Tuberculosis among indigenous municipalities in Mexico: analysis of case notification and treatment outcomes between 2009 and 2013

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ABSTRACT

Objective. *To assess trends in 1) tuberculosis (TB) case notification by year and 2) cumulative treatment outcomes (stratified by type of TB) in relation to the proportion of indigenous population in municipalities in a countrywide study in Mexico for the period 2009–2013.*

Methods. *This ecological operational research study used municipality data for the five-year study period. As no single identifier variable existed for indigenous persons, municipalities were categorized into one of three groups based on the proportion of their indigenous population (< 25% ("low"), ≥ 25% to < 50% ("medium"), and ≥ 50% ("high")). TB case notification rates (CNRs) were standardized to a 100 000 population.*

Results. *For the first four years of the study period (2009 through 2012), for all new TB cases reported nationally, the municipalities with a high proportion of indigenous people (≥ 50%) had the highest CNRs (ranging from 20.8 to 17.7 over that period). In 2013, however, the CNR in the high proportion municipalities dropped to 16.7, lower than the CNR for that year in the municipalities with a medium proportion of indigenous people (P < 0.001). In the municipalities with low and medium proportions of indigenous people, the CNR hovered between 15.1 and 17.3 over the study period. For the 96 195 new TB cases reported over the study period, the treatment success rate ranged between 81% and 84% for all three municipality groups. For previously treated TB cases, CNRs ranged between 1.0 and 1.7 for all three groups over the study period. The average proportion of previously treated TB cases (of all TB cases) was 9% for the three groups in 2009 but dropped to 8% by 2013. The cumulative treatment success rate for all previously treated cases (a total of 8 763 for the study period) was 64% in municipalities with a low proportion of indigenous people, 61% in those with a medium proportion, and 69% in those with a high proportion.*

Conclusions. *Despite the slightly higher CNR in municipalities with predominantly indigenous populations, there were no stark differences in TB burden across the three municipality groups. The authors were unable to confirm if the relatively low CNRs found in this study were a reflection of good TB program performance or if TB cases were being missed. A survey of TB prevalence in indigenous people, with individualized data, is needed to inform targeted TB control strategies for this group in Mexico.*

Key words Tuberculosis, vulnerable groups; diabetes mellitus; public health surveillance; tuberculosis, therapy; operations research; Mexico.

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The Americas has the lowest tuberculosis (TB) burden of all six World Health Organization (WHO) regions, and several countries in the region, including Mexico, are now in a position to target TB elimination (1). The Americas is also one of the few regions that has already met Millennium Development Goal (MDG) Target 6C ("Reducing TB incidence, prevalence and mortality by 2015") (2).

Sustaining progress that has already been achieved and making further gains toward eventual TB elimination will require prompt TB diagnosis and treatment in all population groups, including indigenous people.[4]

Among Mexico's total population of 112 million inhabitants, approximately 12% are indigenous (4). Indigenous people are well dispersed across 99% of the country's 2 457 municipalities (administrative units) but are considered socially vulnerable and are often marginalized. Members of this group often live in precarious housing, are relatively poor, and have higher alcohol consumption rates and a higher risk of developing diabetes mellitus (5–8). These factors predispose indigenous people to developing TB (5–9) and to having problems with adherence to TB treatment—adversely affecting treatment outcomes. For these reasons, the strategic framework for action on TB control in indigenous communities has emphasized the need to increase surveillance of TB burden and monitoring of TB outcomes in indigenous communities (5, 7, 10).

To the best of the authors' knowledge, no previous study from Mexico has assessed trends in TB case notification among indigenous people. Furthermore, a recent systematic review found that no previous study on indigenous people has reported treatment outcomes (5). This type of data would be useful in determining if this group merits more attention from Mexico's National TB Program (NTP) in its efforts toward eventual TB elimination nationwide.

To help fill these data gaps, this countrywide study aimed to assess 1) trends in TB case notification by year and 2) cumulative treatment outcomes (stratified by type of TB) in relation to the proportion of indigenous population in municipalities for the period 2009–2013 in Mexico.

MATERIALS AND METHODS

Study design

This operational research was an ecological study that used countrywide program data.

Study period

The study included all TB cases registered between 2009 and 2013 and was conducted between September 2014 and September 2015.

Setting

General. Mexico is located in North America and has a total area of 1 964 375 km^2—the 14th-largest in the world—and a geographic location and topography that makes access to some communities difficult. The majority of Mexico's central and northern territories are located at high altitudes, and the major urban agglomerations are located in the valleys between mountains. Road access is variable. Mexico City is the capital, and the country has a per capita income of approximately US$ 10 500 (11).

Indigenous people. In Mexico, a person is designated as indigenous based on the above-mentioned definition,[4] provided in the Constitution and conferred by the National Commission for the Development of Indigenous Peoples (*Comisión Nacional para el Desarrollo de los Pueblos Indígenas*, CDI). There are 16 million indigenous people countrywide, speaking about 60 indigenous languages; about 39% live in conditions of marginalization and poverty, and about 62% live in communities with less than 2 500 inhabitants (12).

The municipality is the basic population-level administrative unit in Mexico and is responsible for the welfare of both indigenous and nonindigenous people. Figure 1 shows the spatial distribution of indigenous people by municipality in Mexico (13).

National TB Program. TB management by the NTP is based on national guidelines that are in accordance with WHO guidelines (14, 15). In brief, all patients with presumed TB have sputum collected and sent to specific laboratories for microscopy, with the results forwarded to the referring facility. Active case finding involving symptom screening is conducted in communities and among special groups such as prisoners, drug users, and indigenous persons.

Treatment for new TB cases is Directly Observed Treatment, Short-course (DOTS) (six months), which is supervised by a nurse (at a health facility) or by a community health worker (at the patient's home) (14, 15). For previously treated TB, treatment duration is eight months. All treatment is offered on an ambulatory basis with scheduled visits to the health facility. Where possible, for previously treated TB, sputum culturing and drug-resistance testing is recommended. A tracking system is used to identify patients who do not attend scheduled visits to the health facility. All treatment in public health facilities is offered free-of-charge. TB treatment outcomes are standardized in line with Mexican national guidelines (14).

Study population

The study population included all registered TB patients for the period 2009–2013 in all municipalities in Mexico.

Data sources and variables

Data are transmitted from health units to the regional level and then entered into the National Epidemiological Surveillance System (*Plataforma del Sistema Nacional de Vigilancia Epidemiológica*, SINAVE) database accessible at the national level. Data related to the study objectives, including proportion of indigenous population in municipalities, socio-demographic and clinical characteristics of TB patients, presence of comorbidities, TB case notification, and treatment outcomes, were obtained from the SINAVE database. The proportion of indigenous people in municipalities was validated by cross-checking with records available at the CDI.

Statistical analysis

Data from the SINAVE database were exported to Microsoft Excel (Microsoft Corporation, Redmond, Washington, United States) and used for analysis. The yearly population of Mexico was obtained from national population census data and used to standardize TB case notification rates (CNRs) per 100 000 population.

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[4] Defined by the Mexican Constitution as people descended from the populations inhabiting the country before colonization who have partly or fully maintained their ancestral social, economic, cultural, and political affiliations (3).

FIGURE 1. Spatial distribution of municipalities showing the proportion of indigenous inhabitants, Mexico, 2000
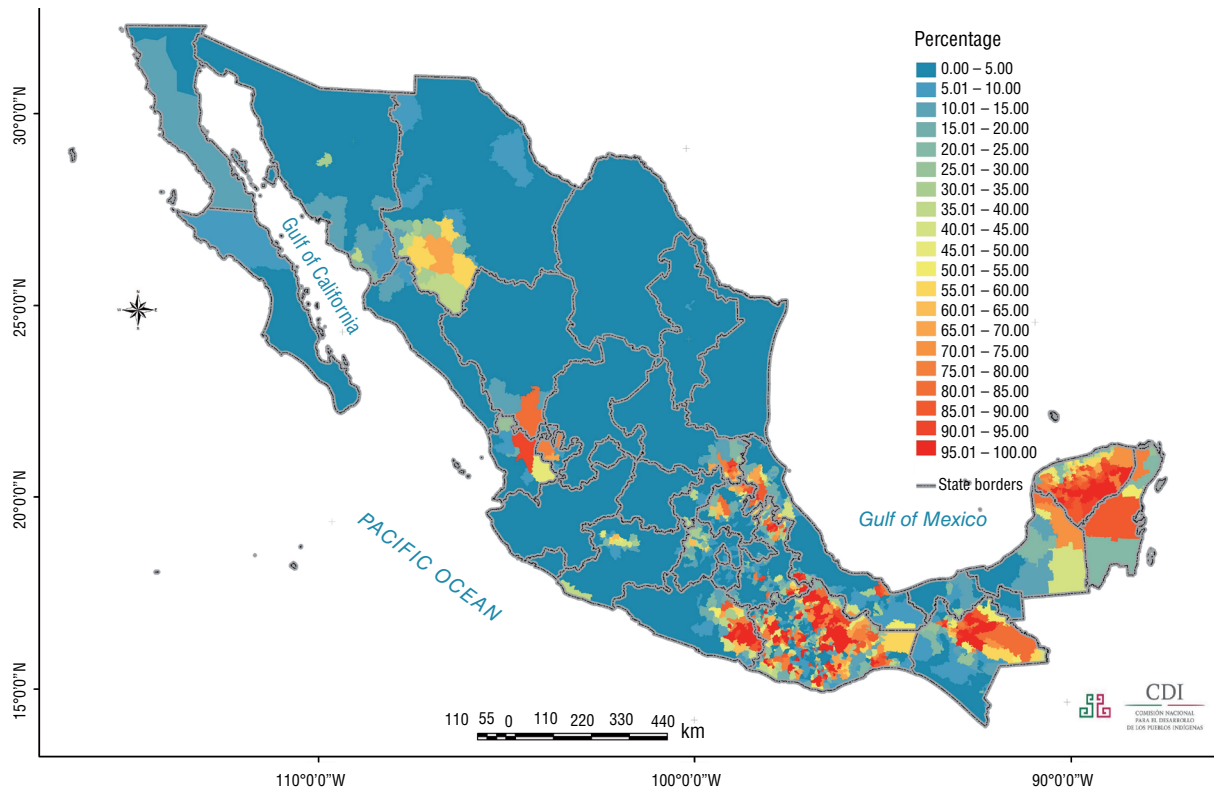
For the purposes of this study, a sensitivity analysis was performed to categorize municipalities into three groups based on the proportion of indigenous inhabitants (< 25% ("low"), ≥ 25% to < 50% ("medium"), and ≥ 50% ("high")). As no single identifier variable exists for indigenous persons, these categories were used as a proxy of TB burden. Differences between the groups were assessed using the chi-square test.

Ethics

Ethics approval was received from the Ethics Advisory Group of the International Union Against Tuberculosis and Lung Disease (Paris) and authorization to conduct the study was received from Mexico's NTP. Because the study involved routine program data and did not contain patient identifiers, the issue of informed consent did not apply.

RESULTS

Trends in TB case notification

Table 1 shows the trend in TB case notification per 100 000 population for new TB and previously treated TB for the period 2009–2013, stratified by the proportion of

the indigenous population of each municipality. For the first four years of the study period (2009 to 2012), for all new TB cases reported nationally, the CNRs were highest in the municipalities with ≥ 50% indigenous populations (ranging from 20.8 in 2009 to 17.7 in 2012). By 2013, however, the CNR in the "high"-proportion municipalities dropped to 16.7, and the highest CNRs for that year (17.3) was found in the "medium"-proportion municipalities ($P < 0.001$). Over the study period, the CNR in the municipalities with "medium" and "low" proportions of indigenous people hovered between 15.1 and 17.3 (Table 1). For previously treated TB cases ($n = 8 763$) (9% of all TB cases for the three groups in 2009, dropping to 8% by 2013), CNRs ranged between 1.0 and 1.7 across the various municipalities, with no sustained trend.

Treatment outcomes

Over the five-year study period (2009–2013), all 96 195 new TB cases and 8 763 previously treated TB cases started TB treatment. Across both categories of TB ($n = 104 958$), 648 484 (62%) were male, 20 771 (20%) had diabetes mellitus, and 7 602 (7%) were HIV-positive. Cumulative treatment outcomes for all TB

cases, stratified by the municipality proportion of indigenous people, are shown in Table 2. For new TB cases, the treatment success rate (TSR) was above 80% (range: 81%–84%) in all three municipality groups. For previously treated TB cases, the TSR was 64%, 61%, and 69% for municipalities with a low (< 25%), medium (≥ 25% to < 50%), and high (≥ 50%) proportion of indigenous people respectively ($P = 0.03$). The proportions of adverse outcomes (failures, deaths, losses to follow-up, and unevaluated) for previously treated TB cases were all higher than for new TB cases.

DISCUSSION

This is the first countrywide study in Mexico that assessed TB case notification and treatment outcomes at the municipality level.

Despite a slightly higher TB CNR in municipalities with a predominantly indigenous population, there were no stark differences in TB burden across municipalities. This finding was surprising, as one would logically expect to see more TB cases in municipalities with higher proportions of indigenous inhabitants. Various studies from Latin America have

TABLE 1. Trend in tuberculosis (TB) case notification rate (CNR) per 100 000 population for new and previously treated cases, stratified by municipality proportion of indigenous people, Mexico, 2009–2013

Variable	Year				
	2009	2010	2011	2012	2013
New TB cases					
Population in municipalities with low proportion of indigenous people (< 25%)	96 722 027	102 712 957	104 018 063	105 271 297	106 492 544
CNR	16.6	16.4	16.8	16.9	16.6
Population in municipalities with medium proportion of indigenous people (≥ 25% to < 50%)	3 651 721	3 950 143	4 001 350	4 049 440	4 096 763
CNR	17.0	16.7	15.4	15.1	17.3
Population in municipalities with high proportion of indigenous people (≥ 50%)	7 176 949	7 592 457	7 663 454	7 733 014	7 805 746
CNR	20.8	19.2	18.6	17.7	16.7
Previously treated TB cases					
Population in municipalities with low proportion of indigenous people (< 25%)	96 722 027	102 712 957	104 018 063	105 271 297	106 492 544
CNR	1.7	1.6	1.6	1.5	1.4
Population in municipalities with medium proportion of indigenous people (≥ 25% to < 50%)	3 651 721	3 950 143	4 001 350	4 049 440	4 096 763
CNR	1.0	1.2	1.4	1.3	1.1
Population in municipalities with high proportion of indigenous people (≥ 50%)	7 176 949	7 592 457	7 663 454	7 733 014	7 805 746
CNR	1.5	1.3	1.6	1.2	1.1

Source: prepared by the authors based on the study results.

TABLE 2. Cumulative treatment outcomes for new and previously treated tuberculosis (TB) cases, stratified by municipality proportion of indigenous people, Mexico, 2009–2013

Variable	Low proportion < 25%		Medium proportion ≥ 25% to < 50%		High proportion ≥ 50%	
	No.	%	No.	%	No.	%
New TB cases						
Total starting treatment	85 925		3 221		7 049	
Treatment outcomes						
Treatment success	69 757	81	2 651	82	5 919	84
Cured	53 022	62	2 191	68	5 050	72
Treatment completed	16 735	19	460	14	869	12
Failed	959	1	21	1	66	1
Died	6 713	8	294	9	633	9
Lost to follow-up	4 429	5	115	4	220	3
Not evaluated	4 067	5	140	4	211	3
Previously treated TB cases						
Total starting treatment	8 014		235		514	
Treatment outcomes						
Treatment success	5 105	64	144	61	355	69
Cured	3 798	47	109	46	281	55
Treatment completed	1 307	16	35	15	74	14
Failed	399	5	14	6	17	3
Died	811	10	27	11	47	9
Lost to follow-up	917	11	15	6	32	6
Not evaluated	782	10	35	15	63	12

Source: prepared by the authors based on the study results.

reported TB CNRs ranging from 210 to 6 700—up to 41 times higher than the rates found in the general population (16–20). Similarly, studies from Africa, Asia, Europe, North America, and the Western Pacific have consistently shown higher TB burdens in indigenous populations (5).

The question that comes to mind is whether the relatively low TB CNRs seen in this study are a genuine reflection of TB program performance, or if TB cases are being missed. As no dedicated interventions to improve TB case finding and management were introduced during the study period, the research team believes TB cases are being missed. A definite answer to this question would require conducting a TB prevalence survey at the municipality level. Such a survey would allow for accurate determination of the expected number of TB cases in various municipalities. This estimate, when compared to the number of notified cases, would help the NTP quantify the number of "missed cases." No such prevalence survey has been done in recent years, but seems merited.

Implications of the study results

Despite the limitation posed by the lack of municipality-level TB prevalence data, the results of this study have a number of interesting implications. First, although the Ministry of Health (*Secretaría de Salud*) is responsible for overseeing all TB activities in Mexico, it relies on eight collaborating institutions to conduct TB case finding and management for various populations in the country. These institutions include corporate industry (e.g., Mexican petroleum) and various entities involved with management of social security. There is, however, no systematic approach for verifying if 1) case detection activities are actually being conducted and 2) TB diagnostic facilities are accessible and have the needed resources. In addition, it cannot be confirmed if all diagnosed TB patients are actually reported and started on treatment. These factors may have influenced the rate of national case notification. Specific operational research to identify possible gaps in these critical aspects of TB control is warranted.

Second, finding ways to improve surveillance of overall TB incidence and prevalence in various population groups is needed as Mexico makes efforts toward TB elimination. This would require access to disaggregated national-level surveillance data that allow for estimation of TB case rates in different racial and ethnic groups, including indigenous populations. What is needed is the inclusion of a new variable (e.g., "race/ethnicity") in the TB registers and in the national TB surveillance system. This would make a real difference in informing evidence-based policies and practices for TB control in indigenous populations and other

specific groups. It would also allow for improved monitoring and management of TB comorbidities—which is not possible with aggregate data (21). In addition, one in five TB patients in Mexico has diabetes mellitus, so this category of cases also needs specific attention.

Finally, one in three previously treated TB patients had adverse treatment outcomes. In a country aiming to eliminate TB, this group merits focused attention as it is known to have a higher prevalence of TB drug resistance, with implications for community spread. This poses a threat and may reverse gains already made toward TB elimination.

Strengths and limitations

Study limitations included the use of the proportion of indigenous persons at the municipality level as a "proxy" for TB burden in this group. This was unavoidable, as the TB surveillance system in Mexico does not include individualized data on indigenous persons. Thus, no numerator to accurately calculate the TB CNR in this group, and make comparisons, was available. This limitation also prevented the assessment of socio-demographic and ecologic variables associated with TB. These variables could be closely associated with TB, so further prospective research in this vein is merited. An additional study limitation stemmed from the broadly inclusive definition of "indigenous people," in terms of both language and ancestral origin, which may have resulted in overestimation of indigenous populations.

Study strengths included the fact that 1) the research was based on data for a five-year period, 2) TB treatment outcomes were standardized, and 3) the proportions of indigenous persons in municipalities were validated by the CDI.

Conclusions

This study showed a decreasing trend in case notification for new TB in municipalities with ≥ 50% indigenous people. No such trend was observed in the two other municipality categories (< 25% and ≥ 25% to < 50% indigenous people) or among those with previously treated TB. Overall, treatment outcomes for new TB cases were better than for previously treated TB cases. This study highlights the importance of finding better ways of identifying TB cases (in terms of both numbers and characteristics) in indigenous populations in Mexico. The resulting, more accurate number of identified cases would provide a numerator upon which overall TB performance in this group could be measured.

Conflicts of interest. None declared.

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RESUMEN

Tuberculosis en municipios con poblaciones indígenas en México: análisis de la notificación de casos y los resultados del tratamiento del 2009 al 2013

Objetivo. Evaluar las tendencias en la notificación de casos de tuberculosis por año y los desenlaces terapéuticos acumulados (estratificados por tipo de tuberculosis), con respecto a la proporción de la población indígena de los municipios, en una investigación de ámbito nacional en México del 2009 al 2013.

Métodos. Estudio ecológico de investigación operativa en el que se utilizaron datos de los municipios correspondientes al período quinquenal definido. Dado que no existía una variable única de identificación de las personas indígenas, los municipios se clasificaron en tres grupos en función de la proporción de su población indígena ("baja", menos de 25%; "intermedia", de 25% a menos de 50%; y "alta", 50% o más). Las tasas de notificación de casos de tuberculosis se normalizaron por 100 000 habitantes.

Resultados. Durante los primeros cuatro años del período del estudio (del 2009 al 2012), los municipios con una alta proporción de indígenas presentaron las más altas tasas de notificación de todos los casos nuevos de tuberculosis (de 20,8 a 17,7 en este período). En el 2013, sin embargo, la tasa de notificación en los municipios con una alta proporción disminuyó a 16,7 casos por 100 000 habitantes y fue más baja que la tasa de los municipios con una proporción intermedia de indígenas (P < 0,001). En los municipios con una proporción baja e intermedia, la tasa de notificación de casos osciló entre 15,1 y 17,3 por 100 000 habitantes durante el período del estudio. En los 96 195 casos nuevos de tuberculosis notificados durante todo el período, la tasa de éxito del tratamiento fluctuó entre 81% y 84% en los tres grupos de municipios. En los casos de tuberculosis anteriormente tratados, las tasas de notificación oscilaron entre 1,0 y 1,7 en los tres grupos durante el período estudiado. El promedio de la proporción de casos de tuberculosis anteriormente tratados (con respecto a todos los casos de tuberculosis) fue 9% en los tres grupos en el 2009 pero disminuyó a 8% en el 2013. La tasa acumulada de éxito terapéutico en todos los casos anteriormente tratados (de un total de 8 763 durante el período del estudio) fue 64% en los municipios con una baja proporción de población indígena, 61% en los municipios con una proporción intermedia y 69% en los municipios donde la proporción era alta.

Conclusiones. Pese a una tasa de notificación de casos discretamente superior en los municipios con poblaciones predominantemente indígenas, no se encontraron diferencias considerables de la carga de morbilidad por tuberculosis en los tres grupos de municipios. Los autores no pudieron verificar si las tasas de notificación relativamente bajas observadas en el presente estudio correspondían a un buen desempeño del programa contra la tuberculosis o se debía a los casos de tuberculosis pasados por alto. Es preciso realizar una encuesta de prevalencia de tuberculosis en las poblaciones indígenas que aporte datos individualizados, con el propósito de fundamentar las estrategias de control de la tuberculosis que se dirigen a este grupo de la población en México.

Palabras clave Tuberculosis, comunidades vulnerables; diabetes mellitus; vigilancia en salud pública; tuberculosis, terapia; investigación operativa; México.