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Burden of tuberculosis in indigenous peoples globally: a systematic review

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SUMMARY

BACKGROUND—The burden of tuberculosis (TB) in the estimated 370 million indigenous peoples worldwide is unknown.

OBJECTIVE—To conduct a literature review to summarize the TB burden in indigenous peoples, identify gaps in current knowledge, and provide the foundation for a research agenda prioritizing indigenous health within TB control.

METHODS—A systematic literature review identified articles published between January 1990 and November 2011 quantifying TB disease burden in indigenous populations worldwide.

RESULTS—Among the 91 articles from 19 countries included in the review, only 56 were from outside Australia, Canada, New Zealand and the United States. The majority of the studies showed higher TB rates among indigenous groups than non-indigenous groups. Studies from the Amazon generally reported the highest TB prevalence and incidence, but select populations from South-East Asia and Africa were found to have similarly high rates of TB. In North America, the Inuit had the highest reported TB incidence (156/100 000), whereas the Metis of Canada and American Indians/Alaska Natives experienced rates of <10/100 000. New Zealand's Maori and Pacific Islanders had higher TB incidence rates than Australian Aborigines, but all were at greater risk of developing TB than non-indigenous groups.

CONCLUSION—Where data exist, indigenous peoples were generally found to have higher rates of TB disease than non-indigenous peoples; however, this burden varied greatly. The paucity of published information on TB burden among indigenous peoples highlights the need to implement and improve TB surveillance to better measure and understand global disparities in TB rates.

Keywords

tuberculosis; indigenous; surveillance; global

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Although the estimated 370 million indigenous people worldwide[1] comprise <5% of the global population, evidence from nations where surveillance data exist suggests that the burden of tuberculosis (TB) falls heavily on indigenous peoples[2–6] and that they are disproportionately affected.[7] Furthermore, of the estimated 8.8 million new cases of TB occurring each year, the burden and current state of TB in the indigenous peoples inhabiting more than 70 countries globally are not known. The Strategic Framework for Action on TB Control in Indigenous Communities emphasizes the need to increase the awareness and surveillance of TB among indigenous peoples by documenting and highlighting the incidence and burden of TB in these groups.[8]

Given the lack of information about TB among the world's indigenous peoples, this systematic literature review was conducted to better understand, document and summarize the burden of TB in indigenous peoples, identify gaps in our knowledge, develop recommendations for future work and provide the foundation to set an appropriate research agenda prioritizing indigenous health within TB control.

METHODS

Search strategy

A systematic literature review using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework[9] was conducted of articles related to the epidemiology of TB in indigenous populations published during January 1990–November 2011, focusing on articles that quantified the burden of TB disease in indigenous groups. PubMed was used to search biomedical literature from Medline, journals and online books. CabDirect was used to ensure that articles published on global issues in the applied life sciences were also searched. Subject and keyword terms used in this review are listed in Table 1.

The United Nation's definition of indigenous peoples, i.e., any group of people who self-identify as indigenous to be indigenous, was used in this paper.[1,10] For countries with disaggregated TB data, indigenous status is largely self-reported; in these countries, the names of the indigenous groups were used for the systematic search. To ensure that the search was comprehensive, names of indigenous groups from nations where disaggregated data do not exist were gathered from Bartlett et al.'s article on indigenous people and global health research,[10] and from organizations representing regional indigenous issues to the United Nations Permanent Forum on Indigenous Issues (UNPFII), specifically the Indigenous Peoples of Africa Coordinating Committee,[11] the Russian Association of Indigenous Peoples of the Far North[12] and the Asia Indigenous Peoples Pact.[13] In addition, country reports submitted to the UNPFII and relevant conference abstracts on indigenous health were used to ensure as broad and inclusive a search strategy as possible.

Study selection

Articles of any language were included if they provided data on the burden of TB disease in indigenous populations that were 1) collected during or after 1990 in Australia, Canada, New Zealand or the United States, or 2) collected during or after 1985 in any other country.

We allowed the five additional years of data where research was infrequent to maximize the number of indigenous groups represented in this study. Primary and secondary research articles, including published government reports, were included. The references of included articles were reviewed to identify additional papers of interest. To ensure the most comprehensive review, studies of all sizes and scope were included. Published literature reviews summarizing findings for a particular group were not included in this review but were read to identify pertinent sources. Articles with unclear methodology regarding incidence or prevalence calculations were excluded (Figure 1).

Data extraction

The World Health Organization (WHO) regions were used to organize articles based on the geographic location of the studies. The region of the Americas was further divided into North and Latin America, the latter including Mexico and the Caribbean. Two authors independently reviewed abstracts and articles for each region and came to a consensus on the inclusion or exclusion of each article. Authors extracted the data using a standardized format developed based on study objectives, a review of similar studies, and the variables needed. Authors verified the extracted data and came to a consensus when discrepancies arose.

The following variables were collected from each included study: location, including country and province or region; name of indigenous groups(s); study design; scope of study; year(s) data were collected; number of people studied; reported burden of TB (incidence or prevalence per 100 000 population); and the TB burden in a local non-indigenous population. TB incidence and/or prevalence were calculated if the number of TB cases and a population estimate were provided. If TB rates in a local non-indigenous population were not provided, the WHO-reported national TB incidence or estimated prevalence for the year data were collected was used for comparison; if the study occurred over multiple years, the WHO reported rate was chosen for the final year of data collection. From these data, a ratio was calculated to estimate the differences in TB incidence and/or prevalence in indigenous and non-indigenous groups.

RESULTS

Subject and keyword searches conducted in PubMed and CabDirect identified 534 unique articles. Four additional articles were identified from the references of papers read. Ninety-one articles related to TB in indigenous peoples in 19 countries were included in the review (Figure 2). Over three quarters of the included articles were published during 2000–2011, but the most recent available data on TB in indigenous populations varied widely between regions and countries. Twenty-seven of 35 articles from countries with disaggregated data were published after 2000; 16 of 18 studies from Latin America and 17/21 studies from South-East Asia were also published after 2000; and studies from the African, Eastern Mediterranean and European regions were largely published before 2000.

There was also substantial variation in the design and scope of the studies included in the review, specifically between countries that had disaggregated national TB surveillance data and those that did not. Many included articles were based on studies of small populations,

reporting no levels of statistical uncertainty; as such, the quality of data within the studies varied. Table 2 summarizes the methodology and scope of the included literature.

TB burden by region

African Region—Although the estimated number of indigenous people living in Africa is 14.2 million,[10] only two studies from the African region fulfilled the inclusion criteria for this review. The included studies relied on small community health surveys, accompanied by medical examinations or reviews of hospital records, to assess TB status within indigenous populations.[14,15] The available data suggest that the prevalence of TB may be substantially higher among indigenous than non-indigenous African populations. The prevalence of TB disease was found to exceed 4000/100 000 among the nomadic Fulani in Chad,[15] and 1800 among the Peul and Dogon peoples in Mali (Table 3).[14]

The Americas: North America—The indigenous groups of North America included in the review are comprised broadly of the following: First Nations (or North American Indians), Metis and Inuit in Canada, and American Indians (AI), Alaskan Natives (AN), Native Hawaiians (NH) and Pacific Islanders (PI) in the United States. Approximately 4.4% of Canada's population reported some indigenous ancestry as of 2009,[10] and in the United States, 2.3 million and 435 000 persons were identified solely as respectively AI/AN and NH/PI in 2008.[44] There are many published studies on the TB burden among indigenous groups living in the United States and Canada. Studies from these two countries predominantly included retrospective reviews based on national governmental surveillance data (Table 3).

The most recent data indicate that TB incidence continues to be substantially higher among indigenous groups across Canada and the United States than among non-indigenous groups.[6,16,17,44–64] In the United States, AI/AN and NH/PI had 6.8 and 22.9 times greater TB incidence than Whites in 2010.[6,16] TB incidence rates in NH/PI are higher than in AI/AN,[6,16,44,59] but tribal-specific data, such as among the Oglala Sioux, reveals pockets where TB incidence is much higher.[47] From 2008 to 2010, TB incidence rose for both AI/AN and NH/PI, but overall TB incidence has decreased among both groups in the last two decades.[53]

TB incidence in indigenous populations in Canada is higher than in the United States. The northern tribes of Canada are most affected by TB: in 2009, TB incidence was 155.8/100 000 among Canada's Inuit, over 150 times the rate among non-aboriginals born in Canada.[17] In comparison, national TB incidence among the Metis and the First Nations peoples were respectively 7.3 and 27.4 times higher than in non-aboriginal Canadians.[17]

The Americas: Latin America and the Caribbean—It is estimated that Latin America is home to 450 indigenous groups comprised of 34 million people, which make up 8% of the region's total population.[10] In Brazil alone, there are an estimated 220 indigenous groups composed of 450 000 people, more than 60% of whom live in the Brazilian Amazon.[65] The majority of the studies from this region included in this review were from the Brazilian Amazon,[19,20,22,23,66–74] with fewer studies coming from Ecuador, Paraguay, Peru and Venezuela (Table 3; Appendix*).[18,21,24–26] No studies from the Caribbean, Mexico or

Central America were found that fit the study criteria, although indigenous communities make up large parts of their populations.[10]

Overall, indigenous peoples across Latin America were found to have extremely high burdens of TB. Brazilian Amazonian groups were some of the most affected, with TB incidence rates often exceeding 1000/100 000, or at least 20 times higher than the incidence in the general Brazilian population.[67,70,73] In particular, the most recent study of the Yanomami people found the incidence of TB to be 2133/100 000, or 37 times higher than in the surrounding non-indigenous population;[72] the prevalence of TB among the Yanomami was estimated to be up to 94 times higher than in the provincial population.[73] Indigenous people living in Cotopaxi Province in Ecuador's highlands had TB prevalence rates reaching 6700/100 000, over 40 times Ecuador's national prevalence.[24] A study of the Ache of Paraguay reported a TB incidence 75 times greater than the national incidence.[18]

Conversely, certain indigenous groups were found to have a TB burden lower than or equal to their non-indigenous counterparts. In Peru, for example, one study found a TB incidence in indigenous peoples similar to or lower than in the general population.[21] Within this study, many Amazonian tribes, such as the Aguaruna, Nomastshiguenga, Shawi and Shapra, had TB incidence rates of 0.4–0.9 times the national incidence.[21] In addition, a study among indigenous children (aged <15 years) in southwestern Brazil showed that TB incidence decreased between 2001 and 2006, attributed in part to a new TB control strategy that had been implemented.[23]

Eastern Mediterranean Region—This review identified one study quantifying the burden of TB among Bedouins in Israel, which found TB incidence to be 18.1/100 000 in 1987, approximately twice as high as the 1990 national Israeli TB incidence.[27]

European Region—The indigenous peoples of Europe are generally considered those who adhere to traditional lifestyles in the Far North. Over 40 broadly defined indigenous populations are recognized in Greenland, Scandinavia and Russia, including the Inuit, the Sami, and the Nenets, Chukchi and Evenks, respectively.[10,63] The Roma are also considered an indigenous group prominent in this region.[75]

The largest and most recent studies quantifying the TB burden in Europe were conducted in Greenland,[29,76] where 80% of persons are indigenous Inuit (Table 3).[10] From 1990 to 2001, the incidence of active TB increased in this population from 85 to 185 cases/100 000.[76] Furthermore, the most recent study found that the odds of developing active TB were 15.3 times higher in indigenous groups compared to those of Danish heritage.[29]

Outside Greenland, there was much less information from the European region. Although Scandinavia is estimated to have approximately 70 000 Sami,[63] no studies were found that described the burden of TB within this population, and government data for TB in areas where the Sami predominantly reside were not disaggregated.[63] Very little is also known about TB within the Roma population;[75] only one study conducted among Roma was

*The Appendix is available in the online version of this article at http://www.ingentaconnect.com/content/iuatld/ijtld/2013/00000017/00000009/art00005

identified for this review, which found the Roma in Barcelona to have a TB incidence 5.3 times greater than Spain's national TB incidence.[30]

More than 280 000 indigenous persons are estimated to live in Russia,[63] but studies quantifying TB incidence or prevalence within these populations were sparse and limited in scope.[28,77–80] The data that exist show indigenous peoples to be substantially more burdened by TB than their non-indigenous counterparts. In areas of northeastern Russia, TB prevalence was found to be 10 times higher among indigenous than non-indigenous persons.[77] However, data suggest that the TB burden has been declining, narrowing the gap between indigenous and non-indigenous groups in Russia.[28,79] No studies with data collected within the last decade were found for this review, and thus the current TB burden among the indigenous of Russia's Far North is largely unknown.

South-East Asia Region—It is estimated that three quarters of the world's indigenous people live in Asia, with over 250 indigenous groups residing in India and 60 in Thailand alone.[10] Despite the large number of indigenous people in Asia, data quantifying the burden of TB were only readily available from India.

Within India, the majority of studies were conducted in the central state of Madhya Pradesh, where tribal groups account for more than 25% of the total population (Table 3).[32–37,81–83] Data on TB burden were primarily gathered through cross-sectional surveys conducted by academic institutions and medical research centers.

In India, the majority of tribal groups demonstrated higher TB burdens than non-tribal peoples.[32,34–37,81–83] The Saharia were the most disproportionately affected, with a TB prevalence from 5 to >100 times greater than India's national TB prevalence.[32,37,83] The differential burden was smaller, but still substantial, between other tribal groups and the national prevalence estimates. For example, the prevalence of TB among the Bhil, Bharia and Nicobarese tribes was 1.3–8.0 times greater than the estimated national TB prevalence, while the Baiga and Jawadhu Hills tribes were found to have TB prevalence measurements 45–50% lower than national estimates.[33,84]

Although the burden of TB was largely found to be greater in indigenous than the non-indigenous groups in India,[85] TB prevalence varied widely between groups even within the same geographic region. Within Madhya Pradesh, TB prevalence was documented to be 0.15% among the Baiga[33] and 0.43% among the Bharia,[34] but between 1.4% and 46% among the Saharia tribal groups.[35–37,83] In a study conducted in Maharashtra State, active TB was identified in only six of 46 tribal groups.[38] However, in tribes where active TB was observed, TB prevalence reached 730/100 000, five times greater than the provincial TB prevalence.[38]

The data also suggest that changes in the TB burden over time have been variable within tribal groups. In Tamil Nadu's Jawadhu Hills Tribes, TB prevalence decreased by four fold from 1989 to 1993.[82,84] However, only a minimal decline in TB has been observed among the Saharia between 1991 and the present,[36,37,82] with reports of increased burden in some areas.[83]

Western Pacific Region—The Western Pacific is home to many indigenous peoples: the Aborigines and Torres Strait Islanders descendants in Australia; the Maori and Pacific Islanders in New Zealand; the mountainous aborigine of Taiwan; fifty-five ethnic minority groups in China; and hills peoples and other aborigine groups in the Philippines, Indonesia, Viet Nam and surrounding nations.[10] However, data on TB burden were available only for Australia, New Zealand, Taiwan and, to a lesser extent, China (Figure 2). The available data indicate that TB continues to disproportionately affect the indigenous populations of the Western Pacific Region (Table 3).

The incidence of TB was lower among the indigenous populations in Australia and New Zealand than in many regions of the world, but in comparison to the non-indigenous populations, the indigenous groups were disproportionately burdened with TB. Although TB incidence has decreased among Australian Aborigines in the past years,[4,86–90] incidence rates remain over seven times higher among Aborigines than among Australian-born non-Aborigines.[4] In Southern Australia and the Northern Territory, Aborigines are most disproportionately affected by TB,[89,90] and have a 13 times higher TB incidence than their non-Aborigine counterparts.[4]

In New Zealand, Pacific Islanders were consistently found to have higher rates of TB than the Maori, but both groups have substantially higher TB incidence than their non-indigenous counterparts.[5,91–93] The most recent studies report TB incidence to be respectively 14.3 and 34.1 times higher in Maori and Pacific Islander populations than in the non-indigenous New Zealandborn.[5] Although the most recent data suggest that TB rates have declined among the Maori and Pacific Islanders in the past 15 years,[5] earlier data reveal lower incidence rates among the indigenous population than currently observed.[92,93]

As was the case for Australia and New Zealand, the burden of TB in the Taiwanese indigenous people is well documented. The most recent measure found TB incidence to be 2.7 times greater for Taiwanese residing in aborigine areas than those in non-aborigine areas.[43] Comparing this study to earlier studies suggests that TB incidence within the indigenous population has been falling in the last 10 years, although there remains a substantial difference in TB rates between indigenous and non-indigenous peoples.[43,94–97]

Data on TB burden for ethnic minorities in China were scarce. Although not considered indigenous peoples by the national government, many scholars assert that China's ethnic minorities fit definitions of indigenous.[10] Existing data are older, with two of the three included studies published more than 20 years ago.[98,99] In 1985, a TB incidence of 6500/100 000 was reported among the E-Lun Chun, a northeastern ethnic group;[98] otherwise no other studies of these people were found. Surveillance data from 1990 show TB prevalence to be highly variable among ethnic minorities, ranging from 47/100 000 for the Bai people to 274/100 000 for the Uyghur, prevalence rates that were respectively 35% of the estimated national prevalence and over twice the estimated national prevalence.[99] The most recent data suggest that ethnic minorities in Sichuan Province are substantially more burdened than any of the nation's ethnic groups measured in 1990.[100]

Indigenous peoples as refugees—Circumstances have led some indigenous peoples to leave their homelands and settle in other countries, sometimes as refugees. Among such groups, data on TB burden for Tibetan and Hmong refugees were available. The incidence of TB for Tibetan refugees living in India was 3.9 times greater than India's national TB incidence, with Tibetans living in central and south India largely more affected than those in northern India.[42,101] Outside of India, the Tibetan refugee communities screened for TB in Minnesota, USA, and Toronto, Canada, had a TB incidence of >4000/100 000.[102,103] In comparison, reported TB incidence rates were lower among Hmong refugees, but the Hmong people still had higher TB rates than non-indigenous peoples. Hmong living as refugees in Thailand had a nine times higher TB prevalence than the Thai national rate.[41,104] Another study found the TB incidence among Hmong in Minnesota, USA, to be 1600/100 000.[102]

DISCUSSION

This is the first systematic review of the literature to examine the TB burden in indigenous populations globally. We found that indigenous peoples in high-, middle- and low-income countries continue to bear a high and disproportionate burden of TB, but this burden varies greatly between groups and regions. The most recent available data suggest that the groups most burdened by TB are located in small regions of Latin America (e.g., the Ache in Paraguay and the Yanomami in Brazil), followed closely by tribes in India (e.g., the Saharia, in Madhya Pradesh) and Africa (e.g., the Fulani, in Chad). The groups least burdened by TB live in high-income countries. Aboriginal Australians, American Indians/Alaskan Natives and the Metis of Canada were found to have the lowest incidence of TB disease among indigenous groups, but the differential TB burden between indigenous and non-indigenous populations in these industrialized nations was greater in many studies than for those in developing nations. Within these industrialized countries, Pacific Islanders, First Nations and the Canadian Inuit bear an especially disproportionate burden of TB. Select groups in Latin America and India also had a highly disproportionate burden of TB, although some tribes from these regions had minimal or no differences in disease burden. Moreover, although the available data suggest that the TB burden has decreased among some groups, such as the Australian Aborigines,[4,86–88] Taiwanese Aborigines,[43,95] Russia's Far North peoples,[28,79] and the AI/AN and NH/PI in the United States,[6,16,44,53,59] disparities in TB case rates remain. These continuing disparities highlight the importance of prioritizing indigenous health in TB control efforts. They also highlight the need to have TB control strategies that are designed and implemented by and for indigenous communities that incorporate unique indigenous perspectives and values, as proposed by the Strategic Framework for Action on Tuberculosis Control in Indigenous Communities.[8] Such strategies should be tailored to the distinctive cultural, social and historic realities of indigenous groups to effectively address the TB burden in different regions.

This review also demonstrates the paucity of available data on the TB burden among indigenous populations outside Australia, Canada, the United States and New Zealand. Although millions of indigenous peoples live in Africa, Asia and Latin America,[10] little is currently known about how TB affects these populations. Specifically, no studies were found for the tribal groups of the Caribbean, Central America or the Middle East, and TB data

were lacking for the majority of tribes in the Far North (e.g., the Sami, the Nenets), South-East Asia/Western Pacific (e.g., indigenous of Malaysia, Cambodia, Viet Nam, Indonesia and the Philippines) and Africa. Published data from these regions included in this review often originated from small studies, as opposed to publications from Australia, Canada, the United States and New Zealand, which generally used national-level surveillance data. This suggests that there is not only a shortage of data but also a paucity of high-quality data, specifically disaggregated national-level surveillance data, that allows for the estimation of TB case rates in different racial/ethnic groups. This reveals the need to increase and improve TB surveillance among indigenous populations. Where strong TB surveillance already exists (e.g., Scandinavia, India), disaggregated data are needed for routine monitoring of TB rates and the effectiveness of TB control in indigenous groups. For example, adding a single variable (e.g., race/ethnicity) to the national TB surveillance system could inform the development of evidence-based policies and practices to effectively address TB among indigenous peoples. In countries or provinces where strong TB surveillance does not yet exist, operational research assessing the burden of TB within indigenous groups is needed. Furthermore, additional research is needed to assess the extent to which drug-resistant TB, TB-HIV (human immunodeficiency virus), other comorbidities (e.g., diabetes) and the burden of TB in children affects indigenous communities.

While the primary aim of this study was to document and summarize the burden of TB in indigenous peoples, this review highlights the need to elucidate reasons for the disproportionately high TB burden among these groups. Social determinants of health are important contributors to the burden of TB among indigenous peoples, who account for approximately 15% of the world's poor[105] and face disparities in terms of employment, income, and access to and quality of education and health care.[44,106] Poverty is a key obstacle in accessing health care, including prompt TB diagnosis with sensitive tools and appropriate treatment.[54] Measures that increase indigenous people's access to quality TB diagnosis and treatment are therefore needed to improve case detection and ensure improved and targeted health service delivery to marginalized indigenous groups.[106] Successful models of health care in indigenous peoples exist. For example, despite the structural, economic and programmatic barriers to health faced by many AI/AN communities, a study from the United States found that AI/ANs more commonly received totally directly observed therapy (DOT) and had similar treatment completion rates compared with other racial/ethnic groups.[44] The availability of DOT through the United States' Indian Health Service (lHS), tribal, and urban Indian health care facilities and other partners, may have contributed to declines in case rates. Additional research is needed to examine structural and programmatic reasons for why the TB burden is higher in many indigenous peoples—but lower in others—and to identify successful strategies for TB prevention accordingly.

Limitations

This systematic review was most limited by the dearth of published data. In some regions of the world, the most recent TB data were from more than 20 years ago, which hinders the ability to accurately assess the current burden of TB within those indigenous populations. As TB surveillance data for indigenous people are unavailable in many areas of the world, researchers calculated estimates of TB based on small studies that sometimes included fewer

than 1000 people. Although these estimates provide invaluable information, especially given the lack of information in general, the small sample sizes in many studies increase the uncertainty of disease estimates; the level of uncertainty around these measurements was unavailable in many cases. As such, differences observed between groups should be interpreted with caution. Moreover, non-standardized methodologies and wide variation in the scope of studies included in this review can limit comparability across studies. For example, comparing state or national data with data collected from smaller studies is especially challenging. Similarly, caution must be taken when comparing TB rates of indigenous groups from different years, even if they reside in the same country (e.g., Maharashtra and Madhya Tribes in India), as external factors, such as changes in TB programs, were not considered in this review. Furthermore, when comparison data were not available, published WHO TB prevalence and incidence rates were used; however, these data also have limitations for the purposes of comparison, as they are national estimates and may therefore not necessarily reflect the non-indigenous population living closest to the indigenous peoples studied. In addition, we recognize that each country with disaggregated data defines their indigenous groups differently, making direct comparisons difficult. As with any systematic review, publication bias was also a limitation.

CONCLUSIONS

This review highlights the disparate impact of TB on the world's indigenous peoples. The results highlight a need to implement and improve TB surveillance in indigenous populations globally to ensure that the burden of TB in indigenous peoples is accurately reflected. The paucity of data that exist on the epidemiology of TB within indigenous peoples, particularly in low- and middle-income countries, demonstrates the need to invest more resources to assess the current TB burden and elucidate its underlying causes. Improved TB surveillance is needed to better measure, understand and address the underlying causes of disparities in TB between indigenous and non-indigenous peoples. Ultimately, this review reveals the need to prioritize indigenous populations worldwide in TB control.

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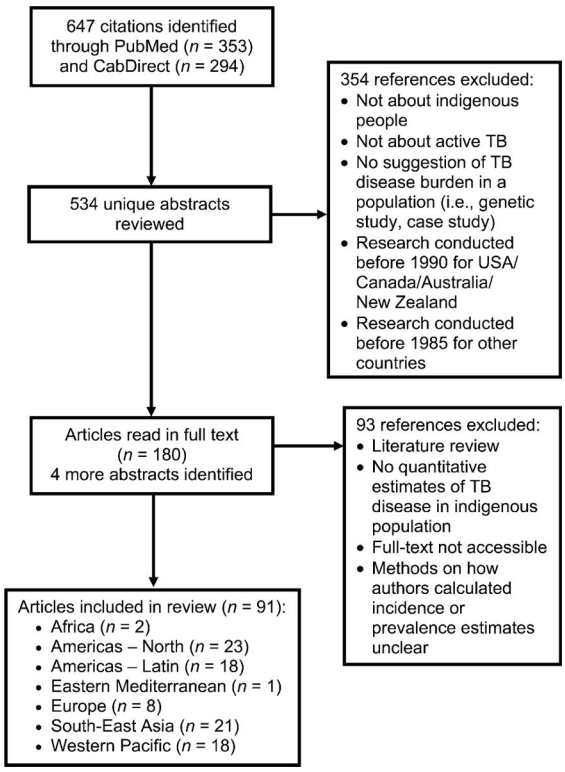

Figure 1.

PRISMA diagram detailing paper selection process. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

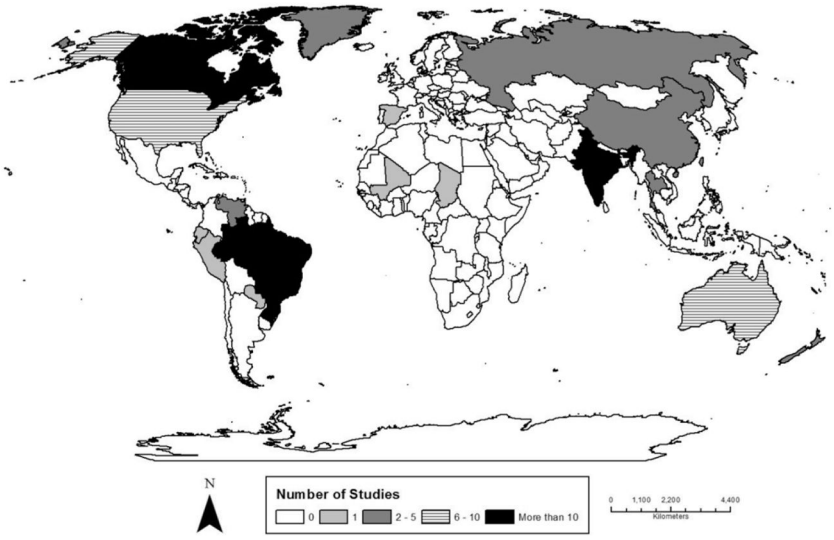

Figure 2.

The number of studies included in review by country. Countries with data include Canada (*n* = 17), India (*n* = 17), Brazil (*n* = 13), United States (*n* = 9), Australia (*n* = 6), Taiwan (*n* = 5), Russia (*n* = 5), New Zealand (*n* = 4), China (*n* = 3), Greenland (*n* = 2), Thailand (*n* = 2), Venezuela (*n* = 2), Chad (*n* = 1), Ecuador (*n* = 1), Israel (*n* = 1), Mali (*n* = 1), Paraguay (*n* = 1), Peru (*n* = 1) and Spain (*n* =1). Some studies in North America covered both Canada and the United States.

Table 1

Search terminology utilized in the review process

Subject search: Tuberculosis/epidemiology, Tuberculosis/ethnology, with each continental ancestry group
Broad key word: ‘Tuberculosis’ with ‘indigenous people(s)’, ‘indigenous population(s)’, ‘tribe’ or ‘tribal’, ‘aboriginal’ or ‘aborigine’
Narrow key word: ‘Tuberculosis’ and any of the following: Maori, Inuit, American Indian, Native American, Alaska Natives, First Nations, Roma, Bushmen, Herdsmen, Hill People; *Asia-specific*: Adivasi, Lahu, Akha, Mon, Lua, Mbri, Karen, Hmong, Miao, Hui (Minority AND China); *Africa-specific*: Aka, Babenjelle, Babongo, Bacwa, Bagyeli, Baka, Bakola, Bakoya, Bambuti, Batwa, Pygmy, Aasax, Akie, Aweer, Barabaig, Dahalo, Datoga, Elmolo, Hadzabe, Hadza, Maasai, Ogiek, Sandawe, Sengwer, Waata, Yaaku, Amazigh, Imazighn, Berbers, Tuareg, Afar, Aka, Babendjelle, Boranna, Dinka, Fulani, Kanuri, Karamajong, Manjo, Nuer, Peul, Pygymy, Tuareg, Tubu, Wodaabe, Bassari, Bororo, Daza, Nemadi, Ogoni, Teda, Khoekhoe, Khoikhoi, Basarwa, Khwe, Nama, San (AND Africa), Tsumkwe; *Far North-specific*: Aleut, Alutor, Chelkancy, Chukchi, Chulymcy, Chuvancy, Dolgan, Ency, Evenk, Itelmen, Kamchadal, Kereki, Kety, Khanty, Koryak, Kumandincy, Mansi, Nanaicy, Negidalcy, Nenets, Nganasan, Nivkhy, Orochi, Oroki, Saami, Sami, Selkup, Shorcy, Soioty, Tazy, Telengity, Teleuty, Tofolar, Tubolar, Tuvin-Todjin, Udege, Ukagiry, Ulchi, Veps

Table 2

Primary study methodology and scope of included studies

	n (%)	Study locations
Study design		
Cohort *	59 (65)	North America (*n* = 21), Latin America (*n* = 11), Eastern Mediterranean (*n* = 1), Europe (*n* = 7), South-East Asia (*n* = 2), Western Pacific (*n* = 17)
Cross-sectional	29 (32)	Africa (*n* = 2), North America (*n* = 1), Latin America (*n* = 7), South-East Asia (*n* = 19)
Case control	3 (3)	North America (*n* = 1), Europe (*n* = 1), Western Pacific (*n* = 1)
Scope		
National	29 (32)	North America (*n* = 11), Latin America (*n* = 3), Europe (*n* = 2), South-East Asia (*n* = 2), Western Pacific (*n* = 11)
Village/town/reserve	25 (27)	Africa (*n* = 2), North America (*n* = 4), Latin America (*n* = 7), Europe (*n* = 2), South-East Asia (*n* = 10)
Province/state/region	17 (19)	North America (*n* = 6), Latin America (*n* = 2), Europe (*n* = 3), South-East Asia (*n* = 1), Western Pacific (*n* = 5)
District	9 (10)	Latin America (*n* = 1), Europe (*n* = 1), South-East Asia (*n* = 6), Western Pacific (*n* = 1)
Facility	7 (8)	North America (*n* = 1), Latin America (*n* = 3), Eastern Mediterranean (*n* = 1), South-East Asia (*n* = 2)
City	4 (4)	North America (*n* = 1), Latin America (*n* = 2), Western Pacific (*n* = 1)

* Includes TB surveillance data. TB = tuberculosis.

Table 3

Summary of the most recent data on TB burden in global indigenous populations by WHO region (see Appendix for complete list of publications)

Region, indigenous group, country	Publications with the most recent data*	Type of study	Scope	Study period	Prevalence or incidence/100 000†		
					Indigenous TB burden‡	Comparative TB burden§	Ratio (indigenous/comparative)
Africa							
Fulani, Chad	Schelling et al., 2005[15]	Cross-sectional	Village/town/reserve	1999–2000	Prevalence: 4600	Prevalence: 429	10.7
Peul and Dogon, Mali	Carta et al., 1997[14]	Cross-sectional	Village/town/reserve	1997¶	Prevalence: 1800	Prevalence: 326	5.5
North America							
Alaskan Natives and American Indians, United States	CDC, 2011[16]	Cohort study	National	2010	Incidence: 6.1	Incidence: 0.9	6.8
Native Hawaiians and Pacific Islanders,# United States	CDC, 2011[16]	Cohort study	National	2010	Incidence: 20.6	Incidence: 0.9	22.9
First Nations, Canada	Ellis et al., 2010[17]	Cohort study	National	2009	Incidence: 27.4	Incidence: 1.0	27.4
Inuit, Canada	Ellis et al., 2010[17]	Cohort study	National	2009	Incidence: 155.8	Incidence: 1.0	155.8
Metis, ** Canada	Ellis et al., 2010[17]	Cohort study	National	2009	Incidence: 7.3	Incidence: 1.0	7.3
Latin America							
Ache natives, Paraguay	Hurtado et al., 2003[18]	Cohort study	Facility	1987–2002	Incidence: 3700	Incidence: 49	75.5
Amazonian tribes, Rondonia or Amazonas State, Brazil	Machado Filho, 2008[20] Basta et al., 2006[19]	Cross-sectional, cohort study	Facility, city	2003	Incidence: 284	Incidence: 55	5.2
					Prevalence: 815.2	Prevalence: 37.5	21.7
Amazonian tribes, Peru	Culqui et al., 2010[21]	Cohort study	National	2008	Incidence: 42.3–400.9	Incidence: 106	0.4–3.8
Aymara (Andes), Peru	Culqui et al., 2010[21]	Cohort study	National	2008	Incidence: 175.1	Incidence: 106	1.7
Brazilian Native Indians, Mato Grosso do Sul, Brazil	Basta et al., 2010[22]	Cross-sectional, cohort study	Village/town/reserve	2006, 1999–2004	Prevalence: 210.8	Prevalence: 55.0	3.8
					Incidence: 1289.6	Incidence: 48.5	26.6
Chine, Ecuador	Romero-Sandoval et al., 2007[24]	Cross-sectional	Village/town/reserve	2001	Prevalence: 6700	Prevalence: 161	41.6
Quechua (Andes), Peru	Culqui et al., 2010[21]	Cohort study	National	2008	Incidence: 103.7	Incidence: 106	1.0
Zulu State indigenous, Venezuela	Romero-Amaro et al., 2008[25]	Cohort study	Province/state/region	1996–2005	52% of TB cases occurred among the indigenous	Incidence: 23.2	>1
Warao people, Venezuela	Fernandez de Larrea et al., 2002[26]	Cross-sectional	Village/town/reserve	1999	Prevalence: 320.0	Prevalence: 48.0	6.7
Eastern Mediterranean							
Bedouins	Greene et al., 1992[27]	Cohort study	Facility	1987	Incidence: 18.1	Incidence: 8.7	2.1
Europe							
Russian indigenous, Russia	Kucherov and Makarov, 2002[28]	Cohort study	District	1999	Incidence: 85.2	Incidence: 37.6	2.3
					Prevalence: 608	Prevalence: 193.3	3.1
Inuit, Greenland	Thomsen et al., 2004[76]	Cohort study	National	2001	Prevalence: 185	Prevalence: 13.0	14.2
Roma, Spain	Casals et al., 2011[30]	Cohort study	Village/town/reserve	1985–2008	Incidence: 90.9	Incidence: 17.0	5.3

Region, indigenous group, country	Publications with the most recent data*	Type of study	Scope	Study period	Prevalence or incidence/100 000†		
					Indigenous TB burden‡	Comparative TB burden§	Ratio (indigenous/comparative)
South-East Asia							
Jawadhu Hills tribes, India	Balasubramanian et al., 1995[84]	Cross-sectional	Village/town/reserve	1992–1993	Prevalence: 209	Prevalence: 461	0.5
Madhya Pradesh tribals (including Baiga, Bhil, Bharia, Saharia), India	Rao et al., 2010[32] Yadav et al., 2010[33] Rao et al., 2010[34] Bhat et al., 2009[81] Rao et al., 2010[36] Rao et al., 2012[37]	Cross-sectional	District, village/town/reserve	2007–2008	Prevalence: 146–1518	Prevalence: 294	0.5–5.2
Maharashtra tribes, India	Narang et al., 1999[38]	Cross-sectional	District	1989–1990	Prevalence: 133	Prevalence: 144	0.9
Nicobarese, India	Murhekar et al., 2004[39]	Cross-sectional	Province/state/region	2001–2002	Prevalence: 735.3	Prevalence: 436	1.7
Forest Peoples, Orissa, India	Kerketta et al., 2009[40]	Cross-sectional	Village/town/reserve	2009¶	Prevalence: 4808	Prevalence: 275	17.5
Hmong, Thailand	Oeltmann et al., 2008[41]	Cross-sectional	Village/town/reserve	2004–2005	Prevalence: 1760¶	Prevalence: 193	9.1
Tibetans, India	Bhatia et al., 2002[42]	Cross-sectional	Village/town/reserve	1996	Incidence: 770	Incidence: 216	3.6
Western Pacific							
Aboriginal/Torres Strait Islanders, Australia	Barry and Konstantinos, 2009[4]	Cohort study	National	2007	Incidence: 6.6	Incidence: 0.9	7.3
Maori, New Zealand	Das et al., 2006[5]	Cohort study	National	2000–2004	Incidence: 20.46	Incidence: 1.43	14.3
Pacific Islanders,†† New Zealand	Das et al., 2006[5]	Cohort study	National	2000–2004	Incidence: 48.79	Incidence: 1.43	34.1
Taiwanese aboriginals, Taiwan	Chang et al., 2011[43]	Cohort study	National	1996–2006	Incidence: 176	Incidence: 65	2.7
Ethnic minorities, Sichuan, China	Wu et al. 2002[100]	Cohort study	Province/state/region	2000	Prevalence: 395	Prevalence: 149 (average)	2.7

*When more than one study on an indigenous group was included, the most recent reference(s) is listed in this table. References for all studies are cited within the text of the results, and specific results from these studies and others can be referred to in the Appendix. References are included based on year of data, not year of publication.

†The data on TB burden among indigenous groups were abstracted from the most recent studies on indigenous groups, and correspond to the sources cited in this table. When more than one study was from the same period of time, the most recent TB data are presented as a range.

‡For most studies, uncertainty estimates were not available. When 95% confidence intervals were reported, they have been listed in the Appendix.

§Data for comparative TB burden were abstracted either from the same studies from which data were reported for the respective indigenous groups or from WHO reports. Additional information about these studies, including their source and scope, can be found in the Appendix.

¶Date study published; no date when data were collected was provided.

#The Pacific Islanders in the United States are recognized as an indigenous group, regardless of birthplace. Data segregated by birthplace were not available for this review. Data were not available that separately reported the TB burden in Native Hawaiians and Pacific Islanders in the United States.

**Data reported for the Metis include only those self-registering as Metis. Anyone with at least some indigenous ancestry can register as Metis.

††As in the United States, the Pacific Islanders of New Zealand are considered an indigenous people, regardless of their birthplace, and as such, are incorporated into this review. TB = tuberculosis; WHO = World Health Organization; CDC = US Centers for Disease Control and Prevention.

Table A.1

The TB burden among indigenous peoples of the WHO African Region, as provided by all sources included in the systematic literature review [*]

Study, year	Country	Indigenous population	Type of study	Scope	Period	Age	TB burden			
							Cases (sample)	Prevalence/ 100000 [†]	Comparison prevalence/ 100000	Ratio [‡]
Carta et al., 1997[14]	Mali	Peul and Dogon	Cross-sectional	Village/town/reserve	1997 [§]	Adults	4 (231)	1800	326 [¶]	5.5
Schelling et al., 2005[15]	Chad	Nomadic Fulani	Cross-sectional	Village/town/reserve	1999–2000	Adults	NA	4600 [¶]	429 [¶]	10.7

[*] The TB burden reported is largely pulmonary. If a distinction was made in the studies between TB types, that has been noted in the table.

[†] TB cases not confirmed.

[‡] Unless otherwise noted, ratio is calculated as the listed prevalence or incidence of the indigenous group divided by the listed TB burden in the comparison group.

[§] Year of data collection not provided. Year of publication was used as substitute.

[¶] Nationwide statistic, retrieved from the WHO. Comparative statistics were for the same year as the data collection unless otherwise noted. NB: WHO prevalence measurements are estimates.

TB = tuberculosis; WHO = World Health Organization; NA = not available.

Table A.2

TB burden among indigenous peoples of the WHO Americas Region North America, as provided by all sources included in the systematic literature review *

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			
							Cases (sample)	Incidence/ 100000†	Comparison incidence/ 100000‡	Ratio§
Blackwood et al., 2003[45]	Canada, Manitoba	General	Cohort	Province	1992–1999	All	281 (−)	48.4	3.0¶	16.1
Bloss et al., 2011[44]	USA, national	AI/AN	Cohort	National	2003–2008	All	914	5.9	1.1#	5.4
		NH/PI					362	14.7		13.4
Brancker and Ellis, 1992[46]	Canada, national	General	Cohort	National	1980–1990	All	NA	NA	NA	8 First Nations 9 Inuit
Breault and Hoffman, 1997[47]	USA, South Dakota	Sioux (Oglala)	Cohort	Village/town/reserve	1985–1994	All	77 (12 048)	63.9	2.9¶	22.0
CDC, 1991[64]	USA, North and South Dakota	Sioux	Cross-sectional (outbreak investigation)	Village/town/reserve	1990 (January–May)	All	2 (7958)	25.1**	10.3††	2.4
CDC, 2010[6]	USA, national	AI/AN	Cohort	National	2008	All	137	5.9	1.1#	5.4
					2009		102	4.3	0.9#	4.8
		NH/PI			2008		69	15.9	1.1#	14.5
					2009		80	18.1	0.9#	20.1
CDC, 2011[16]	USA, national	AI/AN	Cohort	National	2010	All	146 (−)	6.1	0.9#	6.8
		NH/PI					94 (−)	20.6	0.9#	22.9
Clark et al., 2002[48]	Canada, national	First Nations on-reserve	Cohort	National	1997–1999	All	NA	52.2	6.6#All	7.9
		British Columbia						32.3		4.9
		Alberta						76.2		11.5
		Saskatchewan						104.3		15.8
		Manitoba						74.0		11.2
		Ontario						15.9		2.4
		New Brunswick and Nova Scotia						18.1		2.7
Cook et al., 2004[49]	Canada, Manitoba	General	Cohort	Province	1990–2000		147 (−)	7.27 (95%CI 4.90–10.26)	0.18¶	40.4
Dyck et al., 2007[50]	Canada, Saskatchewan	Registered Indians	Cohort	Province	1986–2001	>20		93.8–95	4.4–5¶	18.7–19
		With diabetes								
		Male					20 (1862)	NA		NA
		Female					50 (2802)	106.9		21.4
		Without diabetes								

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			Ratio[§]
							Cases (sample)	Incidence/ 100000[†]	Comparison incidence/ 100000[‡]	
		Male					276 (17 603)	93.8		NA
		Female					245 (17 699)	NA		18.7
Ellis et al., 2010[17]	Canada, national	Aboriginal (general)	Cohort	National	2009	All	342 (−)	27.8	1.0[#]	27.8
		First Nations (North American Indian)					228 (3)	27.4		27.4
		Inuit					89 (−)	155.8		155.8
		Metis					25 (−)	7.3		7.3
Enarson, 1998[51]	Canada, national	General	Cohort	National	1970–1995	All	NA	See graph, p S17		>10
Gessner, 1998[52]	USA, Alaska	AN	Cohort	Province	1987–1994	<14	NA	23.0	5.8[¶]	4.0
Kunimoto et al., 2004[54]	Canada, Alberta	General	Cohort	Province	1994–1998		182 (750)	34.4	1.7[¶]	19.6
Nguyen et al., 2003[55]	Canada, Quebec	Inuit	Cohort	Village/town/reserve	1990–2000	All	51 (−)	See figure, p 1354		310
Pepperell et al., 2011[56]	Canada, Saskatchewan	General indigenous	Cohort	Village/town/reserve	1986–2004	All	NA	38–431	1.3[#]	29.2–331
Phypers, 2003[57]	Canada, national	General	Cohort	National	1970–2001 (2001 rates listed)	<15	(−) 6683	15.3	0.6[#]	25.2
Phypers et al., 2006[58]	Canada, national	General	Cohort	Facility	1970–2001	All	9465 (82764 cases)	NA	NA	1.43–RR (CNS compared to PTB: aboriginal vs. non-aboriginal)
Schneider, 2005[59]	USA, national	AI/AN	Cohort	National	1993–2002	All	(15 075 cases)	8.4	1.5[#]	5.6
Sheardown and Phypers, 2003[60]	Canada, national	All aboriginal	Cohort	National	2001	All	315 (587 cases nationwide)	NA	NA	18% of all cases were in the aboriginal population, versus 16% of all cases occurring in the non-aboriginal Canadian-born population [*]
		Status Indian					200 (587)			
		Non-status Indian/Metis					63 (587)			
		Inuit					52 (587)			
Wang et al., 2000[61]	Canada, British Columbia	Aboriginals, on reserve	Case Control	City	1992–1996	All	202 aboriginal cases	112	1.5[#]1996 (See figure, p 153)	74.6
								17		11.3
		Aboriginals, off reserve			1992–1996			71		47.3
								36		24
Yip et al., 2007[62]	Canada, Alberta	Status Indians	Cohort	Province	1990–2004	<15	45 (124 cases)	10.7	0.4[¶]	26.8
Young, 2008[63]	Far North (Canada, USA–Alaska)	Alaska Natives Yukon	Cohort	National	2004	All	See map, p 92 and table, p 96	25.8	6.5[¶]	4.0
								12.9	44.5[¶]	0.3
		Northwest Territories						23.4	44.5[¶]	0.5
		Nunavut						108.0	44.5[¶]	2.4
		Greenland						121.2	7.1[#]	17.1

[*] TB burden reported is largely pulmonary. If a distinction was made in the studies between TB types, that has been noted in the table.

[†] All incidence measurements are reported per year. If the study occurred over multiple years, the statistic reported is an average annual incidence, unless otherwise noted.

[‡] The comparison groups used in studies from Canada and the United States are the non-aboriginal native-born Canadians and White, non-Hispanic residents for the United States, unless otherwise noted.

[§] Unless otherwise noted, ratio is calculated as the listed incidence of the indigenous group divided by the listed TB burden in the comparison group.

[¶] State, district or provincial statistic, provided by author. Comparative statistics were for the same year as the data collection unless otherwise noted.

[#] Nationwide statistic, provided by author. Comparative statistics were for the same year as the data collection unless otherwise noted.

[**] Authors of this systematic review calculated the incidence based on numbers provided in the designated article.

[††] The comparison group is the TB incidence in the entire US population in 1990 as TB data was not disaggregated by race/ethnicity in the United States until 1993.

TB = tuberculosis; WHO = World Health Organization; CDC = US Centers for Disease Control and Prevention; NA = not available; CI = confidence interval; AI = American Indians; AN = Alaskan Natives; NH = Native Hawaiians; PI = Pacific Islanders; CNS = central nervous system manifestations of TB; PTB = pulmonary TB.

Table A.3

TB burden among indigenous peoples of the WHO Americas Region, Latin America and the Caribbean subdivision, as provided by all sources included in the systematic literature review*

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			
							Cases (sample)	Prevalence or incidence/100000†	Comparison prevalence or incidence/100000‡	Ratio§
Baruzzi et al., 2001[66]	Brazil, province not specified	Panara	Cross- sectional	Village/town/reserve	1995	All	10 (181)	Prevalence: 5525	Prevalence: 92¶	60.1
Basta et al., 2004[67]	Brazil, Rondoni	Surui	Cohort	City	2002	All	20 (864)	Incidence: 1388.9 (smear-positive)	Incidence: 43#1999	32.3
								Incidence: 2314.8 (all forms)	Incidence: 62**1999	37.3
Basta et al., 2006[19]	Brazil, Rondoni	Surui	Cross- sectional	City	2003	All	6 (920)	Prevalence: 815.2	Prevalence: 37.5#	21.7
Basta et al., 2010[22]	Brazil, Mato Grosso	Xavante	Cross- sectional	Village/town/reserve	2006	≥1	1 (476)	Prevalence: 210.8††	Prevalence: 55¶	3.8
			Cohort		1999–2004		37 (~560)	Incidence: 1289.6	Incidence: 48.5#	26.6
Boia et al., 2009[68]	Brazil-Amazonas	Arawak, Tukano, and Maku families (Arapaso, Baniwa, Desana, Kubeo, Hupda, Piratapuya, Tuyuca, Wanana, Tariana, and Tukano)	Cross- sectional	Village/town/reserve	2001	All	6 (333)	Prevalence: 1801.8††	Prevalence: 75¶	24.0
Buchillet and Gazin, 1998[69]	Brazil, Amazonas	Arawak, Tukano, and Maku families (22 tribes)	Cohort	Facility	1990–1996	All	296 (23 000)	Incidence: 200	Incidence: 50¶	4.0
					1977–1994	All	403 (2500)	Incidence: 920	Incidence: 73¶	12.6
Culqui et al., 2010[21]	Peru, nationwide	Amazonic	Cohort, interviews	National	2008	All			Incidence: 106**	
		Ashanninka					68	Incidence: 89.0		0.8
		Shipibo					38	Incidence: 230.0		2.2
		Matsiguenga					23	Incidence: 226.0		2.1
		Aguaruna					20	Incidence: 42.3		0.4
		Shawi					13	Incidence: 92.0		0.8
		Huambisa					11	Incidence: 106.0		1.0
		Yanesha					7	Incidence: 153.1		1.4
		Quichua-Amazonian					6	Incidence: 197.3		1.9
		Achuar					4	Incidence: 121.4		1.2
		Cashibo-Cacataybo					6	Incidence: 400.9		3.8
		Nomastshiguenga					2	Incidence: 53.9		0.5
		Quechua- Lamistas					2	Incidence: 64.0		0.6
		Amarakaire					1	Incidence: 133.0		1.3
		Harakmbut					1	Incidence: 360.5		3.4
		Shapra					1	Incidence: 45.0		0.4
		Aymara-Andes					84	Incidence: 175.1		1.7
		Quechua-Andes					417	Incidence: 103.7		1.0

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden: Cases (sample)	TB burden: Prevalence or incidence/100000†	TB burden: Comparison prevalence or incidence/100000‡	Ratio§
Escobar et al., 2001[70]	Brazil, Rondoni	Indigenous, not specified	Cohort	Province	1992, 1994–1998	All	362 (NA)	Incidence: 1000	Incidence: 100#	10.0
Fernandez de Larrea et al., 2002[26]	Venezuela, Delta Amacuro	Warao People	Cross- sectional	Village/town/reserve	1999	<15	16 (502)	Prevalence: 320	Prevalence: 48¶	6.7
Garnelo et al., 2005[71]‡‡	Brazil, Special Indigenous Sanitary Districts	Indigenous, not specified, represented by district	Cohort, GIS	National	2000–2002	All	NA	Incidence: 302.1–1448.6	NA	>1000
Hurtado et al., 2003[18]	Paraguay	Ache natives	Cohort	Facility	1987–2002	All	80 (1000)	Incidence: 3700	Incidence: 49¶	75.5
Levino and de Oliveira, 2007[72]	Brazil-Amazonas	Icana-Aiari	Cohort	District	2002	All	20 (32 180)	Incidence: 390	Incidence: 57¶	6.8
		Waupes-Papuri					16 (32 180)	Incidence: 200.4		3.5
		Tiquie					6 (32 180)	Incidence: 123.1		2.2
		Yanomami					32 (32 180)	Incidence: 2133.3		37.4
		Rio Negro					9 (32 180)	Incidence: 163.0		2.9
Machado Filho, 2008[20]	Brazil-Amazonas	Indigenous, not specified	Cohort	Facility	1994–1998	All	322 (27 000)	Incidence: 239	Incidence: 64¶	3.7
					1999–2003		446 (31 407)	Incidence: 284	Incidence: 55¶	5.2
Marques et al., 2010[23]	Brazil, Mato Grosso do Sul	Indigenous, not specified	Cohort	Province	2000	<15	224 (1096)	Incidence: 300	Incidence: 60¶	5.0
					2002			Incidence: 70	Incidence: 57¶	1.2
					2003			Incidence: 100	Incidence: 55¶	1.8
					2004			Incidence: 100	Incidence: 53¶	1.9
					2005			Incidence: 50	Incidence: 51¶	1.0
					2006			Incidence: 50	Incidence: 50¶	1.0
Romero-Amaro et al., 2008[25]§§	Venezuela, Zulia	Indigenous, including Anu, Bari, Wayuu, Yukpa	Cohort	Province	1996–2005	All	468 (889)	52% of TB cases occurred among the indigenous peoples	Incidence: 23.2#	>1
Romero-Sandoval et al., 2007[24]	Ecuador, Cotopaxi Province	Indigenous, not specified	Cross- sectional	Village/town/reserve	2001	All	44 (653)	Prevalence: 6700	Prevalence: 161¶	41.6
Sousa et al., 1997[73]	Brazil-Amazonas	Yanomami	Cross- sectional	Village/town/reserve	1992	All	40 (625)	Prevalence: 6400†† (all forms)	Prevalence: 68#	94.1
van Crevel et al., 2004[74]	Brazil-Amazonas, Surinam	Trio Indians	Cross- sectional; interview	Village/town/reserve	1995–2000	All	25 (−)	Prevalence: 420 (95%CI 270–610)	Prevalence: 60¶	7.0

*The TB burden reported is largely pulmonary. If a distinction was made in the studies between TB types, that has been noted in the table.

†All incidence measurements are reported per year. If the study occurred over multiple years, the statistic reported is an average annual incidence, unless otherwise noted.

‡The comparison groups used in studies differed widely between studies. Numbers provided by authors for regional estimates were sometimes regional averages, while other times they were non-indigenous TB rates within those regions. Please refer to the specific studies for more details.

§Unless otherwise noted, ratio is calculated as the listed prevalence or incidence of the indigenous group divided by the listed TB burden in the comparison group.

¶Nationwide statistic, retrieved from the WHO. Comparative statistics were for the same year as the data collection unless otherwise noted. NB: WHO prevalence measurements are estimates.

[#]State, district or provincial statistic, provided by author. Comparative statistics were for the same year as the data collection unless otherwise noted.

[**]Nationwide statistic, provided by author. Comparative statistics were for the same year as the data collection unless otherwise noted.

[††]Authors of this systematic review calculated the incidence or prevalence based on provided numbers in the designated article.

[‡‡]This study presented data primarily in map format, revealing the large disparity in TB burden between regions with many indigenous and non-indigenous peoples. Specific incidence rates were only provided for the seven 'Special Indigenous Sanitary Districts' that had the highest incidence rates, all of which occurred within Legal Amazonia. Please refer to the study to obtain more specific data.

[§§]This study did not provide a denominator for the indigenous population. However, 56% of TB cases (468/889) reported in Zulia, Venezuela, occurred among the indigenous population, with 89% of these cases occurring in the Wayuu peoples. The author concludes that indigenous are disproportionately affected by TB in comparison to the non-indigenous.

TB = tuberculosis; WHO = World Health Organization; GIS = Geographic Information System; NA = not available; CI = confidence interval.

Table A.4

TB burden among indigenous peoples of the WHO Eastern Mediterranean Region, as provided by all sources included in the systematic literature review*

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			
							Cases (sample)	Incidence/100000†	Comparison Incidence/100000	Ratio‡
Greene et al., 1992[27]	Israel, The Negev Desert	Bedouins	Cohort	Facility	1987	All	11 (−)	18.1	8.7§1990	2.1

*TB burden reported is pulmonary.

†All incidence measurements are reported per year.

‡Unless otherwise noted, ratio is calculated as the listed prevalence or incidence of the indigenous group divided by the listed TB burden in the comparison group.

§Nationwide statistic, retrieved from the WHO. NB: WHO prevalence measurements are estimates.

TB = tuberculosis; WHO = World Health Organization.

Table A.5

TB burden among indigenous peoples of the WHO European Region, as provided by all sources included in the systematic literature review*

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			
							Cases (sample)	Prevalence or incidence/100000†	Comparison prevalence or incidence/100000‡	Ratio§
Casals et al., 2011[30]	Spain	Roma	Cohort	Village/town/reserve	1985–2008	All	7 (380)	Incidence: 90.9 (95%CI 68.5–113.2)	Incidence: 17.0¶	5.3
Chernukha et al., 2003[77]	Russia, Far North	Indigenous, not specified	Cohort	Province	2003#	All	NA	NA	NA	10.0 (Incidence)
Galkin and Vasilev, 1994[78]	Russia, Far North	Indigenous	Cohort	Village/town/reserve	1988	All	NA	Incidence: 274.8	Incidence: 32.7**	8.4
					1991		NA	Incidence: 176.1	Incidence: 25.6**	6.9
					1992		NA	Incidence: 220.2	Incidence: 26.4**	8.3
Kucherov and Makarov, 2002[28]	Russia, Chukotka Autonomous District	Chukotka Autonomous Indigenous	Cohort	District	1994	All	NA	Incidence: 303.7	Incidence: 68.4**	4.4
					1999		NA	Prevalence: 1159.5	Prevalence: 272.0**	4.3
								Incidence: 85.2	Incidence: 37.6**	2.3
								Prevalence: 608.0	Prevalence: 193.3**	3.1
Ladefoged et al., 2011[29]	Greenland	Inuit	Case control	National	2004–2006	All	146 (590 controls)	NA	Prevalence: 9.6¶††	15.3
Thomsen et al., 2004[76]	Greenland	Inuit	Cohort	National	1990	All	NA	Prevalence: 85	Prevalence: 9.9¶††	8.6
					2001		NA	Prevalence: 185	Prevalence: 13.0¶††	14.2
Tyryltin, 1990[79]	Russia, Far North	Indigenous, not specified	Cohort	Province	1983–1987	All	NA	Incidence: 89.7	Prevalence: 41.9**	2.1
Vasil'ev et al., 1992[80]	Russia, Far North	Indigenous, not specified	Cohort	Province	1989	All	NA	Prevalence: 280	Prevalence: 220¶1990	1.3
					1990		NA	Prevalence: 199.8		0.9

*TB burden reported is largely pulmonary. If a distinction was made in the studies between TB types, that has been noted in the table.

†All incidence measurements are reported per year. If the study occurred over multiple years, the statistic reported is an average annual incidence, unless otherwise noted.

‡The comparison groups used in studies differed widely between studies. Numbers provided by authors for regional estimates were sometimes regional averages, while other times they were non-indigenous TB rates within those regions. Please refer to the specific studies for more details.

§Unless otherwise noted, ratio is calculated as the listed prevalence or incidence of the indigenous group divided by the listed TB burden in the comparison group.

¶Nationwide statistic, retrieved from the WHO. Comparative statistics were for the same year as the data collection unless otherwise noted. NB: WHO prevalence measurements are estimates.

#Year of data collection not provided. Year of publication was used as substitute.

**State, district, or provincial statistic, provided by the author. Comparative statistics were for the same year as the data collection unless otherwise noted.

††For Greenland, the comparative prevalence numbers are those provided by the WHO for Denmark.

TB = tuberculosis; WHO = World Health Organization; CI = confidence interval; NA = not available.

Table A.6

TB burden among indigenous peoples of the WHO South-East Asian Region, as provided by all sources included in the systematic literature review*

							TB burden			
Author, year	**Country, province**	**Indigenous population**	**Type of study**	**Scope**	**Period**	**Age years**	**Cases (sample)**	**Prevalence or incidence/100000†**	**Comparison prevalence or incidence/100000‡**	**Ratio§**
Balasubramanian et al., 1995[84]	India, Tamil Nadu	Jawadhu-Hills tribes	Cross- sectional	Village/town/reserve	1992–1993	≥15	12 (5755)	Prevalence: 209¶	Prevalence: 461#	0.5
Bhat et al., 2009[81]	India, Madhya Pradesh	Tribals, not specified (refugees)	Cross- sectional	District	2007–2008	≥15	– (22 270)	Prevalence: 387 (95%CI 272–502)	Prevalence: 299 **2006	1.3
Bhatia et al., 2002[42]	India, Himachal Pradesh	Tibetans (refugees)	Cross- sectional	Village/town/reserve	1996	All	1575 (53 959)	Incidence: 770	Incidence: 216#	3.6
CDC, 2005[104]	Thailand, refugee camp	Hmong (refugees)		Village/town/reserve	2004–2006	All	272 (15 455)	Prevalence: 1760¶	Prevalence: 193 **	9.1
Chakma et al., 1996[82]	India, Madhya Pradesh	Saharia	Cross- sectional	Village/town/reserve	1991–1992	≥15	96 (22 250)	Prevalence: 1500	Prevalence: 970 **	1.6
Datta et al., 2001[31]	India, Tamil Nadu	Jawadhu-Hills tribes	Cross- sectional	Village/town/reserve	1989	All	– (16 017)	Prevalence: 840	Prevalence: 459#	1.8
Kaulagekar and Radkar, 2007[85]	India, national	Scheduled tribes	Cohort	National	1998–1999	All	NA	Prevalence: Male 107	Prevalence: Male 74††	1.5
								Prevalence: Female 263	Prevalence: Female 54††	4.9
Kerketta et al., 2009[40]	India, Orissa	Forest peoples, general	Cross- sectional	Village/town/reserve	2009‡‡	Elderly (μ = 68)	15 (312)	Prevalence: 4808††	Prevalence: 275#	17.5
		Dongria Kondh					9 (50)	Prevalence: 18 000¶		65.5
		Kutia Kondh					3 (112)	Prevalence: 2679¶		9.7
		Langia Saora					0 (50)	Prevalence: 0¶		0.0
		Pandi Bhuiyan					3 (100)	Prevalence: 3000¶		10.9
Marras et al., 2003[103]§§,¶¶	Canada, Toronto	Tibetans (refugees)	Cohort	Facility	1998–2000	Adults	24 (525)	Incidence: 4571	Incidence: Canada 6.4#	714.2 (Canada)
									Incidence: India 216#	21.2 (India)
Murhekar et al., 2004[39]	India, Car Nicobar	Nicobarese	Cross- sectional	Province	2001–2002	≥15	– (10 570)	Prevalence: 735.3	Prevalence: 436#	1.7
Narang et al., 1999[38]	India, Maharashtra	Maharashtra, indigenous tribes (*n* = 46)	Cross- sectional	District	1989–1990	All	– (20 596)	Prevalence: 133	Prevalence: 144 **	0.9
		Gond					– (5574)	Prevalence: 136		0.9
		Gond gawari					– (5574)	Prevalence: 100		0.7
		Mana					– (150)	Prevalence: 730		5.1
		Pawara					– (170)	Prevalence: 612		4.3
		Raj Gond					– (5574)	Prevalence: 196		1.4
Nelson et al., 2005[101]	India, national	Tibetans (refugees)	Cross- sectional	National	1994–1996	All	1197 (47 491)	Incidence: 835	Incidence: 216#	3.9
Oeltmann et al., 2008[41]	Thailand, refugee Camp	Hmong (refugees)	Cross- sectional	Village/town/reserve	2004–2005	All	272 (15 455)	Prevalence: 1760¶	Prevalence: 193#	9.1
Rao et al., 2010[36]	India, Madhya Pradesh	Bharia	Cross- sectional	District	2008	≥15	6 (1390)	Prevalence: 432 (95%CI 121–742)	Prevalence: 294#	1.5

Author, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden: Cases (sample)	TB burden: Prevalence or incidence/100000†	TB burden: Comparison prevalence or incidence/100000‡	Ratio§
Rao et al., 2010[34]	India, Madhya Pradesh	Tribals, not specified	Cross- sectional	District	2007–2008	≥15	83 (20 000)	Prevalence: 415¶	Prevalence: 294#	1.4
Rao et al., 2010[32]	India, Madhya Pradesh	Saharia	Cross- sectional	District	2007–2008	All	166 (11 116)	Prevalence: 1518	Prevalence: 294#	5.2
Rao et al., 2012[37]	India, Madhya Pradesh	Saharia	Cross- sectional	District	2007–2008	≥15	113 (9538)	Prevalence: 1394¶	Prevalence: 294#	4.7
Sharma and Tiwari, 2007[83]	India, Madhya Pradesh	Saharia	Cross- sectional	Village/town/reserve	2005–2006	All	164 (355)	Prevalence: 46 197¶	Prevalence: 335#	137.9
Sharma et al., 2010[35]	India, Madhya Pradesh	Bhil	Cross- sectional	Village/town/reserve	2006–2007	All	4 (169)	Prevalence: 2366¶	Prevalence: 314#	7.5
Truong et al., 1997[102]§§,¶¶	United States, Minnesota	Tibetans (refugees)	Cross- sectional	Facility	1992–1994	All	16 (191)	Incidence: 8377 (2–3 years)	Incidence: USA 11#	761.5 (US) 38.8 (India)
		Hmong (refugees)					39 (2456)	Incidence: 1588 (2–3 years)	Incidence: India 216# Incidence: Thailand 137#	144.4 (US) 11.6 (Thai)
Yadav et al., 2010[33]	India, Madhya Pradesh	Baiga	Cross- sectional	Village/town/reserve	2008	All	2 (2359)	Prevalence: 146 (95%CI 0–318)	Prevalence: 294#	0.5

*The TB burden reported is for pulmonary TB.

†All incidence measurements are reported per year. If the study occurred over multiple years, the statistic reported is an average annual incidence, unless otherwise noted.

‡The comparison groups used in studies differed widely between studies. Numbers provided by authors for regional estimates were sometimes regional averages, while at other times they were non-indigenous TB rates within those regions. Please refer to the specific studies for more details.

§Unless otherwise noted, ratio is calculated as the listed prevalence or incidence of the indigenous group divided by the listed TB burden in the comparison group.

¶Authors of this systematic review calculated the incidence or prevalence based on provided numbers in the designated article.

#Nationwide statistic, retrieved from the WHO. Comparative statistics were for the same year as the data collection unless otherwise noted. NB: WHO prevalence measurements are estimates.

**State, district, or provincial statistic, provided by author. Comparative statistics were for the same year as the data collection unless otherwise noted.

††Nationwide statistic, provided by the author. Comparative statistics were for the same year as the data collection unless otherwise noted.

‡‡Year of data collection not provided. Year of publication was used as substitute.

§§Authors of this study referred to their measurements as prevalence. However, our understanding of their study has led us to believe they are actually incidence measurements, and as such, we have reported them as incidence.

¶¶The incidence measurement for this study is not the average annual incidence. It is for the entire study period (1992–1993), or 2–3 years.

TB = tuberculosis; WHO = World Health Organization; NA = not available; CI = confidence interval; CDC = Centers for Disease Control and Prevention.

Table A.7

TB burden among indigenous peoples of the WHO Western Pacific Region, as provided by all sources included in the systematic literature review*

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			
							Cases (sample)	Prevalence or incidence/100000†	Comparison prevalence or incidence/100000‡	Ratio§
Barry and Konstantinos, 2009[4]	Australia, national	Aborigines/Torres Strait Islanders	Cohort	National	2007	All	35 (−)	Incidence: 6.6	Incidence: 0.9¶	7.3
	Capital Territory						0 (−)	Incidence: 0	Incidence: 0.9#	0.0
	New South Wales			—			3 (−)	Incidence: 1.9	Incidence: 1.2#	1.6
	Northern Territory						21 (−)	Incidence: 32.2	Incidence: 2.4#	13.4
	Queensland						7 (−)	Incidence: 4.7	Incidence: 0.4#	11.8
	Southern Australia						3 (−)	Incidence: 10.5	Incidence: 0.8#	13.1
	Tasmania						0 (−)	Incidence: 0	Incidence: 0.5#	0.0
	Victoria						1 (−)	Incidence: 2.9	Incidence: 0.9#	3.2
	Western Australia						0 (−)	Incidence: 0	Incidence: 0.8#	0.0
Calder and Priest, 2006[91]	New Zealand, Auckland	Maori	Cohort	City	1992–1993	All	24 (−)	Incidence: 37.8	Incidence: 2.7#	14.0
		Pacific Islanders					53 (−)	Incidence: 70.9	Incidence: 2.7#	26.3
Chan et al., 2007[94]	Taiwan, national	Aborigines	Cohort	National	1996–2003	<20	NA	Incidence: 81.5	Incidence: 9.6¶	8.5
Chang et al., 2006[97]	Taiwan, eastern	Aborigines	Case control	Village/town/reserve	2000–2006	All	60 (−)	Incidence: 321.1 (all) 152.1 (smear +)	Incidence: 66.7¶	2.3–4.8
Chang et al., 2011[43]	Taiwan, national	Aborigines	Cohort	National	1996–2006	All	NA	Incidence: 176	Incidence: 65¶	2.7
Das et al., 2006[5]	New Zealand, national	Maori	Cohort	National	2000–2004	All	332 (526 281)	Incidence: 20.46	Incidence: 1.43¶	14.3
					1995–1999		352 (523 371)	Incidence: 23.55	Incidence: 2.56¶	9.2
		Pacific Islanders			2000–2004		359 (200 253)	Incidence: 48.79	Incidence: 1.43¶	34.1
					1995–1999		303 (173 181)	Incidence: 51.77	Incidence: 2.56¶	20.2
Howie et al., 2005[92]	New Zealand, national	Maori	Cohort	National	1992–2001	<16	NA	Incidence: 6.4	Incidence: 0.6¶	10.7
		Pacific Islanders					NA	Incidence: 15.2		25.3
Hsu et al., 1990[98]	China, Northeast	E-Lun Chun (Ortochen)	Cohort	Province	1985	All	NA	Incidence: 6500	Incidence: 153 **1990	42.5
Hsueh et al., 2006[96]	Taiwan	Aborigines	Cohort	National	2002	All	NA	Incidence: 289.8	Incidence: 74.6¶	3.9
Li et al., 2004[86]	Northern Territory	Aborigines/Torres Strait Islanders descendants	Cohort	National	2003	All	38 (−)	Incidence: 8.7	Incidence: 0.9¶	9.7
	Capital Territory						0 (−)	Incidence: 0	Incidence: 2.0#	0.0

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden			
							Cases (sample)	Prevalence or incidence/100000†	Comparison prevalence or incidence/100000‡	Ratio§
	Australia, national						5 (−)	Incidence: 4.1	Incidence: 0.8#	5.1
	New South Wales						20 (−)	Incidence: 34.9	Incidence: 1.8#	19.4
	Queensland						6 (−)	Incidence: 4.9	Incidence: 0.8#	6.1
	Southern Australia						2 (−)	Incidence: 8.1	Incidence: 0.8#	10.1
	Tasmania						0 (−)	Incidence: 0	Incidence: 0.5#	0.0
	Victoria						0 (−)	Incidence: 0	Incidence: 1.0#	0.0
	Western Australia						5 (−)	Incidence: 8	Incidence: 0.3#	26.7
Miller et al., 2002[87]	Australia, national	Aborigines/Torres Strait Islanders descendants	Cohort	National	2001	All	42 (−)	Incidence: 9.8	Incidence: 1¶	9.8
	Capital Territory						0 (−)	Incidence: 0	Incidence: 0.4#	0.0
	New South Wales						1 (−)	Incidence: 0.8	Incidence: 1.4#	0.6
	Northern Territory						25 (−)	Incidence: 44.4	Incidence: 2.7#	16.4
	Queensland						9 (−)	Incidence: 7.6	Incidence: 0.9#	8.4
	Southern Australia						1 (−)	Incidence: 4.1	Incidence: 0.6#	6.8
	Tasmania						0 (−)	Incidence: 0	Incidence: 1.7#	0.0
	Victoria						3 (−)	Incidence: 12.2	Incidence: 1#	12.2
	Western Australia						3 (−)	Incidence: 4.9	Incidence: 0.7#	7.0
Oliver et al., 1996[88]	Australia, national	Aborigines/Torres Strait Islanders descendants	Cohort	National	1994	All	199 (−)	Incidence: 10.6	Incidence: 6.7**	1.6
Simpson et al., 2006[89]	Australia, Far North Queensland	Aborigines, Papua New Guineans	Cohort	Province	1998–2002	All	66/92 cases	NA	NA	NA
					1993–1997		57/87 cases			
Simpson and Knight, 1999[90]	Australia, Far North Queensland	Aborigines	Cohort	Province	1993–1997	All	50 (27 818)	Incidence: 35.9	Incidence: 2.3#	15.6
van der Oest et al., 2004[93]	New Zealand	Maori	Cohort	District	1992–2001	All	244 (317 751)	Incidence: 12.5	Incidence: 11**	1.1
Wang and You, 1994[99]	China, national	Bai	Cohort	National	1990	All	NA	Prevalence: 47	Prevalence: 134¶	0.4
		Chaoxian (Chinese Korean)						Prevalence: 61	[50 (urban) 140 (rural)]	0.5
		Hui						Prevalence: 181		1.4
		Kazakh						Prevalence: 180		1.3
		Li						Prevalence: 262		2.0
		Manchu						Prevalence: 90		0.7
		Miao (Hmong)						Prevalence: 163		1.2

Study, year	Country, province	Indigenous population	Type of study	Scope	Period	Age years	TB burden: Cases (sample)	TB burden: Prevalence or incidence/100000†	TB burden: Comparison prevalence or incidence/100000‡	Ratio§
		Mongols (Menggu)						Prevalence: 170		1.3
		Tibetans						Prevalence: 106		0.8
		Tujia						Prevalence: 247		1.8
		Uyghur						Prevalence: 274		2.0
		Zhuang						Prevalence: 103		0.8
Wu et al., 2002[100]	China, Sichuan	Ethnic minorities, not specified	Cohort	Province	2000	NA	NA	Prevalence: 395	Prevalence: urban 172#	2.3
									Prevalence: rural 126#	3.1
Yu et al., 2004[95]	Taiwan	Aborigines	Cohort	National	2001	All	520 (–)	Incidence: 233.5	Incidence: 56.5¶	4.1
					2000		592 (–)	Incidence: 278.4	Incidence: 53.5¶	7.1

*The TB burden reported is largely pulmonary. If a distinction was made in the studies between TB types, that has been noted in the table.

†All incidence measurements are reported per year. If the study occurred over multiple years, the statistic reported is an average annual incidence, unless otherwise noted.

‡For Australia, New Zealand, and Taiwan, comparison rates provided by authors were for non-aboriginal citizens in those countries.

§Unless otherwise noted, ratio is calculated as the listed prevalence or incidence of the indigenous group divided by the listed TB burden in the comparison group.

¶Nationwide statistic, provided by the author. Comparative statistics were for the same year as the data collection unless otherwise noted.

#State, district or provincial statistic, provided by the author. Comparative statistics were for the same year as the data collection unless otherwise noted.

**Nationwide statistic, retrieved from the WHO. Comparative statistics were for the same year as the data collection unless otherwise noted. NB: WHO prevalence measurements are estimates.

TB = tuberculosis; WHO = World Health Organization; NA = not available.