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ORIGINAL ARTICLE

Tuberculosis among the Xavante Indians of the Brazilian Amazon: An epidemiological and ethnographic assessment

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Abstract

Background: Despite broad availability of a national tuberculosis (TB) control program that has proved effective in Brazil, TB remains a major cause of morbidity and mortality among indigenous peoples.
Aim: We report the results of an interdisciplinary investigation of TB epidemiology, healthcare services, and ethnomedicine among the Xavante Indians of Central Brazil.
Subjects and methods: Fieldwork components included clinical assessment of TB (479 subjects, 89.3% of the population = 1 year of age), analysis of medical health records, and ethnographic research.
Results: We found TB to constitute a major health risk, with moderately high annual risk of infection (0.94%), moderate prevalence of infection, high percentage of X-ray images suggestive of TB (14.2% in subjects ≥ 10 years of age), and a relatively low percentage of individuals with reactive TB skin tests (16.6% of reactions ≥ 10 mm) despite high BCG vaccine coverage. We also found a high rate of TB patients showing no evidence of prior infection. Ethnographic interviews show that Xavante and biomedical health perspectives are simultaneously divergent in their etiologies but pragmatically compatible.
Conclusion: Ineffective diagnosis procedures compromise the efficacy of existing TB prevention efforts and threaten to undermine otherwise favorable institutional and cultural conditions.

Keywords: *Tuberculosis, epidemiology, medical anthropology, tuberculin skin test, South American Indians*

Introduction

Tuberculosis (TB) made an early appearance among the indigenous populations of Brazil, causing widespread mortality and depopulation soon after they came into first contact with

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non-Indians. The effects of the disease were not limited to the immediate post-contact period. At present, TB remains a major cause of morbidity and mortality among indigenous peoples in Brazil, and a major public health challenge, especially in the Amazon region (Coimbra and Basta 2007).

A growing number of studies have found evidence that indigenous peoples in Amazonia have an exceptionally high risk of infection by Mycobacterium tuberculosis (MTB), and of developing the disease (Sousa et al. 1997; Baruzzi et al. 2001; Basta et al. 2006c; Levino and Oliveira 2007). A study in the state of Rondônia, southwestern Amazonia, found TB annual incidence rates to be 10 times higher among indigenous peoples than in the general population of the state (Escobar et al. 2001). Incidence rates of 300/100 000 and higher are often reported, far exceeding the national average of 50 new cases for 100 000 people. Between 1991 and 2002 the average incidence of TB among Suruí Indians was approximately 2500 per 100 000, with nearly half the cases diagnosed in children under 15 years old (Basta et al. 2004).

Availability and access to proper health services and technologies (e.g. vaccination, diagnostics, chemotherapy, and Directly Observed Treatment Short Course – DOTS) constitute key elements for a successful TB control program. Notwithstanding, given the complex determination of TB, it is of paramount importance that TB programs also consider the socio-economic and cultural dimensions of the disease. Poor adherence to TB chemotherapy is regarded as one of the greatest obstacles faced by TB programs today worldwide (Chaulet 1987; Farmer et al. 1991; Barnhoorn and Adriaanse 1992). Social sciences, generally, and critical medical anthropology, specifically, are equipped to address stigma, knowledge, and perceptions about the disease and thereby enhance TB control strategies with specifically designed protocols that can yield better results in community-based programs (Jaramillo 1998; Farmer 1999; van Rensburg et al. 2004). This can be of particular relevance when addressing non-Western and indigenous cultures, whose knowledge, values, and attitudes regarding health and disease may diverge sharply from mainstream biomedical practices.

Despite broad availability of a national TB diagnosis and treatment program that has proved effective in the Brazilian national population (Kritski and Ruffino-Netto 2000), TB remains a major cause of morbidity and mortality among indigenous peoples. Recent studies regarding TB among indigenous populations in Brazil suggest that quality and coverage of TB control is deficient (Escobar et al. 2004; Coimbra and Basta 2007). Despite wide recognition that DOTS is an important control strategy, it is not implemented in the majority of indigenous reserves in Brazil, including Xavante reserves. This study seeks to address that disparity through an interdisciplinary investigation of TB epidemiology, healthcare services, and ethnomedicine among the Xavante Indians of Central Brazil. First, we assess TB risk based on clinical assessment of nearly the entire Xavante population ≥ 1 year of age. Second, we evaluate health service response to TB risk by comparing our clinical results with healthcare records. Third, we weigh the significance of our findings in light of ethnographic data regarding Xavante perspectives of TB for a critical medical anthropology of TB health services.

Population and methods

Study population

The Xavante people had a total population of about 13 000 at the time of our fieldwork. They live in seven dispersed reserves in the state of Mato Grosso. The present study was

carried out in the Pimentel Barbosa Indigenous Reserve. Permanent contact with national society was established in the 1940s, with the expansion of economic and demographic frontiers into Central Brazil (Coimbra et al. 2002).

As for all indigenous peoples residing in Brazilian indigenous reserves, local point of service healthcare is administered to the Xavante population by the Indigenous Health Subsystem, which is organized in 34 Special Indigenous Sanitary Districts (Distrito Sanitário Especial Indígena – DSEI), managed by the National Health Foundation (Fundação Nacional de Saúde – FUNASA), a division of the Health Ministry. Although components of a distinct subsystem, DSEIs should articulate with the Unified Health System (Sistema Único de Saúde – SUS), which is operated in decentralized fashion by individual municipalities (Buss and Gadelha 1996; Santos et al. 2008). The National Tuberculosis Control Program operates in similar decentralized fashion, with oversight, financing, and technical guidance occurring at the federal level and responsibility for TB care, prevention, and control residing at the municipal level (Kritski and Ruffino-Netto 2000). There is no distinct plan for TB control among indigenous peoples, including the Xavante. Great diversity in political and economic circumstances between Brazilian regions and municipalities is reflected in the organizational structure of the DSEIs. In the case of the DSEI Xavante, which attends to all Xavante reserves, the health service network is substantially deficient. To a large extent, the FUNASA health staff is poorly prepared technically and operates with great logistical difficulty, making it difficult to achieve its objectives in the totality of the seven Xavante reserves. In the case of TB, transport and referral to the municipal hospital is made by FUNASA staff, who work inside the Xavante reserves, based on respiratory complaints or symptoms. For the Xavante of Pimentel Barbosa, the nearest municipal hospital is in the town of Água Boa, about 120 km away. After diagnosis, TB medicine is dispensed free of charge by the Municipal Health Department and delivered to the village by FUNASA on a monthly basis. In the village, it is administered to patients by FUNASA nurse auxiliaries.

Current health conditions among the Xavante are difficult to evaluate because of scarce information. Overall, their epidemiological profile is marked by high infant mortality (over 80 per 1000), mostly due to diarrhea and pneumonia, which account for 23% and 35% of all hospitalizations, respectively (Coimbra et al. 2002; Lunardi et al. 2007), and high prevalence rates of undernutrition (27.7% in children 0–48 months in 1995) (Coimbra et al. 2002). Sanitary conditions are markedly deficient, intestinal parasitism is widespread, and pemphigus foliaceus is endemic (Friedman et al. 1995; Santos et al. 1995). High prevalence rates of overweight and obesity are documented among adults (68.6% for individuals ≥ 20 years of age) due to rapid nutrition transition (Welch et al. 2009). We are unaware of HIV or HTLV infections in the study population.

Although evidence of TB is documented for some prehistoric populations in highland Peru and Chile, there is insufficient evidence to support its existence in precontact lowland South America (Salzano and Callegari-Jacques 1988; Roberts and Buikstra 2003). Among the Xavante, earlier medical reports did not observe clinical signs or symptoms of the disease in surveyed villages, and found only one positive response to tuberculin skin tests carried out at that time (Neel et al. 1964, 1968). Thus, the scientific perspective is that TB was probably introduced to the Xavante shortly after contact with Brazilian nationals and spread throughout Xavante villages in the 1960s and mid-1970s. That view differs from Xavante oral history, according to which TB (dawaihõ wapru) was one of very few debilitating diseases that affected the pre-contact Xavante population.

More recently, however, the situation has changed drastically. TB has become a major cause of morbidity and mortality among the Xavante, as demonstrated by cross-sectional

surveys. These surveys, intended to detect active TB, have revealed a surprisingly large number of cases that otherwise would have gone untreated (Amarante et al. 1996; Amarante and Costa 2000). The DSEI Xavante is listed as having one of the highest TB incidence rates among indigenous peoples in Brazil (Amarante and Costa 2000; Garnelo et al. 2003).

Analysis of TB morbidity

Analysis of TB morbidity data for the years 1999–2004 was based on the records of the Brazilian National Notifiable Diseases Surveillance System (Sistema de Informação de Agravos de Notificação – SINAN). These data were complemented by data collected at the local FUNASA office and the Municipal Health Department of água Boa, Mato Grosso, to which Xavante Indians from Pimentel Barbosa are referred for TB treatment. Notified cases of TB were used to calculate incidence rates. Cases of TB among the study population were selected from the SINAN database based on patient names.

Field research

Fieldwork was carried out in July 2006 at Pimentel Barbosa village (at the geographical coordinates of 13°19′09″S, 51°40′36″W), which was the largest village in the Pimentel Barbosa Indigenous Reserve, state of Mato Grosso, and which was undergoing a political division into two separate villages at the time. A demographic census and a cross-sectional health survey were conducted among all individuals 1 year of age and older in all households.

At the time of fieldwork the village population was 560 individuals, of whom 50.7% were female and 59.8% were children and adolescents ≤ 15 years of age. The minimum age was 4 months (only 27 children were < 1 year old). The population was distributed in 34 houses with an average of 20 persons per house (median = 16; minimum = 4, maximum = 42).

Following American Thoracic Society guidelines, clinical assessment of TB in the field included signs and symptoms of TB, chest X-rays of the population ≥ 10 years of age, and information about any prior treatment for TB. Any subjects showing fever, prolonged cough, weight loss, chest pain, and/or enlarged lymph nodes were asked to provide a morning sputum sample (American Thoracic Society 2000). Acid-fast Ziehl–Neelsen stained smears were read by light microscope at a field clinic that was set up at the local municipal schoolhouse, adjacent to the village. Ogawa–Kudoh medium was used for the primary isolation and initial identification of MTB following standard methodology (Kudoh and Kudoh 1974). Chest X-rays were taken from subjects (except pregnant women) presenting respiratory symptoms or with previous history of active TB, using a portable Suzuken & Co. X-ray device fitted with Kenz lenses (RX80, output 80 KVP, 20 mA). Radiographs were independently analyzed by two observers, one pneumologist and one radiologist, and findings were recorded in accordance with Boon et al. (2005). Divergent readings were settled by consensus between the two observers.

The prevalence of TB infection was estimated from the tuberculin skin test (TST) survey in accordance with the guidelines for high prevalence regions proposed by Arnadottir et al. (1996). Each participant was injected intradermally on the volar side of the left forearm with 0.1 mL (2 TU) of purified protein derivative (PPD-RT23) (Statens Serum Institute, Copenhagen, Denmark), using 1 mL plastic disposable syringes fitted with 13 × 3.8 mm needles (Becton Dickinson, São Paulo, Brazil). Tuberculin testing was done by a team of three nurses, each of whom read each test independently. Agreement among measurements was high (intraclass correlation coefficient > 0.98). TST positivity was defined as

induration ≥ 10 mm at 72 h after inoculation. We also used the alternative cut-off point of 5 mm.

In Brazil the BCG-ID vaccine is given routinely to neonates to prevent TB. Until recent years the Brazilian Health Ministry recommended revaccination with BCG for school age children (around 7–14 years old) to prevent TB and leprosy (Cunha et al. 2008). Individuals without a typical scar on their right deltoid region and with no vaccination record were considered non-BCG-vaccinated (Pereira et al. 2001).

Ethnographic research was carried out by one of the authors (Welch) during a 14-month participant-observation field study regarding Xavante social organization (Welch 2009). Subsequently, two of the authors (Welch and Coimbra) conducted additional ethnographic research regarding disease histories and ideologies, considered generally, and perceptions of TB infection, disease, and treatment. Ethnographic data were interpreted as subjective representations of individual and sociocultural realities situated within a specific historical, epidemiological, and institutional setting. Ethnographic responses were compared to ascertain areas of convergence and divergence between Xavante and biomedical accounts of TB causation and treatment.

Statistical analyses

Analyses of epidemiological data were done with the Statistical Package for the Social Sciences, version 9.0 (SPSS Inc., Chicago, IL, USA). Association between TB infection and the dependent variables was evaluated using logistic regression. Odds ratios (OR) were used as measures of association. p values < 0.05 were considered statistically significant, and 95% confidence intervals (CI) were constructed around estimates. Fisher's exact tests and χ^2 were used to assess statistical significance differences in the rates and proportions of radiographic patterns. The Annual Risk of Infection (ARI) was derived from the prevalence of infection using the following equation: $\text{ARI} = 1 - (1 - P)^{1/b}$, where P = prevalence of infection according to TST results and b = mean age of the sampled population (Cauthen et al. 2002).

Ethical considerations

Guidelines for research on human subjects set by the Brazilian National Committee on Research Ethics were followed. Ethical approval was obtained from the National Committee on Research Ethics (Comissão Nacional de Ética em Pesquisa – CONEP). The aims and scope of the project were presented to community leaders. Although consent for the research was granted by leaders on behalf of the community, individuals were allowed to decline to participate in the project in whole or in part for any reason and without prejudice. All measurements were observed by at least one Xavante health agent, who helped to explain the objectives of the research and acted as interpreter when necessary.

Results

Epidemiologic findings

A total of 476 subjects (89.3% of the population ≥ 1 year of age) were examined. Of those, 46.4% were males and 53.6% were females. The mean age was 19.2 years (minimum = 1.0, maximum = 91.7). There were 57 losses, of which five were refusals. Other losses were due

to absence from the village at the time of field work, for reasons unrelated to TB. A majority of those not examined were male (77.2%) and children < 15 years of age (56.1%) because, at the time of the study, an important ritual was being held to mark the initiation of village boys into manhood, and some were not available for testing. None of the persons who failed to be tested had a prior history of treatment for TB. The age composition of the study sample and of the losses did not differ (comparing < 15 years and ≥ 15 years of age, $\chi^2 = 0.02$, $p = 0.888$).

In SINAN's database we found records of previous treatment for 37 subjects from Pimentel Barbosa village during the period 1999–2004. The mean incidence rate for this period was 1289.6 per 100 000 inhabitants, with a balanced distribution by sex (51.4% female, $p = 0.755$) and a clear majority of children ≤15 years of age (67.6%, $p = 0.258$). A large majority of the cases (81.1%) were recorded as occurring in 1999.

Through the household survey we identified 38 subjects who had respiratory symptoms suggesting potential TB. All 54 sputum examinations performed on these subjects produced negative results. From those, a total of 37 sputum samples were also seeded in Ogawa–Kudoh medium. *Mycobacterium avium* colonies grew in the samples from two individuals. There was no growth of MTB.

In the village we performed 268 chest X-rays (98.9% of subjects ≥ 10 years of age tested with PPD). A large majority (80.6%) had no radiological alterations; 14.2% showed images suggestive of TB scars, 4.1% showed other abnormalities, and only 1.1% (three individuals) were consistent with active pulmonary TB. Active TB was confirmed in only one person, a 10 years-old girl (the other two were not confirmed after thorough clinical and laboratory screening). The most frequent kinds of alteration included pulmonary fibrosis (7.1%), nodules (7.1%), and nonspecific infiltrates (2.2%).

In individuals with histories of previous TB treatment, 67.6% had normal chest X-rays, whereas 12.6% of those with no treatment records had radiological abnormalities suggestive of TB (Table I).

Although BCG coverage surpassed 90% of the population, an unexpectedly high percentage of individuals (74.4%) presented TST < 5 mm (Figure 1). The prevalence of TB infection as indicated by TST reactions ≥ 10 mm was 16.6%. The prevalence as indicated by TST reactions ≥ 5 mm was 25.6%. The calculated annual risk of infection (ARI) for the Xavante was 0.94%. In multivariate logistic regression analyses, age ≥ 15 years-old was the only predictor of TB infection (TST ≥ 10 mm), with a very high adjusted odds-ratio of 20.0 (CI 9.2–43.3) (Table II). History of TB, number of BCG scars, and number of individuals in the house did not show association with infection. Multivariate logistic regression analyses with TB infection defined as TST ≥ 5 mm showed that males were 2.1 times more likely to

Table I. Radiographic patterns in the Xavante Indians according to history of previous treatment for TB, Pimentel Barbosa Village 2006.

	Previous treatment				
Radiographic patterns	Yes	%	No	%	Total
Normal	25	67.6	191	82.7	216
Active TB suggestive	1	2.7	2	0.9	3
TB Sequel suggestive	11	29.7	27	11.7	38
Other pathology suggestive	0	0.0	11	4.8	11
Total	37	100.0	231	100.0	268

$\chi^2 = 10.9$; d.f. = 3; $p = 0.012$.

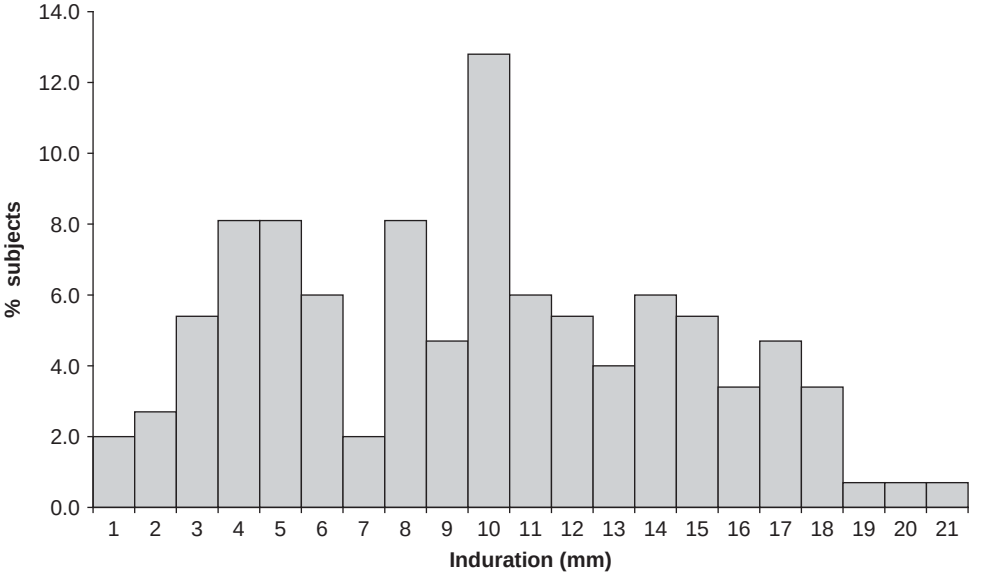

Figure 1. Distribution of TST induration diameters (mm) in Xavante Indians, Central Brazil (July 2006). Total subjects: 476; mean = 3.0 mm; SD = 5.2 mm; 68.7% nonreactors (0 mm) were omitted for convenience.

present tuberculin reactivity (results not shown). The coefficients of the other variables were not substantially changed compared to the model with the 10 mm cut-off point.

Ethnographic findings

Ethnographic fieldwork revealed a diversity of accounts regarding disease and health, considered generally, as well as a general consensus that the population's health status has declined in recent decades. Although all interviewees indicated that traditional curing methods remain efficacious, some individuals also expressed ambivalence about their effectiveness in certain cases of recently introduced diseases or due to what they described as an overall physical and spiritual weakening of the Xavante population since the contact era (1940s) that reduced most people's command of healing knowledge and skills. Although spiritual, magical, and botanical treatments continue to be employed by the community, some people expressed that not all individuals seek to utilize them today.

Biomedical etiology has made certain inroads into Xavante medical ideology in recent decades, principally through the influence of government healthcare practitioners and trained Xavante health agents, who together administer local healthcare at Pimentel Barbosa

Table II. Predictors of TB infection, Xavante Indians, Pimentel Barbosa Village 2006.

Variables	Comparison/reference groups	*n*	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex	Male/Female	221/255	1.4 (0.9–2.3)	1.6 (0.9–2.8)
Age groups (years)	≥ 15/<15	200/276	18.4 (8.6–39.4)	20.0 (9.2–43.3)
Individuals per house	≥ 16/< 16	274/202	0.7 (0.4–1.2)	0.7 (0.4–1.1)
Previous treatment	Yes/No	37/439	1.0 (0.4–2.4)	1.3 (0.5–3.9)
BCG scar	Yes/No	440/36	0.8 (0.3–1.9)	1.3 (0.5–3.4)

village. Furthermore, young people (especially males) now routinely attend a municipal school program, located in the village, with a science curriculum. Consequently, plural medical perspectives are common in the community. The range of variation in Xavante disease ideologies was relatively narrow and tended to reflect neither traditionalist nor biomedical absolutism. Rather, there was a tendency to place trust in both medical systems, although the relative degree of confidence placed in each was personal and contingent. Although age may have been a factor, especially in the degree of familiarity with and trust afforded either traditional medicine or biomedicine, we did not find a clear ideological bifurcation between elders and youths. It was common among people of all ages to affirm the effectiveness of both systems, at least in certain circumstances or for certain illnesses.

Although people tended to express confidence in biomedicine, they also expressed great ambivalence regarding Brazilian medical services. From their perspective, the Xavante people's relationship with Brazilian health services is marred by a long history of inadequate dispensation and lack of cultural sensitivity. Common complaints pointed to deficient allocation of financial and pharmaceutical resources, poor access to competent medical practitioners, and violation of Xavante cultural protocols regarding grave illness and death.

The ethnographic observations presented above also apply to the specific case of TB. The Xavante term dawaihõ wapru ('lung blood') is used for cases that Xavante individuals determine to be or are identified by medical clinicians as TB. As one elder explained, they identify TB as an illness that 'wastes the lungs and causes severe coughing'. Many unfortunate deaths are attributed to TB and it is considered among the gravest of diseases if untreated.

According to interviewees, TB is one of several illnesses that were present among the Xavante in the pre-contact era. All interviewees reported that TB may be malevolently transmitted to individuals using sorcery (simi'õ). Specifically, TB may be caused by contact with a magical powder, which sorcerers apply to convenient objects that they expect an intended victim to touch, such as clubs used in competitive fights (oi'o) or logs carried in footraces (uiwede). Notably, this formulation of TB transmission implicates enemies rather than familiars and situates it in public rather than private contexts.

There was some variation among explanations regarding the causes of contemporary TB cases. Although all individuals mentioned sorcery as a cause of at least some recent TB cases, some individuals also indicated the possibility of biological agency. For example, several individuals specified that cases of what they characterized as rapid-onset TB are caused by sorcery, whereas cases of slow-onset TB are caused by microbes. Others suggested that TB infection caused by sorcery might then be transmitted inadvertently through close bodily contact.

Opinions regarding traditional TB treatment also varied, although all respondents affirmed that the Xavante have botanical cures for TB that were extremely effective in the pre-contact era. Some individuals expressed that these traditional TB cures remain most effective, while others suggested that chemotherapy produces more certain results. Some individuals distinguished between TB infection caused by sorcery and that caused by microbes, indicating that traditional cures are more effective for the former and chemotherapy is more effective for the latter. In all cases, however, respondents claimed that TB did not pose a major health threat until the post-contact era and that contemporary medical treatment protocols are now effective in many, or most, cases. Interviews also revealed a more general pattern, whereby many individuals express the simultaneous beliefs that TB may be transmitted by a magical powder and that biomedical science has correctly identified its biological cause and developed an effective treatment.

Discussion

This study focuses scrutiny on TB control in an indigenous community located in a rapidly developing rural area with ongoing problems in primary healthcare despite increasing access to health services. As compared to our previous TB research among the Suruí from southwestern Amazonia (Basta et al. 2006b,c), the methodologies employed in the present study, including a field radiograph laboratory and extensive ethnographic research, permitted more thorough active case seeking and a critical analysis of local TB health care services. As in that case, this study was limited by the relatively small size of the population investigated, a typical feature of epidemiological research in Amazonian indigenous societies, which rarely exceed 500–600 people per village (e.g. Escobar et al. 2004; Basta et al. 2006c). In such settings, certain indicators of disease risk, such as TB incidence, are subject to increased uncertainty and should be interpreted with caution. Despite that limitation, and the low proportion (1.1%) of radiological findings consistent with active pulmonary TB among study subjects, our results indicate that TB is a major health problem for the Xavante. In addition to a moderately high ARI (around 1.0%), we document a low prevalence of TST reactivity (16.6% for TST reactions ≥10 mm) and high percentage of X-rays showing scars suggestive of TB (14.2%). Those results strongly indicate previous TB and suggest continued risk of disease in this group.

Age was the most important predictor of TB infection as indicated by tuberculin skin tests in the Xavante (Table II). The high odds-ratio encountered for age might suggest that the magnitude of the association may be inflated in this high-prevalence setting, which might limit the precision of estimates. This is because, although our study included nearly 90% of eligible subjects, the sample size is small. It is possible that this 'built-in bias' of the odds ratio might account for part of the association.

TST reactions in BCG vaccinated individuals are usually ≥ 5 mm because vaccination provokes a similar immunological response to infection. We found an unexpectedly high percentage of individuals (74.4%) with TST reactions < 5 mm even though BCG coverage surpassed 90% of the Xavante population. That apparent incongruence may be partially explained by recent studies documenting high frequencies of intestinal parasitism in patients with pulmonary TB and suggesting that the immune modulation induced by helminths may interfere with the immunologic reaction aimed at MTB, facilitating infection and disease (Elias et al. 2005, 2006b; Tristão-Sá et al. 2002) and enhanced susceptibility to active TB. Those studies showed that helminth infection makes the host more permissive to mycobacterial infections and less able to benefit from vaccination (Elias et al. 2006a), with the possible effect of minimal TST reactions. The prevalence of intestinal helmiths in the Xavante is high, with *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms affecting nearly one fourth of the village population (Santos et al. 1995; Coimbra et al. 2002). Similarly, the presence of pemphigus foliaceus, which is endemic at Pimentel Barbosa (Cerna et al. 1993; Friedman et al. 1995), is a grave auto-immune disease that can interfere with the cell-mediated immune system and may decrease rates of positive reactions to TST (Elkayam et al. 2007). Thus, the observed high rate of TST reactions < 5 mm suggest elevated risks of infection and disease despite good BCG coverage.

The complexity of the bacteriological profile of the subject population is further indicated by the isolation of *M. avium* from two sputum-negative Xavante subjects who presented no signs or symptoms of TB. That finding is consistent with reports by other researchers who also found unexplained high frequencies of isolation of mycobacteria other than TB from indigenous subjects in Amazonia (Basta et al. 2006d; Santos et al. 2006).

Similar field research using comparable methodology carried out among another indigenous population in Amazonia yielded an even higher prevalence of active TB (815.2/100 000) as compared to our findings of 210.8/100 000 (one active case in 476 subjects examined) (Basta et al. 2006c), clearly showing the importance of active case finding as a strategy to reduce time of diagnosis in populations with limited access to health resources.

The present study assessed not only the actual occurrence of TB in the population, but also its incidence according to health system records. We were therefore able to evaluate TB health services in the specific sociocultural setting of an indigenous Xavante village. According to SINAN data, the mean annual incidence of TB in Pimentel Barbosa village (1289.6 per 100 000 inhabitants) appeared much higher than for non-Indians in the state of Mato Grosso (48.5/100 000), where the Xavante are located, and for the Brazilian population in general (41.3/100 000) for the period 2000–2004 (Ruffino-Neto 2002; Bierrenbach et al. 2007). That finding is consistent with other morbidity analyses that suggest indigenous societies are at greater risk of TB than non-indigenous peoples (Escobar et al. 2001; Basta et al. 2004; Canadian Tuberculosis Committee 2007; Coimbra and Basta 2007). Nevertheless, our data also provide reason to question the veracity of incidence rates based on health system records and thus limit the conclusions that may be drawn from them.

We learned from reviewing the 37 cases of Xavante subjects that underwent treatment in the period 1999–2004 that nearly 80% had their diagnosis determined only on the basis of nonspecific clinical symptoms, without a single sputum test. Not surprisingly, upon reexamination by our research team, 83.8% of these subjects had a TST <10 mm and approximately 70% showed normal lungs, with no signs of previous pulmonary TB. Those findings suggest misdiagnosis in some cases at the medical facilities to which Xavante individuals are referred. Despite that finding, it may not be assumed that the mean annual incidence of TB reported is grossly overstated since we also found that 27 subjects with no previous clinical history showed radiographic patterns suggesting TB.

The extremely high incidence rates reported in other Amazonian studies may also result from misdiagnosis (Basta et al. 2004, 2006a; Escobar et al. 2001). Diagnosis on clinical grounds only is unreliable because symptoms of pulmonary TB are often similar to other chest diseases. X-rays are important diagnostic tools, but may prove misleading, as when uncharacteristic chest lesions can blur other possible causes of lung diseases in indigenous patients, such as, cancer and paracoccidioidomycosis. The observed clustering of so many new cases of TB in 1 year (1999) in a single village is unlikely, especially if most of them had had no sputum samples tested for acid-fast bacilli, lacked radiological signs of pulmonary TB, and had TST reactions <10 mm.

Our finding that a very high percentage of cases were treated for pulmonary TB without bacteriological confirmation is consistent with other Amazonian field studies (Sousa et al. 1997; Basta et al. 2006a) suggesting that local physicians appear to rush a diagnosis of TB for indigenous subjects without performing recommended laboratory tests according to national and international standards. This finding is of particular concern because the most effective TB prevention measures are early identification and successful treatment of individuals with TB (Comstock and Cauthen 1993; Schluger 2001), which is no less the case in Xavante communities. Extended family households tend to have many occupants living in close quarters, making frequent and intense physical contact between individuals unavoidable.

The failure to properly diagnose TB among the Xavante appear to derive from a mismatch between national and local clinical standards that is not warranted by contemporary infrastructural conditions. The National Tuberculosis Control Program's protocols include

sputum test and radiograph analysis based on a biomedicine oriented towards urban and non-indigenous populations. The failure to apply those protocols to the Xavante people may suggest that health practitioners assume they are locally impractical or unnecessary. However, given infrastructure improvements in recent years, Xavante access to well-equipped laboratories is comparable to that of urban and non-indigenous populations.

Although local clinical procedures should conform to national standards for the effective identification of Xavante individuals with TB, the nationalized strategy of passive diagnosis (limited to subjects who seek health care) is inadequate given local circumstances. Most Brazilian public health services are administered separately for the general and indigenous populations based in part on the principle that health circumstances and needs among indigenous populations are not the same as among the national population (Garnelo et al. 2003). In contrast, TB health services occur outside of this differentiated institutional structure, being operated at the municipal level but overseen at the national level through the National Tuberculosis Control Program and, in principle, being applied to the entire population without regard to indigenous or non-indigenous ethnicity (Buss and Gadelha 1996; Kritski and Ruffino-Netto 2000). National standards indicate the adequacy of limiting clinical diagnosis to individuals who voluntarily seek medical services and present symptoms indicative of possible TB disease. However, conditions in Xavante villages differ from those in national and non-indigenous populations. In Xavante communities, where transmission is facilitated by close proximity between members of large residential groups in internally undivided living spaces, a passive diagnostic strategy does not meet the TB prevention standard of early identification of individuals with TB. Accordingly, the principle of differentiated indigenous health services also should be applied to TB diagnosis strategy. Specifically, active case seeking in Xavante villages and other indigenous communities would greatly improve the efficacy of TB prevention and control efforts.

Despite our conclusion that diagnostic strategies and procedures require immediate revision, we found that efficacy of established treatment measures is enhanced by Xavante health perspectives. Anthropological research on local medical systems among both national and indigenous societies often highlights how cultural health perspectives that diverge from biomedical ones can impede health interventions and treatment, including those addressing TB (Inhorn and Brown 1990; Chemtob et al. 2000). Such literature often attributes poor TB patient compliance to conflicts between local sociocultural systems and biomedical approaches (Brassard et al. 2008; De Villers 1991; Gonçalves 2002; Grange and Festenstein 1993; Vecchiato 1997). Those accounts are often based on traditional anthropological models of ethnomedicine, which contrast magico-religious and biomedical disease etiologies (Foster 1976). However, ethnographic evidence suggests that in multiple health system settings, health concepts are not always neatly bifurcated. For example, it is not unusual for indigenous peoples to maintain supernatural theories of causation and treatment without rejecting biomedical solutions (Pedersen and Coloma 1983; Lepowsky 1990; Langdon 1994; Pollock 1996; Greene 1998). In such settings, critical medical anthropology offers approaches to disentangle the complex relationships between local populations and health service institutions. In some cases, the ideologies of local and indigenous populations are found to be largely compatible with biomedicine but other impediments are shown to deter them from compliance to treatment protocols, such as high cost, inaccessibility, staff noncompliance, communication barriers, user dissatisfaction, and ethnic discrimination by health professionals (Aluoch et al. 1987; Harper et al. 1996; Poss 1998; Buchillet 2000; Greene 2004). In other settings, where medical pluralism is institutionalized, Western medicinal epistemology may be characterized as less antithetical to local concepts of disease causation and treatment, with the result that local medical beliefs may not be

obstacles to clinical treatment for certain disorders (Colson 1971; Adams and Mouse 1985; Janes 1999). Among indigenous Amazonian societies, there is scant documentation of how local health perspectives facilitate the efficacy of biomedicine.

Our ethnographic data suggest that Xavante perceptions regarding TB causation and treatment do not preclude the coexistence of magical and biomedical accounts of TB. Such practical compatibility between supernatural and materialist accounts of events is a recurrent finding in anthropological research. It echoes Evans–Pritchard's classic account of Azande witchcraft, whereby the proximate cause of an unfortunate event may be material (e.g. a microbe), but malevolent use of supernatural agency is seen as the underlying cause (Evans-Pritchard 1937). Similarly, in a typical Xavante configuration, TB may be caused by microbial infection, but the infection may be sent by sorcerers with the aid of a magical powder. Alternatively, magical and biological TB may be seen to coexist, with the former being particularly rapid and best addressed with traditional botanical cures. An interesting ramification of the concurrence of these perspectives is an incongruity between biomedical etiology, which ascribes greater likelihood of transmission to closed environments where repeated and close contact is likely, and traditional Xavante etiology, which implicates precisely the opposite – transmission from socially distant individuals through indirect contact in public venues. In practice, however, that divergence does not compromise biomedical TB prevention efforts, which place emphasis on effective diagnosis and treatment rather than behavioral preventive measures.

Although many Xavante individuals may understand the underlying cause of TB differently from biomedicine, they tend to agree about its gravity if left untreated and the efficacy of medical prophylaxis and treatment protocols. That ideological pluralism is reflected in our research results regarding Xavante participation in TB health programs. We found vaccination participation to be high, with BCG coverage surpassing 90% of the population. In our own field study, we encountered a great deal of enthusiasm to be examined at our field clinic, with only five individuals refusing examination. In SINAN's database, we found no instances of individuals from Pimentel Barbosa village who failed to complete treatment during the period 1999–2004. Thus, the Xavante appear to be well disposed to participate in and adhere to TB prevention, monitoring, and treatment programs.

Certain institutional conditions are also favorable for the detection and treatment of TB at Pimentel Barbosa village. Well trained and dedicated indigenous health agents help bridge the cultural and communication gap between health practitioners and patients, many of whom do not speak Portuguese. FUNASA offers recently improved transportation services to regional medical facilities. The National Tuberculosis Control Program offers standard and effective drugs at no cost and in accessible locations.

The compatibility of Xavante and biomedical health perspectives in an institutional setting largely favorable to TB prevention and treatment efforts highlight that their overall inadequacy is the result of restricted inefficacies in diagnosis procedures. 'Overzealous' diagnosis and a failure to actively identify individuals with TB threaten to undermine the community's favorable stance towards the TB control program and the health of the Xavante population. Systematic misdiagnosis threatens to worsen the already tenuous confidence of the Xavante people in Brazilian health services. Although the Xavante people tend to have very favorable opinions of TB chemotherapy, their overall evaluation of health services are extremely ambivalent due to a complicated history of interaction with government and health agencies. Furthermore, untreated individuals increase the risk of exposure for others, especially considering that Xavante notions of TB transmission implicate precisely those individuals who, from the biomedical perspective, pose very little risk – individuals with whom one has very little physical contact because they are considered adversaries.

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