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Identification of risk factors for cystic echinococcosis in a peri-urban population of Peru

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Summary We conducted a questionnaire-based case—control study to identify risk factors for cystic echinococcosis (CE) in Lima, Peru during July—December 2005. Data were obtained from 32 cases and 64 controls. Multivariate conditional logistic regression showed that having owned ≥10 dogs [adjusted odds ratio (AOR) 8.7, 95% CI 1.3—57.5) and raising sheep (AOR 5.9, 95% CI 1.2—28.1) were independently associated with CE. The belief that CE could be transmitted by food (AOR 0.1, 95% CI 0.01—0.7) and breeding goats (AOR 0.02, 95% CI 0.001—0.6) were protective factors against CE transmission. Our results suggest that preventive measures to decrease the transmission of echinococcosis to humans in Peru should include limiting the number of dogs owned and encouraging owners to restrict dogs' access to food and water used for human consumption.
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1. Introduction

Cystic echinococcosis (CE) is caused by infection with the larval stage of the cestode *Echinococcus granulosus*. CE occurs in most continents and is an important public health problem in the sheep-raising areas of Argentina, southern Brazil, Chile, Peru and Uruguay (Craig and Larrieu, 2006; Moro and Schantz, 2006). Despite a surgical incidence of 123 CE cases per 100 000 and CE prevalences as high as 5% in some areas of Peru there are currently no ongoing control programs (Moro et al., 1997). No epidemiological studies have specifically measured risk factors for CE in the human population in Peru. Identifying those practices that increase the risk of CE transmission to humans is necessary for the design of effective control interventions. We conducted a case—control study to identify areas where preventive efforts may be targeted.

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Table 1 Univariate analysis of risk factors associated with an increased risk of cystic echinococcosis (CE) in a peri-urban population of Peru

Risk factor	Cases (n = 32) n (%)[a]	Controls (n = 64) n (%)[a]	Crude odds ratio (95% CI)	P-value
Past occupation				
Worked at a slaughterhouse	4 (13)	1 (2)	8 (0.9–71.6)	0.06
Worked at home	14 (44)	20 (31)	4.3 (0.8–21.9)	0.08
Pastoralist	11 (34)	26 (41)	0.8 (0.3–1.8)	0.6
Livestock raised				
Sheep	20 (63)	21 (33)	2.9 (1.3–7.0)	0.01
Cattle	21 (66)	33 (52)	1.8 (0.7–4.3)	0.2
Llamas	7 (22)	11 (17)	1.6 (0.4–6.0)	0.5
Goats	2 (6)	17 (27)	0.1 (0.01–0.8)	0.03
Slaughter practices				
Fed dogs offal of slaughtered animals	14 (44)	9 (15)	6.5 (1.8–23.4)	0.004
Home slaughter of livestock	12 (38)	5 (11)	6.3 (0.7–53.3)	0.09
Has seen hydatid cysts in viscera of slaughtered livestock	15 (50)	16 (36)	1.9 (0.5–6.7)	0.3
Sources and storage of water				
Stored water in covered and uncovered containers	13 (41)	11 (17)	3.6 (1.2–10.5)	0.02
Stored water in uncovered containers	6 (19)	6 (9)	2.2 (0.7–7.2)	0.2
Drank water from stream	20 (63)	42 (66)	0.8 (0.3–2.3)	0.7
Drank tap water but boiled it	1 (3)	3 (5)	0.7 (0.07–6.41)	0.7
Stored water in covered containers	6 (19)	24 (38)	0.4 (0.1–1.2)	0.09
Drank tap water without boiling it	1 (3)	15 (23)	0.1 (0.01–0.8)	0.03
Beliefs about echinococcosis transmission				
Believes CE can be acquired from food	4 (13)	30 (47)	0.2 (0.1–0.6)	0.004
Believes CE can be acquired by drinking water	2 (6)	23 (36)	0.2 (0.03–0.7)	0.01
Association with dogs				
Dogs had access to containers used to store water	24 (75)	4 (8)	33.3 (4.5–248.3)	0.001
Played with dogs during childhood	31 (97)	44 (71)	9.7 (1.3–74.3)	0.03
Has seen dogs being fed with hydatid-infected viscera	17 (55)	10 (19)	9.5 (2.1–42.9)	0.003
Dogs had access to dining area	24 (75)	14 (31)	5.8 (1.9–17.3)	0.002
Has owned $\geq$10 dogs	12 (38)	6 (10)	4.9 (1.6–15.4)	0.002
Fed viscera to dogs	18 (56)	17 (27)	3.4 (1.4–8.4)	0.009

[a] Percentages are calculated on the basis of the number of cases and controls who responded.

2. Materials and methods

Cases were enrolled at the Department of Surgery of Hospital Nacional Hipolito Unanue in Lima, Peru from July to December 2005. Cases were defined as patients hospitalized with a diagnosis of CE and in whom CE was later confirmed at surgery. Cases with a previous history of echinococcosis were not enrolled in the study, to minimize recall bias when completing the questionnaire. Most cases were immigrants from the Andean region with a varying length of residence in Lima city. Controls with similar demographic characteristics were selected from a shantytown community in Lima. A census of this community was used to randomly select two controls, matched by gender, age and place of birth with a case. All controls enrolled in the study had no known history of echinococcosis.

A structured questionnaire was developed to collect demographic information. It also included questions on practices thought to be associated with an increased risk of echinococcosis transmission, participants' knowledge and beliefs about echinococcosis transmission, and participants' association with dogs. The questionnaire was pilot tested in non-study patients before the study. Pictures of hydatid cysts were shown to all participants during the interview to aid recall and avoid confusion with other non-hydatid lesions.

The frequencies and percentages for each variable were first calculated. Univariate conditional logistic regression was used to calculate crude odds ratios (OR) and their 95% CIs to identify factors associated with CE. Significant ($P < 0.05$) associations were further examined in multiple conditional logistic regression models to determine adjusted ORs (AORs) and the individual contribution of each factor. Forward and backward stepwise conditional logistic regressions were used to select the best model fit. The analysis was performed using STATA software, version 8.0 (Stata Corp., College Station, TX, USA).

Informed consent was obtained from all study participants who were informed of the purpose, benefits and risks of the study.

3. Results

Thirty-two cases were matched with 64 controls. Demographic characteristics were similar for cases and controls (data not shown). Univariate analysis indicated that several risk factors were associated with an increased risk of CE (Table 1). Neither cases nor controls had knowledge of the aetiology of CE.

The results of multiple conditional logistic regression confirmed that having owned ≥10 dogs (AOR 8.7, 95% CI 1.3—57.5) and breeding sheep (AOR 5.9, 95% CI 1.2—28.1) were significantly associated with CE. The belief that food (AOR 0.1, 95% CI 0.01—0.7) and breeding goats (AOR 0.02, 95% CI 0.001—0.6) could transmit CE were protective factors against CE transmission.

4. Discussion

We found that having owned 10 or more dogs and raising sheep were associated with eight- and sixfold increased odds of CE, respectively, highlighting the importance of dogs and sheep as definitive and intermediate hosts in the life cycle of *E. granulosus* in endemic areas of Peru. The higher human risk of CE with increasing number of dogs owned is consistent with previous studies in Peru that document that up to one-third of dogs may be infected with the adult echinococcus tapeworm (Moro et al., 1999). Several studies have shown an increased risk of CE among individuals who keep several dogs (Campos-Bueno et al., 2000; Larrieu et al., 2002). In this study, feeding uncooked viscera to dogs was reported twice as often by cases than controls and probably contributed to *E. granulosus* transmission, as demonstrated in previous studies (Campos-Bueno et al., 2000; Carmona et al., 1998; Larrieu et al., 2002; Moro et al., 1999).

The higher risk of echinococcosis among subjects who raised sheep is consistent with previous observations in endemic areas of Peru and other countries of Latin America that show that CE is prevalent in areas where sheep are the dominant livestock raised and where dogs are extensively used in their management (Craig and Larrieu, 2006; Moro et al., 1997).

Storage of water in covered containers seems to be a protective factor, probably because this prevented infected dogs from contaminating the water with *E. granulosus* eggs. Previous studies in endemic areas have demonstrated the importance of water in the indirect transmission of echinococcosis (Carmona et al., 1998; Craig et al., 1988; Dowling et al., 2000; Larrieu et al., 2002).

The protective effect noted among individuals who believed that CE could be acquired from food probably reflects certain behavioural practices that may reduce the probability of getting infected through contaminated food. For example, half of those who expressed the belief that food or water could transmit CE did not allow their dogs access to dining areas of the home or to containers used to store water, which reduced the chances of infected dogs contaminating food or water used for human consumption.

We found that raising goats was protective for CE, although it is not entirely clear why this would reduce the risk of CE, rather than increase it. However, in Peru, goats are often bred mainly for their milk and in much lower numbers than sheep. Goats often graze in areas less likely to be contaminated with *E. granulosus* eggs, such as cliffs.

A limitation of the present study is the relatively small sample of cases interviewed, which may explain the inability to find other significant associations in the final multivariate model. Because we interviewed patients regarding events in the past, there is also a potential for recall bias, which may result in over- or underestimation of the true risk.

The findings of this study confirm the continued occurrence of certain practices that facilitate the transmission of *E. granulosus* in endemic areas of Peru. In addition to traditional approaches to *Echinococcus* control, our study suggests that preventive measures should include restricting dogs' access to food and water used for human consumption, and the storage of fresh potable water in covered containers inaccessible to dogs.

Authors' contributions: PLM designed the study protocol, performed the data analysis and drafted the manuscript; CAC, MT, YB and RJ collected the data; LC participated in the development of the study protocol and coordinated various aspects of the study. All authors read and approved the final manuscript. PLM is guarantor of the paper.

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