6114 (43.4)	4969 (42.4)	2742 (36.8)	107 (33.6)
	Not done	196 (15.3)	68 (35.1)	499 (33.6)	2444 (17.4)	2043 (17.4)	2282 (30.6)	82 (25.8)
	Unknown/not reported	1 (0.1)	1 (0.5)	1 (0.1)	12 (0.1)	10 (0.1)	6 (0.1)	1 (0.3)
	RR (95% CI)[f]	1.06 (0.99, 1.13)	0.59 (0.46, 0.77)*	0.63 (0.58, 0.69)*	0.98 (0.95, 1.01)	Ref	0.81 (0.78, 0.84)*	1.01 (0.88, 1.15)
Sputum culture								
	Positive	862 (67.5)	70 (36.1)	619 (41.7)	7699 (54.7)	6647 (56.8)	3484 (46.7)	171 (53.8)
	Negative	217 (17.0)	52 (26.8)	347 (23.4)	3780 (26.9)	2883 (24.6)	1594 (21.4)	58 (18.2)
	Not done	195 (15.3)	70 (36.1)	510 (34.4)	2547 (18.1)	2126 (18.2)	2348 (31.5)	87 (27.4)
	Unknown/not reported	3 (0.2)	2 (1.0)	7 (0.5)	49 (0.3)	53 (0.5)	27 (0.4)	2 (0.6)
	RR (95% CI)[f]	1.19 (1.14, 1.24)*	0.64 (0.53, 0.77)*	0.74 (0.69, 0.78)*	0.96 (0.94, 0.98)*	Ref	0.82 (0.80, 0.85)*	0.95 (0.86, 1.05)

Characteristic	Non-Hispanic, N (%)					Hispanic, N (%)	Multiple/ unknown, N (%)
	AIAN	NHPI	Asian	Black	White		
Previous TB							
Yes	100 (7.8)	5 (2.6)	39 (2.6)	639 (4.5)	465 (4.0)	191 (2.6)	7 (2.2)
No	1170 (91.6)	185 (95.4)	1442 (97.2)	13346 (94.8)	11174 (95.4)	7209 (96.7)	302 (95.0)
Unknown/not reported	7 (0.5)	4 (2.1)	2 (0.1)	90 (0.6)	70 (0.6)	53 (0.7)	9 (2.8)
RR (95% CI)[e]	1.97 (1.60, 2.43)*	0.66 (0.13, 1.29)	0.66 (0.48, 0.91)*	1.14 (1.02, 1.29)*	Ref	0.65 (0.55, 0.76)*	0.57 (0.17, 1.02)
HIV status at time of diagnosis[g]							
Positive	24 (2.3)	1 (0.7)	9 (0.7)	1306 (12.6)	299 (3.4)	298 (5.1)	31 (11.1)
Negative	877 (85.4)	132 (88.6)	952 (78.8)	8045 (77.4)	7076 (79.8)	4471 (77.0)	207 (74.2)
Otherh	121 (11.8)	13 (8.7)	215 (17.8)	932 (9.0)	1302 (14.7)	944 (16.3)	31 (11.1)
Unknown/not reported	5 (0.5)	3 (2.0)	32 (2.6)	106 (1.0)	187 (2.1)	91 (1.6)	10 (3.6)
RR (95% CI)[i]	0.66 (0.44, 0.99)*	0.19 (0, 0.59)*	0.23 (0.10, 0.40)*	3.44 (3.05, 3.89)*	Ref	1.54 (1.32, 1.80)*	3.21 (2.27, 4.54)*
Diabetes mellitus at time of diagnosis[j]							
Yes	193 (16.4)	35 (20.0)	96 (7.2)	1665 (13.7)	1263 (12.3)	1004 (15.2)	31 (10.5)
Unknown/not reported	986 (83.6)	140 (80.0)	1241 (92.8)	10489 (86.3)	9011 (87.7)	5603 (84.8)	264 (89.5)
RR (95% CI)[k]	1.33 (1.16, 1.53)*	1.63 (1.20, 2.20)*	0.58 (0.48, 0.71)*	1.11 (1.04, 1.19)*	Ref	1.24 (1.14, 1.33)*	0.85 (0.61, 1.20)
Immunosuppressed[l] at time of diagnosis[j]							
Yes	41 (3.5)	7 (4.0)	40 (3.0)	660 (5.4)	1116 (10.9)	245 (3.7)	11 (3.7)
Unknown/not reported	1138 (96.5)	168 (96.0)	1297 (97.0)	11494 (94.6)	9158 (89.1)	6362 (96.3)	284 (96.3)
RR (95% CI)[k]	0.32 (0.24, 0.43)*	0.37 (0.11, 0.65)*	0.28 (0.20, 0.38)*	0.5 (0.46, 0.55)*	Ref	0.34 (0.30, 0.39)*	0.34 (0.19, 0.61)*
End-stage renal disease or chronic renal failure at time of diagnosis[j]							
Yes	38 (3.2)	10 (5.7)	12 (0.9)	415 (3.4)	173 (1.7)	140 (2.1)	6 (2.0)
Unknown/not reported	1141 (96.8)	165 (94.3)	1325 (99.1)	11739 (96.6)	10101 (98.3)	6467 (97.9)	289 (98.0)
RR (95% CI)[k]	1.91 (1.35, 2.71)*	3.39 (1.44, 5.74)*	0.53 (0.30, 0.95)*	2.03 (1.70, 2.42)*	Ref	1.26 (1.01, 1.57)*	1.21 (0.38, 2.29)
Type of therapy[m]							

Characteristic	Non-Hispanic, N (%)					Hispanic, N (%)	Multiple/unknown, N (%)
	AIAN	NHPI	Asian	Black	White		
Directly observed therapy alone	878 (83.6)	94 (63.9)	715 (59.0)	8176 (69.7)	5923 (61.1)	3853 (63.5)	147 (61.5)
Self-administered therapy alone	25 (2.4)	13 (8.8)	117 (9.7)	550 (4.7)	800 (8.3)	280 (4.6)	10 (4.2)
Both	141 (13.4)	37 (25.2)	372 (30.7)	2863 (24.4)	2826 (29.1)	1864 (30.7)	79 (33.1)
Unknown/not reported	6 (0.6)	3 (2.0)	8 (0.7)	149 (1.3)	147 (1.5)	72 (1.2)	3 (1.3)
RR (95% CI)[n]	1.06 (1.05, 1.07)*	1 (0.96, 1.05)	0.99 (0.97, 1.01)	1.04 (1.03, 1.04)*	Ref	1.04 (1.03, 1.05)*	1.04 (1.02, 1.07)*
Outcome of therapy[o]							
Completed treatment	907 (82.8)	134 (89.9)	1141 (92.8)	10225 (83.7)	8238 (81.2)	5502 (88.0)	209 (82.9)
Died	111 (10.1)	7 (4.7)	38 (3.1)	1056 (8.6)	1019 (10.0)	304 (4.9)	18 (7.1)
Other[p]	29 (2.6)	4 (2.7)	31 (2.5)	400 (3.3)	363 (3.6)	231 (3.7)	9 (3.6)
Unknown/not reported	49 (4.5)	4 (2.7)	20 (1.6)	534 (4.4)	522 (5.1)	214 (3.4)	16 (6.3)
RR (95% CI)[q]	1.01 (0.99, 1.04)	1.08 (1.03, 1.12)*	1.1 (1.08, 1.12)*	1.02 (1.01, 1.03)*	Ref	1.06 (1.05, 1.07)*	1.02 (0.97, 1.07)

AIAN, American Indian or Alaska Native; *NHPI*, Native Hawaiian or other Pacific Islander; *RR*, risk ratio; *CI*, confidence interval, calculated using the normal approximation (Wald) method when the numerator for the non-reference group RR was >10 and otherwise using a bootstrap method with 10,000 replicates

[a] Standard Federal Regions include the following states and district (informal geographic names assigned by the authors and added parenthetically for reference): 1 (Upper northeast): CT, MA, ME, NH, RI, VT; 2 (Lower northeast): NJ, NY (PR, VI excluded); 3 (Mid-Atlantic): DC, DE, MD, PA, VA, WV; 4 (Southeast): AL, FL, GA, KY, MS, NC, SC, TN; 5 (Upper Midwest): IL, IN, MI, MN, OH, WI; 6 (Southcentral): AR, LA, NM, OK, TX; 7 (Midwest): IA, KS, MO, NE; 8 (Central-mountain): CO, MT, ND, SD, UT, WY; 9 (Pacific-southwest): AZ, CA, HI, NV (AS, GU, MP excluded); 10 (Pacific-northwest): AK, ID, OR, WA [21]

[b] Definitions from the United States Centers for Disease Control and Prevention [7]

[c] Comparing any pulmonary disease ("Pulmonary only"; "Both") versus "Extrapulmonary only" and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals

[d] Includes only persons with any pulmonary TB and abnormal chest radiograph or abnormal chest computerized tomography scan (or both)

[e] Comparing "Yes" versus "No" and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals

[f] Comparing "Positive" versus other testing outcomes ("Negative"; "Not done") and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals

[g] or 2011–2019 only

[h] Includes: indeterminate; not offered; refused; test done, results unknown

[i] Comparing "Positive" versus "Negative" and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals

[j]For 2010–2019 only

[k]Comparing "Yes" versus "Unknown/not reported" and calculated using the White race/ethnicity group as the reference; asterisk designates $P<0.05$ based on confidence intervals

[l]Includes: "Had immunosuppression due to either a medical condition or medication, or immunosuppressive therapy, excluding diabetes mellitus, end-stage renal disease, and HIV/AIDS"; "Had recently received, or was receiving, TNF-α antagonist therapy at the time of TB diagnosis"

[m]For 2009–2017 only. Includes patients alive at diagnosis with initial drug regimen of one or more drugs prescribed

[n]Comparing any directly observed therapy ("Directly observed therapy alone"; "Both") versus "Self administered therapy alone" and using the White race/ethnicity group as the reference; asterisk designates $P<0.05$ based on confidence intervals

[o]For 2009–2017 only

[p]Includes: "Adverse treatment event"; "Lost"; "Moved"; "Not TB"; "Other"; "Refused"

[q]Comparing "Completed treatment" versus other treatment outcomes ("Died"; "Other") and calculated using the White race/ethnicity group as the reference; asterisk designates $P<0.05$ based on confidence intervals

Table 2

Characteristics of tuberculosis (TB) cases in patients aged ≥15 years by race/ethnicity among U.S.-born persons: United States, 2009–2019

Characteristic	Non-Hispanic, N (%)					Hispanic, N (%)	Multiple/ unknown, N (%)
	AIAN	NHPI	Asian	Black	White		
Total number of cases involving patients aged ≥15 years and older	1155 (3.6)	135 (0.4)	980 (3.0)	13118 (40.3)	11394 (35.0)	5477 (16.8)	256 (0.8)
Excess alcohol use within past year							
Yes	431 (37.3)	16 (11.9)	48 (4.9)	3054 (23.3)	2309 (20.3)	954 (17.4)	54 (21.1)
No	708 (61.3)	116 (85.9)	922 (94.1)	9850 (75.1)	8915 (78.2)	4424 (80.8)	181 (70.7)
Unknown/not reported	16 (1.4)	3 (2.2)	10 (1.0)	214 (1.6)	170 (1.5)	99 (1.8)	21 (8.2)
RR (95% CI)[a]	1.84 (1.69, 2.00)*	0.59 (0.37, 0.93)*	0.24 (0.18, 0.32)*	1.15 (1.10, 1.21)*	Ref	0.86 (0.81, 0.92)*	1.12 (0.88, 1.42)
Noninjection drug use within past year							
Yes	224 (19.4)	12 (8.9)	44 (4.5)	2802 (21.4)	1445 (12.7)	964 (17.6)	52 (20.3)
No	907 (78.5)	119 (88.1)	928 (94.7)	10116 (77.1)	9782 (85.9)	4420 (80.7)	186 (72.7)
Unknown/not reported	24 (2.1)	4 (3.0)	8 (0.8)	200 (1.5)	167 (1.5)	93 (1.7)	18 (7.0)
RR (95% CI)[a]	1.54 (1.36, 1.75)*	0.71 (0.41, 1.22)	0.35 (0.26, 0.47)*	1.69 (1.59, 1.79)*	Ref	1.39 (1.29, 1.50)*	1.7 (1.33, 2.17)*
Injection drug use within past year							
Yes	26 (2.3)	4 (3.0)	8 (0.8)	426 (3.2)	382 (3.4)	273 (5.0)	10 (3.9)
No	1107 (95.8)	127 (94.1)	964 (95.1)	12480 (95.1)	10860 (95.3)	5111 (93.3)	226 (88.3)
Unknown/not reported	22 (1.9)	4 (3.0)	8 (0.8)	212 (1.6)	152 (1.3)	93 (1.7)	20 (7.8)
RR (95% CI)[a]	0.68 (0.46, 1.00)	0.90 (0.21, 1.89)	0.24 (0.09, 0.43)*	0.97 (0.85, 1.11)	Ref	1.49 (1.28, 1.74)*	1.25 (0.53, 2.07)
Primary occupation within past year[b]							
Unemployed	418 (39.4)	27 (22.0)	134 (15.1)	4629 (40.9)	2682 (26.8)	1471 (30.0)	63 (26.5)
Other[c]	609 (57.4)	89 (72.4)	745 (83.8)	6369 (56.3)	7099 (71.0)	3312 (67.5)	151 (63.4)
Unknown/not reported	34 (3.2)	7 (5.7)	10 (1.1)	309 (2.7)	217 (2.2)	125 (2.5)	24 (10.1)
RR (95% CI)[d]	1.48 (1.37, 1.61)*	0.85 (0.61, 1.18)	0.56 (0.47, 0.65)*	1.53 (1.48, 1.60)*	Ref	1.12 (1.06, 1.18)*	1.07 (0.87, 1.32)

Characteristic	Non-Hispanic, N (%)					Hispanic, N (%)	Multiple/ unknown, N (%)
	AIAN	NHPI	Asian	Black	White		
Experienced homelessness within past year							
Yes	170 (14.7)	11 (8.1)	19 (1.9)	1799 (13.7)	1138 (10.0)	467 (8.5)	31 (12.1)
No	976 (84.5)	124 (91.9)	960 (98.0)	11217 (85.5)	10191 (89.4)	4976 (90.9)	218 (85.2)
Unknown/not reported	9 (0.8)	0 (0.0)	1 (0.1)	102 (0.8)	65 (0.6)	34 (0.6)	7 (2.7)
RR (95% CI)[a]	1.48 (1.27, 1.71)*	0.81 (0.46, 1.43)	0.19 (0.12, 0.30)*	1.38 (1.28, 1.48)*	Ref	0.85 (0.77, 0.95)*	1.24 (0.89, 1.73)
Resident of correctional facility at time of diagnosis							
Yes	33 (2.9)	2(1.5)	12 (1.2)	817 (6.2)	380 (3.3)	403 (7.4)	16 (6.3)
No	1119 (96.9)	133 (98.5)	967 (98.7)	12248 (93.4)	10967 (96.3)	5036 (91.9)	233 (91.0)
Unknown/not reported	3 (0.3)	0 (0.0)	1 (0.1)	53 (0.4)	47 (0.4)	38 (0.7)	7 (2.7)
RR (95% CI)[a]	0.86 (0.60, 1.21)	0.44 (0, 1.14)	0.37 (0.21, 0.65)*	1.87 (1.66, 2.10)*	Ref	2.21 (1.93, 2.54)*	1.92 (1.18, 3.11)*
Attributed to recent transmission[e]							
Yes	286 (36.1)	12 (14.5)	124 (19.6)	2485 (33.6)	1002 (15.4)	828 (25.0)	54 (30.2)
No	506 (63.9)	71 (85.5)	510 (80.4)	4902 (66.4)	5503 (84.6)	2482 (75.0)	125 (69.8)
RR (95% CI)[a]	2.34 (2.10, 2.61)*	0.94 (0.55, 1.59)	1.27 (1.07, 1.50)*	2.18 (2.05, 2.33)*	Ref	1.62 (1.50, 1.76)*	1.96 (1.56, 2.47)*
Status as infectious[f]							
Sputum acid fast bacilli smear positive, non-cavitary disease	255 (32.2)	26 (32.5)	196 (28.4)	2431 (28.1)	2199 (28.8)	1204 (31.4)	55 (31.8)
Sputum acid fast bacilli smear negative, cavitary disease	44 (5.6)	2 (2.5)	40 (5.8)	715 (8.3)	643 (8.4)	272 (7.1)	15 (8.7)
Sputum acid fast bacilli smear positive, cavitary disease	237 (30.0)	17 (21.3)	145 (21.0)	2578 (29.8)	2016 (26.4)	1025 (26.8)	56 (32.4)
Sputum smear acid fast bacilli negative, non-cavitary disease	255 (32.2)	35 (43.8)	309 (44.8)	2934 (33.9)	2789 (36.5)	1328 (34.7)	47 (27.2)
RR (95% CI)[g]	1.07 (1.01, 1.12)*	0.89 (0.73, 1.08)	0.87 (0.81, 0.93)*	1.04 (1.02, 1.06)*	Ref	1.03 (1.00, 1.06)	1.15 (1.05, 1.26)*

AIAN, American Indian or Alaska Native; *NHPI*, Native Hawaiian or other Pacific Islander; *RR*, risk ratio; *CI*, confidence interval, calculated using the normal approximation (Wald) method when the numerator for the non-reference group RR was >10 and otherwise using a bootstrap method with 10,000 replicates

[a]Comparing "Yes" versus "No"" and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals

[b]For 2010–2019 only

[c]Includes: "Correctional facility employee"; "Health care worker"; "Migrant/seasonal worker"; "Not seeking employment"; "Other"; "Retired"

[d]Comparing "Unemployed" versus "Other" and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals

[e]For 2011–2019 only; using the plausible source-case method[17] to identify TB cases attributed to recent transmission

[f]Includes only persons with any pulmonary TB

[g]Comparing any characteristic associated with infectivity ("Sputum acid fast bacilli smear positive, non-cavitary disease"; "Sputum acid fast bacilli smear negative, cavitary disease"; "Sputum acid fast bacilli smear positive, cavitary disease") versus "Sputum acid fast bacilli smear negative, non-cavitary disease" and calculated using the White race/ethnicity group as the reference; asterisk designates *P*<0.05 based on confidence intervals