



Cystic Echinococcosis at the Human–Animal Interface: Knowledge, Slaughter Practices and Environmental Risk Pathways among Butchers in Eastern Libya

Fathia A Halom^{1*}, Nouara Elazirg Elammari², Hanan K. Bokhamada³, Shahd Al-Saiti⁴, Abdulsalam Almayar⁵

^{1,3,4,5} Department of Biology, Faculty of Education, University of Benghazi, Benghazi, Libya

² Department of Parasitology, Faculty of Medicine, University of Benghazi, Benghazi, Libya.

داء المشوكات الكيسي عند نقطة التماس بين الإنسان والحيوان: المعرفة، وممارسات الذبح، ومسارات الخطر البيئي لدى القصابين في شرق ليبيا

فتحية عبدالحاميد حلوم^{1*}، نورة الأزرق العماري²، حنان خليفة بوخمادة³، شهد السعيطي⁴، عبدالسلام الميار⁵

^{1,3,4,5} قسم الاحياء، كلية التربية، جامعة بنغازي، بنغازي، ليبيا

² قسم الطفيليات، كلية الطب، جامعة بنغازي، مدينة بنغازي، ليبيا

*Corresponding author: fathia.halom@uob.edu.ly

Received: July 29, 2026

Accepted: September 26, 2026

Published: October 12, 2025



Copyright: © 2026 by the authors. This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract:

Background: Cystic echinococcosis (CE), caused by *Echinococcus granulosus* sensu lato, persists where dogs, livestock, slaughter practices and contaminated environments remain epidemiologically connected. Butchers occupy a critical interface because the handling and disposal of infected viscera can either interrupt or reinforce the dog–livestock transmission cycle. Evidence on butcher knowledge and routine practices in Libya remains limited. Objectives: To characterise CE awareness, occupational practices and environmental transmission opportunities among butchers in eastern Libya, and to examine whether recognition of zoonotic transmission was associated with safer disposal of abnormal organs. Methods: An anonymous web-based cross-sectional survey was conducted from March to August. The questionnaire link was distributed through an established online page used by a large proportion of butchers in the study area, and participation was based on voluntary completion of the electronic questionnaire. The analytic dataset comprised 320 butchers from Benghazi, Al-Bayda, Al-Abraq, Al-Marj and Tokra. Descriptive proportions were calculated with 95% Wilson confidence intervals for key indicators. For analysis, disposal of abnormal organs with general refuse or by feeding them to animals was classified as high-risk, whereas burial or burning was classified as lower-risk. Associations were assessed using Pearson's chi-square test and odds ratios where appropriate. Results: Overall, 85.3% (95% CI 81.0–88.8) had heard of CE and 74.7% (69.6–79.1) recognised animal-to-human transmission. Nevertheless, only 14.7% selected the combined dog–sheep option when asked which animals were associated with the disease, indicating incomplete understanding of the canonical transmission cycle. Three-quarters (75.0%) reported having seen hydatid-like cysts in slaughtered animals. High-risk disposal of abnormal organs was reported by 61.6% (56.1–66.7), including disposal with general waste (45.6%) and feeding to animals (15.9%). Stray animals were reported near slaughter sites by 80.6% (75.9–84.6), and 86.6% (82.4–89.9) stated that stray animals fed on slaughter waste at least sometimes. Veterinary supervision was absent or rare for 61.3% of respondents, while only 31.9% (27.0–37.2) had received health education on zoonotic diseases. Correct recognition of zoonotic transmission was not associated with lower-risk

offal disposal (61.5% high-risk disposal among those with correct knowledge versus 61.7% among others; OR 0.99, 95% CI 0.59–1.66; $p = 0.972$). Conclusions: The dominant signal was not simple lack of awareness, but a marked knowledge–practice disconnect embedded within weak waste management, inconsistent veterinary oversight and frequent access of stray animals to slaughter waste. Control in eastern Libya therefore requires a One Health response that combines targeted education with enforceable offal-management procedures, reliable veterinary meat inspection and measures preventing dogs from accessing slaughter waste.

Keywords: Cystic Echinococcosis; *Echinococcus Granulosus*; Butchers; Slaughterhouse; Offal Disposal; Stray Dogs; One Health; Libya.

المخلص

خلفية الدراسة: يستمر داء المشوكات الكيسي (CE)، المتسبب عن طفيلي *Echinococcus granulosus* بمفهومه الواسع، في المناطق التي تظل فيها الكلاب والماشية وممارسات الذبح والبيئات الملوثة مرتبطة وبائياً. ويشغل الجزارون واجهة حاسمة لأن التعامل مع الأحشاء المصابة والتخلص منها إما أن يقطع أو يعزز دورة الانتقال بين الكلاب والماشية. وتظل الأدلة المتعلقة بمعرفة الجزارين وممارساتهم الروتينية في ليبيا محدودة. **الأهداف:** توصيف مستوى الوعي بداء المشوكات الكيسي والممارسات المهنية وفرص الانتقال البيئي بين الجزارين في شرق ليبيا، وبحث ما إذا كان التعرف على الانتقال المشترك بين الحيوان والإنسان مرتبطاً بالتخلص الأقل خطورة من الأعضاء غير الطبيعية. **المنهجية:** أجريت دراسة مقطعية مجهولة الهوية عبر شبكة الإنترنت في الفترة من مارس إلى أغسطس. وزع رابط الاستبيان من خلال صفحة إلكترونية معروفة يستخدمها نسبة كبيرة من الجزارين في منطقة الدراسة، واعتمدت المشاركة على الإكمال الطوعي للاستبيان الإلكتروني. شملت العينة التحليلية 320 جزاراً من بنغازي والبيضاء والأبرق والمرج وتوكره. خُصبت النسب الوصفية مع فترات ثقة 95% (فاصل ويلسون) للمؤشرات الرئيسية. ولأغراض التحليل، صُنِّف التخلص من الأعضاء غير الطبيعية مع النفايات العامة أو عن طريق إطعامها للحيوانات على أنه عالي الخطورة، بينما صُنِّف الدفن أو الحرق على أنه أقل خطورة. وتمت تقييم العلاقات باستخدام اختبار كا مربع لبيرسون ونسب الأرجحية حيثما كان ذلك مناسباً. **النتائج:** بشكل عام، سمع 85.3% (95% CI 81.0–88.8) بداء المشوكات الكيسي، وأدرك 74.7% (69.6–79.1) إمكانية الانتقال من الحيوان إلى الإنسان. ومع ذلك، اختار 14.7% فقط الخيار المشترك (الكلاب والضغف/الأغنام) عند سؤالهم عن الحيوانات المرتبطة بالمرض، مما يشير إلى فهم غير كامل لدورة الانتقال التقليدية. وأفاد ثلاثة أرباع المشاركين (75.0%) برؤية أكياس تشبه الأكياس المائية في الحيوانات المذبوحة. وسُجل التخلص عالي الخطورة من الأعضاء غير الطبيعية لدى 61.6% (56.1–66.7)، بما في ذلك التخلص مع النفايات العامة (45.6%) وإطعامها للحيوانات (15.9%). كما أُبلغ عن وجود حيوانات ضالة بالقرب من مواقع الذبح بنسبة 80.6% (75.9–84.6)، وذكر 86.6% (82.4–89.9) أن الحيوانات الضالة تتغذى على مخلفات الذبح على الأقل في بعض الأحيان. وكان الإشراف البيطري غائباً أو نادراً لـ 61.3% من المشاركين، بينما تلقى 31.9% فقط (27.0–37.2) تثقيفاً صحياً حول الأمراض المشتركة. ولم يرتبط الإدراك الصحيح للانتقال المشترك بتخلص أقل خطورة من الأحشاء (61.5%) تخلص عالي الخطورة بين ذوي المعرفة الصحيحة مقابل 61.7% بين الآخرين؛ $p = 0.99$, 95% CI 0.59–1.66; $p = 0.972$.

الاستنتاجات: لم تكن الإشارة الهامة مجرد نقص بسيط في الوعي، بل كانت انقطاعاً واضحاً بين المعرفة والممارسة نتيجة لضعف إدارة النفايات، وغياب الرقابة البيطرية المنتظمة، والوصول المتكرر للحيوانات الضالة إلى مخلفات الذبح. ولذلك، تتطلب السيطرة على المرض في شرق ليبيا استجابة قائمة على نهج "الصحة الواحدة" (One Health) تجمع بين التثقيف موجه الهدف وإجراءات قابلة للتطبيق لإدارة الأحشاء، ورعاية بيطرية موثوقة لفحص اللحوم، وتدابير تمنع الكلاب من الوصول إلى مخلفات الذبح.

الكلمات المفتاحية: داء المشوكات الكيسي؛ *Echinococcus granulosus*؛ الجزارون؛ المذبح؛ التخلص من الأحشاء؛ الكلاب الضالة؛ الصحة الواحدة؛ ليبيا.

Introduction

Cystic echinococcosis (CE) is a chronic zoonotic infection caused by the larval stages of *Echinococcus granulosus* sensu lato. The parasite is maintained through predator–prey or domestic cycles in which canids, particularly dogs, act as definitive hosts and livestock serve as intermediate hosts. Humans become accidental intermediate hosts after ingesting parasite eggs shed by infected canids, whereas dogs acquire infection through consumption of viable hydatid cysts in infected viscera. The dog–sheep cycle is especially important in many pastoral and Mediterranean settings [1,2,3]. CE remains a substantial public-health, veterinary and economic problem despite being preventable. The disease has a long asymptomatic period, may require complex clinical management and is sustained by ecological and behavioural conditions that often fall outside the reach of clinical services alone. Recent reviews continue to emphasise the importance of integrated surveillance, safe slaughter, dog deworming, prevention of raw-offal access and community engagement under a One Health framework [4,5,6].

North Africa and the wider Mediterranean basin remain important CE transmission zones. Contemporary regional evidence indicates that unsafe slaughter, irregular dog treatment, feeding of uncooked viscera to dogs and limited knowledge about transmission continue to support parasite persistence [7,6]. In Libya, available livestock and abattoir literature confirms the continuing veterinary relevance of hydatid disease across sheep, cattle, goats and camels. Reviews of Libyan evidence have documented long-standing infection in slaughtered livestock, while recent abattoir data from Sabratha and Al-Qubbah indicate that hydatid cysts remain detectable in routinely slaughtered animals [8,9,10,11].

Butchers are an epidemiologically important occupational group because they directly handle organs in which hydatid cysts occur, particularly the liver and lungs. The public-health importance of this occupational setting does not arise primarily from direct transmission from infected meat; rather, it lies in how infected viscera are recognised, contained and destroyed. When infected offal is discarded into accessible waste streams or fed to dogs,

the definitive host can become infected and subsequently contaminate the environment with parasite eggs. Studies from Morocco, Türkiye and Pakistan have shown that slaughterhouse infrastructure, dog contact, knowledge gaps and offal-management behaviour are relevant components of CE risk at the human–animal–environment interface [12,13,14].

Knowledge, however, cannot be assumed to translate directly into preventive behaviour. Recent community studies in Algeria, Türkiye and Ethiopia have identified varying combinations of high disease awareness, incomplete life-cycle knowledge and continuing risky practices, including home slaughter, contact with free-roaming dogs and unsafe offal use [7,15,16]. This distinction is important for intervention design: educational campaigns may improve recognition of disease, but structural constraints such as inadequate waste disposal, weak inspection or uncontrolled dog access may continue to sustain transmission.

The present study therefore examined CE-related knowledge, occupational practices and environmental risk pathways among butchers in five eastern Libyan localities. The primary objectives were to describe awareness of CE and its transmission, document slaughter and waste-management practices, quantify reported dog and stray-animal exposure around slaughter sites, and determine whether correct recognition of zoonotic transmission was associated with safer disposal of abnormal organs. The analysis was framed around the One Health interface linking occupational behaviour, animal hosts and the slaughter environment.

Material and methods

Study design, recruitment and setting

An anonymous, questionnaire-based cross-sectional survey was conducted among butchers working in eastern Libya during the six-month period from March to August. The analytic dataset included participants from five localities: Al-Bayda, Benghazi, Al-Abraq, Al-Marj and Tokra. These sites represent urban and peri-urban settings in which formal abattoir slaughter and non-abattoir slaughter practices coexist. Recruitment was conducted electronically through an established online page used by a large proportion of butchers in the study area. The questionnaire link was made available through this page, and eligible butchers participated voluntarily by completing the electronic survey. Accordingly, the study used a non-probability voluntary-response sampling approach rather than probability-based sampling.

Study population and data source

The source dataset consisted of 320 completed electronic butcher questionnaires and 35 variables covering demographic characteristics, occupational experience, awareness of CE, recognition of transmission and host species, observations during slaughter, offal disposal, veterinary supervision, slaughter-site hygiene, stray-animal exposure, dog contact, personal protective practices, prior zoonotic-disease education and perceived barriers to safe waste disposal. The questionnaire did not request participants' names or other direct personal identifiers. No completely duplicated response records were identified in the spreadsheet. Because some conditional follow-up fields had been completed even when the preceding question did not indicate eligibility, analyses were restricted to variables that could be interpreted consistently across all participants; specifically, the organ-location follow-up for reported family cases was not used in inferential analysis.

Questionnaire domains and analytical definitions

Knowledge was assessed descriptively rather than through a composite score because the questionnaire mixed objective knowledge items, self-rated knowledge, direct occupational observations and perceptions. Correct recognition of zoonotic transmission was defined as selecting “between animals and humans”. Recognition of the dog–sheep cycle was examined separately using the item asking which animals were associated with the disease. Reported observation of cysts in slaughtered animals was treated as occupational experience and not as a measure of animal prevalence.

For the principal practice analysis, disposal of abnormal organs by placement with general refuse or by feeding them to animals was classified as high-risk because both routes may allow access by dogs or other scavenging animals. Burial and burning were grouped as lower-risk disposal options. This classification reflects transmission biology but does not imply that all burial or burning practices were technically adequate, because depth, containment and operational standards were not recorded. Stray-animal access was summarised using the questions on the presence of stray animals near slaughter sites and whether such animals consumed slaughter waste.

Statistical analysis

Categorical variables were summarised as frequencies and percentages. For selected principal proportions, 95% confidence intervals were calculated using the Wilson method. The association between correct recognition of zoonotic transmission and high-risk disposal of abnormal organs was examined using Pearson's chi-square test; an odds ratio (OR) with 95% confidence interval was calculated to quantify the direction and magnitude of the

association. A two-sided p value <0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA).

Ethical considerations

Participation was voluntary and anonymous. Before completing the electronic questionnaire, prospective participants were informed of the purpose of the survey and chose whether to proceed. Submission of the completed questionnaire was treated as implied informed consent to participate. No names or direct personal identifiers were requested or collected.

Results and discussion

Participant characteristics

The analysis included 320 butchers. The largest age group was 30–39 years (34.1%), followed by 20–29 years (25.9%). Almost half of the participants (49.1%) reported more than 10 years of butchery experience. Secondary education was the most common educational level (37.5%), followed by basic education (33.4%). Most respondents were Libyan nationals (75.9%). Participants were distributed across Al-Bayda (25.3%), Benghazi (21.2%), Al-Abraq (19.1%), Al-Marj (18.4%) and Tokra (15.9%). Local animals were the predominant slaughter category for 58.8%, while 28.1% handled both local and imported animals.

Table 1. Demographic and occupational characteristics of participating butchers, grouped by study variable (N = 320).

Variable	30–39			33.4			Main source of slaughter animals
Category	109	81	18.4	Secondary education	19.4	75.9	Mainly local animals
n	34.1	25.3	Tokra		5–10	Egyptian	188
%	40–49	Benghazi	51	120	101	46	58.8
Age (years)	59	68	15.9	37.5	31.6	14.4	Mainly imported animals
<20	18.4	21.2	Education level	University education	>10	Sudanese	42
19	≥50	Al-Abraq	Illiterate	43	157	21	13.1
5.9	50	61	50	13.4	49.1	6.6	Both local and imported animals
20–29	15.6	19.1	15.6	Butchery experience (years)	Nationality	Chadian	90
83	City	Al-Marj	Basic education	<5	Libyan	10	28.1
25.9	Al-Bayda	59	107	62	243	3.1	

Awareness and knowledge of cystic echinococcosis

Most respondents (273/320; 85.3%, 95% CI 81.0–88.8) had previously heard of CE. Veterinarians were the most frequently reported source of information (40.6%), followed by direct observations while working with animals (26.3%) and mass media (23.4%). Despite high awareness, self-rated knowledge was modest: 30.3% described their knowledge as weak and 44.7% as moderate, while only 25.0% considered it good or excellent.

Recognition of zoonotic transmission was relatively high: 239/320 (74.7%, 95% CI 69.6–79.1) stated that the disease is transmitted between animals and humans. However, understanding of the complete domestic transmission cycle was less consistent. When asked which animals were associated with the disease, 51.9% selected sheep alone, 24.1% dogs alone, 14.7% selected both, and 9.4% selected cattle. Thus, although most participants recognised CE as zoonotic, only a minority explicitly identified the combined dog–sheep relationship central to the classical domestic cycle.

Three-quarters of respondents (75.0%) reported having observed hydatid-like cysts in slaughtered animals. The liver was selected as the most frequently affected organ by 45.0%, the lungs by 25.6%, and both liver and lungs by 25.0%; only 4.4% selected the spleen. In total, 95.6% identified the liver and/or lungs, which is consistent with

the principal visceral distribution of CE in livestock. Regarding perceived origin, 75.9% believed local sheep were more frequently affected than imported sheep; this response represents participant perception and was not verified through carcass-level prevalence data.

Table 2. Awareness, knowledge and occupational observations related to cystic echinococcosis, grouped by study variable.

Variable	Category/response	n	%
Awareness of cystic echinococcosis	Had heard of CE	273	85.3
	Had not heard of CE	47	14.7
Main information source	Veterinarian	130	40.6
	Direct animal observations	84	26.3
	Mass media	75	23.4
	Colleagues	31	9.7
Self-rated knowledge	Weak	97	30.3
	Moderate	143	44.7
	Good	60	18.8
	Excellent	20	6.2
Recognition of transmission route	Animal–human transmission	239	74.7
	Transmission only among animals	61	19.1
	Did not know	20	6.2
Animals associated with CE	Sheep	166	51.9
	Dogs	77	24.1
	Both dogs and sheep	47	14.7
	Cattle	30	9.4
Observation of hydatid-like cysts in carcasses	Reported observation	240	75.0
Perceived most affected organ(s)	Liver	144	45.0
	Lungs	82	25.6
	Liver and lungs	80	25.0
	Spleen	14	4.4

Offal disposal and waste-management practices

The disposal pathway for abnormal organs represented a major potential transmission point. General refuse was the most common response (45.6%), followed by burial (23.4%), feeding to animals (15.9%) and burning (15.0%). Combining general refuse and feeding to animals, 197/320 butchers (61.6%, 95% CI 56.1–66.7) reported a high-risk disposal route that could plausibly permit access by dogs or other scavengers. Only 24.1% reported that formal instructions from health or agricultural authorities on slaughter-waste disposal were available to them; 59.1% stated that such instructions were absent and 16.9% did not know.

The broader description of routine waste disposal was consistent with this pattern: almost half (49.7%) identified general rubbish disposal as the most common approach among butchers, whereas 27.2% reported burial, 15.0% burning and 8.1% collection by a cleaning company. Participants identified distance from official disposal sites (32.2%) and lack of incineration facilities (30.6%) as the two leading obstacles to safe disposal, followed by high cost (19.7%) and limited awareness of risk (17.5%).

3.4 Veterinary oversight, slaughter setting and environmental exposure

Veterinary supervision was inconsistent. Only 15.0% reported that a veterinarian was always present during slaughter and 23.8% reported occasional supervision. By contrast, 30.9% described veterinary supervision as rare and 30.3% reported no supervision. Slaughter occurred mainly in official abattoirs for 54.1% of respondents, at home for 32.5%, and in both settings for 13.4%. Site cleanliness was rated as clean by 30.3%, moderate by 44.1% and unclean by 25.6%.

Environmental exposure to free-roaming animals was common. Stray animals were reported near slaughter sites by 258/320 respondents (80.6%, 95% CI 75.9–84.6). Dogs were the predominant stray animal category, either alone (63.1%) or together with cats (26.3%). Moreover, 226 respondents (70.6%) stated that stray animals fed on slaughter waste, and a further 51 (15.9%) reported that this occurred sometimes. Thus, 86.6% (95% CI 82.4–89.9) indicated at least intermittent scavenging of slaughter waste by stray animals. Direct interaction with dogs in the slaughter environment was reported by 60.0% of participants.

3.5 Personal protective practices and zoonotic-disease education

Hand hygiene was more consistently reported than glove use. Handwashing after slaughter was described as always practised by 61.6% and sometimes practised by 24.1%, whereas 9.7% reported rare handwashing and 4.7% reported none. Glove use was always practised by 26.2%, sometimes by 34.1%, rarely by 21.6% and not at all by 18.1%. Separate tools for different animal types were always used by only 20.9%; 29.7% used separate tools

sometimes, while 49.4% reported rare use or no separation. Only 102/320 participants (31.9%, 95% CI 27.0–37.2) had received health education concerning zoonotic diseases.

Table 3. Slaughter, offal-disposal, environmental and personal protective practices, grouped by study variable.

Variable	Category/response	n	%
Disposal of abnormal organs	Discarded with general refuse	146	45.6
	Fed to animals	51	15.9
	Buried	75	23.4
	Burned	48	15.0
Availability of formal disposal instructions	Available	77	24.1
	Absent	189	59.1
	Did not know	54	16.9
Veterinary supervision during slaughter	Always	48	15.0
	Sometimes	76	23.8
	Rarely	99	30.9
	None	97	30.3
Main slaughter setting	Official abattoir	173	54.1
	Home	104	32.5
	Both official abattoir and home	43	13.4
Stray animals near slaughter site	Reported presence	258	80.6
Stray animals feeding on waste	Yes	226	70.6
	Sometimes	51	15.9
Direct contact with dogs around slaughter	Reported contact	192	60.0
Glove use	Always	84	26.2
	Sometimes	109	34.1
	Rarely	69	21.6
	Never	58	18.1
Handwashing after slaughter	Always	197	61.6
	Sometimes	77	24.1
	Rarely	31	9.7
	Never	15	4.7
Zoonotic-disease health education	Received health education	102	31.9

Knowledge–practice relationship

Correct recognition of zoonotic transmission did not correspond to safer offal disposal. Among the 239 respondents who correctly identified animal-to-human transmission, 147 (61.5%) reported high-risk disposal of abnormal organs. Among the 81 participants who either believed transmission occurred only among animals or did not know the route, 50 (61.7%) reported high-risk disposal. The odds ratio was 0.99 (95% CI 0.59–1.66; $p = 0.972$), indicating no evidence that correct recognition of zoonotic transmission was associated with lower-risk disposal behaviour in this dataset. This discordance was further illustrated by the fact that many respondents who understood the zoonotic nature of CE still worked in settings characterised by stray-animal access and general-waste disposal of condemned organs.

Table 4. Association between recognition of zoonotic transmission and disposal of abnormal organs.

Variable	Category	n	High-risk disposal n (%)	Lower-risk disposal n (%)	Association
Recognition of zoonotic transmission	Correctly recognised	239	147 (61.5)	92 (38.5)	1.00 (reference)
	Did not correctly recognise	81	50 (61.7)	31 (38.3)	OR 0.99 (95% CI 0.59–1.66); $p=0.972$

Discussion

This study provides a contemporary occupational perspective on CE transmission risk among butchers in eastern Libya. The principal finding was a clear separation between disease awareness and transmission-preventive behaviour. Although more than four-fifths of participants had heard of CE and almost three-quarters recognised that it can pass between animals and humans, high-risk disposal of abnormal organs remained common, stray animals were frequently present around slaughter sites, and scavenging on slaughter waste was widely reported. The absence of an association between correct zoonotic knowledge and safer offal disposal reinforces the interpretation that CE control in this setting cannot rely on knowledge transmission alone.

The level of general awareness was relatively high. The 85.3% who had heard of CE is close to the 87.7% awareness reported in a 2022 Algerian population survey, where 84.8% also recognised the zoonotic nature of the disease [7]. However, awareness in the present butcher population was substantially higher than that reported in a recent community-based study in southeastern Türkiye, where only 38.5% had heard of CE [15]. These comparisons should not be interpreted as direct population contrasts because the sampling frames and occupational profiles differ. Butchers are repeatedly exposed to abnormal organs and therefore may acquire practical familiarity even in the absence of formal education.

The distinction between general awareness and life-cycle knowledge is epidemiologically important. Only 14.7% selected the combined dog–sheep option when asked which animals were associated with CE, even though 74.7% recognised zoonotic transmission. The domestic cycle depends on dogs acquiring infection from viable cysts in livestock viscera and subsequently contaminating the environment with eggs [1,2]. Incomplete recognition of this link may explain why a participant can correctly label the disease as zoonotic while still failing to identify the critical importance of preventing canine access to infected offal. Similar knowledge fragmentation has been reported elsewhere. In Algeria, high general awareness coexisted with gaps in detailed epidemiological knowledge, while recent work in Türkiye and Ethiopia has similarly shown that knowledge, attitudes and practice do not always move together [7,15,16].

The offal-disposal findings are the most consequential from a transmission perspective. Nearly two-thirds of respondents reported either discarding abnormal organs with general waste or feeding them to animals. Both pathways can reconnect infected livestock tissues with definitive hosts when waste is accessible to dogs. This is especially concerning given that more than 80% reported stray animals near slaughter sites and 86.6% reported at least intermittent scavenging of slaughter waste. The resulting pathway—infected viscera, accessible waste, canine consumption and environmental egg contamination—is precisely the interface targeted by CE control programmes. The World Health Organization and the World Organisation for Animal Health emphasise prevention of dog access to raw offal, effective destruction of infected organs, regular dog treatment and post-mortem meat inspection as core control measures [17,18].

The present pattern is not unique to Libya. Ethnographic work in northern Morocco demonstrated that inadequate slaughterhouse infrastructure, weak oversight and routine disposal practices can normalise risky handling of hydatid-infected viscera [12]. More recent Mediterranean evidence has identified irregular dog deworming and provision of uncooked viscera to dogs as continuing barriers to CE control, particularly in North African settings [6]. By contrast, a recent study in Ardahan, Türkiye, reported deep burial of infected organs by 72.8% of participants who slaughtered animals, illustrating how disposal behaviour can vary substantially between settings [14]. These differences support the need for locally grounded control strategies rather than assuming that a single education message will address all transmission pathways.

Inconsistent veterinary oversight represents a second structural concern. More than 60% of participants reported that veterinary supervision during slaughter was rare or absent. Only 54.1% reported slaughter mainly in an official abattoir, while the remainder slaughtered at home or across both formal and informal settings. Post-mortem inspection is central to identifying hydatid lesions and ensuring that affected viscera are condemned and destroyed in a manner that prevents dog access. Where slaughter takes place outside controlled facilities or inspection is intermittent, the opportunity to remove infected material from the transmission cycle is reduced. Libyan reviews and recent abattoir studies continue to document hydatid infection in slaughtered livestock, confirming that the disposal question remains epidemiologically relevant rather than theoretical [9,10,11].

Personal protective behaviour showed a mixed pattern. Handwashing after slaughter was commonly reported, but consistent glove use was substantially lower. From a CE perspective, the main occupational and community risk is not the ingestion of hydatid cyst tissue itself, because humans acquire infection by ingesting eggs from a contaminated environment. Nevertheless, gloves, hand hygiene and controlled work practices remain important components of broader zoonotic-risk reduction in slaughter settings. The low proportion of participants who had received health education on zoonoses (31.9%) indicates a clear opportunity for occupational training, but the null relationship between zoonotic knowledge and offal disposal suggests that education should be paired with feasible disposal infrastructure and enforceable operating procedures.

The barriers identified by participants reinforce this interpretation. Distance from official disposal sites and lack of incineration facilities were reported more often than limited awareness itself. These responses imply that risky disposal may partly reflect service and infrastructure constraints rather than simple unwillingness to follow safer

practice. A One Health intervention should therefore link butcher education to operational waste collection, designated secure containers, protected disposal points, veterinary inspection and management of free-roaming dogs. In the medium term, slaughterhouse-level surveillance of condemned viscera could provide a practical animal-health indicator while simultaneously improving human-risk reduction.

The findings also have a broader One Health implication for Libya. CE sits at the convergence of animal infection, occupational decision-making, dog ecology and environmental contamination. An intervention delivered only through the health sector would miss the livestock and waste-management components, while veterinary action alone would not address household and occupational behaviour. Integrated action by veterinary services, municipalities, abattoir authorities, public-health programmes and local professional groups is therefore more appropriate. This aligns with recent evidence from endemic settings indicating that sustained CE control is most successful when animal, human and environmental measures are implemented together [5,4,19].

This study has several strengths. It includes a sizeable occupational sample from five eastern Libyan localities and captures not only awareness but also specific behavioural and environmental links relevant to parasite transmission. The separation of objective knowledge, occupational observation and reported practices avoids over-interpreting a single composite KAP score. The analytical focus on the knowledge–practice relationship also helps distinguish educational deficits from structural barriers.

Several limitations should be considered. The survey was self-reported and did not include direct observation of slaughter sites, parasitological examination of animals or environmental detection of *Echinococcus* eggs. Reports of cysts in carcasses and perceptions of higher infection in local sheep therefore cannot be interpreted as measured prevalence. Recruitment through an online butcher page and voluntary questionnaire completion created a non-probability sample; consequently, selection bias cannot be excluded, and butchers who did not use the page or who were less willing to participate may be under-represented. Because names and direct identifiers were intentionally not collected, identity-level duplicate verification was not possible, although no completely identical response records were detected in the dataset. The five study localities do not represent all of Libya, and external generalizability should remain geographically bounded. Some questionnaire responses were not structured with strict skip logic; for this reason, selected conditional follow-up items were excluded from analysis. Finally, the cross-sectional design can identify patterns and associations but cannot establish causal relationships. These limitations do not alter the central observation that risky offal disposal and stray-animal access were common within the surveyed occupational environment.

5. Conclusions

Butchers in eastern Libya demonstrated substantial awareness of cystic echinococcosis, but this awareness did not reliably translate into transmission-preventive practice. High-risk offal disposal, frequent stray-animal access to slaughter waste and limited veterinary supervision created a coherent set of environmental conditions capable of sustaining the dog–livestock cycle of *Echinococcus granulosus sensu lato*. Correct recognition of zoonotic transmission was not associated with safer disposal behaviour, indicating that information campaigns alone are unlikely to be sufficient. Priority actions should combine occupation-specific education with reliable veterinary meat inspection, secure containment and destruction of condemned viscera, accessible municipal waste services and effective prevention of dog access to slaughter waste. Framed as a One Health programme, these measures could convert existing disease awareness into practical interruption of transmission.

Practical One Health priorities

- Introduce a standard operating procedure for hydatid-suspect organs at abattoirs and butcher facilities, including immediate segregation, secure containment and documented disposal.
- Prevent owned and free-roaming dogs from accessing slaughter premises, carcasses and offal; link this measure to regular praziquantel-based dog deworming programmes led by veterinary authorities.
- Strengthen routine post-mortem inspection and record condemnation data in a simple surveillance system that can identify geographic and seasonal clusters.
- Provide targeted training for butchers that explains the dog–livestock–environment cycle rather than limiting education to a general description of hydatid disease.
- Address structural barriers reported by participants through designated disposal points, predictable waste collection and locally feasible destruction methods.
- Coordinate public-health, veterinary, municipal and environmental authorities under a shared CE control plan with measurable indicators.

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 declares no conflict of interest.

References

- [1] Deplazes, P., Rinaldi, L., Rojas, C. A., Torgerson, P. R., Harandi, M. F., Romig, T., ... & Jenkins, E. J. (2017). Global distribution of alveolar and cystic echinococcosis. *Advances in parasitology*, 95, 315-493.

- [2] Romig, T., Deplazes, P., Jenkins, D., Giraudoux, P., Massolo, A., Craig, P. S., ... & De La Rue, M. (2017). Ecology and life cycle patterns of Echinococcus species. *Advances in parasitology*, 95, 213-314.
- [3] Wen, H., Vuitton, L., Tuxun, T., Li, J., Vuitton, D. A., Zhang, W., & McManus, D. P. (2019). Echinococcosis: advances in the 21st century. *Clinical microbiology reviews*, 32(2), 10-1128.
- [4] Hogeia, M. O., Ciomaga, B. F., Muntean, M. M., Muntean, A. A., Popa, M. I., & Popa, G. L. (2024). Cystic echinococcosis in the early 2020s: a review. *Tropical medicine and infectious disease*, 9(2), 36.
- [5] Gharbi, M., & Giraudoux, P. (2024). Cystic echinococcosis (Echinococcus granulosus sensu lato infection) in Tunisia, a One Health perspective for a future control programme. *Parasite*, 31, 30.
- [6] Nocerino, M., Pepe, P., Ciccone, E., Maurelli, M. P., Bosco, A., Boué, F., ... & Rinaldi, L. (2024). Epidemiological update of cystic echinococcosis in livestock and assessment of practices related to its control in the Mediterranean area. *Acta Tropica*, 255, 107240.
- [7] Lounis, M., Belabbas, Z., Telha, T., Bencherit, D., Chebbah, O., Laoues, K., & Abdelhadi, S. (2024). Knowledge, awareness and practice regarding cystic echinococcosis in Algeria: A cross-sectional survey among the general population. *Veterinary Parasitology: Regional Studies and Reports*, 47, 100956.
- [8] Ibrahim, M. M., Ibrahim, W. M., Abdorrahman, M. M., & Ibrahim, K. M. (2016). Livestock hydatid disease (cystic hydatidosis) in Libya: a review. *American Journal of Animal and Veterinary Sciences*, 11(2), 70-84.
- [9] El-Salem, R. M., Khan, A., & Younis, E. Z. (2021). Cystic echinococcosis in slaughtered animals in Libya: A Review. *Journal of Pure & Applied Sciences*, 20(1), 167-171.
- [10] Saleh, W. and Elmahjoob, M.M. (2024) 'Hydatidosis in slaughtered livestock in Al-Qubba City-Libya', *Journal of Pure & Applied Sciences*, 23(2), 113-119.
- [11] Murshid, M., Zahmoul, T., Masaoud, E., Gamag, E., & Almabrouk, A. (2026). Prevalence of Hydatidosis in Sheep, Goats, Cattle, and Camels Slaughtered in Selected Abattoirs in Sabratha City, Libya. *AlQalam Journal of Medical and Applied Sciences*, 613-621.
- [12] Bardosh, K. L., El Berbri, I., Ducrottoy, M., Bouslikhane, M., Ouafaa, F. F., & Welburn, S. C. (2016). Zoonotic encounters at the slaughterhouse: pathways and possibilities for the control of cystic echinococcosis in northern Morocco. *Journal of biosocial science*, 48(S1), S92-S115.
- [13] Alvi, M. A., Li, L., Saqib, M., Ohiolei, J. A., Younas, M. W., Tayyab, M. H., ... & Jia, W. Z. (2021). Serologic evidence of Echinococcus granulosus in slaughterhouses in Pakistan: global alarm for butchers in developing countries. *The Journal of Infection in Developing Countries*, 15(06), 861-869.
- [14] Alan, E. G., & Aydın, N. (2025). Ardahan İlindeki Hayvan Yetiştiricilerinin ve Kasapların Kistik Echinococcosis Hakkındaki Bilgi Düzeyinin Araştırılması. *Turkish Journal of Parasitology*.
- [15] Selcuk, M. A., Kandemir, A., & Simsek, S. (2026). Knowledge, Attitudes, and Practices Related to Cystic Echinococcosis in an Endemic Region of Türkiye: A One Health Assessment. *Preventive Veterinary Medicine*, 106851.
- [16] Efa, D. A., Wang, T., Tefere, G., Stevenson, M. A., Jabbar, A., & Gasser, R. B. (2026). Community knowledge, attitudes and practices related to cystic echinococcosis in Ethiopia: Implications for control. *One Health*, 101456.
- [17] World Health Organization (WHO) (2025) 'Echinococcosis: questions and answers', 15 August 2025. Available at: <https://www.who.int/news-room/questions-and-answers/item/echinococcosis>
- [18] World Organisation for Animal Health (WOAH) (2023) 'Infection with Echinococcus granulosus', Terrestrial Animal Health Code, Chapter 8.5. Available at: https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/2023/chapitre_echinococcus_granulosus.
- [19] Poggio, T. V., Chacon, T., & Larrieu, E. (2024). Successful control of Echinococcosis in Argentina and Chile through a One Health approach, including vaccination of the sheep intermediate host. *Parasitology*, 151(13), 1401-1405.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of JIBAS and/or the editor(s). JIBAS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.