Cogitare Enfermagem

ORIGINAL ARTICLE

PREDICTIVE MODEL FOR THE SOCIOECONOMIC DETERMINANTS OF TUBERCULOSIS AMONG THE INDIGENOUS POPULATION OF THE STATE OF PARÁ, BRAZIL*

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ABSTRACT
Objective: develop a model that is able to identify the correlation between socioeconomic determinants and incidence of tuberculosis in the indigenous population of the state of Pará.
Method: quantitative analytical study, which built a predictive model using Poisson regression for 285 new cases reported in the Notifiable Diseases Information System, from January 2010 to December 2015, in the state of Pará.
Results: the model confirmed that 86% of the total number of new cases can be explained by the variables: receipt of social benefits from the government, income, education and sex. The first variable was considered the most significant with $p<0.10$.
Conclusion: the predictive model is useful as a support for making decisions, since it enables focusing tuberculosis control actions on individuals at greater risk: indigenous men, with no education, who do not receive social benefits.

DESCRIPTORS: Tuberculosis; indigenous population; social conditions; health information system; logistic models.

*Article taken from the master's dissertation "Socioeconomic determinants of tuberculosis: modeling and spatial distribution of cases in the indigenous population of Pará". State University of Pará, 2017.

HOW TO REFERENCE THIS ARTICLE:
Paiva BL, Nogueira LMV, Rorigues ILA, Basta PC, Ferreira AMR, Caldas SP. Predictive model for the socioeconomic determinants of tuberculosis among the indigenous population of the state of Pará, Brazil. Cogitare enferm. [Internet]. 2019 [access "insert day, monh and year"]; 24. Available at: http://dx.doi.org/10.5380/ce.v24i0.64835.

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dx.doi.org/10.5380/ce.v24i0.64835 Cogitare enferm. 24: e64835, 2019

MODELO PREDITIVO DE DETERMINANTES SOCIOECONÔMICOS DA TUBERCULOSE EM POPULAÇÃO INDÍGENA DO ESTADO DO PARÁ, BRASIL

RESUMO

Objetivo: desenvolver um modelo capaz de identificar a correlação entre determinantes socioeconômicos e incidência de tuberculose na população indígena do estado do Pará. Método: estudo analítico e quantitativo, no qual se construiu um modelo preditivo por meio de regressão de Poisson para 285 casos novos notificados no Sistema de Informação de Agravo e Notificação, no período de janeiro de 2010 a dezembro de 2015, no Estado do Pará. Resultados: partindo do modelo construído, pode-se confirmar que 86% do total de novos casos de tuberculose pode ser explicada pelas variáveis: recebimento de benefício social do governo, renda, escolaridade e sexo. A primeira variável foi considerada a mais significativa com nível de p<0.10.

Conclusão: o modelo preditivo é útil como suporte para tomada de decisão, pois permite direcionar ações de controle da tuberculose aos indivíduos sob maior risco: indígenas do sexo masculino, sem escolaridade e que não recebem benefícios sociais.

DESCRITORES: Tuberculose; População Indígena; Condições Sociais; Sistema de Informação em Saúde; Modelos Logísticos.

MODELO PREDICTIVO DE DETERMINANTES SOCIOECONÓMICOS PARA TUBERCULOSIS EN POBLACIÓN INDÍGENA DEL ESTADO DE PARÁ, BRASIL

RESUMEN

Objetivo: Desarrollar un modelo capaz de identificar la correlación entre determinantes socioeconómicos e incidencia de tuberculosis en la población indígena del estado de Pará. Método: Estudio analítico, cuantitativo, en el que se construyó un modelo predictivo mediante regresión de Poisson para 285 casos nuevos reportados al Sistema de Informação de Agravo e Notificação entre enero de 2010 y diciembre de 2015 en el estado de Pará. Resultados: Partiendo del modelo construido, puede confirmarse que el 86% del total de nuevos casos de tuberculosis encuentra explicación mediante las variables: recepción de beneficio social gubernamental, ingresos, escolarización y sexo. La primera variable fue considerada la más significativa, con nivel p<0,10.

Conclusión: El modelo predictivo es útil como soporte a la toma de decisiones, permitiendo orientar acciones de control de la tuberculosis hacia los individuos bajo mayores riesgos: indígenas de sexo masculino, sin escolarización, que no reciben beneficios sociales.

DESCRIPTORES: Tuberculosis; Población Indígena; Condiciones Sociales; Sistemas de Información en Salud; Modelos Logísticos.

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INTRODUCTION

Tuberculosis (TB) is strongly linked to socioeconomic conditions and the environment[1]. It is caused by *Mycobacterium tuberculosis* that mainly strikes the lungs and may affect other organs, resulting in an extrapulmonary form of the disease[2].

According to the World Health Organization (WHO), 95% of tuberculosis cases and deaths occur in developing countries. It is considered to be the leading cause of death by infectious disease around the world, exceeding the Human Immunodeficiency Virus (HIV) and malaria combined[2]. In 2017, there were an estimated 69,569 new cases of TB in Brazil, corresponding to an incidence coefficient of 33.5 cases/100,000 inhabitants. In the North region, 42,700 new cases/100,000 inhabitants were reported and, in Pará, the incidence was 38,600 new cases/100,000 inhabitants[3].

In Brazil, the incidence of TB is higher in indigenous populations than in the non-indigenous population. According to recent studies[4-6], this is due to extreme poverty, malnutrition, substandard housing, intestinal parasites, the transmission pattern in villages, resistance to drugs and high prevalence of latent infection by *Mycobacterium tuberculosis* (MTB).

The dynamics of communicable diseases in a population can be analyzed through mathematical models that aid in understanding problems associated with the disease and others not restricted to the field of health. They also consider the role of other risk factors that contribute to development of the disease[5–7].

Knowledge about the association between the socioeconomic determinants of tuberculosis in the indigenous population of the state of Pará is currently limited and is a challenge for researchers in the field of health. Generating knowledge to support public policy decision making could help reduce inequalities and improve the health conditions of indigenous communities[8].

The objective of the present study is to develop a model able to identify the correlation between socioeconomic determinants and the incidence of tuberculosis in the indigenous population of the state of Pará, in order to propose control strategies tailored to the local reality.

METHOD

This is a quantitative analytical study, carried out with records of TB cases reported in the database of the Notifiable Diseases Information System (SINAN), in cities from the state of Pará, from January 2010 to December 2015. The first step was to comb the SINAN-TB data to identify errors or inconsistencies, such as fields not completed and/or without information, duplicate records and classification errors, among others. However, no record was excluded during this analysis.

To assess the correlation between socioeconomic determinants and the incidence of TB in this population, four variables were examined: receipt of social benefits from the government, average nominal income, education and sex. The first two variables were obtained from the 2010 demographic census, conducted by the Brazilian Institute of Geography and Statistics (IBGE), and the last two from the SINAN database. To calculate the TB incidence rates of the indigenous population in the cities, the numerator was the number of new TB cases reported in SINAN and the denominator was the population data taken from the 2010 demographic census.

In regard to the mathematical model, Poisson distribution was used, also known as the Poisson Log-Linear Model, which is part of the family of Generalized Linear Models

(GLM). This model is suitable for analyzing variables that involve count data. The Poisson regression model entails an analysis of counted data, in the form of count proportions or ratios, and is a useful tool for evaluating the relationship between one or more explanatory variables (independent variables, predictive variables or covariables) (x1 , x2 , ..., xn), which in this study are "indigenous people who receive social benefits from the government", "average nominal income", "education" and "sex", with the latter stratified into "male" and "female".

To prepare the model, the program Minitab, version 16.0, was used, whose operation consists of systematically adding the most significant variable or removing the least significant variable during the weighting stages. Homoscedasticity, lack of multicollinearity and normally distributed residuals were verified to obtain and adjust the regression analysis assumptions.

Inferential statistics through the Poisson regression technique were used to improve the statistical adjustments of the predictive model, where the hypothesis of independence between the number of TB cases and the sociodemographic and economic variables was not rejected. The combination of this data was considered in the following Poisson regression structure: $Y=\beta_0+\beta_1 X_1+...+\beta_p X_{p+e}$ where Y represents the incidence of new cases of TB and X_p represents the independent socioeconomic and economic variables to be observed, also called explanatory variables or independent variables measured without error (nonrandom); β_p represents the coefficient associated with its respective independent variable, and e means the error associated with the model, the residuals. The result of the model is a prediction equation that represents a combination of the whole set of variables that best achieve the objective of the specific multivariate analysis.

The study was approved by the Research Ethics Committee of the Undergraduate Program in Nursing of the State University of Pará, under Opinion No. 1.715.460, on September 6, 2016, in accordance with Resolution 466/2012.

RESULTS

The frequency of new cases of TB in the state of Pará, in relation to the indigenous population, from 2010 to 2015, is presented in Table 1. According to SINAN, 285 cases in the indigenous population were reported, with an annual mean of 48 cases; the highest incidence was in 2012 (63 cases and the incidence rate was 159 new cases/100,000 inhabitants).

Table 1 – Frequency of cases of tuberculosis among the indigenous population in the state of Pará, according to the sociodemographic and economic characteristics of this population, from 2010 to 2015. Belém, PA, Brazil, 2017 (continues)

Sociodemographic and economic profile (n= 285)	N	%	Rate of incidence (RInc)	p-value(±)	CI (95%)	PR(€)	(CI 95%)	p-value
Sex								
Male	151	53.0	144.4	0.0420*	(140.58; 144.41)	11.269	(0.8477 – 1.4981)	0.0434*
Female	134	47.0	140.6		(140.46; 144.54)	1		
Age group								

Less than or equal to 15 years old	51	17.9	126.4	<0.0001**	(107.0; 178.0)	1	(3.2510 – 6.4755)	<0.0001**
15 years old or older	234	82.1	158.6		(125.92; 159.08)	45.882		
Education								
Illiterate	91	31.9	55.3	<0.0001**	(47.38; 91.62)	1	(0.9679 – 2.1267)	0.0891 ns
Literate	109	38.2	144.7		(97.61; 102.39)	14.347		
Not applicable	25	8.8						
Did not answer	60	21.1						
Receives government benefits								
Yes	62	21.8	44.0	0.0449*	(37.65; 50.35)	26.406	(1.0945 – 6.3710)	0.0495*
No	26	9.1	35.2		(34.20; 53.80)	1		
Did not answer	197	69.1						

Source: SINAN /CEPCT/DVS /SESPA (2017).

(±) Rate of incidence (p-value <0.05). ** Highly significant values; *Significant values; NS Non-significant values. (€) Prevalence ratio (PR) (p-value <0.05). ** Highly significant values; *Significant values; NS Non-significant values.

It can be seen that the annual incidence of TB in the indigenous population differs significantly when analyzed on the basis of sex ($p<0.05$), i.e., the prevalence ratio (PR) confirmed that men were 13% (PR ≈ 1.13 times) more likely to have TB than women and was considered significant ($p<0.05$).

In terms of age group, indigenous people 15 years of age or older had a 4.5 (PR ≈ 5 times) higher likelihood of developing TB. In relation to education, the prevalence ratio showed that literate indigenous people had a 1.43 (PR ≈ 1 time) higher likelihood of getting TB than illiterate indigenous people ($p>0.05$). However, it was not considered significant.

With respect to receiving social benefits from the government, it was found that indigenous people who did not receive benefits had a 2.64 (PR ≈ 3 times) higher likelihood of developing the disease than those who did receive benefits ($p<0.05$). In summary, the profile of those with the highest odds of developing TB, in the period from 2010 to 2015, were: indigenous people older than 15 years of age, who did not receive social benefits from the government (Table 1).

Table 2 contains the variables that were selected from the Poisson regression model and provided coefficients, p-values and chi-square. The following were statistically significant: education (-0.004239), male (-0.01089), female (0.01737).

Table 2 – Coefficients and significance level for each factor from the Poisson regression model, Pará/2017. Belém, PA, Brazil, 2017 (continues)

Source of variation	Degrees of freedom	Deviation (Adj.)	Mean (Adj.)	Chi-square	p-value(±)
Regression	5	380.694	76.139	380.69	0.000**

Average nominal income	1	4.647	4.647	4.65	0.031*
Literate	1	173.724	173.724	173.72	0.000**
Men	1	84.662	84.662	84.66	0.000**
Women	1	133.899	133.899	133.90	0.000**
Receives benefits	1	2.761	2.761	2.76	0.097£
Error	38	61.300	1.613		
Total	43	441.995			

Source: Data obtained from the research (2017).

(±) F-test (p-value <0.05). ** Highly significant values; *Significant values; NS Non-significant values. (£) F-test (significant at level of p-value <0.10).

Among the explanatory variables, based on Type III sum of squares, the model produced the following results: Y = 1.110 - 0.000796 * Average nominal income - 0.004239 * education - 0.01089 * male+ 0.01737 * female - 0.0521 * Receives benefits.

The model shows that 86% of the total number of new cases can be explained by the variables: receipt of social benefits from the government, income, education and sex. The Poisson regression model had statistical significance mainly for indigenous people who receive social benefits from the government, with a level of p<0.10.

DISCUSSION

The data produced by the Poisson model confirmed the association between the occurrence of TB and socioeconomic inequalities in indigenous people living in Pará. Indigenous men older than 15 years of age, without education and who did not receive social benefits had higher odds of developing TB.

As in other studies with indigenous populations, such as one conducted at the Brazil-Colombia-Peru-Venezuela border[9], there was a predominance of cases among men (57.9%). In another, in São Gabriel da Cachoeira in the state of Amazonas, in relation to men, it was 60% in urban areas and 57% in rural areas[10].

It is worth noting that the number of cases of TB among men was twice as many as those reported for women, which prompted the WHO to conduct studies from a gender perspective[11] In this sense, the findings of the present study can serve as a heads up for officials to implement actions in health policies for men's health care, especially indigenous men.

Another aspect of the indigenous sociodemographic profile was that the most affected age group was 15 years old or older, similar to the findings in other studies[4,12]. However, a result that differs from the literature is the fact that in Pará, in this study period, the indigenous people most affected by TB were those who were literate. This indicates the need for studies at the local level that are able to identify characteristics that cannot be understood through an analysis of secondary data. However, it is suspected that this phenomenon may be the result of the migration of many indigenous people to cities in search of formal jobs and education. According to data from the IBGE, 76.7% of indigenous people over the age of 15 years can read and write in Brazil, whether in Portuguese or their native tongue[13].

Within the model, this variable behaved differently, since the illiteracy factor is highly

relevant for TB being contracted by indigenous people, i.e., the higher the number of illiterate individuals the greater the odds of contracting the disease.

A study[14] conducted in Rio Grande do Sul, using a dynamic mathematical model, likewise identified an association between TB and incomplete elementary education from the first and fourth grade (R2 =0.75), for the age group of 20 to 49 years. The authors concluded that people with incomplete elementary education (first to fourth grade) and in the age group of 20 to 49 years were more likely to come down with TB. In other words, the model indicates that 75% of the cases of TB reported in the cities of Rio Grande do Sul were associated with these two variables.

The findings of this study, which indicated lack of education as an important factor for contracting TB, demonstrate the need to accelerate preventive action strategies for social determinants through intersectoral policies, since social aspects are not considered much in TB programs.

A pertinent observation in relation to the education variable is that individuals with low levels of education are less likely to go to health services which, consequently, hinders the disease identification process[15].

Another important point revealed in the economic profile analysis is that the incidence of TB was higher among indigenous people who did not receive benefits from the government income transfer program (Bolsa Família). The model also suggested that indigenous people who do not receive this allowance will have greater odds of contracting TB. Indigenous people without access to this government assistance were more vulnerable to conditions of poverty or extreme poverty. Studies[16-18] have shown the positive effects of income transfer programs in terms of health and have had a significant impact on reducing income distribution inequality in Brazil.

It should be noted that in the records of Brazilian databases, such as SINAN, particularly in the state of Pará, flaws were detected, such as underreporting, incompleteness and duplication, which hinders the research process in the system. However, despite the limitations, the data obtained in this study may contribute to the creation of strategies aimed at reducing the incidence rate of TB among indigenous people and enable managers in these areas to redirect the focus of their attention, in relation to the lack of care that exists there.

CONCLUSION

TB is still a serious public health problem, mainly among populations in situations of vulnerability, as is the case of indigenous people, and is associated with the socioeconomic conditions of the population or community.

The study constructed a predictive model to support decision making that would better express the relationship between cases of TB among indigenous people and socioeconomic determinants. It can be affirmed from the study that the number of new cases of TB can be explained by the explanatory variables: average nominal income, literate indigenous people, indigenous men, indigenous women and indigenous people who receive social benefits from the government.

In view of this, there is a need to develop and apply effective public policies, particularly ones that address the health of indigenous men and increased education. The model utilized in the study can also be used as a management tool for decision making, assisting in operational, strategic and financial planning processes related to health and the evaluation of TB control measures in the indigenous population.

There is a consensus that the challenges involved in curbing TB are considerable and that there are obstacles that hinder this process. However, policies developed by the

Brazilian government, together with the determination of health teams, must persist, with a continual focus on reducing the incidence rates of this disease in the indigenous population. This article highlights the need to come up with public policies based on a predictive model, aimed at minimizing inequities in the indigenous population and developing goals for controlling the disease among these people.

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Received: 05/03/2019
Finalized: 09/10/2019

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