

Original article

Cystic Echinococcosis at the Human–Livestock Interface: Knowledge, Offal Disposal and Preventive Practices among Sheep Breeders in Eastern Libya

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Abstract

Cystic echinococcosis (CE), caused by the *Echinococcus granulosus* sensu lato complex, is sustained principally through dog–livestock transmission. Sheep breeders are central to prevention because dog treatment, carcass and offal management, and everyday husbandry practices determine whether the parasite cycle can persist. This study assessed CE knowledge, dog-management practices, offal disposal, and selected environmental risk indicators among sheep breeders in eastern Libya within a One Health framework. An anonymous web-based cross-sectional survey was conducted over six months, from March through August 2026. A structured 35-item Arabic-language questionnaire was distributed through an electronic platform used by sheep breeders. Participation was voluntary, names and direct identifiers were not collected, and submission of the completed questionnaire constituted implied consent. A total of 640 complete questionnaires from eligible sheep breeders in eastern Libya were included in the primary analysis. Associations were examined using odds ratios (ORs), 95% confidence intervals (CIs), chi-square tests, and an exploratory multivariable logistic model in IBM SPSS Statistics. Overall, 66.2% (424/640; 95% CI 62.5–69.8) had heard of CE, but only 25.5% (163/640; 95% CI 22.2–29.0) recognised its zoonotic nature; among respondents who had heard of the disease, the corresponding proportion was 38.4%. More than half (51.7%) reported having observed cyst-like lesions in sheep. Dog contact at the sheep–farm interface was common: 74.7% handled or interacted with dogs near sheep, while only 18.1% reported a dog-care response that included deworming. Stray animals were reported near 48.3% of flocks; among these respondents, dogs were mentioned in 94.2% of stray-animal reports. Burial was the most common action for abnormal organs (43.3%), whereas 29.4% reported a potentially unsafe offal-disposal practice. Receipt of health education was strongly associated with recognition of the zoonotic nature of CE (OR 4.24, 95% CI 2.89–6.22). In multivariable analysis, recognition of zoonotic transmission was associated with lower odds of potentially unsafe offal disposal (adjusted OR 0.15, 95% CI 0.09–0.27), whereas handling dogs near sheep was associated with higher odds (adjusted OR 4.43, 95% CI 2.62–7.51); both associations remained directionally consistent in sensitivity analysis. Among sheep breeders in eastern Libya, general awareness of CE was more common than accurate recognition of its zoonotic nature, while important dog–offal transmission interfaces remained open. Control should prioritise veterinarian-led education, regular praziquantel deworming of dogs, prevention of canine access to raw offal, practical disposal infrastructure, and integrated human–animal–environment surveillance. These measures are consistent with One Health and support sustainable-development priorities related to communicable-disease control and environmentally responsible waste management.

Keywords: Cystic Echinococcosis, *Echinococcus Granulosus*, Sheep Breeders, Offal Disposal.

Introduction

Cystic echinococcosis (CE) is a chronic zoonotic helminth infection caused by the larval stages of the *Echinococcus granulosus* sensu lato complex. The parasite is maintained through predator–prey or domestic transmission cycles in which canids, particularly dogs, act as definitive hosts and livestock act as intermediate hosts. Humans acquire infection accidentally after ingesting parasite eggs shed in canine faeces, whereas dogs become infected mainly by consuming viable hydatid cysts in infected viscera. The dog–sheep–dog cycle remains epidemiologically important in many pastoral and mixed-farming settings [1–5].

CE remains a neglected public-health and veterinary problem despite being preventable [6,7]. The World Health Organization identifies periodic dog deworming, improved slaughter hygiene, safe destruction of infected offal, public education and, where appropriate, livestock vaccination as core control measures. The World Organisation for Animal Health similarly emphasises preventing canine access to carcasses and raw offal, regular praziquantel treatment of dogs at risk, systematic meat inspection and safe inactivation or disposal of infected viscera [8,9]. These recommendations are inherently One Health in character because sustained transmission reflects the interaction of human behaviour, livestock management, dog ecology and environmental contamination. This interpretation is consistent with the contemporary One Health definition, which explicitly integrates human, animal and ecosystem health [10].

Across Africa and the wider Mediterranean region, epidemiological evidence continues to show that canine infection and household or farm-level practices can maintain transmission. An Africa-wide meta-analysis confirmed persistent infection in dogs and highlighted the need for integrated control involving veterinary treatment, meat inspection, management of free-roaming dogs and environmental sanitation [11]. Recent Mediterranean work has also reinforced the practical importance of repeated dog deworming in highly endemic areas [12]. Community studies in Uganda, Iraq, Chile, Türkiye

and Ethiopia have consistently identified incomplete knowledge of CE together with behaviours such as free-roaming dog contact, inadequate deworming and raw-offal feeding [13–17].

Libya has ecological and husbandry conditions compatible with continued CE transmission. Published reviews of slaughtered livestock have documented infection across sheep, goats, cattle and camels and have linked persistence to stray dogs, animal-husbandry practices, slaughter practices and limitations in veterinary control [18]. More recent abattoir data from Al-Qubba also demonstrate ongoing livestock infection and support a continued role for sheep in the local transmission system [19]. Nevertheless, recent field evidence describing what sheep breeders know and what they do at the dog–livestock–offal interface remains limited.

Recent parasitology research from Benghazi has highlighted complementary dimensions of parasite prevention, including the need to strengthen health-related knowledge and preventive awareness among university populations [20] and to integrate clinical surveillance with water, sanitation, food-safety and environmental health interventions within a One Health framework [21]. Collectively, these findings reinforce the local relevance of coordinated, multisectoral parasite-control strategies that bridge human, animal and environmental health.

Risk cannot be inferred from disease awareness alone. A breeder may recognise the term ‘hydatid cyst’ yet remain unaware of the canine definitive host, may treat dogs without using an effective cestocide, or may recognise abnormal organs while disposing of them in a way that permits scavenging. Accordingly, the present study characterises three linked domains: knowledge of CE and its transmission, management of dogs in proximity to sheep, and handling of abnormal organs and slaughter waste. The study also examines environmental conditions, hygiene practices, health-education exposure and practical barriers to safer offal disposal. The analysis is framed as a One Health assessment of modifiable transmission interfaces rather than as a simple awareness survey.

Methods

Study design and recruitment

This anonymous cross-sectional survey was conducted over a six-month period from March through August 2026. The target population for the present analysis comprised sheep breeders or livestock keepers responsible for sheep husbandry in eastern Libya. Recruitment was undertaken electronically through an online page used by sheep breeders. The questionnaire link was available to eligible users of the platform, and participation depended on voluntary completion of the electronic form; the resulting sample is therefore best characterised as a non-probability voluntary-response sample from eastern Libyan localities.

Sample Derivation, Regional Eligibility and Age Classification

The analytical sample comprised 640 electronic questionnaires completed by sheep breeders from the predefined eastern-Libya study area during the study period. All included responses met the geographical eligibility criteria for the present regional analysis. Participant age was recorded in grouped categories (<20, 20–29, 30–39, 40–49 and ≥50 years) and was analysed accordingly.

Questionnaire development and domains

The questionnaire was administered in Arabic and contained 35 items covering demographic and flock characteristics; previous awareness of CE; sources and self-assessment of knowledge; recognition of the zoonotic nature of CE and commonly affected organs; experience of cyst-like lesions in sheep; dog management and dog–flock contact; offal and slaughter-waste disposal; stray-animal presence; personal protective and hand-hygiene practices; family history; previous health education; perceived drivers of transmission; and open-text barriers to safe disposal. The items represent distinct epidemiological and behavioural domains.

Outcome definitions

Recognition of the zoonotic nature of CE was defined as selecting the questionnaire option indicating transmission “between animals and humans”. This variable should be interpreted as recognition of zoonotic transmission, not as proof that the respondent understood the specific dog-to-environment-to-human pathway. A dog-care response was considered to include deworming when the respondent selected either deworming alone or the option indicating both deworming and vaccination. Because the questionnaire did not record the anthelmintic agent, dose or frequency, this variable reflects reported deworming behaviour rather than confirmed effective praziquantel treatment.

A derived variable termed “potentially unsafe offal disposal” was defined as reporting any of the following actions for abnormal organs: feeding them raw to animals, leaving them at the slaughter site, or discarding them with general waste. The qualifier “potentially” is intentional because the survey did not document whether municipal waste was sealed, collected promptly, or accessible to dogs. Burial and boiling before feeding to dogs were not included in this composite; however, the questionnaire did not measure burial depth or the time–temperature conditions of boiling, so those practices cannot be assumed to guarantee parasite inactivation.

Data Quality Assurance

Data-quality screening was undertaken before statistical analysis. Exact-match screening across questionnaire fields was applied as an additional quality-control procedure to enhance the integrity of the analytical dataset.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarised as frequencies and percentages. Table 1 percentages were presented to two decimal places and minimally adjusted for rounding so each mutually exclusive category group totalled 100.00%; frequencies were unchanged. Wilson 95% confidence intervals were calculated for selected primary proportions. Associations between binary exposures and outcomes were expressed as odds ratios (ORs) with 95% confidence intervals, and chi-square tests were used where appropriate. An exploratory multivariable logistic regression model for potentially unsafe offal disposal included, a priori, recognition of the zoonotic nature of CE, receipt of health education, reported availability of official disposal instructions, presence of stray animals near the flock, and handling of dogs near sheep. Adjusted odds ratios (aORs) are reported with 95% confidence intervals. Because the outcome was not rare, ORs are interpreted strictly as odds measures and not as risk or prevalence ratios. Statistical significance was assessed at a two-sided alpha of 0.05.

Consent, anonymity and confidentiality

Participation was voluntary. The electronic questionnaire did not request participant names or direct personal identifiers, and no names were present in the analytical dataset. Submission of the completed questionnaire indicated willingness to participate, and results were analysed and reported only in aggregate.

Results

Participant and flock profile

A total of 640 complete questionnaires from sheep breeders in eastern Libya were included in the primary analysis. The largest age group was 20–29 years (40.47%), followed by participants aged 30–39 years (23.75%). The <20-year age category accounted for 17.66% of the sample. Most respondents were Libyan (66.88%), while 32.97% had attained university-level education. More than half of the participants (57.81%) reported over 10 years of experience in sheep rearing. Local Barqi/national sheep were the predominant type raised by 74.22% of respondents. Flock size varied considerably across participants, with 45.00% managing fewer than 50 sheep and 26.09% reporting flocks of 200 animals or more.

Table 1. Demographic and flock characteristics of participating sheep breeders in eastern Libya (n=640).

Variable	Category	n	%
Age (years)	<20	113	17.66
	20–29	259	40.47
	30–39	152	23.75
	40–49	48	7.50
	≥50	68	10.62
Farm/grazing locality	Benghazi	230	35.94
	Derna	41	6.41
	Tobruk	37	5.78
	Shahat	36	5.62
	Batta	36	5.62
	Al-Nawagiya	31	4.84
	Suluq	30	4.69
	Al-Majhula	29	4.53
	Sultan	28	4.38
	Ajdabiya	26	4.06
	Wadi al-Bab	26	4.06
	Al-Bayda	25	3.91
	Susa	24	3.75
	Al-Marj	22	3.44
	Al-Maqzaha	19	2.97
Education level	Illiterate	20	3.12
	Basic education	195	30.47
	Secondary	85	13.28
	Intermediate diploma	129	20.16
	University	211	32.97
Experience in sheep rearing	<5 years	172	26.88
	5–10 years	98	15.31

	>10 years	370	57.81
Nationality	Libyan	428	66.88
	Chadian	61	9.53
	Syrian	57	8.91
	Egyptian	47	7.34
	Sudanese	47	7.34
Flock size (head)	<50	288	45.00
	50–99	76	11.87
	100–199	109	17.03
	200–499	116	18.13
	≥500	51	7.97
Predominant sheep type	Local (Barqi/national)	475	74.22
	Imported	108	16.87
	Both	57	8.91

Note: Percentages are shown to two decimal places and adjusted for rounding so each category group totals 100.00%; frequencies are unchanged.

Knowledge and field recognition of cystic echinococcosis

Overall, 424 respondents (66.2%; 95% CI 62.5–69.8) had previously heard of CE. Among those who were aware of the disease, direct observation in animals was the most frequently reported source of information (43.6%), followed by veterinarians (28.1%). Despite this awareness, only 163 of all respondents (25.5%; 95% CI 22.2–29.0), equivalent to 38.4% of those who had heard of CE, selected the response recognising transmission between animals and humans. This is interpreted as recognition of the zoonotic nature of CE rather than detailed understanding of the complete transmission pathway. More than half of the full sample (51.7%) stated that they had observed cyst-like lesions in sheep. The liver or lungs were selected as commonly affected organs by 55.3% of respondents, although 35.3% could not recall an affected organ.

Table 2. Knowledge, experience and perceptions related to cystic echinococcosis.

Variable	Category	n	%
Previous awareness of CE	Yes	424	66.2
	No	216	33.8
Information source among aware respondents	Direct observation in animals	185	43.6
	Veterinarian	119	28.1
	Media	60	14.2
	Peers	40	9.4
	Other	20	4.7
Self-rated knowledge among aware respondents	Excellent	34	8.0
	Good	175	41.3
	Moderate	110	25.9
	Poor	105	24.8
Perceived transmission route	Between animals and humans	163	25.5
	Between animals only	281	43.9
	Do not know	196	30.6
Previously observed cyst-like lesions in sheep	Yes	331	51.7
	No	309	48.3
Perceived sheep group more affected	Imported sheep	197	30.8
	Local sheep	157	24.5
	Both/no difference	117	18.3
	Do not know	169	26.4
Organ reported as commonly affected	Liver	211	33.0
	Lungs	143	22.3
	Spleen	14	2.2
	Other	46	7.2
	Could not recall	226	35.3

Percentages for information source and self-rated knowledge use respondents who had previously heard of CE (n=424) as the denominator; all other percentages use n=640. Perceived differences between local and imported sheep are subjective observations and should not be interpreted as prevalence estimates.

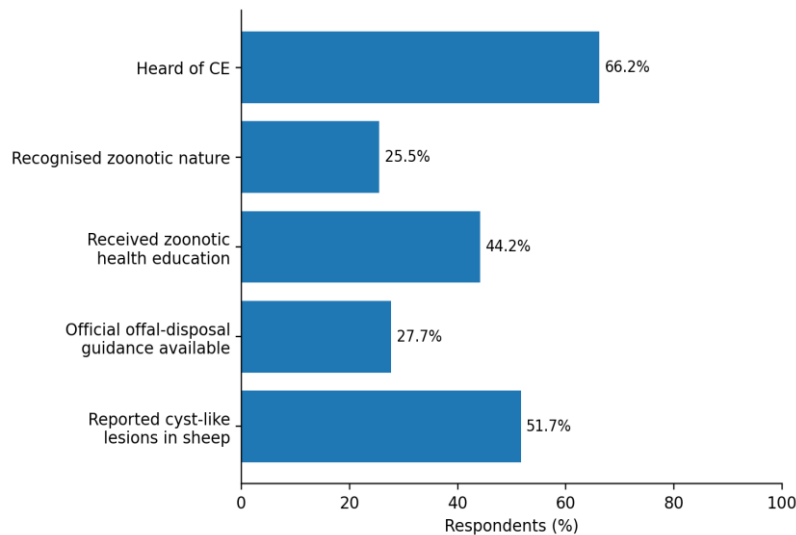


Figure 1. Awareness, zoonotic understanding and selected prevention-related indicators among sheep breeders in eastern Libya (n=640)

Dog management and offal-disposal practices

Dog–livestock contact was frequent. Four hundred and seventy-eight respondents (74.7%; 95% CI 71.2–77.9) reported dealing with dogs near sheep. Only 116 (18.1%; 95% CI 15.3–21.3) selected a dog-care response that included deworming, whereas 260 (40.6%) reported using neither medicines nor vaccinations. A further 185 respondents reported preventive vaccination without deworming; because the questionnaire did not specify the vaccine, this response cannot be interpreted as CE-specific prevention. Approximately 43.8% reported that they never prevented dogs from approaching the flock. Burial was the most common action for abnormal organs (43.3%). Feeding abnormal organs raw to animals was reported by 14.7%, and 14.5% discarded them with general waste. Taken together with the small number who left organs at the slaughter site, 29.4% met the study definition of potentially unsafe offal disposal. Only 27.7% reported that formal instructions for disposal of affected organs were available.

Table 3. Dog-management and offal-disposal practices among sheep breeders in eastern Libya (n=640).

Variable	Category	n	%
Preventive management of guard dogs	No medicines/vaccinations used	260	40.6
	Preventive vaccination reported	185	28.9
	Both deworming and vaccination	105	16.4
	Deworming reported	11	1.7
	Other	79	12.3
Prevention of dog approach to flock	Always	164	25.6
	Sometimes	160	25.0
	Rarely	36	5.6
	Never	280	43.8
Handles/interacts with dogs near sheep	Yes	478	74.7
	No	162	25.3
Action taken with abnormal organs	Burial	277	43.3
	Boiled before feeding to dogs	100	15.6
	Discarded with general waste	93	14.5
	Fed raw to animals	94	14.7
	Other	75	11.7
	Left at slaughter site	1	0.2
Official instructions for disposal of affected organs	Yes	177	27.7
	No	298	46.6
	Do not know	165	25.8
Usual method for disposal of slaughter waste	Burning	310	48.4
	General refuse	178	27.8
	Burial	82	12.8
	Cleaning company	5	0.8
	Other	65	10.2

Environmental interface, hygiene and reported barriers

Stray animals were reported near 309 flocks (48.3%; 95% CI 44.4–52.2). Among respondents who reported strays, dogs were included in 291 reports (94.2%) and 112 (36.2%) stated that these animals fed on slaughter waste either sometimes or routinely. Personal hand hygiene was more consistently reported than glove use: 80.0% stated that they always washed their hands after handling sheep, whereas only 18.8% always used gloves when handling dogs or sheep. Fewer than half (44.2%; 95% CI 40.4–48.1) had received health education about zoonotic diseases.

Open-text responses indicated that physical access to safe disposal was a prominent constraint. After thematic coding, distance or transport to official disposal sites was mentioned in 62.7% of questionnaires, lack of awareness in 18.4%, and lack of incinerators in 17.7%. Because more than one theme could occur in a single response, these percentages are not mutually exclusive.

Table 4. Environmental conditions, hygiene practices and reported barriers among sheep breeders in eastern Libya (n=640).

Variable	Category	n	%
Stray animals near sheep	Yes	309	48.3
	No	331	51.7
Glove use when handling dogs/sheep	Always	120	18.8
	Sometimes	199	31.1
	Rarely	74	11.6
	Never	247	38.6
Handwashing after handling sheep	Always	512	80.0
	Sometimes	97	15.2
	Rarely	31	4.8
Family history of CE	Yes	28	4.4
	No	460	71.9
	Do not know	152	23.8
Previous health education on zoonoses	Yes	283	44.2
	No	357	55.8
Open-text disposal barriers (multiple-coded themes)	Distance/transport to official disposal sites	401	62.7
	Lack of incinerators	113	17.7
	Lack of awareness	118	18.4
	No designated disposal site/dump	26	4.1
	Lack of oversight	18	2.8
	Random/unregulated slaughter	8	1.2

Barrier themes were coded from open-text responses and are not mutually exclusive. Stray-animal species and feeding behaviour were interpreted only among respondents who reported stray animals near the flock.

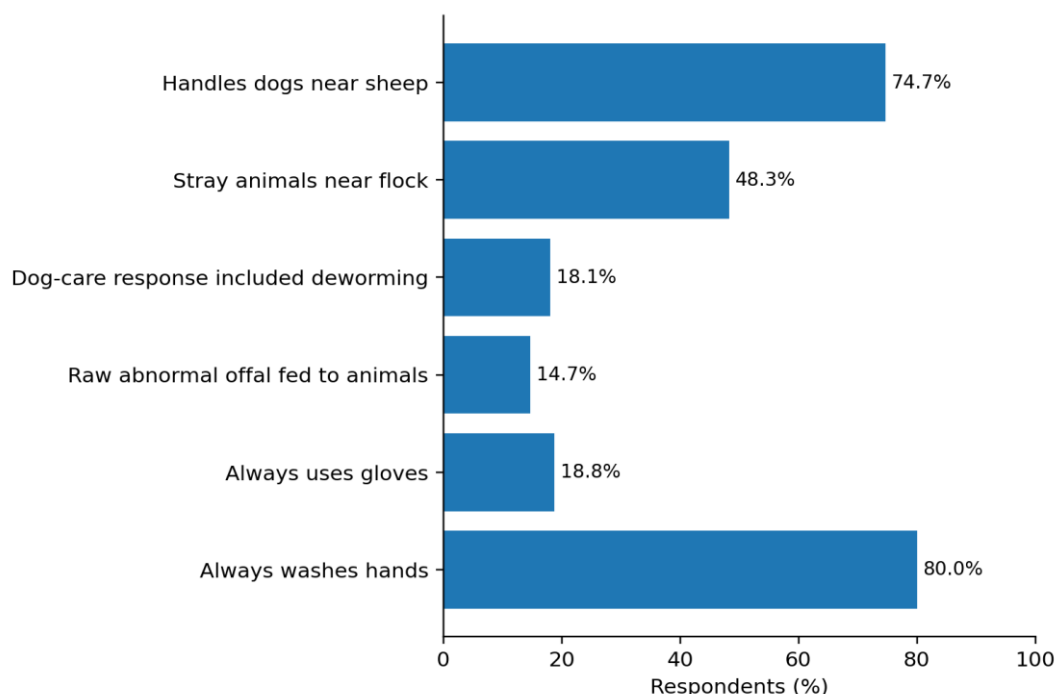


Figure 2. Selected exposure-related and protective practices among sheep breeders in eastern Libya (n=640).

Associations between knowledge and risk-related practices

Receipt of previous health education was associated with recognition of the zoonotic nature of CE: 40.3% of respondents who had received health education selected animal–human transmission compared with 13.7% of those who had not (OR 4.24, 95% CI 2.89–6.22; $p < 0.001$). The association remained similar in sensitivity analysis (OR 3.84, 95% CI 2.43–6.07).

In the multivariable model, recognition of the zoonotic nature of CE was independently associated with substantially lower odds of potentially unsafe offal disposal (aOR 0.15, 95% CI 0.09–0.27), whereas handling dogs near sheep was associated with higher odds (aOR 4.43, 95% CI 2.62–7.51). These associations remained directionally consistent in the sensitivity analysis. By contrast, associations involving health education, reported official instructions and stray-animal presence were not statistically robust across the primary and sensitivity analyses and should be interpreted cautiously. Given the 29.4% prevalence of the composite outcome, these estimates should be read as odds ratios rather than as risk ratios.

Table 5. Selected associations and sensitivity analysis.

Outcome/predictor	Primary estimate	95% CI	p value	Sensitivity estimate	95% CI
Recognition of zoonotic nature of CE: health education (yes vs no)	OR 4.24	2.89–6.22	<0.001	OR 3.84	2.43–6.07
Potentially unsafe offal disposal: recognition of the zoonotic nature of CE	aOR 0.15	0.09–0.27	<0.001	aOR 0.26	0.14–0.47
Potentially unsafe offal disposal: health education	aOR 1.17	0.75–1.83	0.490	aOR 1.59	0.98–2.59
Potentially unsafe offal disposal: official disposal instructions	aOR 0.86	0.52–1.42	0.547	aOR 0.74	0.43–1.27
Potentially unsafe offal disposal: stray animals near flock	aOR 1.35	0.90–2.00	0.143	aOR 0.93	0.60–1.45
Potentially unsafe offal disposal: handles dogs near sheep	aOR 4.43	2.62–7.51	<0.001	aOR 3.55	2.03–6.22

Primary analyses included all eligible questionnaires. Sensitivity analyses were performed using an exact-pattern quality-control dataset to assess the robustness of the principal associations.

Discussion

This survey identifies a practical One Health problem at the sheep–dog–offal interface in eastern Libya: general awareness of CE was substantially higher than recognition of its zoonotic nature. About two-thirds of respondents had heard of the disease, yet only about one quarter of the full sample selected the animal–human transmission option. This distinction matters because control depends not merely on recognising cysts but on understanding how infected viscera, dogs and environmental contamination connect the animal and human components of the parasite cycle. Similar discrepancies between disease awareness and transmission knowledge have been reported among livestock-keeping populations elsewhere, including Iraq and Uganda [13,14]. More recent One Health surveys in Chile, Türkiye and Ethiopia likewise show that risky dog and offal practices can persist even where some degree of community awareness is present [15–17].

A related educational signal has been reported locally among University of Benghazi pharmacy students, where parasitology-related knowledge was incomplete despite university-level training [20]. Although the population and parasite differed, the finding supports the need for targeted, context-specific zoonosis education rather than assuming that nominal exposure to health information produces accurate prevention knowledge.

The dog-management findings are particularly relevant. Almost three-quarters of respondents reported interacting with dogs near sheep, but only 18.1% reported a management response that included deworming. This figure should not be interpreted as confirmation of effective CE control because the questionnaire did not record the ant helminthic product or frequency. For CE, the relevant canine intervention is regular treatment with a cestocidal drug such as praziquantel. WHO guidance recommends periodic dog deworming, while the WOA Terrestrial Code advises treatment every four to six weeks for dogs known or suspected to have access to raw offal or livestock in transmission settings [8,9]. The high proportion reporting vaccination without deworming is also important: routine dog vaccination may be good veterinary practice, but it does not substitute for praziquantel-based control of intestinal *E. granulosus* infection.

Offal handling represents the second critical control point. Burial was the most commonly reported response to abnormal organs, and a smaller group reported boiling organs before feeding them to dogs. Both practices are potentially safer than raw feeding only when correctly implemented. The survey did not measure burial depth or boiling conditions and therefore cannot establish whether viable protozoa would have been reliably inactivated. WOA recommends preventing dogs from accessing offal and specifies effective inactivation procedures, including adequate heat treatment or controlled freezing. Raw feeding, uncontrolled disposal with general refuse and leaving viscera at the slaughter site are more directly concerning because they can reconnect infected livestock organs with definitive hosts [9].

Nearly one third of participants reported one of these potentially unsafe disposal practices. The strong inverse association between recognition of the zoonotic nature of CE and potentially unsafe offal disposal is therefore epidemiologically coherent. Respondents who selected animal–human transmission had markedly lower odds of reporting potentially unsafe

disposal, and this relationship persisted after the exact-pattern sensitivity analysis. Although a cross-sectional survey cannot demonstrate that knowledge caused safer behaviour, the result supports the practical value of education that explicitly links visible cysts in livestock to dog infection and subsequent environmental contamination. In the present dataset, previous health education was also strongly associated with recognition of the zoonotic nature of CE. Because the outcome was common, the adjusted OR should not be read as a relative risk; the magnitude of association may appear larger on the odds scale than on a prevalence-ratio scale.

Dog contact near sheep was independently associated with potentially unsafe offal disposal. Dog proximity to a flock is not, by itself, a mechanism of dog infection; the decisive exposure is access to infected viscera, carcasses or other tissues containing viable metacestodes. Nevertheless, frequent dog handling in a setting where unsafe offal disposal occurs marks an intensive dog–livestock interface and may increase opportunities for the domestic cycle to persist. This distinction is important for intervention design: the objective should not simply be to remove working or guard dogs from livestock systems, but to ensure regular cestocidal treatment and to prevent those dogs from scavenging carcasses or consuming untreated offal. Control programmes that are workable for pastoral livelihoods are more likely to be sustained than programmes based on generic separation messages.

Environmental findings add a further layer. Almost half of respondents reported stray animals near sheep, and dogs were the dominant stray species reported in those settings. However, the association between stray-animal presence and potentially unsafe offal disposal was not statistically robust in the eastern-Libya analysis, so the survey does not support a strong independent inference from this variable. The practical relevance of free-roaming dogs nevertheless remains well established in CE ecology and control literature, and African meta-analytic data indicate continuing canine infection across the continent [11]. Accordingly, management of unowned or free-roaming dogs should be integrated with offal control rather than treated as an isolated intervention.

The finding that approximately half of respondents had seen cyst-like lesions in sheep is noteworthy but should not be interpreted as a measure of animal prevalence. Farmer recognition is susceptible to misclassification, and other lesions can resemble hydatid cysts. Likewise, perceptions that imported or local sheep are more commonly affected are subjective. Reliable comparison of animal sources requires standardised post-mortem inspection and, ideally, parasitological or molecular confirmation. The continuing detection of CE in slaughtered livestock in Libya, including recent data from Al-Qubbah, supports the need to link questionnaire-based behavioural surveillance with veterinary abattoir surveillance [18,19].

Recent work from Benghazi on paediatric *Entamoeba* infection similarly linked parasitological evidence with water, sanitation, food safety and One Health-oriented prevention [21]. Together, these Libyan studies support a broader surveillance model in which human, animal and environmental parasite data are interpreted jointly rather than in isolation. Practical infrastructure emerged as an important constraint. Distance or transport to official disposal sites was the most frequently coded barrier, while lack of awareness and lack of incinerators were also recurrent. This pattern argues against relying on health education alone. If breeders understand the risk but safe disposal remains geographically or logistically inaccessible, unsafe practices may continue. A One Health control package for eastern Libya should therefore combine targeted education with realistic disposal pathways, accessible veterinary support, dog deworming, strengthened meat inspection, and surveillance data that connect farms, slaughter points, canine populations and human health services. The study has several limitations. Recruitment through an electronic page produced a voluntary non-probability sample and may under-represent breeders with limited internet access. The number of users who viewed or opened the survey link was unavailable, so a participation rate could not be calculated. Restricting the analysis to eastern Libya improved geographical coherence but does not make the sample population-representative. All behaviours were self-reported and are therefore vulnerable to recall and social-desirability bias. No biological testing of sheep, dogs or humans was performed, so the survey describes behavioural and perceptual risk indicators rather than infection prevalence. Some questionnaire items lacked skip logic, generating internally inconsistent answers for dependent questions; analyses of stray-animal species and feeding behaviour were therefore restricted to respondents who first reported stray animals. The questionnaire collected age in categories rather than exact years, and formal psychometric scale validation was not part of the analytical approach because the items represented heterogeneous epidemiological domains. Because the survey was anonymous, respondent identity could not be independently verified; exact-match screening was therefore used as a supplementary data-quality procedure to test the stability of key associations, but it cannot determine which identical response patterns, if any, represented true duplicates. These limitations should be considered when generalising the findings to the wider sheep-breeding population of eastern Libya.

Conclusions

The survey indicates that sheep breeders in eastern Libya operate within a transmission interface in which dogs, livestock and slaughter waste remain closely connected. Awareness of CE was relatively common, but accurate recognition of zoonotic transmission was limited, reported dog deworming was uncommon, and almost one third of respondents described offal-disposal practices that could permit canine access. The most consistent analytical signals were that recognition of the zoonotic nature of CE was associated with safer offal handling and that dog contact near sheep was concentrated among respondents reporting potentially unsafe disposal. These findings support a control strategy centred

on regular praziquantel treatment of at-risk dogs, strict prevention of access to raw offal, locally feasible disposal systems, veterinarian-led risk communication and coordinated animal–human–environment surveillance.

One Health and Sustainable Development implications for control

The study operationalises One Health by linking human risk communication, livestock management, canine treatment, slaughter-waste control and environmental sanitation. This integrated approach is consistent with the contemporary One Health definition [10]. It also has a sustainable-development dimension: CE control contributes directly to SDG 3 through prevention of neglected and other communicable diseases, while safer containment and disposal of slaughter waste aligns with the broader waste-management principles of SDG 12 [22,23].

- Human health: deliver concise risk communication explaining that human infection follows ingestion of eggs from environments contaminated by infected dogs, rather than direct transmission from hydatid cysts in sheep.
- Animal health: establish regular praziquantel-based deworming schedules for working and guard dogs, supported by veterinary follow-up and clear recording of treatment frequency.
- Food safety and slaughter: strengthen post-mortem inspection and ensure that organs containing suspected hydatid cysts are destroyed or treated in a manner that prevents access by dogs.
- Environmental management: improve access to designated disposal points and secure slaughter-waste containment, particularly where distance to official sites is a practical barrier.
- Surveillance: link farm-level behavioural surveys with abattoir data, canine monitoring and human case reporting to identify persistent transmission areas and evaluate interventions.

Consent to participate

Participation was voluntary. Implied informed consent was obtained electronically through participants' decision to complete and submit the anonymous questionnaire after receiving study information.

Conflict of interest

The authors declare no conflict of interest.

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