



RESEARCH ARTICLE

Clinical and radiological patterns of computed tomography-confirmed hydatid cyst disease in Nineveh Governorate, Iraq: a retrospective study

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ABSTRACT

Hydatid cyst disease (cystic echinococcosis, CE) is a chronic parasitic zoonosis that is caused by *Echinococcus granulosus*, a significant public health concern in the Middle East. The aim of the current study was to describe characteristics and assess associations between exposures and disease patterns among computed tomography (CT)-confirmed cases. The study was a retrospective study of 200 patients with CT-confirmed hydatid cysts treated at a tertiary teaching hospital in Mosul for CE, between September 2024 and August 2025. The median age of the patients was 31 years, and 53% of them were female. About two-thirds (63.5%) lived in the countryside, and half of them kept dogs. Livestock exposure was common, particularly sheep-related exposure. The liver was the predominant organ involved (67.5%), followed by the lung (19.5%). Multivariable analysis showed that sheep farming was inversely associated with extra-hepatic (adjusted odds ratio [aOR] 0.40; 95% CI 0.19–0.83) and pulmonary involvement (aOR 0.37; 95% CI 0.17–0.82). CE is disproportionately prevalent among young adults in rural regions, and appeared to be associated with environmental exposures. Sheep farming was inversely associated with disease dissemination, although this finding should be interpreted cautiously and may reflect better animal farming or hygiene standards. These findings may help inform future public health strategies through improved community education and targeting high-risk groups.

Keywords: Computed tomography; Cystic echinococcosis; *Echinococcus granulosus*; Hydatid cyst; Iraq.

INTRODUCTION

Hydatid (cystic) echinococcosis (CE) is a global zoonosis, which is caused by the larval form of *Echinococcus granulosus*, a tapeworm, which survives in areas where domestic dogs and livestock are in contact (Shams *et al.*, 2022). Humans become accidental intermediate hosts through ingestion of *Echinococcus* eggs contaminating food, water, soil, or fomites contaminated with dog faeces (Shams *et al.*, 2022). Hydatid larvae are usually asymptomatic; clinical presentation occurs only when growing cysts cause a mass effect, rupture, or superinfection (Govindasamy *et al.*, 2023). Due to the non-specificity of presentations and the slow course of the disease, imaging modalities are often used for diagnosis (Das *et al.*, 2025).

Computed tomography (CT) offers superior contrast and is considered the most reliable modality to determine the location, size, number, daughter cysts, and calcification of extra-hepatic lesions (Abbasi *et al.*, 2021; Zhang *et al.*, 2025). Although CE is endemic in Iraq, there is little local epidemiologic evidence (Abood & Naef, 2023), particularly with multivariate analysis to control confounders, which could affect disease patterns and presentation (Possenti *et al.*, 2016). Previous studies from Iraq and neighboring countries have shown higher prevalence of CE among women and in rural settings, but results are inconsistent, and few of these studies

include multivariable analyses adjusting for confounders (Issa *et al.*, 2022; Fakhri *et al.*, 2024; Ghorbani *et al.*, 2024; Shafiei *et al.*, 2025).

This was a retrospective study of CT-proven hydatid cases that were managed in a tertiary hospital in Mosul. This study aimed to characterize socio-demographic features, environmental exposures, and radiologic patterns and to explore factors associated with disease presentation, organ involvement, and cyst multiplicity among confirmed cases (extra-hepatic and pulmonary involvement) and cyst multiplicity. Knowledge of these determinants can help guide targeted prevention efforts and inform clinicians on early prevention and management of this disease.

MATERIALS AND METHODS

Study design

This retrospective case-only observational study was carried out at a tertiary teaching hospital in northern Iraq. The hospital receives patients from both rural and urban areas of the governorate. Medical records of patients diagnosed with CE based on characteristic CT findings between 1 September 2024 and 1 August 2025 were reviewed. The International Committee of Medical Journal Editors (ICMJE) guidelines were adhered to, and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed.

Inclusion and exclusion criteria

Inclusion criteria were: (i) age ≥ 5 years. This age restriction was applied because children younger than 5 years are typically managed at the affiliated pediatric hospital, whose radiology records were not accessible through the adult hospital database used for this retrospective review. (ii) diagnosis confirmed based on characteristic CT findings (used for diagnosis, with CT or ultrasound for lesion characterization; Philips Brilliance 64-slice scanner), and (iii) complete demographic and clinical records. Exclusion criteria included incomplete medical data or lack of CT confirmation. We screened 245 records; 45 were excluded (30 for incomplete data and 15 for lack of CT confirmation), leaving 200 cases for analysis.

For this study, a CT-confirmed case was defined as a well-defined, non-enhancing, fluid-attenuation cystic lesion showing characteristic features of CE – including daughter cysts, detached membranes, or wall calcification. While the World Health Organization Informal Working Group on Echinococcosis (WHO-IWGE) staging relies primarily on ultrasound, CT was used here for diagnostic confirmation and detailed lesion characterization rather than formal disease staging.

Data collection

We used a structured data-collection form to extract variables from radiology reports and medical records. Demographic variables included age, sex, residence (rural/urban), occupation, and educational level. Environmental exposures included dog ownership and livestock rearing. Livestock exposure was recoded into three categories: no livestock, sheep (including sheep alone or in combination with other animals), and other livestock (goats or cattle without sheep); source of drinking water (tap, well/river); vegetable washing practices (water only, saltwater, vinegar, or detergent); and family history of CE. Clinical variables included presenting symptoms, organ involvement on imaging (liver, lung, combined liver–lung, spleen, or other sites), number of cysts (one, 2–3, ≥ 4), largest cyst diameter (< 5 cm, 5–9 cm, ≥ 10 cm), and previous hydatid surgery. Exposure variables were coded categorically. Sheep farming was defined as a binary variable (yes/no), with no or non-sheep livestock as the reference category. No formal sample size calculation was performed, as we included all eligible CT-confirmed cases diagnosed during the study period. The sample size was therefore determined by case availability and was considered adequate for exploratory multivariable analyses.

We defined the three outcomes as follows: (i) multiple cysts were defined as the presence of two or more cysts (categorized as 2–3 or ≥ 4) versus a single cyst; (ii) extra-hepatic disease meant any organ involvement outside the liver; and (iii) pulmonary involvement meant lung involvement, including both isolated pulmonary disease and combined liver–lung disease. Patients with combined liver–lung involvement were included in both the extra-hepatic and pulmonary involvement analyses, as these represent clinically relevant manifestations of disseminated disease.

Statistical Analysis

We entered all data into Microsoft Excel and analyzed them with SPSS version 26. For continuous variables, we report mean $\pm$ standard deviation or median (interquartile range [IQR]), depending on distribution. Categorical variables are shown as frequencies and percentages. We used chi-square tests to examine associations between exposures and outcomes, and calculated odds ratios (ORs) with 95% confidence intervals (CIs) for the key comparisons.

To identify independent predictors of (i) multiple cysts, (ii) extra-hepatic disease, and (iii) pulmonary involvement, we built three multivariable logistic regression models and report adjusted odds ratios (aORs). We predefined reference categories for each categorical predictor – male sex, urban residence, tap water source, and no sheep farming. The full univariate analyses are in Supplementary Material 1; Table 2 shows the three pre-specified comparisons we considered most clinically relevant. Model fit was

checked with the Hosmer–Lemeshow test, and we set statistical significance at $P < 0.05$.

Ethical Considerations

The Nineveh Health Directorate Ethics Committee approved this study on 1 August 2024 (reference 6447). Because the study was retrospective, we sought informed consent from patients during follow-up visits or by telephone whenever possible. For those we could not reach, the ethics committee granted a waiver of consent for anonymized data. All procedures followed the Declaration of Helsinki, and we handled patient information anonymously and confidentially.

RESULTS

We identified 200 patients with CT-confirmed hydatid cysts. Mean age was 32.3 ± 14.2 years (range 6–78), median 31 years (IQR 21–40). Women made up 53% of cases. The majority (63.5%) resided in rural districts, while 49.0% lived in Mosul city. Labourers accounted for about one-fifth (18%) of the cohort. Table 1 summarizes the baseline characteristics.

Table 1. Baseline demographic, environmental, and clinical characteristics of CT-confirmed hydatid cyst patients (N = 200)

Characteristic	n (%)
Age group (years)	
0–20	42 (21.0)
21–40	106 (53.0)
41–60	47 (23.5)
61–80	5 (2.5)
Median age (IQR)	31 (21–40)
Sex	
Female	106 (53.0)
Male	94 (47.0)
Residence	
Rural	127 (63.5)
Urban	73 (36.5)
Dog ownership	
Yes	97 (48.5)
No	103 (51.5)
Livestock rearing	
No livestock	93 (46.5)
Sheep ($\pm$ mixed)	78 (39.0)
Other livestock	29 (14.5)
Water source	
Tap	84 (42.0)
Well	55 (27.5)
Other	61 (30.5)
Vegetable washing	
Water only	128 (64.0)
Salt water	35 (17.5)
Vinegar	31 (15.5)
Detergent	6 (3.0)
Family history of hydatid disease	
Yes	73 (36.5)
No	127 (63.5)
District	
Mosul	98 (49.0)
Tal Afar	21 (10.5)
Other districts	81 (40.5)
Occupation	
Laborer	36 (18.0)
Farmer	34 (17.0)
Housewife	32 (16.0)
Unemployed	32 (16.0)
Student	26 (13.0)
Other	40 (20.0)

IQR = interquartile range.

Fewer than half of the participants (48.5%) owned dogs, which were used for herding and guarding. Livestock rearing was reported by 78 (39.0%) patients (sheep alone or with other livestock) and 29 (14.5%) patients reported other livestock (goats or cattle without sheep). The primary source of drinking water was tap water for 42.0% of patients and wells for 27.5%. Approximately two-thirds of households (64.0%) washed vegetables with water only, and a small proportion used saltwater (17.5%), vinegar (15.5%) or detergent (3.0%). 73 (36.5%) patients had a family history of CE.

Abdominal pain was the most common presenting symptom, occurring in 43.5% of patients, followed by cough and/or chest pain (20.5%). But 17.0% were found incidentally on imaging done for other complaints. This indicates that there is a large pool of subclinical disease in the community, which is in line with the slow growth of hydatid cysts. Incidental detection was observed in all age groups and urban and rural areas, highlighting the need for continued diagnostic awareness even in the absence of clinical suspicion of CE. Only 9.5% had had prior surgery for CE. On imaging, the liver was the most frequently affected organ (67.5%), followed by the lung (19.5%), combined liver–lung involvement (8.0%), spleen (3.0%) and other sites (2.0%). Most patients (66.0%) had 2–3 cysts; 24.5% had a single cyst and 9.5% had ≥ 4 cysts. As far as the size of the cysts, 49.5% had cysts with the largest diameter of 5–9 cm, 28.5% had cysts < 5 cm and 22.0% had cysts ≥ 10 cm. Representative CT images of typical hepatic and pulmonary hydatid cysts are presented in Figures 1 and 2.

Medical records were not systematically collected for detailed CT characteristics, such as daughter cysts, wall calcification, cyst rupture, and superinfection, in the retrospective records reviewed for this review. These features were recorded in the original radiology reports and helped confirm the diagnosis of cystic echinococcosis, but were not extracted in a standardized format appropriate for quantitative reporting.

Selected unadjusted comparisons are displayed in Table 2; the full univariate analysis is available in Supplementary Material 1. On bivariate analysis, sheep farming was associated with significantly lower odds of extra hepatic involvement (odds ratio [OR] 0.48, 95% CI 0.25–0.91, $p = 0.03$). There was no significant association between sex and isolated pulmonary disease (OR 0.73, 0.39–1.36, $p = 0.40$) or between dog ownership and harbouring multiple cysts (OR 0.87, 0.46–1.67, $p = 0.81$).

Table 3 presents adjusted ORs derived from three logistic regression models. Sheep farming remained inversely associated with both extra hepatic disease (aOR 0.40, 0.19–0.83) and pulmonary involvement (aOR 0.37, 0.17–0.82) after controlling for age, sex, residence, dog ownership, water source and family history. Age showed no statistically significant association with pulmonary involvement after multivariable adjustment (aOR 1.02 per year, 95% CI 1.00–1.04, $P = 0.113$), and this trend should be interpreted cautiously. Likewise, family history of hydatidosis did not reach significance for multiple cysts (aOR 2.04, 95% CI 0.95–4.34, $P = 0.066$); any apparent trend likely reflects shared household

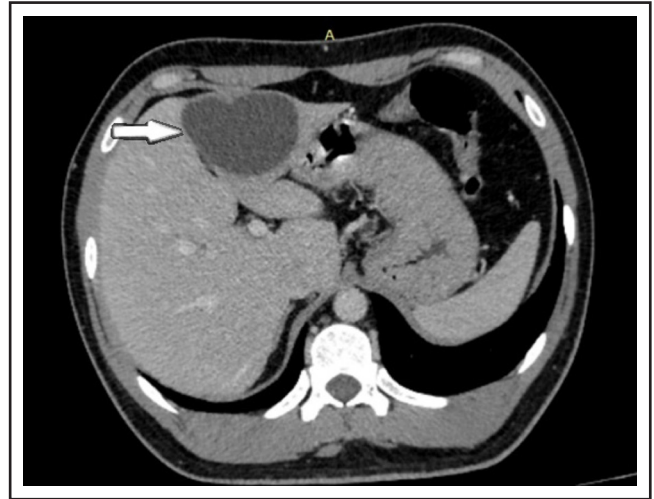


Figure 1. Axial contrast-enhanced abdominal CT demonstrating a well-defined, non-enhancing, fluid-attenuation cyst in the left lobe of the liver, consistent with hepatic hydatid disease.

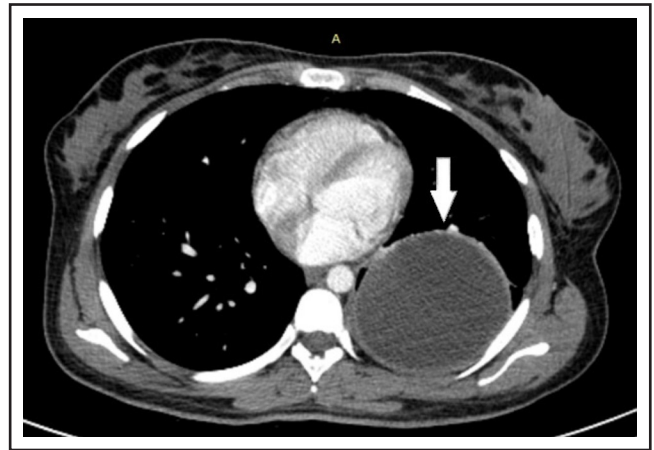


Figure 2. Axial contrast enhanced chest CT demonstrating a large, well-defined, non-enhancing, fluid-attenuation cyst in the left lung posteriorly, consistent with pulmonary hydatid disease.

Table 2. Selected unadjusted associations between key exposures and disease patterns

Exposure–Outcome comparison	Odds ratio (95% CI)	p value
Sheep farming vs extra-hepatic involvement	0.48 (0.25–0.91)	0.03
Female sex vs pulmonary involvement	0.73 (0.39–1.36)	0.40
Dog ownership vs multiple cysts	0.87 (0.46–1.67)	0.81

OR = odds ratio; CI = confidence interval. Only selected clinically relevant exposure–outcome comparisons are presented.

Table 3. Adjusted associations between selected exposures and disease patterns

Predictor	Multiple cysts (aOR, 95% CI, P -value)	Extra-hepatic disease (aOR, 95% CI, P -value)	Pulmonary involvement (aOR, 95% CI, P -value)
Age (per year)	1.00 (0.98–1.02), $P=0.998$	1.01 (0.99–1.03), $P=0.332$	1.02 (1.00–1.04), $P=0.113$
Female (vs male)	0.77 (0.39–1.53), $P=0.455$	0.62 (0.33–1.16), $P=0.136$	0.56 (0.29–1.10), $P=0.095$
Rural (vs urban)	0.67 (0.33–1.38), $P=0.275$	1.41 (0.74–2.70), $P=0.296$	1.74 (0.86–3.51), $P=0.123$
Dog ownership (yes vs no)	0.90 (0.46–1.77), $P=0.767$	1.12 (0.60–2.08), $P=0.729$	1.53 (0.79–2.96), $P=0.207$
Sheep farming (vs no/other livestock)	0.58 (0.29–1.18), $P=0.134$	0.40 (0.19–0.83), $P=0.014^*$	0.37 (0.17–0.82), $P=0.014^*$
Unsafe water (vs tap)	1.35 (0.68–2.68), $P=0.386$	0.83 (0.44–1.56), $P=0.569$	0.70 (0.36–1.36), $P=0.293$
Family history (yes vs no)	2.04 (0.95–4.34), $P=0.066$	1.20 (0.64–2.28), $P=0.568$	0.82 (0.41–1.63), $P=0.570$

aOR = adjusted odds ratio; CI = confidence interval. * Indicates significance ($p < 0.05$). Model goodness of fit statistics (Hosmer–Lemeshow $p > 0.65$; Nagelkerke R^2 0.06–0.11) indicated acceptable, albeit limited, explanatory power. Reference categories: male sex, urban residence, no dog ownership, no or non-sheep livestock, tap water source, and no family history of hydatid disease.

exposure rather than a robust independent effect, and should not be overinterpreted. None of the other exposures (sex, rural residence, dog ownership or unsafe water source) were independently linked to multiple cysts or extra hepatic disease.

DISCUSSION

This study provides an in-depth account of CE in Nineveh Governorate, Iraq by reviewing 200 CT-confirmed cases within one year. Our results underline the significant contribution of demographic and environmental factors and provide new information on the patterns of the disease.

Most of the patients were young adults (mean age 32 years), with the largest proportion in the 21–40 years age group. A similar result was found in three studies from Kurdistan Region, Iraq, in which most hydatid cyst cases occurred among adults aged 20–40 years, and this was attributed to increased occupational exposure during farming and livestock handling (Issa *et al.*, 2022; Mustafa *et al.*, 2024; Rahman, 2024). Another study that was conducted in Basrah, Iraq, also found that hydatid cyst risk is higher among individuals most actively engaged in livestock rearing and dog handling (Abdulhameed, 2018). Similar patterns have been reported in Asian countries, where the highest infection rates occur in the 21–40 years age group, with the explanation that this demographic represents the workforce most involved in livestock rearing and domestic animal care, a finding echoed in Iraq and regional studies (Borhani *et al.*, 2021).

Dog ownership and livestock rearing were highly prevalent in our cohort. Nearly half of patients owned dogs, and a substantial proportion had livestock exposure, particularly sheep-related. These practices are common in rural settings and may increase human exposure to *Echinococcus granulosus* eggs through contamination of soil, water, and household environments. However, unadjusted analyses showed no association between dog ownership and multiplicity of cysts, nor between dog ownership and pulmonary disease. In contrast, sheep farming emerged as a significant inverse association with extra hepatic and pulmonary involvement, even after multivariable adjustment. Across regional and global studies, unadjusted analyses often show no significant link between dog ownership and cyst multiplicity or pulmonary involvement. Conversely, sheep farming has occasionally been reported as showing an inverse association with extra-hepatic or pulmonary echinococcosis after controlling for confounders such as age, sex, and rural exposure (Possenti *et al.*, 2016; Ma *et al.*, 2023; Paduraru *et al.*, 2023). The counter-intuitive inverse association of sheep farming observed in this study may reflect superior animal husbandry, routine dog deworming, and increased disease awareness among professional farmers, but it may also reflect residual confounding or unmeasured differences between households. Similar findings from Iranian studies demonstrate that proper sheep management and controlled slaughter practices reduce parasite transmission (Hosseini *et al.*, 2021; Borhani *et al.*, 2024; Abolhasani *et al.*, 2025).

Access to clean water remains an important public health priority, especially in developing countries. Unsafe water practices and poor washing of vegetables are common practices in endemic regions and are possible routes of transmission of cystic echinococcosis. On the other hand, studies by Possenti *et al.* (2016), Hajipour *et al.* (2021), and Raimkulov *et al.* (2024) have reported non-significant associations after adjustment, which suggests that risk may be mediated indirectly by environmental and socioeconomic factors.

Consistent with the biology of CE, the liver is the most common site (two-thirds of the patients), followed by the lungs (one-fifth of the patients). Less common is combined or extra-hepatic disease (e.g., spleen, kidneys). Late presentation may be manifested by multiple cysts and large lesions (≥ 10 cm). Clinical presentation is

most commonly abdominal pain and respiratory symptoms, and approximately 15–20% of patients have no symptoms. Imaging typically shows low-density cysts with daughter cysts or calcification, which are typical of classical radiologic descriptions (Pakala *et al.*, 2016; Yu *et al.*, 2021; Solomon *et al.*, 2025). It is important to note that 17% of the cases were detected incidentally. This is probably just the tip of the iceberg, as hydatid cysts can develop over many years without causing any symptoms. It also emphasizes that clinicians should consider CE in the differential diagnosis when unexpected cystic lesions are found on routine imaging, even in the absence of classic symptoms.

The inverse association between sheep farming and extra-hepatic or pulmonary involvement is biologically counter-intuitive, since sheep are intermediate hosts in the *Echinococcus granulosus* life cycle. We do not interpret this as evidence of a protective effect. More plausibly, it reflects residual confounding – sheep-farming households may differ from non-farming households in ways we did not measure, such as socioeconomic status, routine dog deworming, or slaughter hygiene. Selection bias is another possibility, if sheep farmers present earlier with isolated hepatic disease due to greater awareness, while non-farmers present later with more disseminated disease. Differences in healthcare-seeking behaviour could also play a role. Alternatively, professional farmers may adhere to stricter animal husbandry standards than small-scale or occasional livestock keepers. These explanations remain speculative, and the finding should be treated as hypothesis-generating rather than conclusive (Mateus *et al.*, 2016; Merino *et al.*, 2017; Abdulhameed, 2018).

Age-related differences in organ involvement suggest that older individuals may be more likely to develop pulmonary or multi-organ disease, which is probably due to cumulative exposure and immunologic adaptation. Family history can suggest genetic predisposition or common environmental factors, but most of the associations are not statistically significant. Overall, disease dissemination and multiplicity remain multifactorial and not fully understood (Abdulhameed, 2018; Acosta-Jamett *et al.*, 2022; Stefaniak *et al.*, 2023).

The strengths of the study are the relatively high sample size, the application of CT to verify all diagnoses, and the thorough evaluation of demographic, environmental, and clinical factors. We used multivariable models to adjust for measured confounders and to determine independent relationships. On the other hand, this study has several limitations that should be acknowledged. The retrospective design and reliance on medical records and self-reports introduce recall bias. Because the study was conducted at a single hospital, the results may not generalize to other Iraqi regions. Even though we used logistic regression, we could not include some potentially relevant confounders, such as socioeconomic status and dietary practices. Finally, the cross-sectional nature of the data limits any inference about causality. Future prospective studies with longitudinal follow-up across multiple governorates are needed to strengthen the evidence base.

In this cohort, CT-confirmed CE was observed most frequently among young adults living in rural areas, and several environmental exposures appeared to be related to disease presentation. An inverse association was found between sheep farming and extra-hepatic or pulmonary involvement; however, this finding should be interpreted carefully, as it may reflect residual confounding, selection bias, or differences in healthcare-seeking behaviour. The findings may assist clinicians in managing affected patients and support community-based educational initiatives in endemic regions. Clinicians should maintain a high index of suspicion for CE in patients with abdominal or respiratory symptoms, and use CT to evaluate cyst characteristics beyond size and location.

Conflict of Interest Statement

The author declares that they have no conflict of interest.

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Author contributions

The author confirms sole responsibility for the conception, data collection, analysis, and manuscript preparation, and meets all ICMJE authorship criteria. No additional contributors requiring acknowledgment were involved in this study.

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