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RESEARCH ARTICLE

Computed Tomography (CT) Patterns of Hepatic Cystic Echinococcosis (CE) Cysts: A 19-Year Retrospective Study at a Tertiary Center in Sana'a, Yemen

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Abstract

Background Echinococcus granulosus sensu lato, a hepatic cystic echinococcosis (CE), is a major public health concern in endemic regions, such as Yemen. Understanding their prevalence, computed tomography (CT) patterns, and socio-demographic characteristics is crucial for effective disease management.

Methods This retrospective study analyzed the medical records of 835 patients diagnosed with hepatic CE cysts at Al-Thawra Modern General Hospital, Sana'a, Yemen, between 2004 and 2023. Data on patient demographics, CE cyst characteristics, WHO Informal Working Group on Echinococcosis (IWGE) classification, and radiological evidence suggestive of complications were collected from the CT reports and analyzed using SPSS version 26.

Results The patients (66.47% female, median age 35 years) had 1,669 cysts, which were predominantly solitary (67%) and located in the right lobe (50.06%). The most common classifications were CE1 (38.56%) and CE3 (34.02%). The most common radiological finding suggestive of a complication was mass effect (38%). Other findings included intrabiliary rupture (4%) and intraperitoneal rupture (1.4%) with an annual mean of 44 cases.

Conclusions The high prevalence, especially among young females, underscores the need for improved hygiene, standardized CT reporting for complex or preoperative cases, and a national registry to control this disease in Yemen.

Keywords Hepatic cystic echinococcosis · Echinococcus granulosus s.l. · Yemen · Prevalence · WHO-IWGE classification · CT scan · Public health · Computed tomography patterns

Abbreviations

CE	Cystic Echinococcosis
CE1-CE5	WHO IWGE Classification Stages 1–5 for Cystic Echinococcosis
CT	Computed Tomography
IQR	Interquartile Range
IWGE	Informal Working Group on Echinococcosis (World Health Organization)
MRCP	Magnetic Resonance Cholangiopancreatography
MRI	Magnetic Resonance Imaging
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
US	Ultrasound
WHO	World Health Organization

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1 Introduction

Cystic echinococcosis (CE), caused by the larval stage of the parasitic tapeworm *Echinococcus granulosus sensu lato*, remains a significant global public health challenge, particularly in endemic regions, where livestock farming is common. The disease primarily affects the liver and lungs, posing a substantial burden in areas such as Mediterranean, Central Asia, South America, and parts of Africa. Recent estimates have indicated a global incidence of 2.6 per 100,000 people in 2019, with prevalence rates ranging from 0.7 to 5% in community-based studies in endemic regions [1]. Despite control programs in some areas, the disease persists due to socioeconomic factors, inadequate sanitation, and close human-animal interactions.

In Yemen, CE is a pressing endemic concern exacerbated by limited healthcare infrastructure, ongoing conflicts, and widespread agricultural practices. Local studies have reported human prevalence rates of 0.7–2.87%, with the liver being the primary site of infection [2, 3]. Risk factors, including contact with dogs, low literacy, and the consumption of contaminated water or vegetables, are prevalent, particularly in rural areas. The disease disproportionately affects females and younger adults, likely due to occupational and domestic exposure. Regional data from neighboring countries, such as Saudi Arabia and Jordan, highlight similar epidemiological challenges across the Arabian Peninsula, underscoring the need for region-specific insights [4, 5].

Ultrasound (US) is the primary imaging modality used for the diagnosis and screening of hepatic CE because of its accessibility, non-invasiveness, and ability to visualize pathognomonic features [6, 7]. Computed tomography (CT) is a valuable complementary tool, particularly for complex cases, preoperative planning, assessment of complications (e.g., rupture, infection, biliary communication), detection of calcifications, and equivocal US findings [6]. CT offers detailed anatomical information that is crucial for surgical management. However, in Yemen, access to CT imaging is limited and standardized region-specific CT data are scarce, hindering comprehensive understanding and management strategies.

This study aimed to address these gaps by analyzing the prevalence, CT patterns, and sociodemographic characteristics of hepatic CE cysts in patients aged > 19 years at a tertiary center in Sana'a, Yemen. By comparing these findings with global and regional data, we sought to elucidate Yemen's unique epidemiological context and inform targeted public health interventions. Ultimately, this study contributes to the global understanding of CE and provides a foundation for improved clinical practices and prevention strategies in Yemen and other endemic settings.

2 Materials and Methods

2.1 Study Design and Setting

This retrospective descriptive study was conducted at Al-Thawra Modern General Hospital, a tertiary referral center in Sana'a Yemen. This study analyzed the computed tomography (CT) patterns and epidemiological characteristics of hepatic CE cysts diagnosed between January 2004 and April 2023.

2.2 Participants

We reviewed the records of 1,400 patients with suspected or confirmed CE. After applying the inclusion and exclusion criteria, 835 patients with 1,669 hepatic CE cysts were included in the final analyses. The inclusion criteria were as follows: (1) Yemeni patients of any age or sex; (2) confirmed hepatic CE cysts via abdominal CT; and (3) complete CT reports available in the hospital archives. The exclusion criteria were as follows: (1) postoperative cases with prior cyst surgery ($n=320$), (2) chest CT scans with only partial upper abdominal imaging ($n=195$), (3) diagnosis based solely on ultrasound without CT confirmation ($n=50$), and (4) incomplete or illegible records ($n=35$). A flow diagram of the patient selection process is shown in Fig. 1.

2.3 Data Collection

Data were extracted from archived papers and electronic medical records using standardized forms to ensure consistency. The primary data source was abdominal CT reports, supplemented with patient charts for demographic information. The collected variables included (1) demographic information (age, sex, date of diagnosis), (2) CE cyst characteristics (number, size, location in liver segments, WHO Informal Working Group on Echinococcosis (IWGE) classification for CE), and (3) radiological evidence suggestive of complications (e.g., mass effect, signs of rupture, and infection detected on CT). Two independent radiologists reviewed the CT scans to verify cyst characteristics, and discrepancies were resolved by a third senior radiologist. The data were crosschecked by trained research assistants to minimize transcription errors and all records were anonymized to protect patient confidentiality. Data regarding the specific rural or urban origin of patients were not consistently available in the archived records and thus could not be analyzed.

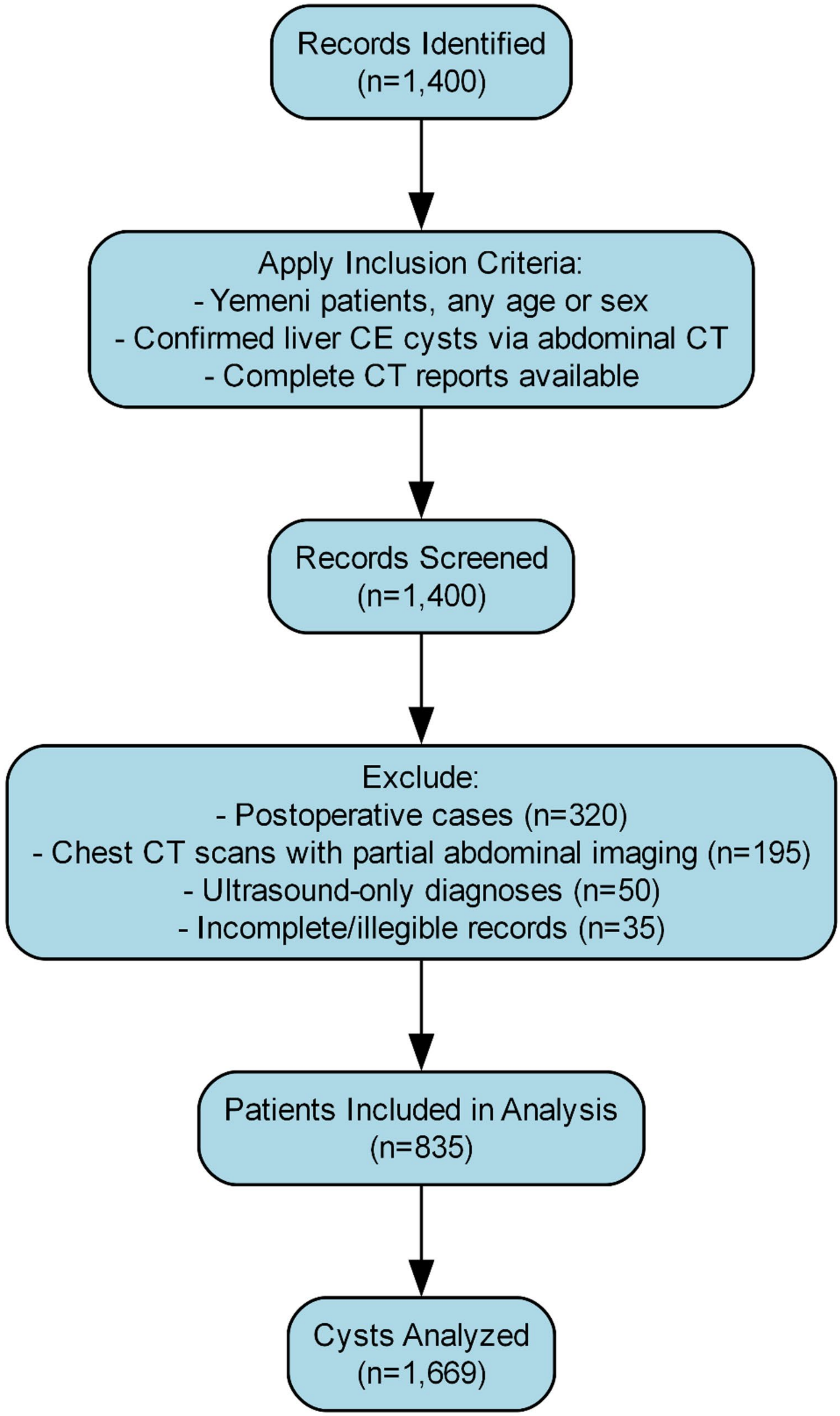

Fig. 1 Flowchart of patient selection

2.4 Variables

The primary variables were categorized as demographic (age, sex, and diagnosis date) and clinical (cyst number [solitary or multiple], size [in mm], location [right, left, or both lobes; specific segments], WHO IWGE classification for CE [CE1-CE5] [7], and radiological evidence suggestive of complications). Cyst size was measured as the maximum diameter on CT, and radiological evidence suggestive of complications was defined on the basis of CT findings (e.g., mass effect as compression of adjacent structures and direct or indirect signs of rupture or infection). All variables were recorded according to standardized radiological and epidemiological protocols.

2.5 Bias

All eligible records from the study period were systematically screened to reduce selection bias. Information bias was minimized by using standardized data collection forms and independent CT reviews performed by multiple radiologists. Patients with incomplete or ambiguous CT reports were excluded to ensure the integrity of the data. Potential confounding factors, such as variations in radiologist expertise, were addressed by consensus review of discrepant cases.

2.6 Statistical Analysis

Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the demographic and clinical characteristics. Continuous variables (e.g., age and cyst size) were reported as means with standard deviations (SD) or medians with interquartile ranges (IQR), depending on the distribution normality. Categorical variables (e.g., sex, cyst type, and WHO classification) are presented as frequencies and percentages. No inferential statistical tests were performed as the study focused on descriptive epidemiology. Missing data were minimal (<1%) and handled by listwise deletion.

2.7 Ethical Considerations

This study was approved by the Institutional Review Board of Al-Thawra Modern General Hospital in Yemen (approval no. TMGH/2023/014). This study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki. The requirement for informed consent was waived by the Institutional Review Board of the Al-Thawra Modern General Hospital owing to the retrospective nature of the study and the use of anonymized data. Patient confidentiality was maintained throughout the study.

3 Results

3.1 Demographic Characteristics

This study included 835 patients diagnosed with hepatic CE cysts with a median age of 35 years (IQR, 2–100 years). Nearly half (402, 48.14%) of the patients were aged 21–40 years, followed by 258 (30.90%) aged 41–60 years. Females predominated, comprising 555 (66.47%) cases, compared with 280 (33.53%) males. The mean annual number of diagnosed cases was 44 (SD: 5.88), with a median of 41 (IQR: 35–56). Annual cases ranged from 30 in 2004 to a peak of 77 in 2014, followed by a slight decline to 42 in 2017, and stabilization at 41–68 cases per year from 2018 to 2023 (Fig. 2, Supplementary Table S1). The demographic characteristics are summarized in Table 1.

3.2 Radiological Patterns of Hepatic CE Cysts

A total of 1,669 cysts were identified in 835 patients, with solitary cysts in 563 (67.43%) and multiple cysts in 272 (32.57%). The mean cyst size was 71.82 mm (SD: 85.28 mm). Cysts were most frequently located in the right lobe (418, 50.06%), followed by both lobes (219, 26.23%), and the left lobe (198, 23.71%). Multiple liver segments were involved in 511 (61.20%) cases, compared to single segments in 324 patients (38.80%). Segment VII was the most commonly affected (391, 46.83%), followed by Segment VIII (296, 35.45%), and Segment IV (255, 30.54%). According to the WHO Informal Working Group on Echinococcosis (IWGE) classification, CE1 (322, 38.56%) and CE3 (284, 34.02%) were the most prevalent cyst types, followed by CE2 (96, 11.50%), CE5 (68, 8.14%), and CE4 (65, 7.78%) (Table 2).

3.3 Radiological Evidence Suggestive of Complications in Hepatic Cystic Echinococcosis (CE) Cysts

Radiological findings suggestive of complications were observed in 602 (72.10%) patients. Mass effect was the most common finding, identified in 316 patients (37.84%). Other complications included exophytic growth ($n=122$, 14.61%), intrahepatic duct dilatation ($n=48$, 5.75%), vascular compression ($n=39$, 4.67%), biliary rupture ($n=35$, 4.19%), infection or abscess ($n=25$, 2.99%), intraperitoneal rupture ($n=12$, 1.44%), and extrahepatic duct dilatation ($n=8$, 0.96%). No complications were observed in 233 (27.90%) patients. Total cyst rupture (intrabiliary and intraperitoneal) occurred in 47 patients (5.63%). The complications are summarized in Table 3.

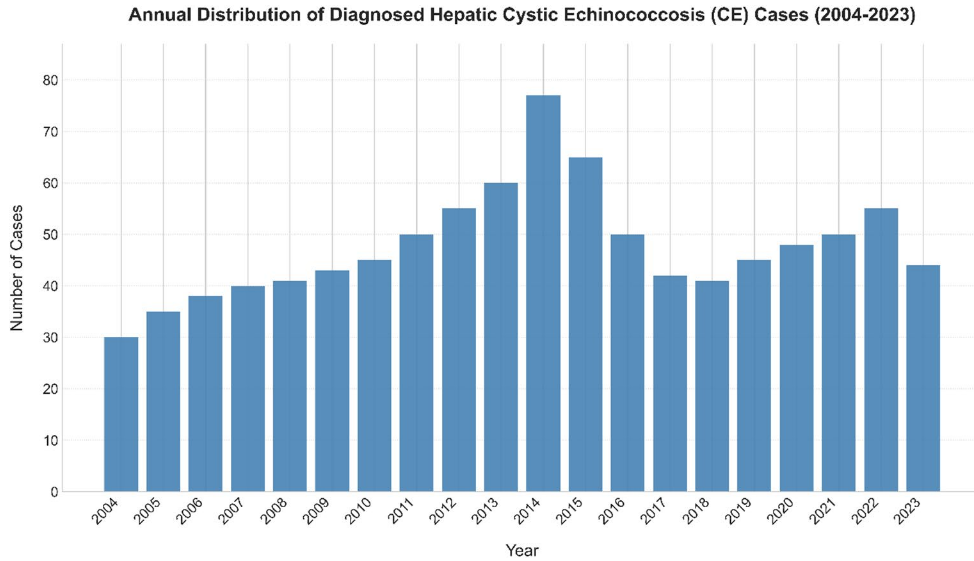

Fig. 2 Annual distribution of diagnosed hepatic cystic echinococcosis (CE) cases

Table 1 Demographic characteristics of patients with cystic echinococcosis (CE) cysts

Characteristic	Frequency (n)	Percentage (%)
Age (years, median, IQR)	35 (2–100)	
Age Group		
0–20 years	96	11.50
21–40 years	402	48.14
41–60 years	258	30.90
61–80 years	75	8.98
81–100 years	4	0.48
Sex		
Male	280	33.53
Female	555	66.47
Diagnosed Cases per Year		
Mean ± SD	44 ± 5.88	
Median (IQR)	41 (35–56)	

Note: The annual case counts are detailed in Supplementary Table S1

Table 3 Radiological findings suggestive of complications in hepatic cystic echinococcosis (CE) cysts

Complication	Frequency (n)	Percentage (%)
No Effect	233	27.90
Mass Effect	316	37.84
Exophytic Growth	122	14.61
Intrahepatic Duct Dilatation	48	5.75
Vascular Compression	39	4.67
Intra-biliary Rupture	35	4.19
Infection/Abscess	25	2.99
Intraperitoneal Rupture	12	1.44
Extrahepatic Duct Dilatation	8	0.96

Note: Percentages sum to >100% as patients may have multiple radiological findings suggestive of complications. The total number of patients with at least one of these findings was 602 (72.10%). Clinically significant complications such as total cyst rupture (intrabiliary and intraperitoneal) occurred in 47 patients (5.63%)

Table 2 Computed tomography patterns of hepatic cystic echinococcosis (CE) cysts

Radiological Pattern	Frequency (n)	Percentage (%)
Cyst Type		
Solitary	563	67.43
Multiple	272	32.57
Total Cysts Recorded	1,669	
Cyst Size (mm, mean ± SD)	71.82 ± 85.28	
Location in Liver		
Right Lobe	418	50.06
Both Lobes	219	26.23
Left Lobe	198	23.71
Number of Liver Segments		
Single Segment	324	38.80
Multiple Segments	511	61.20
Liver Segments		
Segment I	51	6.11
Segment II	168	20.12
Segment III	180	21.56
Segment IV	255	30.54
Segment V	217	26.03
Segment VI	325	38.92
Segment VII	391	46.83
Segment VIII	296	35.45
WHO IWGE Classification		
CE1	322	38.56
CE3	284	34.02
CE2	96	11.50
CE5	68	8.14
CE4	65	7.78

Note: Percentages for CE cyst type and WHO classification are based on total patients (n = 835). Percentages for segments are based on patients with involvement in those segments and can sum up to >100% owing to multiple segment involvement per patient

4 Discussion

This study aimed to elucidate the prevalence, radiological patterns, and CT-detected complications of hepatic CE cysts in Yemen and to compare them with findings from endemic regions globally and locally within Yemen. The findings of this study provide valuable insights into the burden and patterns of CE and highlight the critical need for targeted public health intervention.

The estimated annual incidence of hepatic CE cysts in Sana'a, Yemen, was approximately 44 cases per year over 19 years, which was significantly higher than the rates reported in Iraq (14 cases per year), Oman (0.41 cases/year), Saudi Arabia (1 case per year), and Jordan (13 cases per year) [8–11]. This high incidence underscores the persistence of CE as a public health challenge in Yemen, likely driven by poor socioeconomic conditions, inadequate sanitation, and close interactions with livestock and dogs [12].

Studies in Yemen have reported prevalence rates of 2.87% in humans and 0.7% in livestock, with the liver being the most commonly affected organ [3, 13]. These findings align with global patterns in which CE is endemic in temperate zones, including the Mediterranean, Central Asia, and parts of South America and Africa, with some regions reporting prevalence rates as high as 1583/100,000 individuals [14, 15].

The gender and age disparities observed here reflect global trends in CE. Females were disproportionately affected, with a female-to-male ratio of 2:1, similar to findings in Iraq (1.7:1), but higher than regional reports from Jordan and Saudi Arabia [8, 10, 11]. The mean age at diagnosis was 35 years, and the highest incidence was observed in the 21–40-year age group. This finding aligns with global patterns, in which CE is most common among young and middle-aged adults due to prolonged exposure and delayed symptom manifestation [16, 17].

The increased risk to women in rural Yemen may stem from higher exposure to domestic animals and zoonotic parasite transmission through contaminated water and inadequately washed vegetables [18]. Farmers and individuals involved in agricultural activities are particularly vulnerable to frequent contact with definitive hosts such as dogs and livestock [19]. Socioeconomic factors and occupational exposure have also been highlighted as critical risk factors for CE [20, 21].

This study identified 1,669 cysts in 835 patients, with solitary cysts being the most common. These findings are consistent with those of Ali et al. (2017) [11] and Gharbi et al. (1981) [22], who emphasized the predilection for single lesions. The average cyst size (71.82 mm and predominance in the right liver lobe, particularly segment VII, agree with previous research linking these characteristics to the liver vascular anatomy and parasite lifecycle [23, 24]. Multiple liver segments were also noted, reflecting disease progression and a delayed diagnosis.

Although ultrasonography (US) is established as the primary diagnostic and screening modality for CE [6, 7], computed tomography (CT) provides crucial additional information in specific clinical scenarios. CT is particularly valuable for delineating complex cyst morphology, detecting calcifications, assessing vascular and biliary relationships, and identifying complications such as rupture or secondary infection, especially prior to surgical interventions [6, 25, 26]. Findings such as daughter cysts and extensive calcification on CT are highly suggestive of CE. Although US is more accessible and cost-effective for initial assessment, detailed cross-sectional CT imaging is indispensable for intricate cases and comprehensive preoperative evaluation [27, 28].

The World Health Organization (WHO) classification of CE cysts showed that CE1 (38%) and CE3 (34%) stages were the most common, indicating a mix of early and transitional cysts. This is consistent with findings from other endemic regions, where the CE1 and CE3 stages are predominant because of active transmission dynamics [29]. Factors such as longer disease duration and the host immune response contribute to the progression of cysts to calcified or inactive stages [30, 31].

The mass effect was the most common CT finding suggestive of a complication, affecting 38% of patients, similar to the findings of Dziri et al. (2001) [32]. Other CT-detected complications included intrahepatic duct dilatation, vascular compression, and cyst rupture of the biliary tree (4%) and peritoneum (1.4%). These rates for CT-detected ruptures align with global estimates of rupture frequency (20–50%) and underscore the importance of timely intervention to prevent severe outcomes [23, 33].

The infection rate of 3% in this study is comparable to previous findings of secondary bacterial infection in 5–8% of cases [34]. Intrabiliary rupture is a serious complication associated with increased morbidity and requires advanced imaging techniques such as magnetic resonance cholangiopancreatography (MRCP) for accurate diagnosis and management [35]. Globally, the risks of recurrence and postoperative complications underscore the need for comprehensive management [36, 37].

The peak incidence of CE in 2014, followed by stabilization in subsequent years, reflects improvements in diagnostic capacity and awareness. However, the steady incidence highlights the need for sustained control efforts, such as national education programs and interventions targeting livestock management and dog deworming [38]. Public health strategies in Yemen are critical, and should focus on a one-health approach. This includes interrupting the parasite life cycle through regular deworming of dogs (definitive hosts), proper disposal of livestock offal (to prevent infection of intermediate hosts), and inspection of meat. Crucially, community education on improving personal hygiene (e.g., handwashing), thoroughly washing vegetables, ensuring safe drinking water sources, and reducing close contact with potentially infected dogs and their feces is paramount. Addressing these risk factors, as emphasized in other endemic regions [39, 40], is crucial.

Effective control measures, including regular deworming of dogs, proper disposal of livestock offal, and public health education, have been successful in reducing transmission in endemic regions, such as China and Argentina [41]. Vaccination programs targeting intermediate hosts and collaborative efforts between the veterinary and public health sectors have shown promising results in interrupting the parasite life cycle [42, 43].

In Yemen, community education should focus on improving hygiene practices such as thoroughly washing vegetables and reducing contact with infected animals. Establishing a national registry of CE cases would enhance surveillance and enable targeted intervention. While US remains the cornerstone for initial diagnosis and screening for CE, for patients who undergo CT for further evaluation (e.g., complex cases, preoperative planning), the adoption of standardized CT acquisition and reporting protocols across healthcare facilities could improve diagnostic consistency, data comparability for surveillance, and ultimately, management outcomes.

The strengths of this study include the large sample size, long study period, and detailed radiological analysis using CT imaging. However, the retrospective study design may have introduced selection and information bias. The single-center design limits generalizability and the absence of clinical follow-up data limits the assessment of treatment outcomes. Furthermore, data on specific patient origins (rural vs. urban) and detailed clinical symptomatology at the time of CT were not consistently available from the retrospective review of imaging reports, thus limiting deeper epidemiological correlations. Additionally, the study did not include data on treatment modalities or outcomes, as this was beyond the scope of the CT report analysis. Future studies should incorporate multicenter prospective studies to address these limitations and explore the socioeconomic and environmental factors that contribute to CE in Yemen.

5 Conclusion

Our study demonstrated that hepatic CE cysts are a significant health concern in Yemen, with a notably higher prevalence than that in other endemic regions. The most commonly affected demographic group included young women, who often presented with large solitary cysts predominantly located in the right hepatic lobe. CT is valuable for detailed assessment of complex CE cysts and for preoperative planning. These findings emphasize the need for improved public health awareness, targeted interventions, and improved diagnostic practices to mitigate the transmission and impact of CE. Establishing a national registry for CE and investing in further research are critical for understanding and controlling this disease. Ultimately, coordinated efforts in prevention, education, and healthcare resource allocation are imperative to reducing the burden of CE in Yemen.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s44197-025-00429-3.

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Author Contributions MMA-S conceived of the study, designed the protocol, participated in data interpretation, and drafted the manuscript. YAO participated in data acquisition and drafting of the manuscript. LAS, MA-H, and MA-A participated in data acquisition and radiological review. HMJ supervised the project, participated in study design and data interpretation, and critically revised the manuscript. All authors have read and approved the final manuscript.

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Data Availability The datasets generated and/or analyzed during the current study are not publicly available because of patient privacy restrictions but are available from the corresponding author (Haitham M. Jowah, h.jowah@su.edu.ye) upon reasonable request.

Declarations

Ethical Approval and Consent to Participate This study was approved by the Institutional Review Board of Al-Thawra Modern General Hospital in Yemen (approval no. TMGH/2023/014). This study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki. The requirement for informed consent was waived by the Institutional Review Board of the Al-Thawra Modern General Hospital owing to the retrospective nature of the study and the use of anonymized data. Patient confidentiality was maintained throughout the study.

Consent for Publication Not applicable. This manuscript does not contain any individual data (including details, images, or videos) that require specific consent for publication.

Competing Interests The authors declare no competing interests.

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