

FACTORS ASSOCIATED WITH *TAENIA SOLIUM* CYSTICERCOSIS: ANALYSIS OF NINE HUNDRED FORTY-SIX PERUVIAN NEUROLOGIC PATIENTS

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Abstract. In most developing countries, 10% of acute neurologic cases are patients with neurocysticercosis (NCC). Determining specific factors associated with contracting NCC will facilitate its diagnosis and prevention. We examined multiple socioeconomic, demographic, environmental, medical, and behavioral characteristics of 946 Peruvian neurologic patients for a correlation with NCC, which was diagnosed by the highly specific and sensitive electroimmunotransfer blot (EITB) or immunoblot assay. Eighteen percent (172 of 932) of serum samples and 28% (101 of 362) of cerebrospinal fluid samples were EITB-positive. The proportion of EITB-positive persons was similar for all socioeconomic levels. Significant factors associated with NCC were: 1) being born outside Lima, 2) having raised pigs, 3) more than 20 years of age, 4) a history of seizures, and 5) a history of taeniasis. Of these factors, raising pigs is the only one that is amenable to intervention, via improvements in animal husbandry.

Neurocysticercosis (NCC), an infection by the larval cystic stage of *Taenia solium*, is a common disease in developing countries where free-ranging pigs are raised.^{1,2} The life cycle of *T. solium* includes the pig as the normal intermediate host (harboring the larval vesicles or cysticerci) and humans as the definitive host (harboring the adult form or tapeworm). Humans can also serve as the intermediate host and develop the cystic form of the disease by accidental ingestion of *T. solium* eggs. Cysts commonly lodge in the central nervous system (CNS), but may also be found in subcutaneous tissue, muscle, the eyes, and in other parts of the body.³ Epilepsy and intracranial hypertension are the most common clinical forms of NCC, but because of the highly variable location of the cysts in the CNS, NCC is often seen with diverse neurologic symptoms.^{4,5}

Sound, effective, and economical control programs for NCC require judicious, strategic targeting of specific risk factors for intervention. Determination of factors associated with a disease requires an accurate diagnostic standard. Until the recent introduction of the electroimmunotransfer blot (EITB) or immunoblot assay for *T. solium* antibodies, diagnostic tests were not sensitive and specific enough to achieve this task.⁶⁻⁸ The development of the EITB assay has provided a sensitive (95-98%), specific (100%), and practical serologic test^{9,10} that is accurate enough to be used as

a standard in epidemiologic settings. Using the EITB, we determined the major risk factors in 946 Peruvian neurologic patients suspected of having NCC.

MATERIALS AND METHODS

We attempted to recruit all patients from public and private clinics to our laboratories for cysticercosis testing. Since ours is the only laboratory where serologic testing for cysticercosis is performed in Peru, we are fairly certain that we have access to most if not all cysticercosis-associated neurologic cases. We perform the EITB at no charge. Socioeconomic, environmental, medical, and behavioral information, as well as blood samples, were collected from participants between April 1990 and November 1991. Cerebrospinal fluid (CSF) specimens (362) were also obtained from a subset of patients who happened to have spinal taps performed for medical reasons. The EITB assay was performed as previously described⁹ and the results were provided to the patients free of charge. Results were expressed as either positive, negative, or indeterminate. Tests with indeterminate results were repeated and only reproducible results were accepted. Both CSF and serum samples were tested blindly and separately.

A positive EITB test result indicates at least one of the following conditions: 1) intestinal taeniasis, 2) NCC, or 3) cysticercosis outside of CNS. In this study, a patient with a positive EITB assay result and neurologic symptoms was considered to have NCC. Some seronegative cases may represent old infections (i.e., calcified cysts), or infections with insufficient immunologic response to be detected by the EITB.^{11,12} The contribution of these subgroups to the total number of seronegative cases cannot be quantified.

Patient information collected include age, sex, and birthplace. Birthplaces were classified as either Lima or outside Lima. Lima is the main urban center of the country, containing 35% of the total population, and cysticercosis is not

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TABLE 1

Comparison of serum and cerebrospinal fluid (CSF) electroimmunotransfer blot results in 348 paired samples of Peruvian neurologic patients*

	CSF+	CSF-
Serum+	92 (26)	14 (4)
Serum-	5 (1)	237 (68)

* Values are the no. (%).

considered to be endemic there. Address, occupation and education of all residents, the location of their household (i.e., urban, suburban, or rural) and a list of furniture in each house were recorded. Construction materials (floor, walls, roof) of the house, source of water, toilet (grouped as complete toilet facilities, latrine only, or no facilities), sewage (with or without sewage connections), number of persons living in the house, total number of rooms, and number of bedrooms were noted. Ownership of electrical appliances and luxury items (piano, personal computer, video cassette recorder, or car) were documented. Also noted were any history of pig raising or slaughtering, reports of having seen triquina (the colloquial term for porcine cysticercosis), a history of taeniasis, headache, dizziness, seizures, and family medical history including taeniasis or seizures.

Association between each of these variables and positive EITB assay results was analyzed using the chi-square test. Significant associations ($P < 0.05$) were further examined with multiple logistic regression models (EGRET[®] statistical software; Statistics and Epidemiology Research Corp., Seattle, WA) to determine the individual contribution of each factor. In these models, results of the EITB test served as the dependent outcome variable.

Crude odds ratios (COR) were derived from the proportion of EITB-positive and negative cases associated with each factor. Adjusted odds ratios were obtained from regression models, which accounts for interactions between factors.

RESULTS

Our database included information from the questionnaires of 946 patients, serum EITB results from 932 and CSF EITB results from 362. Of the patients who contributed CSF samples, 96% also provided serum samples (348 of 362). Eighteen percent of the EITB serum samples (172 of 932) and 28% of the CSF samples (101 of 362) were EITB-positive. Correlation between the EITB results of patients with both serum and CSF samples is shown in Table 1. The male:female ratio for the entire group was 1.26:1 (527 men: 419 women). All age groups had more than 10% seropositivity; however, the proportion of seropositive persons increased with age ($P < 0.001$, by linear association test). Age-stratified prevalence is shown in Figure 1.

A positive EITB result in serum was significantly associated with the following factors: birthplace outside Lima with a COR of 3.95, and a 95% confidence interval (CI) of 2.47-6.33, pig raising (COR = 2.62, 95% CI = 1.84-3.73), being older than 20 years of age (COR = 2.43, 95% CI = 1.57-3.77), seizures (COR = 2.21, 95% CI = 1.50-3.25), dirt floor (COR = 2.08, 95% CI = 1.30-3.34), history of

taeniasis (COR = 1.85, 95% CI = 1.16-2.95), house in a rural zone (COR = 1.79, 95% CI = 1.11-2.89), no toilet or sewage system in the house (COR = 1.59, 95% CI = 1.05-2.40), having fewer than three rooms for sleeping (COR = 1.44, 95% CI = 1.03-2.03), and living outside Lima (COR = 1.85, 95% CI = 1.06-3.23) (Table 2).

Using multiple logistic regression analysis, the best fit model with a positive serologic EITB result as the outcome again confirmed the following risk factors: birthplace outside Lima, seizures, older than 20 years of age, a personal history of taeniasis, and pig raising. Our model was based on 769 patients for whom data was available on all analyzed variables. Table 3 shows the odds ratios for each individual factor.

DISCUSSION

For our population of patients suspected of having NCC, the major factors associated with *T. solium* infection include being born outside Lima, having seizures, being more than 20 years of age, a history of taeniasis, and having raised pigs. Neither headache nor dizziness had a significant association with seropositivity. These findings are similar to those observed in a different, hospital-based series of lower middle class patients,⁵ and lend additional support to the concept that NCC is an important cause of epilepsy in disease-endemic areas.^{5,13} In this study, we examined patients from all socioeconomic levels and showed that cysticercosis affects similarly both upper and lower socioeconomic groups. Whether this study population is truly representative of the entire country of Peru cannot be evaluated since only persons with access to a diagnostic test were studied and the study group was drawn completely from symptomatic patients. In disease-endemic areas, most seropositive persons are asymptomatic.^{14,15} The cost of the test was not a selective factor since the EITB was offered for more than two years free of charge.

We have avoided using the term risk factor because this is a cross-sectional study and a cause-and-effect relationship can not be directly established between the factors and the disease itself. Nevertheless, we did clearly show the association between cysticercosis and certain distinguishing factors.

Most persons born outside Lima are from rural areas where domestic pigs are commonly found and sanitation is poor. In these areas, pigs are allowed to range freely and have access to human feces for food. Infected and uninfected pigs alike are slaughtered without going through veterinary inspection and pork is frequently infested with *T. solium* cysts.¹⁶ Free-ranging pigs can be fed at minimal cost since the majority of their food is obtained by scavenging. However, corralling pigs, thus restricting their access to human feces, although more expensive in the short term, can be promoted as cost-effective because a cyst-free pig is generally sold at much higher prices than an infected one.

Other potential measures for controlling *T. solium* cysticercosis include 1) detection and treatment of tapeworm carriers, using either a sensitive serologic test as the EITB, or antigen detection in stools, and/or 2) mass human chemotherapy for *T. solium* tapeworms in endemic populations. The former option, which requires a high degree of com-

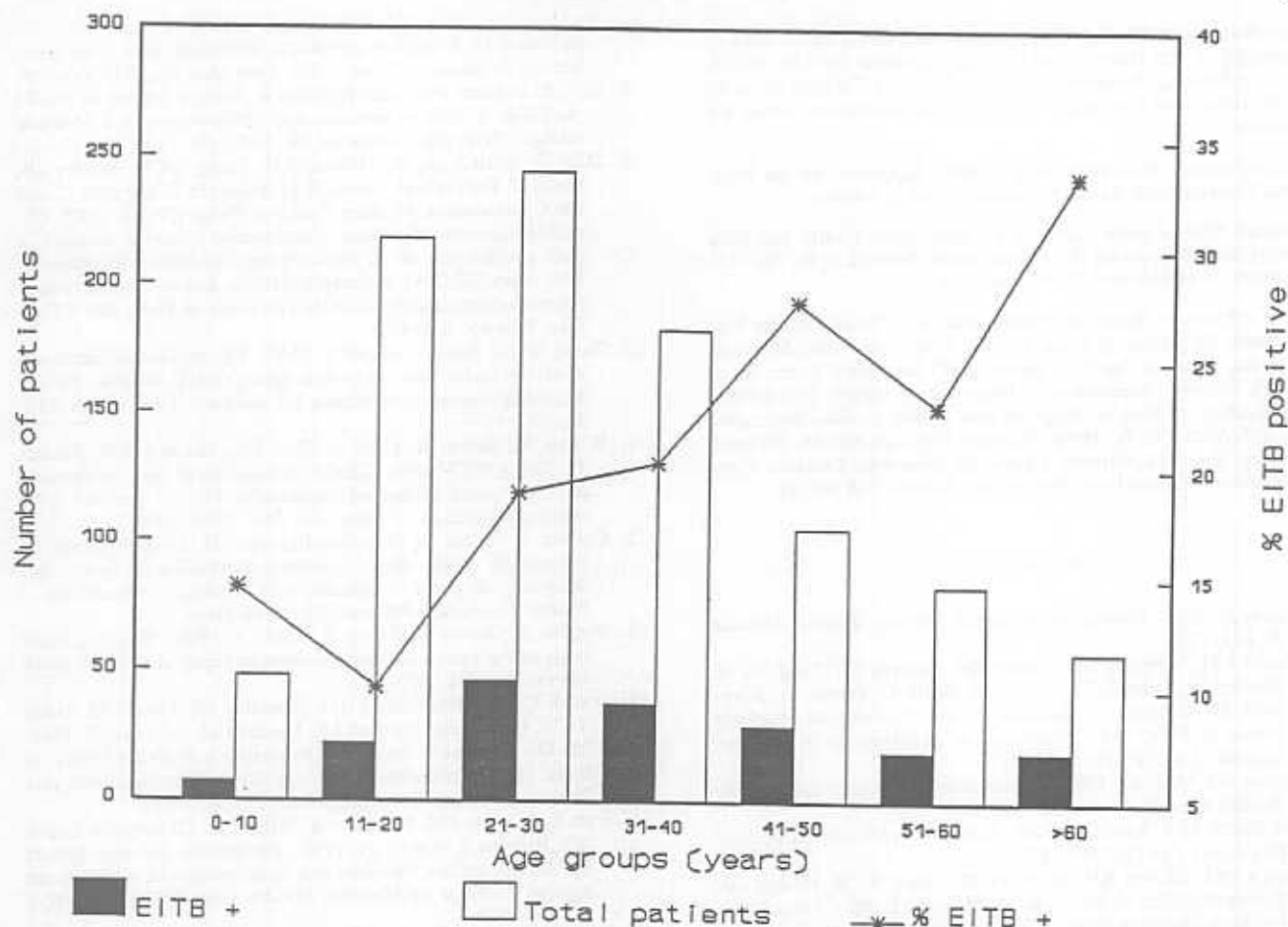


FIGURE 1. Prevalence of electroimmunotransfer (EITB)-detectable serum antibodies to *Taenia solium* by age group in 946 Peruvian neurologic patients. Age was not recorded for eight patients, including two who were positive in the EITB ($P < 0.001$, by linear association test).

community cooperation, may be difficult to accept by the villagers because of their cultural background or personal beliefs and is both expensive and time-consuming. Mass chemotherapy was tested in Ecuador with a resulting four-fold decrease in the prevalence of porcine cysticercosis after one year.¹⁷ The effect, however, was not persistent because six years later, the prevalence of porcine cysticercosis had re-

turned to pretreatment levels (Proano J, unpublished data). These options neglect the porcine reservoir, thus permitting continued human infection to occur. When inadequate hygienic facilities are present, massive chemotherapy may also cause a large increase in the number of *Taenia* eggs in the environment.

Since sanitary conditions (latrines, sewage disposal, and potable water) are difficult to achieve and unlikely to be generally improved in rural communities of developing countries, control of cysticercosis through sound pig husbandry practices appears to be the most accessible and cost-effective target for control programs.

TABLE 2

Factors associated with electroimmunotransfer blot (EITB) seropositivity for cysticercosis in 946 Peruvian neurologic patients

Factors	No. of cases	EITB+		P*
		No.	(%)	
Pig raising†	421	108	(26)	<0.001
Born outside of Lima, Peru†	622	149	(24)	<0.001
More than 20 years of age†	660	143	(22)	<0.001
Seizures†	504	112	(22)	<0.001
Dirt floor	97	29	(30)	<0.005
History of taeniasis†	108	29	(27)	<0.05
House in rural area	100	27	(27)	<0.05
No toilet in house	149	37	(25)	<0.05
Fewer than three bedrooms	401	84	(21)	<0.05
Residency outside Lima	269	48	(18)	<0.05

* By chi-square test.

† All factors with $P < 0.05$ were further analyzed using multiple logistic regression models. Only five were confirmed to be significant (see Table 3).

TABLE 3

Multiple logistic regression analysis for best fit with a positive electroimmunoblot transfer result (EITB) as outcome*

Risk factors associated with EITB+	Adjusted odds ratios	95% confidence intervals
Born outside Lima, Peru	2.59	1.48-4.52
Seizures	2.49	1.63-3.81
More than 20 years of age	1.92	1.17-3.14
History of taeniasis	1.72	1.03-2.87
Pig raising	1.69	1.10-2.58

* The model was based on the data from 769 patients.

Acknowledgments: We thank all the personnel of the Laboratory of Parasitology of the Universidad Peruana Cayetano Heredia for efforts in performing the serologic assays, Dr. Luis Cordero for technical advising, and the Sajino Working and Discussion Group for cooperation.

Financial support: This study was partially supported by the International Development Research Centre, Ottawa, Canada.

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