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Factors associated with pneumonia in Yanomami children hospitalized for Ambulatory Care sensitive conditions in the north of Brazil

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Abstract *In developing countries, pneumonia is the leading cause of sickness and mortality in childhood, especially among vulnerable groups. The scope of this study was to analyze the factors associated with pneumonia in Yanomami children hospitalized for Ambulatory Care Sensitive Conditions (ACSC). Hospital admissions were divided into two groups: i) pneumonia; and ii) other causes, according to the Brazilian ACSC list. Adjusted hospitalization rates were estimated and unconditional logistic regression was used to analyze factors associated with pneumonia. Over 90% of the registered cases were considered ACSC. The adjusted rate of ACSC was 18.6/1000. The odds ratio of hospitalization for pneumonia was 2.7 (CI: 1.3-5.4) times higher in children aged between 0.1 and 5.9 months; 1.9 (CI: 1.1-3.3) times higher in children who were hospitalized for 8-14 days; and three (CI: 1.2-7.5) times higher in children with a secondary diagnosis of malnutrition. The excess of avoidable hospitalizations is a clear indication of the low quality of care and limited accessibility to primary health care in indigenous territories, which is contrary to the assistance model proposed by the indigenous healthcare subsystem in Brazil, which should in theory focus on welfare technologies based on primary health care.*
Key words *Pneumonia, Hospital admissions, Risk factors, Indigenous health services*

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Introduction

During the past three decades, there has been an increase in the number of studies, in various parts of the world, related to hospital admissions for ambulatory care sensitive conditions (ACSC)[1]. The vast number of studies, originating in the most diverse health systems and regions of the planet, were impelled by the method used to provide proxy information, not only as regards the quality and accessibility of primary healthcare, but also for its usefulness in indicating ethnic or racial inequalities and for producing valuable information about the economic impact this has on the health sector[2-5].

Even though there has been a significant reduction in the number of cases of this disease in recent years, pneumonia is still the leading cause of sickness and death in childhood. This has a very negative impact in developing countries and in regions with high levels of social inequality, where there is a shortage of human and financial resources[6,7]. Estimates suggest that, due to severe clinical complications, between 7% and 13% of all known cases of pneumonia require advanced care in a hospital environment[8]. It is not unusual for more serious cases to result in death, especially in children under the age of twelve months[9,10].

Although pneumonia is one of the main causes of sickness and death in childhood, specific studies on the issue are scarce in relation to the indigenous populations in Brazil. The few studies identified in the literature[11-14] investigated samples of children who live outside the Amazon region. Official statistics from the Brazilian Ministry of Health are even sparser and usually limited to administration reports used exclusively by management. In general, the analyses are based on hospital admissions secondary data, which confirms the importance of pneumonia, especially in children under the age of sixty months[11-14]

The relevance of pneumonia in a morbidity/mortality profile on indigenous children, associated with a lack of studies on the subject and an analysis of potentially avoidable hospitalization to assess models of assistance indirectly based on primary health care, motivated this study. Our aim was to analyze factors associated with pneumonia in Yanomami children admitted to hospital for ambulatory care sensitive conditions (ACSC) in the states of Amazonas and Roraima, located in the Brazilian Amazon region.

Methods

Population and area of study

Health care is provided to the Yanomami living in Brazil by the Special Yanomami Indigenous Sanitary District (DSEI), linked to the Ministry of Health's Special Health Secretariat (SESAI/MS).

DSEI-Yanomami includes thirty-seven Base Hubs that operate like primary health units, providing assistance to nearly nineteen thousand Indians of the Yanomami group who inhabit approximately two hundred and seventy-two villages, located in the States of Amazonas and Roraima.

According to Albert[15], the Yanomami consist of a cultural and linguistic group composed of four territorially adjacent sub-groups who speak mutually intelligible languages: the Yanomam, the Yanomami (or Yanomae), the Sanumá and the Ninam (or Yanam). Based on these cultural characteristics, the population is geographically distributed in seven regions: *Auaris; Parima; Surucucu; Uraricoera; Mucajai and Paapiu*, located in the state of Roraima; Upper Amazonas and Lower Amazonas, located in the state of Amazonas.

Study Outline

A hospital-based epidemiological observational study was conducted, using available records at the Hospital da Criança Santo Antônio (HCSA) (St. Anthony Children's Hospital), located in Boa Vista, capital of the state of Roraima (RR), between January 1, 2011 and December 31, 2012.

The HCSA is the only hospital in the State specializing in pediatrics and is responsible for 92% of all hospital admissions of Yanomami children aged between 0.1 and 59.9 months[16]. This hospital not only provides hospitalization for Yanomami children from RR, but also for the inhabitants of the entire Northeastern region of the state of Amazonas. The HCSA is a public hospital, specializing in high complexity healthcare, administered directly by the municipality and exclusively affiliated to the Unified Health System (SUS).

Data source

The hospital admittance authorization (AIH) forms, were the main source of data used in this study. In addition to this, the records of the HCSA indigenous coordination department

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were also consulted, together with data from the Indigenous Health Center (CASAI) in Boa Vista.

The population database was taken from the demographic model used by the Indigenous Health Care Information System (SIASI).

Data collection tool and variables

All data collected was transcribed on to a standardized form, specially designed for the purpose of this research.

The following variables were taken into consideration: full name; color or race; ethnic group; sex; age group; place of origin; duration of hospitalization; background details 90 days prior to hospital admittance; concomitant symptoms of malnutrition; main diagnosis; death outcome.

The Unified Health System (SUS) Hospital Information System (SIH-SUS) is the only DATASUS information system that registers details of a person's color or race and ethic group. However, it is known that the registration and reliability of these records is precarious or even nonexistent, thereby jeopardizing a detailed analyses about the ethnic relationships/affiliations of Brazilian indigenous groups. In the case of our study, this problem was resolved by the classification or re-classification of individuals, based on an inspection of the areas used to fill out the names/surnames and place of residence[17]. This is the case because most of the Yanomami who live in Brazil use an ethnonym (for example, Maria Yanomami) or the region where they come from as their surname (for example, Maria Palimiutheri – the 'theri' suffix refers to the place she comes from which, in this case, is Palimiu).

Inclusion and exclusion criteria

Children admitted to pediatric units, aged between 0.1 and 59.9 months, of both sexes and who spent twenty-four hours or more in hospital, were included in this survey[18].

Children with genetic syndromes or congenital malformations were excluded, since these conditions involve additional in-patient care risks, as well as longer hospital stays, when compared to other children.

In order to avoid repeated records, an analysis was conducted to identify possible duplications, according to the methodology proposed by Souza and Santos[19].

Operational classification

All cases were classified based on the *main diagnosis* variable, which is codified according to a list of categories of three and four characters taken from the International Statistical Classification of Diseases and Related Health Problems (ICD-10).

The potentially avoidable pediatric admissions were classified according to the Brazilian List of Ambulatory Care Sensitive Conditions (ACSC), which is also based on the ICD-10. On the basis of this classification, the records were grouped into two categories: i) bacterial pneumonias (or simply pneumonias); and ii) other avoidable hospital admissions.

In cases involving more than one diagnosis, main causes of diseases such as pneumopathies, malnutrition and diarrhea were prioritized, rather than those recorded as upper respiratory tract infection, anemia and dehydration, respectively[5,12,20].

In the case of children who had been re-admitted to hospital for the same principal cause, during a period of fifteen days after their previous hospitalization, the two hospital stays were added together, so that these were considered as one period of hospitalization, that is to say, these were treated as single hospital admittance. This procedure was aimed to ensure the independence of these records[12,20].

Statistical analysis

An estimate was made of the hospital admittance rate (HAR) by ACSC, including in the numerator the frequency of ACSC occurrences, and in the denominator the average population of children between 2011 – 2012, according to sex, age group and geographic location, multiplied by one thousand, as shown below.

$$\text{HAR} = \frac{\text{frequency of hospital admissions}}{\text{average population during the period}} \text{ x } 1{,}000$$

The risk of hospitalization was estimated by means of ratio rates accompanied by their respective 95% confidence interval levels.

These rates were standardized by the direct method, with exact 95%[21] confidence intervals level, using the World Health Organization (WHO) New World Standard population. The descriptive analysis included absolute and relative frequencies, as well as the generation of contingency tables.

Non-conditional logistic regression was used to identify factors associated with hospital admissions for pneumonia. The Odds Ratio (OR) was used as a measurement of association, accompanied by its respective 95% confidence interval.

The statistical modeling began with a selection of co-variables associated with hospital admissions for cases of pneumonia, considering a significance level of 20% in a simple regression. In the multiple regressions, the co-variables were introduced according to an increasing sequence of 'p' values obtained in the simple regression. In addition, the corrected Akaike Information Criterion (AIC) was used to assess the goodness of fit the model. Variables with a significance level of 5% were retained in the final model. The statistical significance of the associations was evaluated by means of the Likelihood Ratio Analysis test[22].

The presence of interactions between the co-variables was also evaluated. Cook's Distances were used to evaluate influential observations. The final adjustment of the logistic model was evaluated using the envelope graph for the residual component of the standard deviation[23], which represents an empirical reliability band, useful to detect deviations in the assumed distribution.

The data were analyzed with the help of the version 3.1.1. R statistical program (http://www.r-project.org).

Ethical aspects

This study was approved by the Research Ethics Committee at the Federal University of Roraima, under Certificate of Presentation for Ethical Consideration (CAAE).

Results

A total of three hundred and eighty-eight hospital admission registrations were found for Yanomami children. Of these, three hundred and fifty-nine (93%) were classified as Ambulatory Care Sensitive Condition (ACSC) admissions, of which two hundred and fifty (69.4%) related to pneumonia. The second group of hospital admission cases involved infectious gastroenteritis and related complications (19.4%), and the third involved cases of malnutrition (4.4%).

Children aged between 12.0 and 23.9 months were those who presented the highest percentage of ACSC (27.6%). Hospitalization for pneumonia occurred mainly among younger children (0.1 to 5.9 months old) of the male sex (Table 1). Hospitalization for pneumonia was also found mainly among children who spent a period of between one and seven days in hospital and among those who came from the Parima, Auaris and Upper Amazon areas.

Records of hospital admissions over the preceding ninety days, cases where death was the outcome and malnutrition, respectively, were found in 7.2%, 4.4% and 12% of the children with pneumonia (Table 1).

The standard ACSC rate for children under sixty months was 18.6 hospital admissions per thousand inhabitants, which represents a risk of hospitalization 3.4 times higher in relation to non-indigenous children in the state of Roraima, and 3.8 times higher when compared to non-indigenous children living in the North of Brazil (Table 2).

No hospital admissions were observed among co-variables in the diagnostic stage of the final model. A point of influence was observed, with high residuals, which had a negative repercussion on the co-efficient estimates, which is why we decided to exclude these from our analyses. After the final adjustment was made to the logistical model (Graph 1), it was seen that the chances of children between the ages of 0.1 and 5.9 months being admitted to hospital were 2.7 times higher than among children of between 24.0 and 59.9 months of age. Children who had spent a period of between eight and fourteen days in hospital also presented a 1.9 greater chance of being hospitalized for pneumonia than children admitted to hospital for a shorter period. Meanwhile, children who had been given a secondary diagnosis of malnutrition presented a 3.0 greater chance of being admitted to hospital for pneumonia than children who were not given a secondary diagnosis of malnutrition (Table 3).

Discussion

It was seen that almost all the cases of hospital admissions analyzed in this investigation were considered to be potentially avoidable. The rates of Ambulatory Care Sensitive Conditions (ACSC) admissions were significantly higher among Yanomami children, compared to registered cases involving non-indigenous children from the state of Roraima and from the North of Brazil. Furthermore, as has been reported by other authors, in different contexts[12-14,20,24], pneumonia and diarrhea were the main causes for hospitalization.

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Table 1. Demographic & clinical factors of Yanomami children under the age of sixty months, hospitalized with bacterial pneumonia, at the Hospital da Criança Santo Antônio (St. Anthony Children's Hospital), Boa Vista, Roraima, between January 2011 and December 2012.

Variables	Bacterial pneumonia % (n)	Other causes % (n)	Total
Age Group (months)			
0.1 to 5.9	31.6 (79)	15.6 (17)	26.7 (96)
6.0 to 11.0	22.0 (55)	23.8 (26)	22.6 (81)
12.0 to 23.9	25.2 (63)	33.0 (36)	27.6 (99)
24 to 59.9	21.2 (53)	27.5 (30)	23.1 (83)
Gender			
Female	42.4 (106)	51.4 (56)	45.1 (162)
Male	57.6 (144)	48.6 (53)	54.9 (197)
Region			
Upper Amazonas	20.0 (50)	15.7 (17)	18.7 (67)
Auaris	20.8 (52)	19.4 (21)	20.4 (73)
Lower Amazonas	9.2 (23)	7.4 (8)	8.7 (31)
Paapiu	9.2 (23)	19.4 (21)	1.3 (44)
Parima	21.6 (54)	19.2 (21)	20.9 (75)
Surucucu	9.2 (23)	5.5 (6)	8.1 (29)
Uraricoera & Mucajaí	10.0 (25)	12.9 (14)	10.9 (39)
Hospital stay (days)			
1 to 7	44.0 (110)	53.2 (58)	46.8 (168)
8 to 14	37.6 (94)	25.7 (28)	34.0 (122)
15 or more	18.4 (46)	21.1 (23)	19.2 (69)
Hospitalization (previous 90 days)			
No	92.8 (232)	93.6 (102)	93.0 (334)
Yes	7.2 (18)	6.4 (7)	7.0 (25)
Malnutrition			
No	88.0 (220)	94.5 (103)	90.0 (323)
Yes	12.0 (30)	5.5 (6)	10.0 (36)
Death			
No	95.6 (239)	96.3 (105)	95.8 (344)
Yes	4.4 (11)	3.7 (4)	4.2 (15)

Table 2. Standard rates of hospital admissions for Ambulatory Care Sensitive Conditions (ACSC) among Yanomami children under the age of sixty months and non-indigenous children in the state of Roraima and in the Northern region of Brazil, between January 2011 and December 2012.

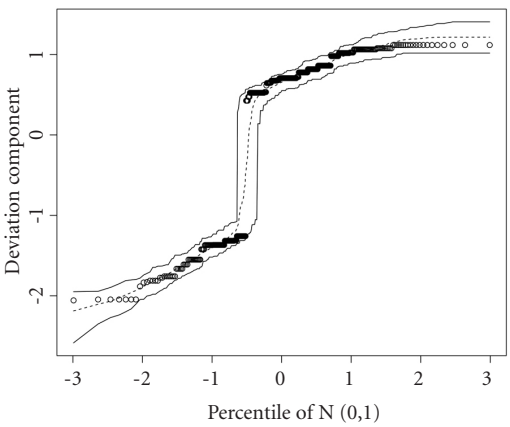
Categories	Standard rates/100 inhabitants (95% CI)	Ratio of standard rates/100 inhabitants (IC 95%)
Yanomami	18.6 (16.6-20.7)	1
Roraima	5.5 (5.4-5.7)	3.4 (3.1-3.6)
North of Brazil	4.9 (4.8-4.9)	3.8 (3.4-4.2)

The ACSCs admissions a group of health-related problems and diseases that are preventable when a diagnosis and effective outpatient treatment is carried out in good time, thereby reducing the chance of undesirable outcomes, among which we hereby highlight hospital admittance[25,26]. However, high percentages of ACSC can be a reflection, not only of the low quality of primary health care and distortions in health care access[2,27-29], but also the excessive costs imposed on the health systems[5].

Despite the impact that pneumonia has on the profile of child morbidity and mortality, it was only from 2009 onwards that a global plan of action was initiated to help prevent and control the disease. In view of the importance that pneumonia has on health, this plan was seen as one of the critical points to meet one of the eight Millen-

nium Development Goals (MDGs). This is specifically true with respect to the reduction, by the year 2015, of global infant mortality by two-thirds among children under the age of five in comparison with the rates reported for the year 2000[30].

Although Brazil has met its goals in reducing infant mortality before the date established, with levels at under eighteen deaths per thousand live births, the pattern for this indicator is geographically heterogeneous in children under five. The indices for newborn babies and children from the Northern and Northeastern regions of the country, for example, are frankly unfavorable, when compared with other population groups in Brazil[30].



Graph 1. Adjusted logistic model, with envelope system graph for residual component of the standard deviation, in Yanomami children under the age of sixty months, Hospital da Criança Santo Antônio, (St. Anthony Children's Hospital), Boa Vista, Roraima, from January 2011 to December 2012.

The importance of adopting measures aimed at the prevention and control of pneumonia in childhood – which include the introduction of a 10-valent pneumococcal conjugate vaccine, conditional cash transfer, increasing the coverage of family health programs, among others – are now widely recognized[31,32]. As a whole, these measures produce overall improvements in the population's quality of life, by reducing rates of infant malnutrition, avoidable hospital admissions and, ultimately, by having a positive impact on mortality statistics[28,33-35].

In spite of the fact that the above measures have been adopted[36], and even though hospital admissions for cases of pneumonia have been gradually reduced in children under the age of five in the overall population in Brazil, cases of pneumonia in Yanomami children have emerged as the main cause of avoidable hospital admissions. They also present a high risk in comparison to the general population in Brazil[37,38], from the Northern region of the country, from the state of Roraima and, above all, when compared with other countries that are considered to be developed[5,10,37].

In general, studies about pediatric hospitalizations, register an excessive number of hospital admissions for pneumonia in children of the male sex[4,34]. Although the sex variable had been selected during the simple logistical regression and was later eliminated during the model ad-

Table 3. Factors associated with hospital admissions for bacterial pneumonia in Yanomami children under the age of sixty months, Hospital da Criança Santo Antônio (St. Anthony Children's Hospital), Boa Vista, Roraima, between January 2011 and December 2012.

Variables	Gross OR (80% CI)	Adjusted OR (95% CI)	p*
Age Group (months)			
24 to 59.9	1.0	1.0	**0.005**
0.1 to 5,9	**2.6 (1.7-4.1)**	**2.7 (1.3-5.4)**	
6.0 to11.0	1.2 (0.8-1.8)	1.1 (0.6-2.2)	
12.0 to 23.9	1.0 (0.7-1.5)	0.9 (0.5-1.6)	
Hospital stay (days)			
1 to 7	1.0	1.0	**0.041**
8 to 14	**1.8 (1.3-2.5)**	**1.9 (1.1-3.3)**	
15 and more	1.1 (0.7-1.6)	1.0 (0.6-2.0)	
Malnutrition			
No	1.0	1.0	**0.011**
Yes	**2.3 (1.3-4.2)**	**3.0 (1.2-7.5)**	

* Maximum likelihood estimation test for adjusted OR Final sampling model = 359.

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justment, it is noteworthy that among Yanomami children the predominance of hospital admissions for those of the male sex with pneumonia was also observed.

Another point that could help in understanding why there is such a high percentage of avoidable hospital admissions among Yanomami children, especially in the Parima, Auaris and in the Upper Amazon regions, is the fact that dozens of sub-groups are living in a widely spread area within a bi-national territory (Brazil-Venezuela). They occupy one hundred and ninety-two thousand square kilometers, of tropical rain forest and difficult terrain, divided by numerous rivers, creeks and streams[38].

Some authors argue that the geographic location of these territories, especially those located in remote indigenous areas and/or those that are difficult to reach, impose innumerable logistical and operational challenges which greatly hamper access and timely contact between indigenous people and health service professionals[1,10,39,40], and which lead to many cases of potentially preventable hospitalizations.

Another element which was initially shown to be associated with hospital admissions for pneumonia, but which was not included in the final model, was the number of recorded deaths. This unfavorable outcome of any hospital admission affected approximately 5% of Yanomami children receiving in-patient care for pneumonia. Recent studies[6,7] indicate that pneumonia continues to be the main cause of infant mortality, which reinforces the importance and impact that this has on vital statistics. This is true both in the case of indigenous and non-indigenous populations, since several studies produced both in Brazil and abroad[13,14,41] show that pneumonia is one of the main causes of death in this age group.

This finding is particularly important, because it offers yet another clue to understanding why there is such a high mortality rate amongst these children. This is especially true of children under the age of twelve months, the coefficients of which are high enough to place them in one of the groups that have the highest infant mortality rates in Brazil and in the world[40,42,43]. In this respect, it seems reasonable to assume that the high percentage of deaths from diseases that can be prevented through primary health care is just another sign of the fragility of the indigenous healthcare sub-system.

Among the factors associated with hospital admissions for pneumonia, children aged between 0.1-5.9 months show the greatest chance of being hospitalized. Analogically speaking, in a study conducted in children hospitalized in the Philippines, those under the age of six months showed a greater risk of dying from pneumonia[44]. The immaturity of the immunological system of these children, especially those who are not exclusively breast-fed or who present a delicate state of health, associated with limited access to vaccination programs, place this group in a situation of vulnerability in view of the infections that can result in pneumonia[10]. Studies conducted among the Suruí Indians in Rondônia and the Guarani from the South and Southeastern regions of Brazil, also show that children under the age of twelve months are more likely to be hospitalized for low respiratory tract diseases, especially pneumonia[12,13].

Evidence has accumulated over the last three decades that shows that episodes of acute malnutrition can affect the immunological system in children, especially those under the age of five. Based on this perspective, a recent study by Pantoja et al.[40] revealed high rates of acute malnutrition among Yanomami children, especially in those under the age of six months. Therefore, it is reasonable to assume that, as seen in this investigation, the increased chances of being hospitalized for pneumonia in children under the age of six months can, at least partly, be the result of the precarious nutritional status of the children studied.

Malnutrition is usually present in most of the hospital admissions for pneumonia[11,34,45]. However, this is not always appreciated or adequately managed by the health teams, especially in children under the age of two, which has a negative effect in periods of lengthy prognostic procedures or hospital stays, which often result in the death of the child[46,47].

As also observed in other indigenous groups in Brazil[12,14], the average hospital stay of over seven days, for Yanomami children with pneumonia, may be considered a long period. The need for a prolonged hospital stay can indicate that these children had a precarious state of health before the episode that led to their hospital admission, or that the disease showed serious clinical symptoms. It can also be because the teams did not have the means to provide adequate treatment to these children and to monitor their development prior to the case being resolved in the villages.

As mentioned in previous studies, the difficulty of access to villages in the Yanomami Indigenous Territory, together with the lack of university level professionals in the health care teams,

especially doctors, and the lack of an adequate health care infrastructure in indigenous areas[38,40], represent on-going challenges that are often difficult to overcome.

Although the hospital admission authorizations (AIH) provide a restricted source of information about the socioeconomic conditions of these families and the clinical and demographic characteristics of the children and their mothers, it was possible to retrieve a series of additional data. This helped to identify factors associated with hospital admissions for cases of pneumonia by using a strategy to seek additional data both in and outside the hospital for the purpose of this study,

In addition, we would stress the fact that no procedure was undertaken to reclassify the diagnostics, which could translate into estimates that over or under-value the illnesses or diseases that led to the hospitalization of the Yanomami children. In the case of pneumonia, some authors advise that it is not unusual for diseases like asthma, that leave a patient wheezing and short of breath, to be mistaken for pneumonia or other respiratory diseases[14,48]

In spite of its limitations, this study was able to provide evidence, not only about the relevance of avoidable cases of hospital admissions and to identify factors associated with hospitalization in cases of pneumonia, but also the challenges that face the health care model proposed by the indigenous health care sub-system in Brazil. In theory, the latter should be based on primary health care technologies, capable of preventing or minimizing health problems that can lead to hospitalization or avoidable deaths.

Collaborations

RV Caldart worked on the concept, field work, data analysis and the final draft of this work, PC Basta, JDY Orellana and L Marrero were involved in the concept, data analysis and final draft.

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