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Major Article

Characteristics of basic health units and detection of tuberculosis cases

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Abstract

Introduction: Tuberculosis (TB) is an infectious and contagious disease caused by *Mycobacterium tuberculosis*. TB emerged in the 21st century as an unsolved public health problem. This study aimed to analyze the relationship between the characteristics of basic health units (BHUs) and the number of TB cases detected in Maranhão, Brazil. **Methods**: An ecological, analytical study was conducted using the municipalities in the state of Maranhão as the unit of analysis. Data regarding the number of detected TB cases was obtained from the *Sistema de Informação de Agravos de Notificação* database, and the characteristics of the BHUs were obtained from the first cycle of data collection for the Program to Improve Access and Quality of Basic Care. The BHU structure was classified as adequate (80%–100%), partially adequate (60%–79%), poorly adequate (40%–59%), or inadequate (<40%) according to the presence of specified items. The number of BHUs per municipality in each adequacy category was estimated. Inflated Poisson regression analysis was performed to estimate the incidence density ratios (IDRs) and the 95% confidence intervals (95% CIs). **Results**: Municipalities with a higher level of BHU adequacy had a higher number of detected TB cases (IDR = 1.61, 95% CI: 1.01–2.60). **Conclusions**: Better structured health services in primary care may be associated with better detection and/or notification of TB cases.

Keywords: Tuberculosis. Primary health care. Structure of services.

INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis*[1]. TB is one of the leading causes of death from infectious diseases among adults worldwide and remains an unresolved public health problem in the 21st century[2].

Two billion people (one-third of the world's population) are infected with *M. tuberculosis*. Among these, approximately 9.27 million people become ill, and two million die each year, including 460,000 who are co-infected with human immunodeficiency virus (HIV)[3].

On the global scale, Brazil remains one of the countries with the highest TB burden (along with India, China, and South Africa), which together account for 80% of the total estimated cases in the world. Brazil has the 16th highest number of TB cases and the 22nd highest incidence rate. Across Brazil, an

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estimated 66,796 new cases occurred in 2016, and 4,543 deaths were due to TB in 2015[1,4].

In 2012, a total of 1,935 new TB cases were reported in Maranhão, which has an incidence rate of 28.8/100,000 inhabitants for all forms of TB and 16.3/100,000 inhabitants for smear-positive cases. Although the incidence rate trended downward between 2001 and 2010, the disease remains endemic. The mortality rate in 2012 was 2.1/100,000 inhabitants in the state and 3.9/100,000 inhabitants in the capital[5]. The state includes eight municipalities considered priority areas for TB control based on the criteria established by the Brazilian Ministry of Health, which recommends the decentralization of TB control activities to the primary health care (PHC) system, especially through the Family Health Strategy (FHS) and the Community Health Agents Strategy (CHAS)[6], to develop essential actions for disease control.

The FHS and the CHAS are important allies in the fight against TB; however, greater territorial coverage and better team training are needed because these programs are the main gateway into the health system. Professional qualification is important, as TB control involves various cultural, socioeconomic, and subjectivity factors[7].

Despite progress in diagnosis and treatment, TB morbidity and mortality rates remain high. Several reasons for these high rates include poor administration of TB control programs, treatment abandonment, poverty, population growth, migration, and a significant increase in cases in regions with high HIV prevalence[8,9]. Proper diagnosis and treatment for pulmonary TB are the primary methods of disease control. Efforts should be made to detect cases early and provide appropriate treatment to disrupt the disease transmission chain.

Improvement in the detection, diagnosis, treatment, and follow-up of TB cases is influenced by various important factors, including structure, organization, and functionality of health services and reliable records systems to reduce underreporting and improve the care and monitoring of patients[10,11].

Both the detection of cases and the delivery of TB treatment must be conducted in the PHC system; however, little is known about the impact of the structure of basic health care services on TB detection rates. Therefore, this study aimed to analyze the relationship between the number of TB cases detected and the characteristics of basic health units (BHUs) in Maranhão.

METHODS

An ecological, analytical study was conducted using municipalities in the state of Maranhão as the unit of analysis. This analysis was conducted as part of a multicenter study ("External Evaluation and Census of Basic Health Units, PMAQ-AB") in partnership with universities and research institutes in Brazil and under the coordination of the Federal University of Pelotas (UFPel). In compliance with Resolution 196/96 of the National Health Council, this study was approved by the Ethics Committee of UFPel (official letter 38/12, 10/05/2012).

Statistical analysis was performed using the STATA program, version 11.0. (Texas, USA). The dependent variable, the number of cases of pulmonary TB detected, was obtained from the database of the *Sistema de Informação de Agravos de Notificação* (SINAN) at the State Department of Health, using all cases reported and confirmed in 2013.

Demographic and socioeconomic variables were obtained from several databases. The proportion of population coverage estimated by FHS for 2012 was obtained from the History of Coverage of Family Health in the Department of Primary Care of the Ministry of Health[12]. The urban development index (UDI) (2010), Gini index (2012), demographic density (2010), urbanization rate (2010), and percentage of extremely poor individuals in permanent private households (2010) were obtained from the Atlas of Human Development in the Brazil database[13]. Population size (2010) was obtained from the Demographic Census of Brazilian Institute of Geography and Statistics (IBGE)[14]. The proportion of the population with water supply (2010), gross domestic product (GDP; 2010), and illiteracy rate (2010) were obtained from the database of the Unified Health System of Brazil (DATASUS – acronym in Portuguese)[15].

The variables for the structural characteristics of BHUs (infrastructure and organization) were obtained from the database of the external evaluation of the census conducted during the first cycle of the PMAQ-AB from 2012 to 2013. All BHUs in all municipalities were evaluated according to the following criteria:

* Infrastructure: Physical facilities (bathroom for employees, toilet for male clients, toilet for female clients, adaptations for people with disabilities, slop hopper, common waste disposal, clinic, pharmacy, reception area, reception rooms, dressing room, waiting area, sterile storage, washing/decontamination area, procedure rooms, nebulization room, vaccination room, area for observation, and meetings/educational activities), environment (air circulation, lighting, smooth and washable surfaces, acoustics, and privacy), external accessibility (sidewalk, railing, ramps, regular flooring, non-slip flooring, and adapted entrance door), and signage (standalone displays/plaques/other, schedules, services, staff list, ombudsman's phone, and signaling method).

The adequacy of the infrastructure was determined based on the sum of the items present and was classified into four categories: adequate, when the BHU met 80%–100% of the criteria; partially adequate, when 60%–79% of the criteria were met; poorly adequate, when 40%–59% of the criteria were met; and inadequate, when fewer than 40% of the criteria were met[16]. The percentage of BHUs in the municipality in each category of adequacy was estimated.

* Organization: The percentage of BHUs in the municipality meeting the following criteria: (1) at least one FHS team, (2) an FHS team operating for at least two shifts and 5 days a week, (3) a vehicle on demand, and (4) a minimum number of professionals on the team (at least one doctor, one nurse, one nursing assistant, and four community health agents).

* Minimum structure for the evaluation of suspected TB in primary care: The percentage of BHUs in the municipality that had at least one doctor and/or nurse plus a stethoscope,

a thermometer, personal protective equipment (PPE), TB notification forms, and HIV rapid tests available at all times

For the descriptive analyses, the variables were analyzed according to the classification of municipalities in the eight health administration macro-regions (São Luís, Imperatriz, Coroatá, Balsas, Pinheiro, Presidente Dutra, Caxias, and Santa Inês) and in the eight municipalities considered priorities for TB control in the state because they had a number equal to or greater than 100,000 inhabitants and had an incidence rate higher than 47/100,000 inhabitants (Açailândia, Caxias, Codó, Imperatriz, Paço do Lumiar, São José de Ribamar, São Luís, and Timon)[17].

The number of TB cases detected in Maranhão was considered as the dependent variable, and the main independent variable was the proportion of BHUs across all municipalities that met the minimum structure criteria for the evaluation of suspected TB. To fit the model, the following independent variables were included: the proportion of population coverage estimated by the FHS, categorized as adequate (≥70%) or inadequate (<70%), Gini index, UDI, demographic density, proportion of the population with water supply, illiteracy rate, and proportion of extreme poverty in the population categorized in tertiles.

A zero-inflated Poisson regression model with robust fit was used to estimate the association between the minimum structure for the evaluation of suspected TB in the BHUs and the number of detected TB cases. The variables with $p<0.20$ in the univariate analysis were included in the adjusted analysis. Only the variables with $p<0.05$ were retained in the final model. The incidence density ratio (IDR) with a 95% confidence interval (95% CI) was estimated.

RESULTS

In 2013, Maranhão had a pulmonary TB incidence rate of 19.8 cases/100,000 inhabitants. No notification was available in 68 municipalities (31.34%).

Despite the high illiteracy rate (35.5%), the capital of Maranhão stands out because its socioeconomic indicators are good. Other priority municipalities for TB control had high proportions of extremely poor individuals, such as Codó (25.0%) and Caxias (17.2%). All macro-regions had high FHS coverage (86.7%–98.0%) above the state average (71.4%). However, among the priority municipalities, São Luís had the lowest FHS coverage (27.5%) and Timon had the best (100%) (**Table 1**).

TABLE 1: Distribution of demographic, socioeconomic, and health characteristics by macro-regions of health and municipalities priority for tuberculosis control, Maranhão, 2010–2012.

Localization	Demographic density (inhabitants /km²)		UDI (0 - 1)		GINI index (0 - 1)		Extremely poor individuals (%)		The urbanization rate (%)		Illiterate rate (% >15 years)		Water supply (%)		FHS coverage (%)	
	x	*sd*	*x*	*sd*	*x*	*sd*	*x*	*sd*	*x*	*sd*	*x*	*sd*	*x*	*sd*	*x*	*sd*
Maranhão	81.1	223.9	0.59	0.05	0.55	0.44	27.8	11.8	56.3	19.9	25.6	7.0	81.3	10.0	71.4	79.0
Macro-regions																
São Luís	234.0	416.3	0.57	0.05	0.56	0.03	33.4	11.0	52.5	21.8	26.5	7.7	74.7	9.0	90.7	18.8
Imperatriz	43.8	63.6	0.62	0.06	0.55	0.05	19.2	13.8	65.9	20.4	21.3	6.5	87.7	9.1	86.7	19.6
Coroatá	38.8	28.0	0.59	0.05	0.55	0.45	25.7	10.4	58.0	17.7	29.4	7.1	83.7	7.0	94.8	10.5
Balsas	4.8	1.7	0.62	0.04	0.57	0.05	20.9	10.9	68.1	18.7	17.0	4.0	83.6	11.9	89.1	22.1
Pinheiro	34.8	19.2	0.58	0.03	0.55	0.04	31.5	8.6	47.2	15.6	21.8	4.6	77.9	8.9	94.6	12.2
Presidente Dutra	20.1	14.6	0.57	0.39	0.52	0.04	29.0	9.9	56.5	15.8	28.7	4.1	82.0	9.5	94.6	15.7
Caxias	39.9	30.9	0.59	0.04	0.54	0.02	24.3	12.2	57.6	19.4	27.5	7.3	82.3	9.5	98.0	4.9
Santa Inês	33.0	34.0	0.57	0.04	0.53	0.03	25.5	9.8	57.7	20.4	26.0	5.4	87.6	7.0	95.5	13.4
Priority municipalities	**(inhabitants /km²)**		**(0 - 1)**		**(0 - 1)**		**(%)**		**(%)**		**(%>15 years)**		**(%)**		**(%)**	
Açailândia	17.8		0.67		0.56		10.1		75.1		17.6		89.5		55.1	
Caxias	29.5		0.62		0.55		17.2		76.4		25.7		85.0		83.8	
Codó	26.9		0.59		0.57		25.0		68.6		30.4		87.2		69.8	
Imperatriz	180.8		0.73		0.56		3.5		94.7		10.8		96.5		58.2	
Paço do Lumiar	786.9		0.72		0.49		7.7		74.9		5.7		76.6		54.4	
São José d Ribamar	899.8		0.70		0.51		7.4		23.1		6.7		74.6		54.2	
São Luís	1,215.6		0.76		0.55		4.5		94.4		35.5		80.7		27.5	
Timon	89.0		0.64		0.50		9.6		86.9		17.2		89.4		100.0	

Source: IBGE (Census 2010); Atlas of Human Development 2013; Department of Primary Care / Health Ministry.

Inadequacy of the BHU infrastructure was noted primarily in the areas of signaling (68.0%), accessibility (72.5%), physical facilities (64.9%), and environment (43.6%). Only 28.8% of the BHUs had an adequate minimum structure for the evaluation of suspected TB cases (**Tables 2** and **3**).

In the macro-regions, the greatest levels of inadequacy were noted in the areas of physical facilities (47.5%–75.7%), environment (15.5%–70.1%), signaling (50.3%–84.6%), and external accessibility (50%–86.7%). More than half of the BHUs in the macro-region of Santa Inês met the criteria for minimum adequate structure (56.28%), whereas the other macro-regions had a high percentage of inadequate BHU structure (15.6%–26.2%).

Among the priority municipalities for TB control, Açailândia did not have any BHU with adequate infrastructure. Three municipalities, São José de Ribamar (72%), São Luís (52%), and Paço do Lumiar (50%), had the highest proportions of adequate BHUs with minimum infrastructure to evaluate cases of suspected TB. Four municipalities, Paço do Lumiar, São José de Ribamar, Caxias, and Codó, did not have any inadequate BHUs (**Tables 2** and **3**).

Most municipalities had BHUs with at least one FHS-type team both in the state (91.0%) and in the macro-region (85.5%–94.8%). Overall, 83.8% of the BHUs in the state and 68.8%–89.8% of those in the macro-regions operated for two shifts and 5 days of the week. An on-demand vehicle was available in 95.6% of the BHUs in the state, with a range of 84.8%–100% in the macro-regions. However, more than half of the macro-regions did not have teams with a minimum number of staff in the BHU (51.6%, range 25.2%–77.4%) (**Table 4**).

Three macro-regions, Coroatá (58.0%), Balsas (50.7%), and Santa Inês (74.8%), had the highest percentages of BHUs that met the minimum criteria for the number of staff. Among the priority municipalities for TB control, Caxias (3.1%), Imperatriz (3.3%), and São José de Ribamar (8.7%) had the lowest percentages of BHUs that met the minimal staff criteria (**Table 4**).

TABLE 2: Distribution of the characteristics (infrastructure) of the health units by macro-regions of health and municipalities priority for tuberculosis control, Maranhão, 2012–2013.

Localization	Physical facilities				Environment				Signage			
	Adequate	Partially adequate	Poorly adequate	Inadequate	Adequate	Partially adequate	Poorly adequate	Inadequate	Adequate	Partially adequate	Poorly adequate	Inadequate
	%	%	%	%	%	%	%	%	%	%	%	%
Maranhão	1.1	6.0	27.9	64.9	9.7	17.6	25.9	43.6	0.1	3.7	28.1	68.0
Macro-regions												
São Luís	2.2	9.1	28.7	59.8	15.7	24.2	29.1	30.9	-	4.2	32.7	63.0
Imperatriz	0.9	4.8	23.7	70.3	0.4	19.4	35.4	44.6	0.4	1.9	28.6	68.9
Coroatá	0.4	5.8	29.4	64.2	4.5	12.2	37.1	46.1	-	1.3	14.0	84.6
Balsas	2.5	6.2	43.7	47.5	11.2	35.0	36.2	15.5	-	2.5	25.0	72.5
Pinheiro	0.8	2.7	20.7	75.7	4.3	5.9	19.5	70.1	-	3.1	43.8	52.9
Presidente Dutra	0.3	5.5	24.7	69.3	4.8	14.0	25.4	55.7	-	0.0	20.3	79.7
Caxias	0.7	2.8	24.1	72.3	17.0	24.8	35.4	22.7	0.7	21.9	26.9	50.3
Santa Inês	0.8	6.9	37.2	54.9	18.1	14.7	22.9	44.1	-	0.8	25.9	73.1
Priority municipalities												
Açailândia	-	4.5	18.1	77.2	-	4.5	36.3	59.0	-	4.5	36.3	59.0
Caxias	-	-	46.8	53.1	31.2	21.8	43.7	3.1	-	28.1	43.7	28.1
Codó	-	12.5	68.7	18.7	-	18.7	43.7	37.5	-	-	31.2	68.7
Imperatriz	2.5	2.5	33.3	55.5	-	22.2	41.6	36.1	-	2.7	44.4	52.7
Paço do Lumiar	-	10.0	50.0	40.0	-	40.0	50.0	10.0	-	-	20.0	80.0
São José de Ribamar	8.0	20.0	32.0	40.0	12.0	40.0	28.0	20.0	-	24.0	40.0	36.0
São Luís	12.0	26.0	44.0	18.0	32.0	22.0	28.0	18.0	-	14.0	48.0	38.0
Timon	-	-	18.9	81.0	24.3	27.0	24.3	24.3	-	24.3	21.6	54.0

Source: PMAQ-AB.

TABLE 3: Distribution of the characteristics (infrastructure) and minimum structure for evaluation of suspected tuberculosis (TB) in the health units by macro-regions of health and municipalities priority for TB control, Maranhão, 2012–2013.

Localization	External accessibility				Minimum structure for evaluation of suspected TB			
	Adequate	Partially adequate	Poorly adequate	Inadequate	Adequate	Partially adequate	Poorly adequate	Inadequate
	%	%	%	%	%	%	%	%
Maranhão	2,7	4,1	20,6	72,5	28,8	28,9	23,2	19,1
Macro-regions								
São Luís	5,3	6,5	28,7	59,4	29,6	27,5	25,3	17,4
Imperatriz	0,9	5,8	20,3	72,8	20,8	35,9	20,8	23,3
Coroatá	0,4	1,8	19,4	78,2	11,7	34,8	29,4	23,9
Balsas	8,7	8,7	32,5	50,0	18,7	38,7	22,5	20,0
Pinheiro	0,8	1,9	16,7	80,4	37,4	25,5	18,7	18,3
Presidente Dutra	1,1	0,7	11,4	86,7	16,9	26,5	30,2	26,2
Caxias	5,6	4,2	26,2	63,8	36,6	33,3	18,4	15,6
Santa Inês	1,3	4,7	14,2	79,6	56,2	20,7	15,1	7,7
Priority municipalities								
Açailândia	-	-	18,1	81,8	27,2	18,1	27,2	27,2
Caxias	15,6	3,1	43,7	37,5	37,5	46,8	15,6	-
Codó	-	-	25,0	75,0	12,5	56,2	31,2	-
Imperatriz	-	8,3	41,6	50,0	25,0	58,3	11,1	5,5
Paço do Lumiar	-	20,0	30,0	50,0	50,0	50,0	-	-
São José de Ribamar	12,0	-	28,0	60,0	72,0	28,0	-	-
São Luís	30,0	10,0	34,0	26,0	52,0	30,0	16,0	2,0
Timon	-	5,4	29,7	64,8	37,8	32,4	21,6	8,1

Source: PMAQ-AB.

In the unfitted analysis, the characteristics of the municipalities that were associated with the highest number of detected TB cases were as follows: less than 70% FHS coverage (IDR = 12.10; 95% CI: 3.66–40.06), a higher tertile of social inequality according to the Gini index (2nd tertile, IDR = 3.42, 95% CI: 1.12–10.44), a higher population density (IDR = 3.69, 95% CI: 1.43–9.51), and a higher number of BHUs with adequate structure (IDR = 4.16, 95% CI: 1.41–12.26).

The characteristics associated with the lowest number of detected TB cases included 2nd tertile of UDI (IDR = 0.31, 95% CI: 0.20–0.47), 2nd tertile of illiteracy rate (IDR = 0.59, 95% CI: 0.36–0.97), and higher urbanization (2nd tertile, IDR = 0.25, 95% CI: 0.10–0.63; 3rd tertile, IDR = 0.22, 95% CI: 0.08–0.61) (**Table 5**).

After adjusting for socioeconomic variables, the municipalities with a higher number of adequate BHUs were associated with the highest number of TB cases (IDR = 1.61, 95% CI: 1.01–2.60), 3rd tertile of UDI (IDR = 3.27, 95% CI: 1.70–6.29), and lower FHS coverage (IDR = 6.29, 95% CI: 3.67–10.79). Higher rates of urbanization remained associated with a lower occurrence of reported TB cases (**Table 5**).

DISCUSSION

The demographic, socioeconomic, and health indicators portray a poor state, with a low UDI, unequal distribution of income, and endemicity and spread of TB. This situation contributes to the maintenance of high disease incidence and mortality rates in Maranhão, in contradiction with the goal of eliminating the endemic disease as a public health problem proposed by the World Health Organization.[18] However, the results of the present study indicate that improvements in basic health units favor the detection of TB cases, favoring a faster diagnosis.

Although the average ESF coverage of the population was 71.4% across the state, the coverage ranged from 27.5% to 83.8% in the TB control priority municipalities. In addition, these municipalities had a high rate of illiteracy, as observed in Codó (30.47%) and São Luís (35.51%). The illiteracy rates

TABLE 4: Distribution of the characteristics (organizational) of health units by macro-regions of health and municipalities priority for tuberculosis control, Maranhão, 2012-2013.

	Existence of ESF				Operating for 2 shifts and 5 days				Vehicle on demand				Have minimum team			
	Yes		No		Yes		No		Yes		No		Yes		No	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Maranhão	1,630	90.9	168	9.34	1516	83.8	292	16.1	885	95.6	60	6.3	766	48.3	818	51.6
Macro-regions																
São Luís	393	91.8	35	8.1	374	84.6	68	15.3	241	91.2	23	8.7	160	42.7	214	57.2
Imperatriz	174	89.2	21	10.7	170	89.0	21	19.9	56	84.8	10	15.1	34	22.5	117	77.4
Coroatá	192	88.0	26	11.9	172	79.6	44	20.3	129	94.1	8	5.8	115	58.0	83	41.9
Balsas	65	85.5	11	14.4	71	89.8	8	10.1	16	100.0	0	-	33	50.7	32	49.2
Pinheiro	238	94.8	13	5.1	211	84.0	40	15.9	168	98.1	3	1.8	107	48.4	114	51.5
Presidente Dutra	231	87.1	34	12.8	230	87.7	32	12.2	131	95.6	6	4.3	107	46.3	124	53.6
Caxias	128	93.4	9	6.5	95	68.8	43	31.1	54	96.4	2	3.5	55	40.1	82	59.8
Santa Inês	209	91.6	19	8.3	193	84.2	36	15.7	100	92.5	8	7.4	155	74.8	52	25.2
Priority municipalities																
Açailândia	17	77.2	5	22.7	17	85.0	3	15.0	4	66.6	2	33.3	3	18.7	13	81.2
Caxias	32	100.0	-	-	28	87.5	4	12.5	4	100.0	-	-	1	3.1	31	96.8
Codó	16	100.0	-	-	13	81.2	3	18.7	11	91.6	1	8.3	10	62.5	6	37.5
Imperatriz	34	100.0	-	-	36	100.0	-	-	2	100.0	-	-	1	3.3	29	96.6
Paço do Lumiar	10	100.0	-	-	10	100.0	-	-	9	100.0	-	-	1	10.0	9	90.0
São José de Ribamar	24	100.0	-	-	8	32.0	17	68.0	16	94.1	1	5.8	2	8.7	21	91.3
São Luís	44	89.8	5	10.2	46	92.0	4	8.0	6	75.0	2	25.0	11	23.4	36	76.6
Timon	36	100.0	-	-	15	42.8	20	57.1	11	91.6	1	8.3	18	50.0	18	50.0

Source: PMAQ-AB.

TABLE 5: Zero-inflated Poisson regression analysis not adjusted and adjusted between tuberculosis cases and the minimum infrastructure of the basic health units, Maranhão, 2012-2013.

Variable	No. of TB cases							
	Not adjusted				Adjusted			
	IDR	95% CI	*p*	*Vuong*	IDR	95% CI	*p*	*Vuong*
Minimum infrastructure				3,12				3,70
Adequate	4.16	1.41–12.26	0.010		1.61	1.01–2.60	**0.049**	
Partially adequate	1.69	0.94–3.07	0.081		1.04	0.58–1.86	**0.899**	
Pouco Poorly adequate	1.29	0.79–2.09	0.309		0.71	0.41–1.24	**0.228**	
Inadequate	Ref.				Ref.			
% FHS coverage				2.20				
≥70%	Ref.				Ref.			
<70%	12.10	3.66–40.06	<0.001		6.29	3.67–10.79	**<0.001**	
UDI				3.16				
1° tertile	Ref.				Ref.			
2° tertile	0.31	0.20–0.47	**<0.001**		0.84	0.49–1.45	**0.539**	
3° tertile	1.29	0.31–5.36	0.730		3.27	1.70–6.29	**<0.001**	
Demographic density				2.83				
1° tertile	Ref.				Ref.			
2° tertile	0.77	0.48–1.24	0.280		0.97	0.52–1.80	**0.917**	
3° tertile	3.69	1.43–9.51	0.007		3.10	1.75–5.50	**<0.001**	
Urbanization index				3.06				
1° tertile	Ref.				Ref.			
2° tertile	0.25	0.10–0.63	0.003		0.43	0.25–0.72	**0.002**	
3° tertile	0.22	0.08–0.61	0.004		0.34	0.21–0.56	**<0.001**	

IDR: incidence density ratio; **95% CI:** 95% confidence interval. Only the variables that remained in the adjusted model were presented.

were above the state average, which may contribute to a greater difficulty in the recognition and/or perception of the disease carrier state, and in seeking and adhering to treatment. This finding corroborates the results of Silva's study[19], in which cessation of TB treatment was considered high in youth with low schooling, thus contributing to continuous transmission in the community and an increase in TB cases.

In addition to the vulnerability imparted by the demographic and socioeconomic characteristics of the population, weaknesses in the characteristics of the BHUs may contribute to the low detection of TB cases. Several studies[20-24] have described weaknesses in management, physical structure, access to primary health care services, qualification of staff, and adequacy of staffing that compromise the diagnosis and timely treatment of TB.

The high proportions of inadequacy of physical facilities (64.9%), environment (43.7%), signaling (68.1%), and accessibility (72.5%) may hamper the population's access to health services and the development of health activities. In addition, this inadequacy may affect the detection and treatment of TB. Similar results were found in the study by Garcia *et al.*[20], which reported unsatisfactory indicators of structure, environment, and accessibility in the Espírito Santo BHU.

According to the Manual of Physical Structure of the BHU[25], health service facilities are evaluated based on the technologies available and other aesthetic or sensory components perceived by sight, smell, and hearing, such as lighting, temperature, and ambient noise. Adequate ventilation is essential to maintain sanitation on the premises of the BHU. Hence, it is recommended that all rooms have windows or adequate indirect ventilation (exhaust fans) to allow air circulation to ensure that the staff can perform their activities in a safe manner.

We found that more than half of the BHUs operated in two shifts and had a vehicle available on demand. More than half of the BHUs did not meet the minimum team composition criteria[6]. Trigueiro *et al.*[26] and Monroe[27] emphasized the need for sufficient human resources and infrastructure elements for TB control activities, with a focus on the active search for respiratory symptomatology by community health workers and adequate diagnosis and treatment. Santos[28] highlighted the relevance of the entire team, which is preferably multi-professional, in working toward the social inclusion of patients and the reduction of treatment abandonment[29,30]. Santos *et al.*[31] describe the performance of ESF professionals in the control of TB and indicate deficiencies in structure and organization as factors that hinder the functioning of the National Tuberculosis Control Program in the daily work of the FHS teams.

In assessing the organization of basic care, Garcia *et al.*[20] demonstrated the need for greater investment in the incorporation of physicians and other professionals in basic care for the development of health activities, which resulted in greater suspicion and search for TB cases in the work routine and greater resolution to diagnose cases.

In a municipality of the metropolitan region of João Pessoa, Paraíba, Monroe *et al.*[27] highlighted the advances in TB control related to the development of prevention, cure, rehabilitation, and home visits by multidisciplinary teams, demonstrating the relevance of the presence and completeness of the health team in the unit.

In the fitted regression analysis, BHUs with a better score on the minimum structure criteria also reported a greater number of detected TB cases, which may suggest that TB cases are underestimated in municipalities with inadequate BHU structure. The late diagnosis of TB may result in a more severe presentation of the disease, with more sequelae in the long term, higher mortality, and perpetuation of the transmission chain[32].

BHUs meeting the minimal structure criteria had an improved ability to diagnose TB cases, indicating that greater investment results in a greater chance of performing an efficient clinical examination under appropriate biosafety conditions.

When no minimum elements are present in the BHU to evaluate suspected TB cases, diagnosis and treatment may be delayed, which increases the risk of disease transmission and reduces the chances of a cure. The time elapsed from diagnosis to the beginning and completion of treatment is fundamental to the control of TB infection[33].

The percentage of inadequate FHS coverage (IDR: 6.29, $p<0.001$) remained associated with the fit of the model, indicating that when coverage is inadequate, the number of reported TB cases is lower. Low FHS coverage may compromise the accessibility of health services in primary care, leading the user to seek health services in secondary care when their clinical condition has deteriorated. A study by Dantas *et al.*[34] conducted in Natal, Rio Grande do Norte, evaluated the factors associated with the first choice of place for the diagnosis of TB, demonstrating that low FHS coverage may influence the choice of emergency services as the first place for a TB diagnosis.

Similarly, a study by Wysocki *et al.*[35] on the delay in the search for an initial consultation for a TB diagnosis showed that the initiative to seek care is strongly linked to the search for competent professionals, satisfaction with the care provided, and patients' confidence in the experience and capacity of the team.

The municipalities in the highest tertile of UDI had the highest number of TB cases (IDR: 3.27, p<0.001, 3rd tertile) most likely because geographic areas with a lower UDI are associated with a deficient structure of the health services network, which is unable to adequately address existing problems[36].

Additionally, high population density (IDR: 3.10, p<0.001, 3rd tertile) remained associated with the highest number of detected cases after adjustment. Maranhão has impoverished municipalities, with low demographic density and poor sanitary conditions.

In contrast, the higher urbanization rate (IDR: 0.43, p<0.002, 2nd tertile, IDR: 0.34, p<0.001, 3rd tertile) was associated with a lower number of TB cases. Social inequality in the state and precarious living conditions in several segments of society may have had a negative influence on the detection of TB cases. In an analysis of TB trends and their determinants in 135 countries, Dye *et al.*[8] demonstrated that social and economic factors are related to the incidence of TB.

This is the first study conducted in Maranhão that links detected TB cases with characteristics of BHUs as assessed in the first BHU census. This study helped correct the scarcity of research that takes into account the characteristics of the BHU structure. The study had several limitations, such as the possibility of TB underreporting in the state, even though SINAN is the main source of data for the reporting of TB cases and provides the data that can be used to estimate the epidemiological and operational indicators for the country. In addition, the PMAQ-AB data collection instrument, which was used to evaluate the structure of the BHUs, was not expected to collect the data on specific drugs and tests for TB.

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