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ORIGINAL ARTICLE

Determination of copro-prevalence of *Echinococcus granulosus* and associated factors in domestic dogs: a household cross-sectional study in Huancarama, Peru

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ABSTRACT. Echinococcosis is an important disease with regard to public health and the leading role that humans have in fulfilling the transmission cycle. The objective of this study was to determine the copro-prevalence of *Echinococcus granulosus* in dogs from homes in Huancarama, Peru, and the factors associated with this infection. The research was basic, prospective, quantitative, observational, cross-sectional, and analytical. This study was approved by the Institutional Ethics Committee for the Use of Animals (CIEA) and the Institutional Research Ethics Committee (CIEI) of the Universidad Peruana Cayetano Heredia. The sample comprised of 519 homes. A geographic information system (GIS) was used to develop layers of information on the study area with georeferencing of the locations of these homes. Information processing was performed using Excel for Windows 2010, Statistical Package for the Social Sciences SPSS 25 software, and ArcGIS 10.8. Univariate and multivariate logistic regression tests were performed to determine the possible associations. Categorical variables were statistically contrasted using the chi-square test with 95% confidence intervals and $P \leq 0.05$, which indicated the extreme degree of significance. It was found that 94.4% of the houses had dogs and that the prevalence of *E. granulosus* was 27.7% (95/343; 95% CI 22.8-32.6). The distance from the house to the cattle slaughterhouse was associated with disease occurrence ($P < 0.01$). Locations in the Suni altitude zone presented a higher prevalence (41.8%) ($P < 0.05$). Lack of knowledge that humans can contract echinococcosis was associated with disease occurrence ($P < 0.05$).

Keywords: Echinococcosis; dogs; prevalence; copro-ELISA; spatial distribution.

INTRODUCTION

Cystic echinococcosis (CE) is a parasitic zoonotic infection caused by the larval stage of the cestode *Echinococcus granulosus sensu lato*. This parasite fulfills its biological cycle between domestic dogs and some wild canids (definitive hosts) and livestock animals (intermediate hosts). Humans act as aberrant hosts after the accidental ingestion of parasite eggs (Sierra-Ramos & Valderrama-Pomé, 2017). This parasite is distributed worldwide and occurs in many parts of South America, including Argentina, Peru, Bolivia, Chile, Uruguay, and southern Brazil. The Andean localities of the central and southern highlands of Peru present conditions that enable the maintenance of the biological cycle of the parasite, which is endemic for cystic echinococcosis in both animals (sheep and cattle) and humans (Sanchez *et al*., 2022). In South America, dogs are the definitive hosts with the greatest epidemiological significance (in which the strobilar or adult stage develops) (Larrieu *et al*., 2014). Therefore, the diagnosis of *E. granulosus* infection in dogs is very important. This plays a key role in epidemiological studies and control programs for cystic echinococcosis (Frison de Costas *et al*., 2014).

Cystic echinococcosis is a neglected disease that manifests in poor and rural populations (Harada *et al*., 2019), and the main factors that lead to transmission and persistence of infection include the close coexistence of animals or humans with dogs, poor hygienic-sanitary conditions, cultural customs, and low socioeconomic status. Persistence of the biological cycle of *E. granulosus* is favored by the coexistence of intermediate and definitive hosts; some habits of the inhabitants of such regions, such as feeding dogs with viscera, close contact with dogs, drinking untreated water or eating unwashed raw vegetables and fruits, ignorance of hygiene rules, and lack of veterinary surveillance for deworming of dogs and controlling the slaughter of intermediate hosts (Ramírez *et al*., 2018; Apt *et al*., 2000; Carrión-Ascarza *et al*., 2021).

In the larval stage of the parasite, hydatid cysts develop in the viscera of the host, especially in the lungs and liver of humans and herbivorous animals. This reduces the productivity of these animals. Death of an infected herbivore or its slaughter for human consumption and release of infected viscera into the environment completes the life cycle of the parasite if dogs have access to infected organs and eat them. This gives rise to dog-domestic species cycles (Zuñiga-A *et al*., 1999). Such cycles are so common that in some non-endemic areas of Peru, up to 6.3% prevalence of echinococcosis is reported among dogs that ingest viscera from slaughterhouses, since the animals slaughtered in these facilities may have come from endemic areas (Montalvo *et al*., 2018). One such area is the Huancarama district, where an average prevalence of 19% in slaughtered animals has been reported (Peña & Valderrama, 2022). This situation worsens when slaughterhouses in human settlements are small and poorly equipped (Khan *et al*., 2018), thereby becoming sources of infection.

On the other hand, long distances in rural areas may preclude the transportation of animals to rural slaughterhouses in the area. In such situations, slaughter is carried out almost exclusively at home and by the owner himself (Frison de Costas *et al*., 2014). However, unsupervised slaughter of herbivorous animals constitutes the main transmission route for infection in the canine host (Pavletic *et al*., 2017).

Given the significance of this disease with regard to public health and the leading role that humans have in fulfilling the transmission cycle, it is necessary to understand the social and cultural environment of people affected by cystic echinococcosis and determine the level of knowledge that they have in this regard (Khan *et al*., 2018; Ramírez *et al*., 2018). This can be achieved through surveys. Hence, the objective of the present study was to determine the copro-prevalence of *E. granulosus* in dogs from homes in Huancarama and the factors associated with this infection.

MATERIALS AND METHODS

Description of the research ethics setup

The study protocol, which included the interview guide and the informed consent statement for the owners of the dogs, was approved by the following committees of the Universidad Peruana Cayetano Heredia: Institutional Ethics Committee for the Use of Animals (Certificate 008-03-21) and the Institutional Research Ethics Committee (Certificate 064-01-21), under the category of expedited review. In addition, respondents signed an informed consent statement as a sign of acceptance. The survey was conducted under anonymous conditions, and the respondents' participation was voluntary. The District Municipality of Huancarama and the National University Micaela Bastidas de Apurímac authorized the research to be conducted.

Population and sample

The houses in Huancarama were considered the population units to be analyzed. To establish the number of households potentially involved in the research, the 2017 National Census (XII of Population, VII of Housing, and III of Indigenous Communities) (INEI, 2022) was taken into account, considering both the urban-rural and rural sectors. In this case, the only village considered to be marginally urban was Huancarama, which is the capital of the district and its most populated area. All dwellings in the district were identified and listed. Dwellings were selected through proportional random stratified sampling, considering each village as a stratum. Thus, it was ensured that the number of households surveyed and sampled was equitable according to the number of dwellings in each village to avoid any bias. The following formula was used for this purpose.

$$n = (NZ^2P[1-p]) / (E^2[N-1]+Z^2P[1-p])$$

Where:

n = Sample size: 519

N = Population size: 2366

Z = Confidence level (99%): 2.58

P = Baseline prevalence: 0.5

E = Tolerable upper limit of error (5%): 0.05

All the buildings in these dwellings were plotted on a district map so that they could be randomized. Through this, it was aimed to achieve greater efficiency in assigning samples using Google Maps (web map application server belonging to Alphabet Inc.) The population studied corresponded to the total number of existing dwellings in all locations of the Huancarama district (2,366). From these, a sample size of 519 dwellings was selected, and fecal samples were taken only from the dwellings where dogs were kept (490 dwellings), as indicated in Table 1.

Procedure

The team of interviewers was trained to complete the questionnaire. In addition, identification credentials and biosafety clothing (latex gloves, waterproof hooded protective suits, respirators with particle filters, and face shields, among others) were provided in accordance with the recommendations of the Pan-American Health Organization (OMS, 2020).

The interviewers toured all the randomly selected dwellings. If a given home did not respond when the team members called, they went to the adjoining house, to the left or right, if necessary. Observations of echinococcosis in homes in Huancarama district were based on the collection of dog fecal samples from residences in both rural and urban areas. Consequently, the observational unit was a household unit.

Fresh fecal samples were collected from dogs. The samples were collected in the form of one excreta per bottle.

Table 1. Sample size among households in the Huancarama district, Peru

Village	Dwellings	Sample	%
Huancarama	749	171	32.9
Llactabamba	52	11	2.2
Pampahura	107	24	4.6
Matecclla	71	16	3.0
Acco	65	14	2.8
Tunyabamba	35	8	1.5
Tambo	33	7	1.4
Chihuarque	67	15	2.9
Arcahua	71	15	3.0
Sayhua	125	28	5.3
Karhuakahua	78	17	3.3
Pichiupata	223	50	9.7
Ahuanuqui	45	10	1.9
Lambraspata	92	20	3.8
California	38	8	1.6
Los Ángeles	94	21	4.0
Sotapa Pararani	110	24	4.7
Other	311	59	11.3
Total	2366	519	100

The team searched for feces both inside and outside the house. One fecal sample was collected from each household. The biological sample collection bottles had a capacity of 120 cc, with a wide mouth and hermetic sealing. The sample placed in each bottle did not exceed the capacity of the bottle. Care was taken not to externally soil the bottle such that the sample would not have to be discarded later.

The samples were labeled according to the enumeration of the files. When the feces sample form had been completed with all the necessary information, the samples were refrigerated until they were transferred to the laboratory. General standards for the transportation of biological materials were followed. The samples were sent within 10 days, and the reasons for sample referral were informed via telephone.

For sample referral, it was verified that the fecal samples from the dogs were properly identified and labeled with a complete identification form. The bottles were carefully cleaned and sealed externally using 1% bleach. The bottles were individually wrapped in absorbent paper and packed in cardboard boxes, in which they were properly distributed to prevent spillage. The empty spaces between bottles were immediately filled with absorbent paper. The cardboard boxes were then placed inside a Styrofoam box and refrigerants were placed in this box.

In the laboratory, samples that were kept for 48 h were frozen at -80 °C, those that were kept for over 4 days were maintained at -70 °C, and those that were kept for ≥ 7 days were maintained at -20 °C. The samples were processed using a copro-ELISA technique. The laboratory issued a report detailing the number of samples that tested positive using the copro-ELISA. Dog feces containing traces of the parasite represented evidence and was supported by this method of immunodiagnosis (copro-ELISA), which has been used in control programs in many countries, including Cyprus, Spain, Peru, and Argentina (Frison de Costas *et al*., 2014).

The results were reported to the Huancarama Health Center, with the recommendation to carry out activities of mass deworming of dogs and to diagnose the owners of the dogs and any person living in the homes where a dog tested positive, as recommended by Larrieu *et al.* (2014).

Technique and instruments

The copro-ELISA test was performed using the techniques and instruments described in the study by Jara *et* *al*. (2019), who indicated that this test had a sensitivity of 96.1% (95% CI:85.9-99.6) and a specificity of 98.2% (95% CI:89.5-100). Likewise, they indicated that its negative predictive value (NPV) was 96.5% (95% CI:91.7-100) and its positive predictive value (PPV) was 98% (95% CI:94.1-100).

Georeferencing of dogs raised in the sampled homes

To visualize the spatial distribution of echinococcosis on the corresponding map, a geographic information system (GIS) was used to develop data layers obtained from all locations in Huancarama district. Through this, georeferencing of 343 points corresponding to the houses where the owners had dogs was achieved, using the ArcGIS software (version 10.8) and GPS (GARMIN eTrex® 10) to generate the corresponding coordinates.

Statistical analysis.

Observations and processing of the information were carried out using Excel for Windows 2010 and the Statistical Package for the Social Sciences SPSS 25 software. Categorical variables were statistically contrasted using the chi-square test and odds ratios with 95% confidence intervals, and a value of $P \leq 0.05$ was taken to indicate the extreme degree of significance. Univariate and multivariate logistic regression tests were performed to determine possible associations between echinococcosis and the following: location of the home; distance from the slaughterhouse; altitude of the home; number, sex, and age of the dogs; veterinary control; lockdown; sterilization; and feeding with viscera. The lowest number was used as the reference value to seek the best biological model, with the following details: $g(x) = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 3x3 + \beta 4x4 + \beta 5x5 + \beta 6x6 + \beta 7x7 + \beta 8x8 + \beta 9x9 + \beta 10x10$. The variables of dog owners' knowledge of echinococcosis, domestic animal species sensitive to this infection, and transmission from dogs to people were not included in the model.

RESULTS

The study showed that 94.4% of households had dogs (490/519; 95% CI:92.3-96.5). On average, there were 0.6 dogs per home. In addition, it was estimated that there was a ratio of three people for each dog. The prevalence of *E. granulosus* in dogs in the Huancarama district was 27.7% (95/343; 95% CI:22.8-32.6).

Univariate logistic regression analysis showed that the distance from the dwellings to the slaughterhouse was associated with *E. granulosus* infection in dogs. The highest prevalence of echinococcosis occurred in households in the rural sector, which were more than 1000 m away from the population center of Huancarama (33.2%) ($P < 0.05$). Likewise, the altitude of the house was associated with *E. granulosus* in dogs, such that locations in the Suni altitude zone had a higher prevalence of echinococcosis in dogs (41.8%) than in the Quechua zone (25%) ($P < 0.05$). However, the slaughtering of animals in homes did not show any statistically significant association with echinococcosis in dogs. In addition, the characteristics of the dogs raised in Huancarama, such as the number of dogs kept, sex, age, veterinary control, confinement, sterilization, and feeding with viscera, also did not show any statistically significant association with echinococcosis ($P > 0.05$) (Table 2). Furthermore, as shown in Figure 1, fecal samples of dogs with *E. granulosus* (red dots) were distributed across all locations in the Huancarama district.

Table 3 shows that lack of knowledge that humans can contract echinococcosis was associated with *E. granulosus* in dogs (22.6%) ($P < 0.05$). However, unawareness of the existence of echinococcosis and that dogs can transmit this infection to people did not show any statistically significant association with *E. granulosus* in dogs ($P > 0.05$).

The multivariate logistic regression analysis showed that dogs whose homes were more than 1000 m away from the district slaughterhouse had a protective factor against echinococcosis (OR = 0.37; $P = 0.006$). The other factors studied did not show any statistically significant association ($P > 0.05$).

DISCUSSION

The majority of households in the Huancarama district had dogs (70%). This was similar to the findings of studies conducted in Bucaramanga, Colombia (67%) (Florez & Solano, 2019) and Coquimbo, Chile (63-89%) (Acosta-Jamett *et al*., 2010). However, this proportion was higher than in Peruvian cities such as Abancay (47.8%) (Valderrama & Serrano, 2020), Lima (55.6-60.4%) (Soriano *et al*., 2017; Esparza *et al*., 2020) and Callao (56.1-61.9%) (Rendón *et al*., 2018; Harada et al., 2019); as well as in the cities of Havana, Cuba (63%) (Pino-Rodríguez *et al*., 2017), Buenos Aires, Argentina (47.9-57%) (Brusoni *et al*., 2007; Zumpano *et al*., 2011; Tortosa *et al*., 2016), Viña del Mar, Chile (57%) (Morales *et al*., 2009) and Chapecó, Brazil (52.5%) (Paula *et al*., 2018).

The average number of dogs per dwelling in urban and rural areas estimated in the present study was 0.6. This was similar to what was found in Neuquén, Argentina (0.6) (Brusoni *et al*., 2007), but lower than what was reported in Coquimbo, Chile (0.8-2.8) (Acosta-Jamett *et al*., 2010) and in Lima, Peru (1.6-1.7) (Esparza *et al*., 2020; Soriano *et al*., 2017). In addition, the canine population density was high, considering that the human-to-dog ratio determined was very close (3:1), i.e. exceeding the 10:1 ratio recommended by the WHO (2020). The locations surveyed in the Huancarama district were mostly rural, with deficient socioeconomic development and a precarious standard of living, which increases the risk to human health from such a large canine population.

The high percentage of dog ownership found in this study may have been related to local cultural factors, the lack of animal population control, and responsible surveil-

Table 2. Characteristics of dog ownership, homes and *E. granulosus* in the Huancarama district, Peru

Factors	"Dogs with *E. granulosus* n (%)"	"Dogs without *E. granulosus* n (%)"	Total (100%)	OR	95% CI	*P*
Characteristics of the house						
Distance to slaughterhouse (m)						
< 200	3 (15.8)	16 (84.2)	19			0.026
200-400	14 (27.5)	37 (72.5)	51	0.49	0.2-1.2	0.11
401-1000	11 (15.5)	60 (84.5)	71	0.98	0.2-3.9	0.975
> 1000	67 (33.2)	135 (66.8)	202	0.37	0.2-0.8	0.006
Species slaughtered in the house						
Cattle	5 (45.5)	6 (54.5)	11	2.39	0.6-9.6	0.181
Sheep	5 (27.8)	13 (72.2)	18	0.57	0.2-2.2	0.994
Goats	4 (36.4)	7 (63.6)	11	1.44	0.4-5.9	0.514
Pigs	27 (31.4)	59 (68.6)	86	1.22	0.7-2.2	0.376
Altitude of the house (m)						
Suni zone 3500-4000)	23 (41.8)	32 (58.2)	55			
Quechua zone (2300-3500)	72 (25.0)	216 (75.0)	288	2.16	1.2-3.9	0.012
Dog ownership						
Number of dogs						
> 4	-	5 (100.0)	5			0.662
2-4	49 (30.2)	113 (69.8)	162	-	-	0.999
1	46 (26.1)	130 (73.9)	176	-	-	0.999
Sex of dogs						0.344
Female	26 (24.3)	81 (75.7)	107			
Male	69 (29.2)	167 (70.8)	236	0.77	0.5-1.3	0.344
Age of dogs (years)						
> 8	2 (25.0)	6 (75.5)	8			0.182
2-8	80 (30.1)	186 (69.9)	266	1.85	0.9-3.6	0.066
< 2	13 (18.8)	56 (81.2)	69	1.44	0.3-7.9	0.678
No veterinary control	85 (29.5)	203 (70.5)	288	1.88	0.9-3.9	0.089
No confinement	78 (28.1)	200 (71.9)	278	1.1	0.6-2	0.758
Unsterilized	95 (28.3)	241 (71.7)	336	-	-	0.999
Fed with viscera	13 (22.4)	45 (77.6)	58	0.72	0.4-1.4	0.326

lance policies (Paula *et al.*, 2018). All locations surveyed in the Huancarama district, except for the location of Huancarama itself, were located in rural areas, where the number of dogs tended to be higher (WHO, 1990; Pino-Rodríguez *et al.*, 2017; Rendón *et al.*, 2018), despite socioeconomic conditions that tended to be poorer (Harada *et al.*, 2019). On the other hand, the human-animal interaction generated through possession of dogs would benefit the people who cohabit with them, such as reduced stress, increased self-esteem, and increased psychological well-being, etc. (Rendón *et al.*, 2018). Dogs can perform functions of guardianship, companionship, or hunting (Esparza *et al.*, 2020); however, the high percentage of ownership reported in the present survey shows the importance of for-

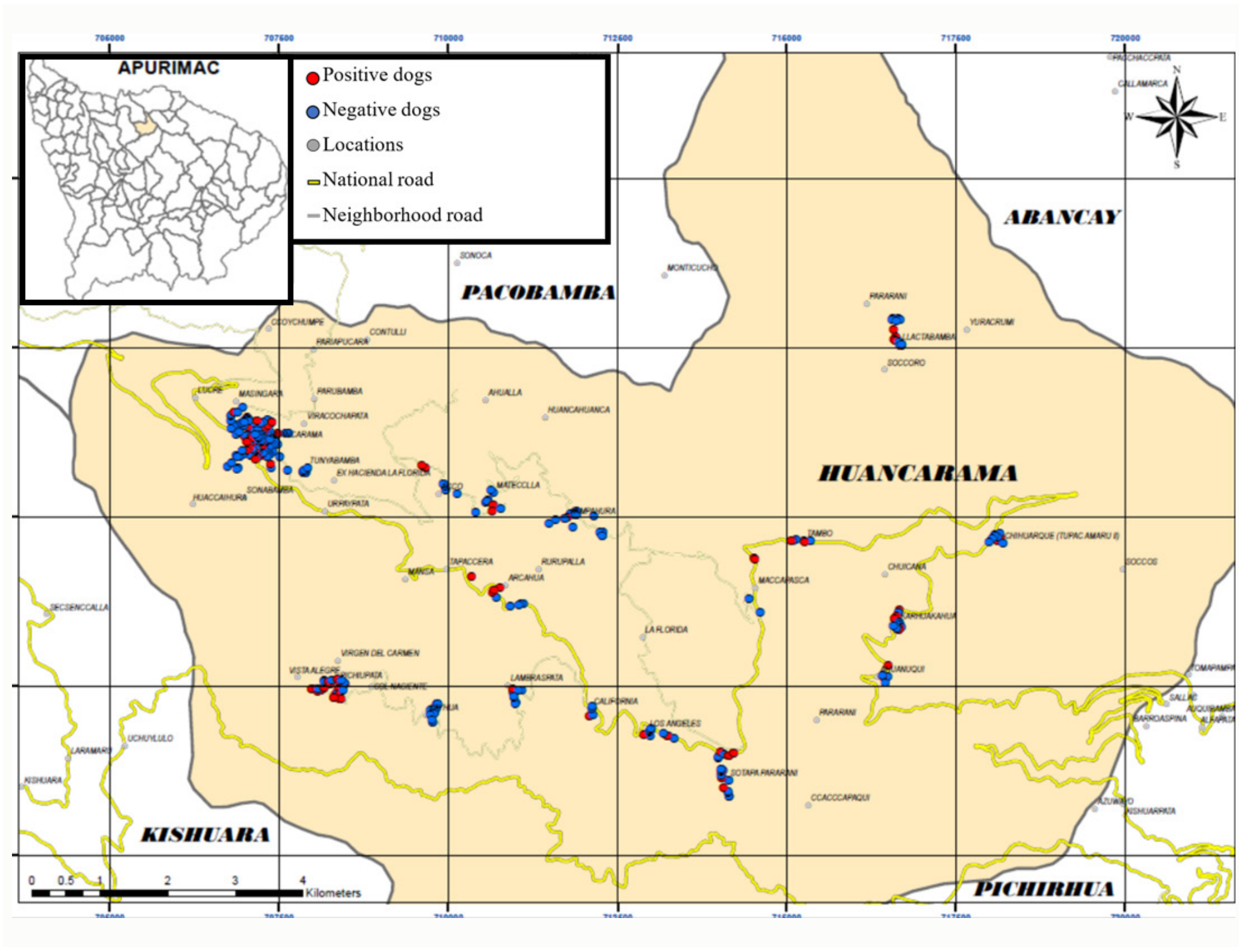

Figure 1. Map of distribution of fecal samples from dogs with owners, with (in red) and without (in blue) *E. granulosus* infection, in different locations in the Huancarama district.

tifying responsible ownership of companion animals and prevention of zoonotic diseases in the population of the District Municipality of Huancarama and its Health Center, pursuant to Law No. 30407 on Animal Protection and Welfare (Valderrama & Serrano, 2020).

The prevalence of *E. granulosus* in the dogs in this study was high (27.7%). It was much higher than that reported among dogs belonging to slaughterhouse workers and viscera traders in metropolitan Lima (13.8%) (Merino *et al.*, 2017); or among dogs in the provinces of Rio Negro (6.5%) (Larrieu *et al.*, 2014), La Rioja (15.9%) (Amaya *et al.*, 2016) and Jujuy, in Argentina (2-27.7%) (Frison de Costas *et al.*, 2014), and in the XII Region of Chile (1.8%) (Álvarez *et al.*, 2005). In addition, the locations of Pichiupata, California, and Sotapa Pararani presented exceedingly high prevalence (73.3%, 50%, and 43.5%, respectively), comparable only with what was reported from towns in the district of San José de Quero in Junín, Peru (50%) (Santivañez *et al.*, 2010).

This high prevalence in the most remote rural sectors probably occurred due to the precarious nutritional status of dogs. However, access to raw viscera containing hydatid cysts from cattle slaughtered at home is the main risk factor (Merino *et al.*, 2017). People tend to dispose of solid waste behind their homes, including household waste, thereby contaminating the environment and increasing the risk of contagion (Montalvo *et al.*, 2018). Along these lines, it can also be noted that the percentage of echinococcosis infection among pigs slaughtered in the slaughterhouse of Huancarama was 77%, probably as a result of poor knowledge and deficient practices among pork producers (Sierra-Ramos & Valderrama-Pomé, 2017). It is also worth mentioning that there is only one municipal slaughterhouse located in the capital of the Huancarama district, which means that for the most remote rural residents, slaughtering animals in their own homes is preferred, in order to avoid the complication of moving the animals to the district capital.

The distance from the houses to the slaughterhouse was associated with *E. granulosus* in dogs, such that the highest prevalence occurred in sectors that were more than 1000 m away from the village of Huancarama, where the slaughterhouse is located ($P < 0.05$). This is because most remote locations do not have a municipal slaughterhouse,

Table 3. Dog owners' knowledge about the parasite cycle of *E. granulosus* and its presence in dogs in the Huancarama district

Factors	"Dogs with *E. granulosus* n (%)"	"Dogs without *E. granulosus* n (%)"	Total (100%)	OR	95% CI	*P*
Echinococcosis	87 (28.7)	216	303	1.61	0.7-3.6	0.251
Species that can contract *E. granulosus:*						
Cattle	95 (28.9)	234 (71.1)	329	-	-	0.998
Goats	95 (28.3)	241 (71.7)	336	-	-	0.999
Dogs	94 (28.2)	239 (71.8)	333	3.54	0.4-28.3	0.234
Sheep	93 (28.0)	239 (72.0)	332	1.75	0.4-8.3	0.479
Pigs	88 (27.9)	227 (72.1)	315	1.16	0.5-2.8	0.74
Humans	43 (22.6)	147 (77.4)	190	0.57	0.4-0.9	0.02
that dogs can transmit *E. granulosus* to people	1 (11.1)	8 (88.9)	9	0.32	0-2.6	0.26

so slaughtering of animals is done at home, thus facilitating the consumption of viscera by dogs and increasing disease prevalence (Merino *et al.*, 2017; Montalvo *et al.*, 2018).

The locations in the Suni altitude zone (3500-4000 m.a.s.l.) presented a higher prevalence of echinococcosis in dogs than those in the Quechua zone (2300-3500 m.a.s.l.) ($P < 0.05$). This finding differs from that reported in other studies, such as in the Quebrada area (2200-2700 m.a.s.l.) and the Puna area (3000 m.a.s.l.) of Jujuy, Argentina, where the prevalence was similar (11.7-14% and 2-14.8%, respectively) (Frison de Costas *et al.*, 2014). Similarly, in a previous study on pigs slaughtered in the slaughterhouse of Huancarama in 2013, the percentage of cystic echinococcosis infection was higher in pigs from Andahuaylas (2926 m.a.s.l.) than in pigs from Huancarama (2965 m.a.s.l.), Pacobamba (2720 m.a.s.l.), and Kishuara (3665 m.a.s.l.), with no relationship with altitude (Sierra-Ramos & Valderrama-Pomé, 2017).

Contrary to what several authors have suggested (Frison de Costas *et al.*, 2014; Amaya *et al.*, 2016; Merino *et al.*, 2017; Montalvo *et al.*, 2018), neither the characteristics of dogs raised in the locations of Huancarama (such as the number of dogs bred, sex, age, veterinary control, confinement, sterilization, and feeding with viscera) nor the slaughter of animals in homes showed any association with echinococcosis in dogs. This was probably because infection with this parasite spread endemically throughout the district. However, it was difficult to observe the owners' habits regarding their feeding of their dogs because the residents of this district were very suspicious about letting strangers into their homes.

The lack of knowledge on whether cattle and humans can contract echinococcosis is associated with echinococcosis in dogs. This is a concern considering that this disease is zoonotic. The inhabitants neglect their self-care to avoid contracting the infection by maintaining contact with their dogs or feeding them with raw viscera contaminated with hydatid cysts (Amaya *et al.*, 2016), especially from cattle slaughtered at home. It should be noted that the Apurimac region, where the Huancarama district is located, is not a sheep area, but backyard breeding of species such as cattle and pigs is practiced especially (INEI, 2017).

The multivariate logistic regression analysis showed that dogs whose homes were more than 1000 m from the district slaughterhouse had 63% protection against echinococcosis. This was because, unlike homes in the urban-rural area where the slaughterhouse is located, homes in rural areas are far from each other, which would make it difficult for a dog to travel to eat some viscera with hydatid cysts that had been improperly disposed of in another household. Therefore, dogs that were found to be infected would not have become infected by eating raw viscera supplied by their owners, considering that these owners were aware of the risks that this implies. Rather, they would mainly have become infected from viscera that had been improperly discarded by residents of neighboring houses in the urban-rural sector.

It should be emphasized that this was the first survey on the presence of echinococcosis in dogs in the Huancarama district. There is a latent risk factor due to deficient possession of dogs that are usually fed raw viscera, fruits, or waste from the slaughterhouse of the city (Reyes *et al*., 2012; Larrieu *et al*., 2014; Amaya *et al*., 2016). However, this survey presented some limitations, considering that even though the surveys were carried out using an interview guide, the interviewee's responses had to be trusted. Moreover, if there had been prior knowledge of the number of dogs in the district and in each village would have helped in designing a more accurate sample size and thus to obtain more precise results.

The lack of echinococcosis control strategies has allowed for the spread of infection in the study area. The results of this study demonstrated that *E. granulosus* is present throughout the district, highlighting that echinococcosis constitutes a public health problem. The present results may form a useful basis for subsequent studies and are valuable with regard to the implementation of mitigation and control strategies in the district studied and in the province of Andahuaylas. For this reason, the results from this research have been reported to the Huancarama Health Center, with a view to undertaking deworming programs for dogs and people who were living in homes from which canine fecal samples were positive for *E. granulosus*.

Competing interests statement

The authors declare that they did not have any conflict of interest.

Author contributions

GM and FJU were involved in the data collection, analysis, and interpretation. AAV participated in the study conception, data analysis and interpretation, writing, design, critical review of the article, statistical advice, and technical or administrative advice. All authors approved the final version of the manuscript.

Ethics statement

The study protocol was approved by the Institutional Ethics Committee for the Use of Animals (Certificate 008-03-21) and the Institutional Research Ethics Committee (Certificate 064-01-21), of the Universidad Peruana Cayetano Heredia, under the expedited review category.

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