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Environmental Impact and Seroepidemiology of HTLV in Two Communities in the Eastern Brazilian Amazon

Luiz Fábio Magno Falcão,[1,2] Hellen Thais Fuzii,[1] Rosana Maria Feio Libonati,[1] Tinara Leila de Souza Aarão,[1] André Gustavo Moura Guimarães,[2] Luisa Carício Martins,[1] and Juarez Antônio Simões Quaresma[1,2]*

[1]*Immunopathology Laboratory of the Center of Tropical Medicine, Federal University of Pará, Belém-Pará, Brazil*
[2]*Center of Biological and Health Sciences, University of the State of Pará, Belém-PA, Brazil*

The objective of this study was to detect antibodies for human T lymphotropic virus (HTLV) in subjects residing in two communities located in the eastern Brazilian Amazon and on the shores of the Tucuruí hydroelectric power plant. A total of 657 serum samples were analysed using an enzyme-linked immunosorbent assay with an anti-HTLV antibody (Symbiosis, São Paulo, Brazil), demonstrating a virus prevalence of 4.7%. Most individuals with HTLV were aged over 30 years ($P = 0.013$), were unmarried ($P = 0.019$), resided in the area for more than 10 years ($P = 0.001$), had a low level of education ($P = 0.015$), and had a family income of up to $305 (100%). In contrast, there was no significant association between infection and sex, city of birth, haemotransfusion, or previous surgery. The prevalence observed in these communities suggests that the residents should be concerned about HTLV infection, and that some areas may become endemic for HTLV. ***J. Med. Virol. 85:1585–1590, 2013.***

KEY WORDS: hydroelectric plant of Tucuruí; health impact; prevalence; Brazil

INTRODUCTION

The Amazonia has become integrated into the world economy at different times in history through the supply of natural resources such as the wilderness drugs, *Hevea brasiliensis*, mineral raw materials, and biodiversity. It is also considered one of last energy reserves in the world, given its potential for hydroelectric energy production [Couto, 1999; Oliveira et al., 2006].

Development in Brazil has increased the use of water for energy production to support the implementation of industrial projects and sustain population growth. A solution to this growing need involves the use of the Tucuruí hydroelectric power plant, which is located in the Eastern Brazilian Amazon [De Queiroz and Motta-Veiga, 2012].

However, migratory movements and geographically uneven population growth observed in the areas of power plant installation has contributed to an increased incidence and prevalence of several transmissible diseases [Couto, 1999; Oliveira et al., 2006]. Before installation of the power plant, Tucuruí city had less than 10,000 inhabitants; currently, the population is more than 100,000 people [De Queiroz and Motta-Veiga, 2012]. An intense migration brought thousands of people from various parts of Brazil and South American countries that were attracted to the area by the development of large enterprises [Tubaki et al., 2004]. During the second stage of construction of the Tucuruí Hydroelectric Power Plant, prostitution and the incidence of syphilis, infectious hepatitis, and human immunodeficiency virus (HIV) infection significantly increased in nearby cities [Tetteh et al., 2004].

The state of Pará has one of the highest human T lymphotropic virus (HTLV) prevalence rates in Brazil [Catalan-Soares et al., 2005]. Recent studies in the Brazilian Amazon have confirmed the significant

Conflicts of interest: None.

*Correspondence to: Juarez Antônio Simões Quaresma, Núcleo de Medicina Tropical, Universidade Federal do Pará. Avenida Generalíssimo Deodoro, 92 Belém, PA 66055-240, Brazil. E-mail: juarez@ufpa.br

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presence of HTLV in the region, including in indigenous communities. According to previous studies, virus prevalence is highly variable due to the extensive coverage area of more than three million km^2 [Ishak et al., 2007], and may undergo considerable epidemiological changes following large migrations as in Tucuruí in the last few decades [Couto, 1999; Oliveira et al., 2006; De Queiroz and Motta-Veiga, 2012].

Thirty years since power plant construction began in Tucuruí, a considerable impact on public health has persisted. This article reports the seroprevalence of HTLV on the basis of four exploratory expeditions in the Eastern Brazilian Amazon, specifically in two sustainable development communities located on the shores of the Tucuruí hydroelectric power plant, whose inhabitants actively participated in implementing this large project.

MATERIALS AND METHODS

Study Area and Study Communities

The Tucuruí hydroelectric power plant is a large enterprise on the Tocantins River located on the Eastern Brazilian Amazon in Tucuruí city in the state of Pará. The dam is 11 km long and 78 m high and has a reservoir of 2,850 km^2. When running at full power, it is the largest 100% hydroelectric Brazilian power plant [De Queiroz and Motta-Veiga, 2012].

In this study, two communities that were located downstream the Brazilian Amazon power plant were chosen, including Alcobaça and Ararão. These micro areas have an estimated population of 3,225 adult inhabitants [Pinto et al., 2011]. The study included individuals registered in the family health program of the lake region of the Tucuruí Hydroelectric Power Plant, a population characterized by sustainable development, stilt-type residences, whose main subsistence activities include artisanal fishing, hunting, and animal breeding, as well as growing okra, potato, and cassava, among others.

Study and Sample Calculation

This was a transversal, analytical, population-based study, performed between September 2008 and March 2010. To calculate the sample size, an expected prevalence of 3.01% was used based on research conducted in a semi-isolated community in the Eastern Brazilian Amazon by Vallinoto et al. [2006]. Using a prevalence of 0.9% for HTLV in the population based on a study by Catalan-Soares et al. [2005], the power of the test was 80%, the confidence interval was 95%, and the alpha level was 5%. Thus, for this population, an initial estimated sample of 237 individuals was obtained and 657 eventually underwent evaluation, which accounted for 20.3% of the total population, selected by convenience.

Data Collection

The study included individuals who voluntarily agreed to undergo a screening test for HTLV and who received primary health care services in the region examined during four excursions to localities. Epidemiologic and demographic information was collected using a clinical and epidemiological form pattern before sample collection to identify variables associated with HTLV, such as age range, sex, marital status, education, time of residence in the area covered by the study, city of birth, family income, history of surgery, and blood transfusion. Data collection was conducted by trained interviewers to avoid information bias.

Sample Collection and Analysis

For serology procedures, 15 ml of venous blood from the upper limb of each participant was collected in tubes identified with a code and containing ethylenediaminetetraacetate as an anticoagulant, which were immediately stored at −20°C. Next, samples were transported on ice in a sealed styrofoam box to the Laboratory of Immunopathology of the Nucleus of Tropical Medicine, Federal University of Pará, located in the city of Belém/PA, where they were centrifuged at 1,500*g* for 5 min to obtain the serum, which was separated into aliquots and stored at −20°C in cryogenic tubes identified for subsequent processing.

For diagnostic purposes, serum was analysed according to the manufacturer's instructions using an enzyme-linked immunosorbent assay test for anti-HTLV antibodies (Symbioys, São Paulo, Brazil), which has been approved by the Food and Drug Administration and by the Ministry of Health of Brazil [Vallinoto et al., 2006].

Statistical Analysis

All information collected was organized using Excel 2007 software (Microsoft Corporation, Redmond, WA) and analysed using BIO ESTAT version 5.0 (Civil Society Mamirauá, Manaus, Brazil) and Epi Info version 3.5.1 (Centers for disease control and prevention, Atlanta, GA) for statistical calculations. Significance was analysed using the chi-square test and G test, the latter when the expected frequency for analysis was less than 5. Associations were evaluated by determining the prevalence ratio. Multiple logistic regression analysis was used to determine the contribution of each variable showing a significant association for the study endpoint. An α level of 0.05 was used to reject the null hypothesis.

Ethical Aspects

The present study was approved by the Ethics Committee of the Nucleus of Tropical Medicine of the Federal University of Pará (Opinion No. 023/2010).

Research Involving Human Beings rules and their complementary of the National Health Council/Ministry of Health of Brazil (Res. 196/96) was compiled based on the Declaration of Helsinki guidelines of 1975, revised in 1983.

RESULTS

Among the 657 subjects evaluated, 4.7% (n = 31) showed positive serology results for HTLV. The highest prevalence of infection occurred in subjects aged ≥ 30 years (n = 27) compared to those aged 18–29 years (n = 4); prevalence in the ≥30 years group was three times higher than in the latter group. Antibodies to HTLV were detected in 11 people who reported being single, which were 2.27× higher than in subjects in stable relationships. Low education was also associated with higher rates of HTLV infection in subjects with four or fewer years of study (n = 26). In this group, seroprevalence was nearly three times higher than in other groups (Table I).

However, the primary factor associated with HTLV infection in communities of Alcobaça and Ararão was the duration that subjects had resided in these areas. Those who lived in the area for >10 years showed strong predisposition for contracting HTLV (n = 23) and were three times more likely to acquire the virus. Moreover, individuals who were unmarried, those of low education level, and those aged above 30 years also showed a strong association with infection (Tables I and II).

All HTLV-positive individuals reported a family income equivalent to $305 (Table I). In contrast, the following variables were not significantly associated with presence of HTLV: sex, previous surgery, blood transfusion, and/or characteristics of each person (Table I).

TABLE I. Distribution of Study Subjects According to the Selected Variables, Tucuruí/PA, from 2008 to 2010

	Serological reaction					
Variables	HTLV+(%), 31 (4.7%)	HTLV−(%), 626 (95.3%)	Total (657)	95% CI	PR (*P*-value)	*P*-value (—)
Age range				1.17	9.33	3.31 (0.013)*
18–29 years	4 (1.85%)	212 (98.15%)	216			
30 years or more	27 (6%)	414 (94%)	441			
			657			
Marital status				1.31	4.68	2.27 (0.019)*
Single	11 (8.5%)	117 (91.5%)	128			
Married/stable union	20 (3.8%)	509 (96.2%)	529			
			657			
Education level				1.13	7.48	2.91 (0.015)*
≤4 years	26 (6.2%)	394 (93.8%)	420			
>4 years	5 (2%)	232 (98%)	237			
			657			
Residence time				1.51	7.32	3.32 (0.001)*
Above 10 years	23 (7.5%)	282 (92.5)	305			
Until 10 years	8 (2.3%)	344 (97.7)	352			
			657			
Sex				0.56	2.37	1.15 (0.42)
Female	20 (4.98%)	382 (95.02%)	402			
Male	11 (4.31%)	244 (95.69%)	255			
			657			
Surgeries				0.66	3.03	1.42 (0.23)
Yes	9 (3.73)	232 (96.27%)	241			
Not	22 (5.29%)	394 (94.71%)	416			
			657			
Family income						—
≤$ 305	31 (5%)	576 (95%)	607			
>$ 305	00 (0%)	50 (100%)	50			
			657			
Naturalness				0.36	5.94	1.46 (0.41)
Native	29 (5.2%)	529 (94.8%)	558			
Migrant	2 (2%)	97 (98%)	56			
			657			
Hemotransfusion				0.36	6.07	1.48 (0.4)
Yes	2 (3.3%)	59 (96.7%)	61			
Not	29 (4.8%)	567 (95.2%)	596			
			657			

95% CI: 95% confidence interval; PR, prevalence ratio.
*Test of the chi-square or G test (level $\alpha < 5\%$).

TABLE II. Contribution of Each Variable Associated With Infection by the HTLV Tucuruí/PA, 2008–2010

Variables	Ratio of changes	95% CI		*P*-value
Residence time	3.4	1.4701	7.7929	0.0042
Marital status	2.8	1.2659	6.1923	0.0110
Education level	3.08	1.0261	9.2465	0.0449
Age range	3.56	1.0225	12.4206	0.0460

95% CI: 95% confidence interval.

DISCUSSION

Until the 1960s, the Tucuruí region was sparsely populated, and most inhabitants were concentrated along the riverbanks. During the next decade, geometric demographic growth was observed due to the increase in migration of workers for the construction of the Tucuruí Hydroelectric Power Plant, a factor that induced population growth in the Amazonia. At the height of the power plant construction, more than 55,000 immigrants began to work on and have access to the land, resulting in rapid demographic expansion of a culturally and socially diverse population. Most migrants were from the northeast region of the country [Vasconcelos et al., 2006; De Queiroz and Motta-Veiga, 2012], which is an endemic area for HTLV [Catalan-Soares et al., 2005].

Despite this, the Tucuruí Hydroelectric Power Plant was built during the Brazilian military dictatorship, a time when there was relatively little concern for the environment, and the Brazilian government did not evaluate the health impacts resulting from power plant installation [Fearnside, 2001]. The building of power plants has contributed to changes in epidemiological patterns of several pathologies, including HTLV, particularly in Alcobaça and Ararão, since these communities actively participated in the construction.

Notably, several studies have already suggested an increased dissemination of transmissible diseases due to power plant construction [Couto, 1999; Oliveira et al., 2006]. A staggering increase in the incidence of syphilis and HIV was observed in regions near the Tucuruí hydroelectric power plant during the second stage of its construction [Oliveira et al., 2006]. Studies in other countries showed similar results. At the Merowe dam in Yemen, the number of HIV/AIDS cases significantly increased. At the Barekese dam in Ghana, an increase in infectious hepatitis was observed [Tetteh et al., 2004].

After more than three decades of construction, a staggering increase in the incidence of syphilis and HIV was observed in regions near the Tucuruí hydroelectric power plant. Several social, economic, and spatial changes were observed in the Eastern Brazilian Amazon. Despite a high incidence of HTLV reported in various studies in the Brazilian Amazon, including indigenous areas [Ishak et al., 2003, 2007], no studies have evaluated the prevalence of HTLV downstream of the power plant, which are geographic areas with limited access to public health services. However, the prevalence of HTLV in Alcobaça and Ararão was much higher than that reported in previous studies of other Amazon regions [Vallinoto et al., 2006; Ishak et al., 2007; Dos Santos et al., 2009]. There is sufficient data showing that the area is endemic for this virus, and that the state of Pará has one of the highest prevalence rates for HTLV in Brazil. Research conducted by Vallinoto et al. [2006] in the community of Santana do Arari, Marajó island, in the state of Pará showed one of the highest prevalence rates for the virus (3.09%); however, the prevalence was lower than that reported in this study, which was 4.7%.

To understand better the prevalence rates of HTLV, the two communities examined in this study were divided into two age ranges. The highest virus infection rate occurred in subjects aged $\geq$30 years when compared with subjects aged between 18 and 29 years (Table I). Previous studies showed that HTLV prevalence increases with age; this increased susceptibility may be attributable to the increased exposure to sexual partners with viraemia over time. Analysis of antibodies to the HTLV in a region of high endemicity in Japan also showed an increasing seroprevalence with age [Eshima et al., 2009]. The prevalence of HTLV in 907 pregnant women in Gabon in the five main cities of the country showed an increased prevalence with age [Etenna et al., 2008]. Similar results were described by Moxotó et al. [2007] in Salvador/Bahia in Brazil and Forbi and Odetunde [2007] in Ibadan/Oyo, Nigeria.

A retrospective study conducted in a haemocentre in Uberaba/MG, Brazil between 1995 and 2008 revealed that HTLV-seropositive bachelors had more sexual partners than married couples or those in stable unions [De Lima et al., 2010]. On the basis of this study, the possibility of greater polygamous sexual activity can be excluded since the highest HTLV seroprevalence was observed among the single subjects. Research conducted in the district of Ngwelezane/KwaZulu involving a total of 1,018 subjects reported no significant association between seropositivity for HTLV and marital status [Bhigjee et al., 1993].

Low education was associated with higher rates of HTLV infection; additionally, 100% of seropositive subjects had family incomes of less than $305 (Table I). These factors have been associated with

predisposition to infection, particularly in the less-developed regions in Brazil, such as the Eastern Brazilian Amazon Moxotó et al. [2007]. A similar result was also observed by Orland et al. [2004] and Murphy et al. [1999], whose findings demonstrated a higher prevalence of HTLV in individuals with less education and income.

A residence duration of more than ten years in Alcobaça and Ararão was another factor associated with HTLV infection (Table I); therefore, residence duration is a determinant for acquiring the virus (Table II). This reflects the epidemiological aspect of a "cluster" specific to the virus that may be responsible for perpetuation of infection in the studied areas. Although the actual route of transmission is unknown, breast feeding and sexual transmission are the most likely routes since these mechanisms are typically responsible for HTLV endemicity in semi-isolated populations according to an a study conducted in the village of Kararao, Pará, Brazil [Ishak et al., 2001].

HTLV may have existed before the intense migration to various localities during power plant construction. A staggering increase in the incidence of syphilis and HIV was observed in regions near the Tucuruí Hydroelectric Power Plant. This led to a fundamental change in the epidemiological pattern of HTLV in the areas surveyed, and the virus continues to perpetuate over the years due to strong intra-familial and sexual transmissibility because such localities are isolated from other communities. These results warrant the implementation of a large-scale project aimed at the prevention of HTLV in both Alcobaça and Ararão.

Blood transfusions, which are admittedly a variable associated with HTLV transmission, as well as surgery, do not seem to increase the rate of acquiring the infection (Table I). This may be because HTLV testing has been made mandatory in blood banks in Brazil since 1993 and sterilization of surgical instruments has become more stringent in the country; these actions significantly reduced HTLV transmission through these routes.

Despite the intense migratory flux exhibited in the Tucuruí region, there were no increased rates of HTLV infection in the migrant population currently residing in Alcobaça and Ararão (Table I). This can be explained by the fact that most of these people moved away from the region after completing the power plant construction.

Lastly, the results obtained in this study support the implementation of strategies aimed at improving population health, particularly with regard to preventing HTLV, since no programs are currently in place. The use of river resources constitutes an important means of development; however, alterations in the ecosystem and sociocultural system cannot be ignored due to their direct and indirect effects on the epidemiology of various diseases. Preventive measures must be implemented when dams are constructed. This includes the control of not only vector-borne diseases such as malaria, yellow fever, and schistosomiasis, but also contagious diseases to reduce the negative impact of expanding energy resources for the country and reduce the threat of disease to individuals living in developing areas.

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