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High prevalence of pulmonary tuberculosis in the indigenous population of Puerto Nariño, Colombian Amazonia

Alta prevalencia de tuberculosis pulmonar en la población indígena de Puerto Nariño, Amazonía de Colombia

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ABSTRACT

Tuberculosis (TB) remains a significant public health challenge, disproportionately impacting vulnerable groups, particularly indigenous populations.
Objetive To investigate the epidemiological behavior of TB among the indigenous communities in Puerto Nariño, Amazonas.
Materials and Methods Descriptive cross-sectional study across 23 indigenous communities, employing an active case-finding approach through house-to-house medical consultations. Respiratory symptomatic (RS) individuals, defined as those with a cough of any duration, were identified and assessed. Diagnostic evaluations included serial sputum smear microscopy and cultures using MGIT™ liquid and Löwenstein-Jensen (LJ) solid media. Cultures identified as *Mycobacterium tuberculosis* complex underwent drug susceptibility testing for first-line anti-TB medications. Confirmed TB cases were reported to the healthcare system. The study excluded non-indigenous individuals from the analysis and categorized cases by age. The indigenous communities and TB cases were geographically mapped.
Results Of the population examined, 95% (5,837 individuals) were indigenous, with 16.7% (972/5837) identified as RS. Seventy-six TB cases were diagnosed, with childhood TB accounting for 43.4% of the cases. MGIT™ cultures were positive in all TB cases, and 18.2% (6/33) of children under 15 had positive sputum smears. Notably, one case of multidrug-resistant TB (MDR-TB) was reported in a child.
Conclusions The prevalence of TB was almost 50 times higher in the indigenous , than in the general Colombian population according to official reports. The findings highlight a critical public health concern, with TB prevalence significantly higher among indigenous populations in Puerto Nariño compared to the general Colombian population. Targeted interventions are urgently needed to address this disparity.

Keywords: Tuberculosis; indigenous population; Puerto Nariño; childhood tuberculosis; epidemiology; respiratory symptoms *(source: MeSH, NLM)*.

RESUMEN

La tuberculosis (TB) sigue siendo un importante desafío en la salud pública, que afecta de manera desproporcionada a los grupos vulnerables, en especial a los pueblos indígenas.
Objetivo Investigar el comportamiento epidemiológico de la tuberculosis en las comunidades indígenas de Puerto Nariño, Amazonas.
Materiales y Métodos Estudio descriptivo transversal en 23 comunidades indígenas, empleando la búsqueda activa de casos mediante consultas médicas casa a casa. Se identificaron y evaluaron individuos sintomáticos respiratorios (SR), definidos como aquellos que tenía tos de cualquier duración. Las evaluaciones diagnósticas incluyeron

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baciloscopias seriadas de esputo y cultivos en medio líquido MGIT™ y medio sólido de Löwenstein-Jensen (LJ). Los cultivos identificados como complejo *Mycobacterium tuberculosis* se sometieron a pruebas de susceptibilidad a medicamentos antituberculosos de primera línea. Los casos confirmados de tuberculosis se notificaron al sistema de salud. El estudio excluyó del análisis a personas no indígenas y clasificó los casos por edad. Se georreferenciaron las comunidades indígenas y los casos de tuberculosis.

Resultados De la población examinada, el 95% (5 837 individuos) fueron indígenas, el 16,7% (972/5 837) fueron sintomáticos respiratorios. Se diagnosticaron 76 casos de tuberculosis, de los cuales el 43,4% fue tuberculosis infantil. Los cultivos de MGIT™ fueron positivos en todos los casos de tuberculosis y el 18,2% (6/33) de los niños menores de 15 años tuvieron baciloscopia de esputo positiva. Se identificó un caso de tuberculosis multirresistente (TB-MDR) en un niño.

Conclusiones La prevalencia de tuberculosis fue casi 50 veces mayor en la población indígena en comparación con la población general colombiana, según informes oficiales. Los hallazgos resaltan un problema crítico de salud pública, por lo que se necesitan intervenciones específicas para abordar esta problemática.

Palabras Clave: Tuberculosis; poblaciones indígenas; Puerto Nariño; tuberculosis infantil; epidemiología; sintomáticos respiratorios *(fuente: DeCS, BIREME)*.

Tuberculosis (TB) is an infectious disease primarily caused by *Mycobacterium tuberculosis*, it is transmitted mainly through airborne aerosols, when a person with untreated pulmonary TB disease speaks, sings, coughs, sneezes, or spits (1). TB primarily affects the lungs but can also involve other parts of the body, resulting in extrapulmonary tuberculosis. According to who estimates, 10.6 million people became ill with TB in 2022, 55% were men, 33% were women, and 12% were children (aged 0–14 years), TB caused an estimated 1.30 million deaths includes people with HIV (1). Official TB worldwide reports are based on information provided by health institutions through passive epidemiological surveillance; this is inefficient since most of the time the vulnerable population does not measure the risk of getting ill, so patients do not go to the health systems in a timely manner (1,2). In Colombia were reported for 2023, 19,932 cases of TB for a national incidence of 35.61 cases per 100,000 inhabitants (3). A total of 882 cases were reported in the indigenous population, for a national incidence of 34.1 cases per 100,000 indigenous inhabitants, and childhood TB incidence rate of 4.8 cases per 100,000 children under 15 years of age (3). The department of Amazonas reported a tuberculosis incidence rate of 75.24 cases per 100,000 inhabitants, the highest in the country (3).

In Colombia, indigenous people constitute 4.4% of the population, with 79% living in rural areas (4) with a low coverage of basic services (electricity, water supply, sewage, and natural gas) compared with the urban and non-indigenous populations. In addition, most of the indigenous population live under conditions of extreme poverty; the greater the unmet basic needs, the greater the inequalities reflected in health indicators for the indigenous population compared to other populations (1,5).

The situation of childhood TB (under 15 years of age) in the indigenous population is critical due to its paucibacillary nature and the scarce symptoms present in ill children, which makes its diagnosis difficult (6); this poses a major challenge for TB programs in different regions of the world (7).

Several factors contribute to the risk of developing TB, including an individual's immune status, recent infection with the bacteria (8), residence in regions with high TB incidence, inadequate treatment for latent TB, and belonging to high-risk groups such as indigenous populations (9).

Some studies have reported high prevalence of TB in indigenous populations compared to non-indigenous populations (10). For example, incidences of 377 and 333 per 100,000 inhabitants per year have been found in the indigenous population of Brazil (11) and in the Inuit population of Canada (12), respectively.

The objective of this study was to determine the epidemiological situation of pulmonary tuberculosis in 23 indigenous communities of Puerto Narino (Amazonas) in the period from March to October 2016.

MATERIALS AND METHOD

Type of study and settings

Cross-sectional descriptive study in 23 indigenous communities in the municipality of Puerto Nariño- Amazonas (Colombia, South America) (13,14)the clonal expansion of one strain often limits its application in local MTBC outbreaks. The use of an alternative reference genome and the inclusion of repetitive regions in the analysis could potentially increase the resolution, but the added value has not yet been defined. Here, we leveraged short and long WGS read data of a previously reported MTBC outbreak in the

Colombian Amazon Region to analyze possible transmission chains among 74 patients in the indigenous setting of Puerto Nariño (March to October 2016). The 2014 DANE census (Departamento Administrativo Nacional de Estadística) was used to determine the study population, and the ATICOYA (Indigenous Association of Ticunas, Cocamas, and Yaguas in spanish) census was used to approach each community. Since the houses are located in the rural area of the municipality of Puerto Nariño they lack municipal nomenclature, hence, the localization of homes within each Indian community was done by drawing maps by hand based on direct observation. A numerical code was assigned to each house to locate each participant in the study. For subsequent follow-up, individuals in each home were coded to facilitate the location of each TB patient and their corresponding household healthy individuals.

Study population

Individuals from 23 indigenous communities of the Municipality of Puerto Nariño-Amazonas, who recognized themselves as indigenous.

Definition of Respiratory Symptomatic (RS)

Individual presenting cough with or without expectoration of any duration.

Tuberculosis case definition

RS patients positive for acid-fast bacilli (AFB) were diagnosed through light microscopy smear analyses and/or positive culture, and/or a positive molecular test for *Mycobacterium tuberculosis* complex.

Data collection instrument

A survey was created and adjusted based on those previously designed for studies of active and latent TB, in HIV-positive patients (15), and vulnerable populations deprived of liberty (16). Variables related to coding, location, risk factors, previous history, and laboratories were adjusted according to the particularities of the population addressed in this study. For the approval of the final data collection instrument, several meetings with physicians, bacteriologists, epidemiologists, anthropologists, Indigenous people from the area, and nurses were needed and the data collection instrument was approved. We got approval of the Informed Consent form from the Ethical Committee of the Medical School. To correctly fill out the instrument application in the field all personnel of physicians and nurses were trained accordingly.

Field work flow

Staff

The field work was carried out by (i) eight physicians who actively searched for RS through medical consultation; (ii) two respiratory therapists who collected spontaneous or induced sputum samples in RS individuals; (iii) four bacteriologists who processed the collected sputum samples and made the diagnosis of active tuberculosis through serial smear microscopy, cultures, and sensitivity tests; (iv) two laboratory assistants; (v) three anthropologists and (vi) a mediator between the project staff and the indigenous authorities of the ATICOYA who carried out the prior consultation before conducting the study and two indigenous liaisons who supported the logistics and movement of the researchers through the different indigenous communities.

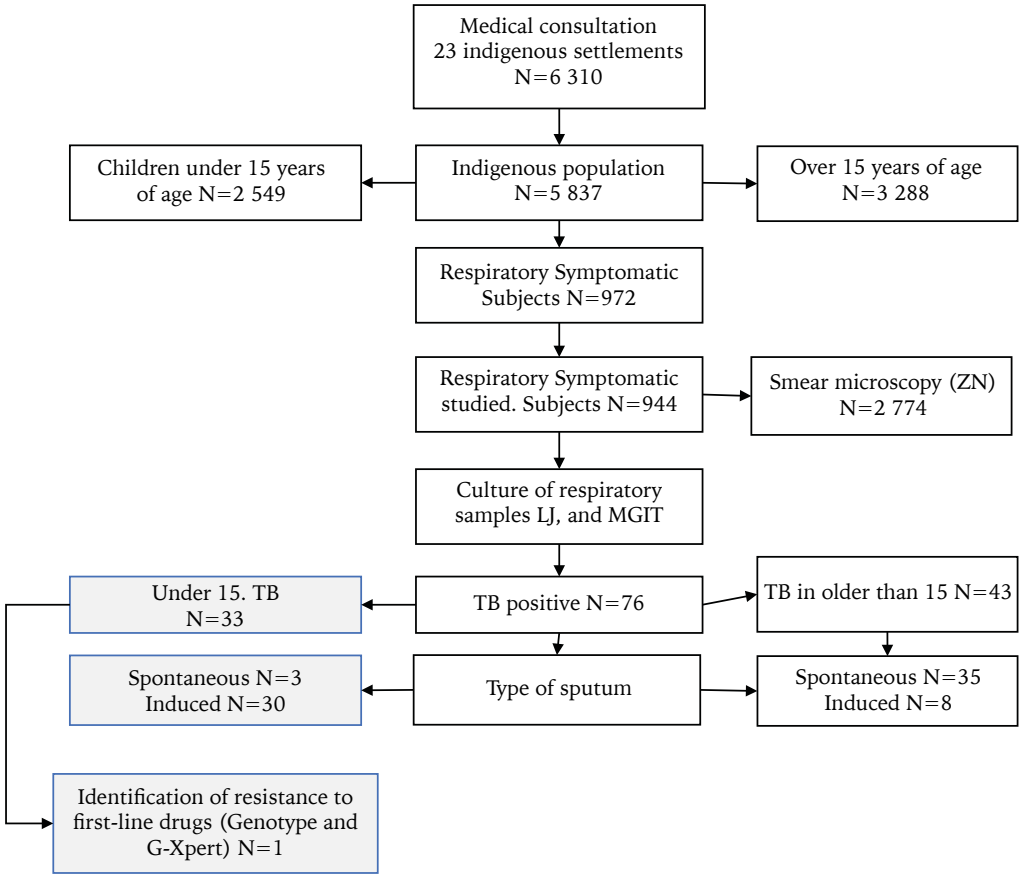
Active RS search

Medical consultations by each professional were distributed according to the maps made. In the municipal seat of Puerto Nariño, homes were equitably assigned by neighborhoods and blocks, while in rural communities a number of homes were equitably assigned per physician. Each physician in each home briefly explained the purposes of the research project, informed that participation was voluntary, and asked whether or not they agreed to participate. After accepting, the adults signed the informed consent form and in the case of childhood infants, it was signed by the parents or a responsible adult. Right after, the physician started the medical evaluation of all the individuals and filled out the instrument designed for the study for each person on tablets containing the electronic form of the survey. To all participants who according to the physician met the RS criteria, the respiratory therapists took three sputum samples (either spontaneous or induced) (Figure 1).

Phenotypical and molecular identification and drug susceptibility characterization of mycobacterium tuberculosis

Sample Collection and Preparation: Due to the geographical challenges of the region and the logistical constraints of river travel, sputum samples were collected serially on the same day, with an interval of 15 to 30 minutes between each sample. This approach aimed to prevent the loss of RS individuals. Participants unable to expectorate and those under 15 years of age underwent induced sputum collection using nebulizers with hypertonic saline solution for 15 minutes, followed by postural drainage.

Figure 1. General workflow of TB research in the remote setting of Puerto Nariño, Amazonas, Colombia (13,14). The gray squares highlight the importance of childhood tuberculosis in the indigenous population



Smear microscopy, was performed in the clinical laboratory of the Local Hospital of Puerto Nariño, using the Ziehl–Neelsen (zn) staining method following the guidelines outlined in the WHO Manual (17,18) Sputum samples were transported and maintained at 4 °C until processing in Amazonas Public Health Laboratory in Leticia. Sputum samples were decontaminated with N-acetyl-l-cysteine-sodium hydroxide (naoh-nalc) method and the concentrated sediments were subjected to smear microscopy using the Ziehl–Neelsen (zn) staining method (17,19). Furthermore , the concentrated sediments of the first sample of each patient was cultured per duplicate on Lowenstein-Jensen (lj) culture medium (18) and into one mycobacterial growth indicator tube (MGIT) (19) incubated in MGIT 460 bactec instrument (bd Diagnostics, Sparks, md, usa). All positive cultures for acid fast bacilli were sent to the Mycobacteria Laboratory of the School of Medicine of Universidad Nacional de Colombia (Bogota Campus) for identification (Figure 1).

Phenotypical and Molecular Identification and Drug susceptibility testing of *Mycobacterium tuberculosis* strains: Identification was carried out using the immunochromatographic method bd mgit™ TBc Identification Test (TB Id), following the manufacturer's instructions (Becton, Dickinson and Company [bd], New Jersey, U.S.). The susceptibility to anti-TB drugs was determined by bactec mgitTM sire, incubated in MGIT 460 bactec instrument (bd Microbiology Systems New Jersey, U.S.) (20).

Molecular identification of mtbc strains and detection of mutations conferring resistance to inh and rif were carried out using the Genotype mtbdrplus VER 2.0 (Hain Lifescience) using the manufacturer's instructions (http://www.hainlifescience.de). Additionally, mtbc strains were confirmed using nested real-time pcr GeneXpert mtb/rif, results were placed in one of four categories; very low, low, medium, or high. Rifampin resistance results were reported as susceptible or resistant. Microbiological and molecular positive results were promptly communicated to local and national public health authorities to facilitate effective tuberculosis management and control in the study population.

Statistical analysis

An Excel database was consolidated, excluding the non-indigenous population from the study. All the va-

riables were operationalized in this database and then exported to the Stata® program (21). Descriptive statistics were determined in each community to differentiate childhood TB. For the analysis, descriptive statistics were used using absolute and relative values to summarize the categorical variables; for continuous variables, medians and interquartile ranges (iqrs) were used. Frequency estimators were also reported in the form of rates and 95% confidence intervals were calculated.

Georeferencing

Based on the observation, a spatial representation (manual maps) of the indigenous communities studied was made. Subsequently, the data were processed for their georeferencing by using the OpenStreetMap (22) and qgis 2.18.9 Las Palmas tools (23), which helped to show the spatial distribution of the indigenous population in relation to TB. This made it possible to locate each community, the prevalence of TB, the presence or absence of TB, and the location of tuberculosis cases in each community for subsequent follow-up.

Ethical aspects

Since establishing TB prevalence in the Indigenous population was the scope of the study, prior consultation with the Indigenous authorities of the ATICOYA was required and the conduction of the study in the territory of Puerto Nariño was granted. After the approval, the study was submitted to the Ethics Committee of the School of Medicine of Universidad Nacional de Colombia, which approved it. Informed consent was explained, performed, and signed before each medical evaluation. In no way and at no time were coercive procedures applied. The information was confidential and used exclusively for the study. The cases of TB detected were reported to the General Social Security Healthcare System, which provided the data to the Epidemiological Surveillance System (SIVIGILA in Spanish) to initiate treatment and medical and nursing follow-up following the guidelines for TB care in Colombia.

RESULTS

Population description

6,310 people participated in the study, of which 5,837 identified themselves as indigenous population and 4,391 (75.2%) of them lived in rural areas. The indigenous community located in a rural area with the largest number of inhabitants was San Martin de Amacayacu (531 inhabitants) (Table 1).

Table 1. Distribution by community of the indigenous population (*Urban area)

Community	Number	%
Puerto Narino*	1,446	24.8
San Martin de Amacayacu	531	9.1
Puerto Esperanza	440	7.5
San Francisco de Loretoyacu	398	6.8
Ticoya	391	6.7
Naranjales	346	5.9
12 de Octubre	249	4.3
San Juan de Atacuari	236	4
20 de Julio	234	4
7 de Agosto	215	3.7
San Juan del Soco	189	3.2
San Pedro de Tipisca	184	3.2
Tres Esquinas de Boyahuazu	152	2.6
Puerto Rico	152	2.6
Patrulleros	122	2.1
Nuevo Paraíso	111	1.9
San Jose de Villa Andrea	110	1.9
Palmeras	96	1.6
Valencia	80	1.4
Santarem	57	1
Santa Teresita del Nino Jesús	55	0.9
Santa Clara de Tarapoto	37	0.6
Others	6	0.1
Total	5,837	100

Of the total population, 51.4% were men, with a median age of 17.5 years (IQR=27.4) with a range of 0.1 to 96.5 years; it is a young population with 54.8% of the population being under 20 years of age. Of the indigenous population, 75.9% belong to the Ticuna ethnic group, 14.2% to the Cocama ethnic group, and 7.9% to the Yagua ethnic group. Of the population, 85.6% belong to the subsidized healthcare system and 7.4% are uninsured (Table 2).

Respiratory symptoms and cases of tuberculosis

Respiratory symptoms

16.7% of the total indigenous population were found to be RS (972/5 837). 56.1% of RS (545/972) were men. 70.7% belonged to the Ticuna ethnic group. 74.1% were in overcrowded conditions. 49.8% had previous contact with someone who had TB. In addition, 11.2% reported having no knowledge of previous contact with TB (Table 2).

97.1% (944/972) of RS were evaluated through sputum sample. The 2.9% of the RS that could not be found for sample collection after several unsuccessful visits were referred to

their insurers for further follow-up. In nine indigenous communities, more than 20% of their total population were reported to have RS. These were in order: Santa Teresita del Nino Jesus (30.9%), 12 de Octubre (29.7%), Puerto Rico (26.3%), Valencia (23.8%), 7 de Agosto (22.8%), San Francisco de Loretoyacu (21.6%), Santa Clara de Tarapoto (21.6%), San Juan de Atacuari (21.6%), and San Martin de Amacayacu (20.9%). A total of 39.6% (374/944) of RS were under 15 years of age, of which 97.8% were sampled. 84% of the samples in children under 15 years of age were induced sputum.

Of the total number of RS examined, 8.1% (76/944) were TB cases; 9% (33/366) of RS under 15 years of age had TB. The indigenous communities with the highest percentage of sick RS (TB) were in order: Tres Esquinas de Boyahuazu (17.6%), Ticoya (16.3%), San Juan de Atacuari (14%), Patrulleros (12.5%), Valencia (11.1%), and San Francisco de Loretoyacu (10.8%). The urban area of Puerto Nariño was the area with the most reported cases (12), followed by San Juan de Atacuari (7) and Tres Esquinas de Boyahuazu (6) (Table 3).

Table 2. Demographic characteristics of the indigenous population, respiratory symptoms and cases of tuberculosis

Variable	Population	% Population	Respiratory symptoms number	% Respiratory symptoms	Cases of tuberculosis	% Cases of tuberculosis
Gender						
Men	2,837	48.6	545	56.1	48	63.2
Women	3,000	51.4	427	43.9	28	36.8
Total	5,837	100.0	972	100.0	76	100.0
Ethnic group						
Ticuna	3,745	64.2	687	70.7	41	53.9
Cocama	684	11.7	146	15.0	16	21.1
Yagua	339	5.8	126	13.0	19	25.0
Others	97	1.7	13	1.3	0	0.0
Total	5,837	100.0	972	100.0	76	100.0
Overcrowding						
3 or more people per room	4,028	69.0	720	74.1	64	84.2
No overcrowding	1,809	31.0	252	25.9	12	15.8
Variables of clinical importance:						
Previous contact with tb	1,399	24.0	484	49.8	25	32.9
Expectoration with blood	2	0.0	2	0.2	2	2.6
Coexistence with tb	468	8.0	160	16.5	10	13.2
Previous diagnosis of tuberculosis	132	2.3	75	7.7	6	7.9
Current treatment	4	0.1	4	0.4	1	1.3
bcg scar*	4,257	72.9	705	72.5	47*	61.8
Healthcare system						
Subsidized	4,999	85.6	845	86.9	69	90.8
Uninsured	431	7.4	79	8.1	6	7.9
Contributory	213	3.6	48	4.9	1	1.3
Total	5,837	100.0	972**	100.0	76	

*17 children did not have a bcg scar (51.5%)
**16.7% are respiratory symptoms

Table 3. RS and tuberculosis in the indigenous population

Community	Population	RS Examined		TB cases	
	Number	Number	%	Number	%
Tres Esquinas de Boyahuazu	152	34	23	6	17.6
Ticoya	391	43	11.5	7	16.3
San Juan de Atacuari	236	50	21.6	7	14
Patrulleros	122	16	13.9	2	12.5
Valencia	80	18	23.8	2	11.1
San Juan del Soco	189	27	14.3	3	11.1
San Francisco de Loretoyacu	398	83	21.6	9	10.8
Puerto Narino**	1,446	122	8.8	12	9.8
20 de Julio	234	41	17.9	4	9.8
San Pedro de Tipisca	184	33	17.9	3	9.1
7 de Agosto	215	48	22.8	4	8.3
Naranjales	346	63	19.1	5	7.9
Puerto Rico	152	40	26.3	3	7.5
12 de Octubre	249	71	29.7	4	5.6
Santa Teresita del Nino Jesus	55	17	30.9	1	5.9
Puerto Esperanza	440	76	18	3	3.9
San Martin de Amacayacu	531	108	20.9	1	0.9
Santa Clara de Tarapoto	37	8	21.6	-	-
Palmeras	96	16	16.7	-	-
San Jose de Villa Andrea	110	16	14.5	-	-
Others	6	1	16.7	-	-
Nuevo Paraiso	111	11	9.9	-	-
Santarem	57	2	3.5	-	-
Total	5,837	944**	16.7	76	8.10%

** 28 RS were excluded as it was not possible to collect a sample from them.

TB cases

Seventy-six cases of tuberculosis were diagnosed in the indigenous population, 63.2% (48/76) were men; 53.9% (41/76) were indigenous from the Ticuna ethnic group; 25% (19/76) were Yagua; and 21.1% (16/76) were Cocama (Table 2). Of the total number of cases, 90.8% belonged to the subsidized healthcare system. The median age was 19.3 years (IQR=39.5) and the range was 1.2 to 82.1 years. A total of 43.4% of all identified cases of TB were reported in children under 15 years of age (childhood TB).

A total of 32.9% of the cases reported having had previous contact with persons diagnosed with TB, 61.8% of the cases had a history of BCG vaccination, and 7.9% had had a previous diagnosis of TB (Table 2).

50% of the TB cases were sampled by induced sputum. 76% of the cases were smear negative. 100% of the cases were culture positive. One of the cases was resistant to rifampicin and isoniazid (Table 4).

Of the cases diagnosed with TB, 73.7% (56/76) had cough of less than 15 days duration; 19.6% of them (11/56) were BK positive. 26.31% of the TB cases (20/76) had cough of 15 days or more duration and 35% (7/20) had positive BK. 34% of the cases (26/76) had no expectoration and only 17.1% (13/76) of the TB patients met the definition of RS, according to the surveillance protocol and the care guide issued by the Colombian Ministry of Health (Table 4).

50% of the TB cases (38/76) required sample collection using the hypertonic saline induced sputum technique. Of these samples, 78.9% (30/38) were collected from children under 15 years of age and 21.1% (8/38) from adults; the other 50% of the cases identified did not require induced sputum and the sample was collected through spontaneous sputum. 81.4% of these samples (35/43) were over 15 years of age (Table 4).

24% of all TB patients (18/76) were smear positive. Regarding age, smear microscopy was positive in 18% (6/33) of children under 15 years of age (childhood TB cases) and in 28% (12/43) of individuals aged 15 years. 100% of the TB cases had positive cultures in Löwenstein Jensen solid medium and in MGIT liquid medium. When testing for resistance to first-line drugs, one case of childhood TB resistant to Rifampicin and Isoniazid (MDR-TB) was identified in the community of San Juan del Soco, which corresponded to 3% of these cases (Table 4).

Table 4. Duration in days of cough and expectoration in TB cases in the indigenous population

Variable	Total	%	Childhood TB	%	TB greater 15	%
Cough						
From 1 to 6 days	35	46.1	16	48.5	19	44.2
From 7 to 14 days	21	27.6	11	33.3	10	23.2
From 15 to 30 days	13	17.1	5	15.2	8	18.6
More than 30 days	7	9.2	1	3	6	14
Total	76	100	33	100	43	100
Expectoration						
No expectoration	26	34.2	9	27.2	17	39.5
From 1 to 6 days	18	23.7	9	27.2	9	20.9
From 7 to 14 days	19	25	11	33.3	8	18.6
From 15 to 29 days	4	5.3	2	6.06	2	4.7
More than 30 days	9	11.8	2	6.06	7	16.3
Total	76	100	33	100	43	100
Type of sputum						
Spontaneous	38	50	3	9.1	35	81.4
Induced	38	50	33	90.1	8	18.6
Serial smear microscopy						
Positive	18	24	6	18	12	28
Negative	58	7	37	82	31	72
Culture						
Löwenstein Jensen (LJ).	76	100	33	100	43	100
MGIT™ Liquid Medium	76	100	33	100	43	100
Identification of resistance to first-line drugs						
Genotype	1	1.3	1	3.03	0	0
G-Xpert	1	1.3	1	3.03	0	0
Total	76	100	33	100	43	100

The prevalence of tuberculosis in indigenous communities of Puerto Narino in this study was 1,302 cases per 100,000 inhabitants (95% CI: 1 233 to 1,374 cases/100,000 indigenous). The Yagua ethnic group showed the highest prevalence with 4,086 cases per 100,000 inhabitants (95% CI: 3,964 to 4,210 cases /100,000 indigenous Yaguas), followed by the Cocama ethnic group with 1,927.7 cases per 100,000 inhabitants (95% CI: 1,844 to 2,015 cases /100,000 indigenous Cocama) and the Ticuna ethnic group which had 925.1 cases per 100,000 inhabitants (95% CI: 866 to 986 cases /100,000 indgenous Ticuna). 73.9% of the communities (17/23) reported TB cases; Boyahuazu was the community with the highest prevalence (3,947 cases per 100,000 inhabitants), followed by San Juan de Atacuari (2,966 cases per 100,000 inhabitants) and Valencia (2,500 cases per 100,000 inhabitants) (Figure 2, Table 5).

Figure 2. Georeferencing of TB cases, prevalence per 100,000 inhabitants, Puerto Nariño (Amazonas), 2016

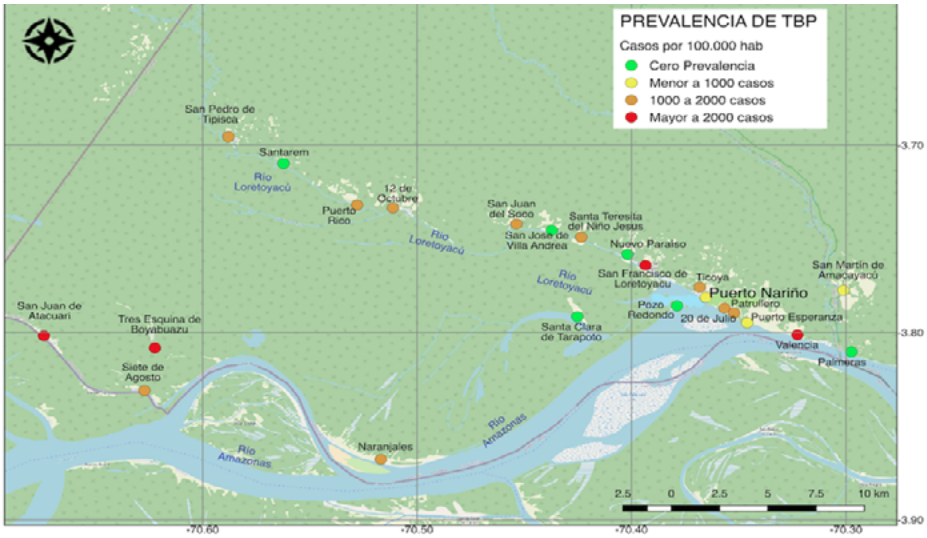


Table 5. Prevalence of tuberculosis per 100,000 inhabitants in indigenous communities

Community	Population			Childhood TB			Adult TB		
	No.	Cases	P	No.	Cases	P	No.	Cases	P
Tres Esquinas de Boyahuazu	152	6	3,947.4	70	4	5,714.3	82	2	2,439.0
San Juan de Atacuari	236	7	2,966.1	116	2	1,724.1	120	5	4,166.7
Valencia	80	2	2,500.0	40	2	5,000.0	40	0	0.0
San Francisco de Loretoyacu	398	9	2,261.3	158	3	1,898.7	240	6	2,500.0
Puerto Rico	152	3	1,973.7	63	0	0.0	89	3	3,370.8
7 de Agosto	215	4	1,860.5	111	3	2,702.7	104	1	961.5
Santa Teresita del Nino Jesus	55	1	1,818.2	23	0	0.0	32	1	3,125.0
Ticoya	391	7	1,790.3	174	2	1,149.4	217	5	2,304.1
20 de Julio	234	4	1,709.4	92	0	0.0	142	4	2,816.9
Patrulleros	122	2	1,639.3	52	1	1,923.1	70	1	1,428.6
San Pedro de Tipisca	184	3	1,630.4	94	1	1,063.8	90	2	2,222.2
12 de Octubre	249	4	1,606.4	113	2	1,769.9	136	2	1,470.6
San Juan del Soco	189	3	1,587.3	85	1	1,176.5	104	2	1,923.1
Naranjales	346	5	1,445.1	146	4	2,739.7	200	1	500.0
Puerto Narino*	1446	12	829.9	587	6	1,022.1	859	6	698.5
Puerto Esperanza	440	3	681.8	178	2	1,123.6	262	1	381.7
San Martin de Amacayacu	531	1	188.3	242	0	0.0	289	1	346.0
Palmeras	96	0	0.0	36	0	0.0	60	0	0.0
Santa Clara de Tarapoto	37	0	0.0	19	0	0.0	18	0	0.0
Nuevo Paraiso	111	0	0.0	59	0	0.0	52	0	0.0
Santarem	57	0	0.0	29	0	0.0	28	0	0.0
San Jose de Villa Andrea	110	0	0.0	60	0	0.0	50	0	0.0
Others	6	0	0.0	2	0	0.0	4	0	0.0
Total	5,837	76	1,302.0	2,549	33	1,294.6	3,288	43	1,307.8

*Urban area. Prevalence per 100,000 inhabitants. **P: Prevalence.

DISCUSSION

In this study, the prevalence of tuberculosis in the indigenous population of Puerto Nariño (1,302 cases/100,000 inhabitants) was higher than the prevalence of tuberculosis in the country for the same year 2016 (28.5 cases/100,000 inhabitants), 47.5 times the national prevalence. Although this study did not determine the incidence of tuberculosis in this population, the National Institute of Health of Colombia in the 2016 Tuberculosis event report, informed that the incidence of tuberculosis in Puerto Nariño in 2016 was 954.2 cases/100,000 inhabitants, this figure corresponds to 37 times the national incidence for that same year (25.7 cases/100,000 inhabitants).

These communities often face higher TB incidence and prevalence rates due to a combination of factors such as poor access to healthcare, malnutrition, and living conditions that facilitate the spread of the disease. Cultural and geographical barriers also complicate diagnosis and treatment, leading to lower rates of early detection and higher mortality.

The high prevalence found is consistent with that reported in a study of the indigenous population of the Yanomani people (Brazil), in which the prevalence of TB was 6,400 cases per 100,000 inhabitants (24), as well as in the indigenous population in Chine (Ecuador) with a prevalence of 6 700 cases per 100,000 inhabitants (25). Therefore, Colombia, being a multicultural country, health authorities must strengthen public health actions for the control of tuberculosis in the indigenous population

Another important finding in this study is the detection of a high number of childhood TB cases: 33/76 (43%). This result differs from the 2023 national report, in which childhood TB accounted for only 2.9% of the total number of cases reported for 2023; 4.4% of the total number of cases nationally are indigenous population and 21.3% are indigenous population of the total number of childhood TB cases (3). The high frequency of childhood TB found in the indigenous population in this study reflects the characteristics of the population structure of this ethnic group, which is made up mostly of young people between 15 and 24 years of age, followed by the group of children between 5 and 14 years of age. In addition, the aging rate of this population (17.1%) is significantly lower than that of the general population (40.4%) (4).

This study found high prevalences of childhood TB. The lowest were Puerto Nariño with 1,022.1 per 100,000 indigenous children under 15 years of age, followed by San Pedro de Tipisca with 1,063.8 per 100,000 indigenous children under 15 years of age. The communities with the highest prevalence of childhood TB were Tres Esquinas

de Boyahuazu with 5,714.3 per 100.000 indigenous children under 15 years of age and the community of Valencia with 5,000 cases per 100,000 indigenous children under 15 years of age, in contrast to the findings of a study conducted in Armenia (Colombia) in indigenous and non-indigenous children in the region (26), which reported a prevalence of 16.6 cases per 100,000.

Multidrug resistant tuberculosis (MDR-TB) is an event of great interest in public health, due to the economic, social, and psychological implications of this disease for the family and for the patient. For the year 2023, 2,4% of MDR-TB was reported in indigenous people and 1,5% in the child population (27). In this study, MDR-TB was found in 1,31% of TB patients. When characterized by age, 3% of the cases of childhood pulmonary tuberculosis were resistant to first-line drugs. Puerto Nariño is a municipality located in a border area with two countries, Brazil and Peru, which have higher rates of MDR-TB than Colombia.

Changing the definition of RS for this study made it possible to find a more significant number of cases of active TB, improving the detection of tuberculosis in vulnerable populations, in which 16.7% of the indigenous people were RS. A similar finding was reported in a study in a population deprived of liberty in Colombia, in which 15% of RS was detected (16). These results differ from those found in other studies such as in Tulcan (Ecuador), on the border with Colombia, a prevalence of RS of 2.8% was found in the indigenous population (28); another study conducted in Mitu (Colombia) in 2001 reported a prevalence of RS of 4.4% in the indigenous population (29). The differences found with previous studies may be related to the modification of the definition of RS (individual presenting cough with or without expectoration of any duration).

A total of 8.1% of RS identified through active search (76/944) had TB which is similar to the result

of the study reported by Guerra in the prison population, in which 8% of (16) the RS studied had TB. Introducing a new definition of RS in a vulnerable population may optimize identifying patients who do not meet the conventional definition of RS.

In this study, induced sputum was used to collect the sample in children under 15 years of age (318) and in adults (102) who could not expectorate. This technique was used to diagnose active TB in 33 children and 43 adults. This demonstrated its usefulness, similar to the study conducted by (author) in Malawi in children under 15 years of age (30); it was observed that induced sputum was a safe, adequate, non-traumatic, and accepted method by the patient and their parents. In doing so, the sample collection was improved in 97% of the participants and *Mycobacterium tuberculosis* was identified in 8% of them. Similarly, the study by Butov et al. agrees that sputum induction with hypertonic solution improves the detection rate of mtb in sputum. Those findings suggest that this method of sample collection can be used in resource-limited countries without significant adverse effects (31).

In this study, cough had a duration of less than 15 days in 73.7% of the cases of TB in indigenous people. This was an important finding that is consistent with that reported in a study conducted in Tanzania in outpatients over 5 years of age (32), which concluded that *Mycobacterium tuberculosis* can be detected in sputum before the individual has a cough of two weeks or more, since 12.7% of the patients evaluated had positive smear sputum, a figure similar to that found in this study (19.6%). This finding suggests making the classic definition of RS more flexible depending on the type of population studied.

In the study by Mesa et al., they conclude that tuberculosis is a disease with high social determinant, its intervention requires political commitment, trained personnel, access to medicines and improvement of epidemiological surveillance systems (33). The high numbers of tuberculosis found in the study indicated recent transmission and failures in the early diagnosis of tuberculosis, which is necessary to strengthen the control program with specific strategies for the indigenous population, emphasizing children under 15 years of age ♠

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