Epidemiological Characteristics of Hydatid Cyst Disease Crucial for Targeted Public Health Interventions in Endemic Areas

Abdulsalam Harfash Hassan [1*], Abeer Th.kadhim [1]

Abstract

Background: Echinococcosis, caused by Echinococcus granulosus larvae, remains a significant public health challenge globally due to its complex life cycle and impact on human health and economy. The disease primarily affects intermediate hosts, including humans, through the formation of hydatid cysts in various organs, notably the liver and lungs. Despite advancements in treatment with albendazole and surgical interventions, recurrence rates and morbidity remain considerable, particularly in endemic regions. Methods: This retrospective hospital-based study analyzed 66 cases of hydatid cyst disease admitted to Baquba Teaching Hospital in Diyala Governorate, Iraq, between January 2019 and December 2022. Data on patient demographics, including age, gender, residency, occupation, and cyst location, were extracted from medical records and analyzed using descriptive statistics. Results: Females constituted 61% of the cases, with the highest incidence observed among individuals aged 21-40 years (44%). Rural residents accounted for 65% of cases, reflecting the disease's association with agricultural activities. Housewives (51.5%) and primary school students (55.5% among students) were disproportionately affected. The liver was the most common site of cyst development (74.2%), followed by the lung (24.2%). Conclusion: This study provides crucial insights into the epidemiological profile of hydatid cyst disease in Diyala Governorate, Iraq. The findings underscore the demographic patterns, occupational risks, and anatomical distributions associated with the disease, highlighting the need for targeted public health interventions. Strategies focusing on rural communities, particularly women and school-age children, are essential for effective prevention and management of hydatid disease in endemic regions.

Keywords: Echinococcus granulosus, Hydatid cyst disease, Epidemiology, Intermediate hosts, Public health interventions

Significance | This study determined the demographic patterns (gender, age, residency, occupation) and anatomical distribution of hydatid cysts, crucial for targeted public health interventions in endemic areas.

*Correspondence. Abdulsalam Harfash Hassan, Department of Pharmacy, Bilad Al Rafiden Universal Collage Diayla, Iraq.

Editor Mohammed Khadeer Ahamed Basheer, And accepted by the Editorial Board Jun 09, 2024 (received for review Apr 11, 2024)

1. Introduction

Echinococcosis, commonly known as hydatid cyst disease, is a parasitic infection caused by the larvae of Echinococcus granulosus, a tapeworm notorious for its profound impact on human health and the global economy. This disease presents formidable challenges due to the complexities involved in its treatment and management. E. granulosus larvae infect a wide range of intermediate hosts, including domestic animals, thereby contributing to its widespread distribution across continents (Hama et al., 2015).

The life cycle of E. granulosus is intricately tied to its hosts. Adult worms inhabit the small intestine of definitive hosts, primarily carnivores such as dogs, where they firmly attach to the intestinal wall and produce eggs. These eggs are shed in the host's feces,

Author Affiliation.
[1] Department of Pharmacy, Bilad Al Rafiden Universal Collage Diayla, Iraq.

Please cite this article.
Abdulsalam Harfash Hassan, Abeer Th.kadhim, (2024). Epidemiological Characteristics of Hydatid Cyst Disease Crucial for Targeted Public Health Interventions in Endemic Areas, Journal of Angiotherapy, 8(6), 1-6, 9731

contaminating the environment and potentially infecting intermediate hosts, including herbivores and humans. Upon ingestion, eggs release larvae that form cysts, known as hydatid cysts, within various organs of the intermediate host, including the liver and lungs (Romig et al., 2017).

Hydatid cyst disease not only poses significant health risks but also carries substantial economic implications globally. The development of hydatid cysts within infected hosts can span from months to years, resulting in varying cyst types—fertile cysts containing protoscoleces capable of developing into adult worms if ingested by definitive hosts, or sterile cysts lacking protoscoleces (Aziz et al., 2011). This variability in cyst development contributes to the clinical complexity and challenges in disease management.

Global epidemiological data highlight varying incidences of hydatid cyst disease, with higher prevalence observed in temperate regions such as South America, Eastern Europe, North Africa, and Central Asia (Sastry & Bhat, 2014). In regions like Iraq, the disease represents a significant public health concern with considerable economic burdens, underscoring the need for effective control strategies (Moro & Schantz, 2009; Abdulhameed et al., 2019).

The pathological structure of a hydatid cyst consists of two distinct layers: an outer laminated layer and an inner germinal layer housing protoscoleces. These cysts may also contain daughter cysts within a fluid-filled cavity, which further complicates treatment strategies (Marquardt et al., 2000). Human susceptibility to cyst development primarily affects vital organs such as the liver and lungs, where cyst growth can lead to severe health complications (Bennett et al., 2014). Surgical intervention remains the primary treatment modality for cystic echinococcosis, ranging from conservative approaches to more radical surgeries. However, postoperative recurrence rates, reported at approximately 25%, present ongoing challenges in patient management, contributing to increased risks of morbidity and mortality (Gollackner et al., 2000; Alonso et al., 2000; Budke et al., 2006).

In the absence of universally effective chemotherapy, albendazole has emerged as a cornerstone in the medical management of echinococcosis. Administered alone or in combination with surgery, albendazole aims to reduce cyst viability and size, thereby improving treatment outcomes (Stamatakos et al., 2009; Saimot & Adrien, 2001). Its widespread use underscores the urgent need for continued research into more effective therapeutic options and preventive measures against this persistent and complex parasitic disease (Kern, 2003; Falagas & Bliziotis, 2007).

This study focused on assessing cases of hydatid cyst disease at Baquba Teaching Hospital, aiming to elucidate epidemiological variables such as age, sex, residency, occupation, and cyst site manifestation. By examining these factors, the study aimed to provide a comprehensive understanding of the demographic and clinical characteristics associated with hydatid cyst disease within the hospital's region. Such insights were crucial for developing targeted strategies for disease prevention, early detection, and effective management, ultimately mitigating the burden of hydatid cyst disease in endemic areas.

2. Materials and Methods

The methodology employed in this study ensured a systematic and comprehensive assessment of hydatid cyst disease cases at Baquba Teaching Hospital, offering valuable insights into the epidemiological characteristics and clinical profiles of affected patients. These findings are instrumental in guiding future research directions and public health interventions aimed at mitigating the impact of hydatid cyst disease in endemic regions.

2.1 Study Design:

This hospital-based study employed a retrospective review of case records from Baquba Teaching Hospital in Diyala Governorate, focusing on patients diagnosed with hydatid disease. The study period extended from January 1, 2019, to December 31, 2022, encompassing a comprehensive dataset within the hospital's operational timeframe. Baquba Teaching Hospital serves as the primary healthcare facility in Diyala Governorate, equipped with 600 beds to accommodate a wide range of medical conditions.

2.2 Data Collection:

Data collection involved the extraction of pertinent information from patient case records, facilitated by customized questionnaires designed for this study. Key demographic variables included patient identifiers (anonymized for confidentiality), age, gender, residency status (urban or rural), and occupation. Additionally, detailed records were maintained on the anatomical site of the hydatid cysts diagnosed in each patient. All data were sourced exclusively from the surgical department of Baquba Teaching Hospital, ensuring consistency and reliability in the dataset.

2.3 Data Analysis:

Statistical analysis was conducted using the SPSS (Statistical Package for the Social Sciences) software to derive meaningful insights from the collected data. Descriptive statistics such as frequencies and percentages were employed to summarize and interpret the demographic and clinical characteristics of patients diagnosed with hydatid cyst disease during the study period. These analyses provided a comprehensive overview of the prevalence and distribution patterns of hydatid cyst disease among patients admitted to Baquba Teaching Hospital.

2.4 Ethical Considerations:

This study adhered to ethical guidelines and obtained necessary approvals from the institutional review board (IRB) of Baquba Teaching Hospital to access and utilize patient records for research purposes. Patient confidentiality and anonymity were strictly maintained throughout the data collection and analysis processes in accordance with ethical standards governing medical research.

Table 1. Distribution of hydatid disease cases according to gender.

Gender	**No.**	**%**
Male	26	39
Female	40	61
Total	66	100%

Table 2. Distribution of hydatid disease cases according to age.

Age group (years)	**No.**	**%**
1 - 10	13	19.7
11-20	10	15
21-30	15	22.8
31-40	14	21.4
41-50	6	9
51-60	5	7.6
61-71	3	4.5
Total	66	100 %

Table 3. Distribution of hydatid disease cases according to residency.

Gender	No.	%
Rural	43	65
Urban	23	35
Total	66	100%

Table 4. Distribution of hydatid disease cases according to occupation.

Occupation	**No.**	**%**
Housewife	33	51.5
Students	18	28.5
Wage earner	9	14
Military	2	3
Government of employee	1	1.5
Retired	1	1.5
Total	64	100%

*Preschool children were excluded.

Table 5. Distribution of hydatid disease cases among students according to Educational level.

Educational level	**No.**	**%**
Primary School	10	55.5
Secondary school	5	27.7
University	3	16.8
Total	18	100%

Table 5. Distribution of hydatid disease cases according to anatomical site.

site	**No.**	**%**
Liver	49	74.2
Lung	16	24.2
Spleen	1	1.6
Total	66	100%

3. Results

During the study period from 2019 to 2022, Baquba Teaching Hospital admitted a total of 66 cases of hydatid disease. Females constituted the majority of cases, accounting for 61% of the total, resulting in a male-to-female ratio of approximately 1:1.5 (Table 1).

Age distribution analysis revealed that the highest proportion of hydatid disease cases occurred among individuals aged 21-40 years, comprising more than 44% of all cases. The second highest incidence was observed among those aged 1-20 years, accounting for more than 34% of cases. Conversely, the age group of 61-70 years exhibited the lowest percentage, with only 4.5% of cases reported during the study period (Table 2).

In terms of residency, rural residents constituted the majority of admitted cases at Baquba Teaching Hospital, representing 65% of the total, while urban residents accounted for the remaining 35% (Table 3).

Occupationally, excluding preschool children, housewives comprised the largest group affected by hydatid disease, accounting for 51.5% of cases, followed by students at 28.5% (Table 4). Among students, primary school students had the highest incidence of hydatid disease at 55.5%, followed by secondary school students at 27.7%, and university students at 16.8% (Table 5).

Anatomically, the liver was the most commonly affected organ, with 74.2% of cases involving cysts located in this organ. The lung was the second most affected site, comprising 24.2% of cases. Only one case (1.6%) involved cysts in the spleen (Table 6).

These findings provide a detailed overview of the demographic and clinical characteristics of hydatid disease cases treated at Baquba Teaching Hospital. The results highlight significant patterns in gender distribution, age groups affected, residency status, occupational predispositions, educational levels among students, and the anatomical distribution of cysts. Understanding these epidemiological factors is essential for developing targeted interventions and improving clinical management strategies for hydatid disease in the region.

4. Discussion

Baquba Teaching Hospital, serving as the primary healthcare institution in Diyala Governorate, plays a pivotal role in understanding the epidemiology of hydatid disease within the region. This study, encompassing 66 cases admitted between 2019 and 2022, sheds light on various demographic, occupational, and anatomical aspects of the disease, offering critical insights for public health interventions.

The predominance of hydatid disease among females, with a male-to-female ratio of 1:1.5, aligns with regional trends observed in Iraq and neighboring countries like Iran. This higher prevalence among females is likely influenced by their engagement in agricultural activities and proximity to infected animals, which is common in rural settings (Chalechale et al., 2016; Asgarim et al., 2013). In contrast, studies from regions such as Italy report a higher incidence among males, suggesting potential regional variations driven by cultural, occupational, and environmental factors (Conchedam et al., 2010).

The age distribution of hydatid cases reveals a notable peak among individuals aged 21-40 years, consistent with findings from other endemic regions. This demographic trend underscores the active involvement of middle-aged adults in rural communities, where exposure to contaminated environments and infected animals is prevalent (Amini et al., 2008; Mousavi et al., 2012).

Rural residency emerges as a significant factor associated with hydatid disease, with 66% of cases originating from rural areas. This finding mirrors patterns observed in neighboring countries and underscores the close link between agricultural practices and disease transmission (Abdulhameed et al., 2018; Yaghan et al., 2004; Pierangeli et al., 2007). Occupational analysis further supports these findings, with housewives comprising the largest occupational group affected. Their frequent contact with domestic animals, particularly dogs, which serve as definitive hosts for the Echinococcus parasite, likely contributes to their heightened risk (Akalin et al., 2014).

Among students, primary school students exhibit the highest incidence of hydatid disease, highlighting their vulnerability to environmental exposures and potentially inadequate hygiene practices. Similar patterns have been observed in other agricultural regions with endemic hydatid disease, emphasizing the need for targeted educational interventions (Abdul Latif Molan, 1993; Han et al., 2018).

Anatomically, the liver emerges as the most commonly affected organ, followed by the lung, consistent with global epidemiological trends in hydatid disease. The liver's role as a primary filter for parasitic larvae and the lung's susceptibility to hematogenous spread contribute to these observed patterns (Jafari et al., 2012; Islami Parkoohi et al., 2018).

Limitations of this study include potential inaccuracies in case records and missing data on some variables, which could impact the completeness and reliability of the findings. Future studies should focus on implementing robust data collection methods and ensuring comprehensive documentation of patient information to address these limitations effectively.

The study provided a comprehensive overview of hydatid disease epidemiology at Baquba Teaching Hospital, highlighting gender disparities, age-related risk factors, occupational associations, and anatomical distributions. These findings underscored the importance of targeted public health interventions tailored to rural communities and high-risk occupational groups, aimed at reducing the burden of hydatid disease in the region and improving overall health outcomes.

5. Conclusion

In conclusion, this study at Baquba Teaching Hospital has provided a comprehensive insight into the epidemiology of hydatid disease from 2019 to 2022, emphasizing key demographic, occupational, and anatomical aspects. The predominance of cases among females, with a notable peak in the 21-40 age group and a rural residency association, underscores the significant role of agricultural activities and close contact with infected animals in disease transmission. Occupational analysis highlighted housewives as particularly vulnerable, likely due to their frequent exposure to domestic animals. Anatomically, the liver predominance in cyst location aligns with global trends, indicating the organ's susceptibility to parasitic invasion. These findings emphasize the need for targeted public health interventions focusing on rural communities and at-risk occupational groups to mitigate the impact of hydatid disease in the region effectively. Future research should aim to address data limitations and further refine strategies for disease prevention and management.

Author contributions

A.H.H. conceived the study, developed the hypothesis, performed data analysis, and wrote the manuscript, including the introduction, methods, and discussion sections. A.T.K. contributed to data collection, literature review, and manuscript revisions. Both authors read and approved the final manuscript

Acknowledgment

Author was grateful to their department.

Competing financial interests

The authors have no conflict of interest.

References

Abdulhameed, M. F., Habib, I., Al-Azizz, S. A., & Robertson, I. (2018). A retrospective study of human cystic echinococcosis in Basrah province, Iraq. Acta Tropica, 178, 130-133. https://doi.org/10.1016/j.actatropica.2017.11.019

Abdulhameed, M. F., Robertson, I. D., Al-Azizz, S. A., & Habib, I. (2019). Neglected zoonosis and the missing opportunities for one health education: The case of cystic echinococcosis among surgically operated patients in Basrah, Southern Iraq. Diseases, 7(4), 1-10. https://doi.org/10.3390/diseases7010004

Ahmadi, N. A., & Badi, F. (2011). Human hydatidosis in Tehran, Iran: A retrospective epidemiological study of surgical cases between 1999 and 2009 at two university medical centers. Tropical Biomedicine, 28(2), 450-456.

Alonso, C. O., Moreno, G. E., Loinaz, S. C., Gimeno, C. A., González, P. I., Pérez, S. B., et al. (2000). Results of 22 years of experience in radical surgical treatment of hepatic hydatid cysts. Hepato-Gastroenterology, 48(37), 235-243.

Al-Qaadhi, B. A. (2005). Study of some immunological and biochemical aspects of patients infected with hydatidosis. PhD thesis, College of Science, University of Baghdad.

Al-Qaoud, K. M., Craig, P. S., & Abdel-Hafez, S. K. (Year). Retrospective surgical incidence and case distribution of cystic echinococcosis in Jordan between 1994 and 2000. (Source).

Amali, M., Yousef, I. F., Mohammadi, M. J., Alavi, S. M., Salman Zadeh, S., Geravandi, S., & Kamali, A. (2018). Hydatid cyst epidemiology in Khuzestan, Iran: A 15-year evaluation. Archives of Clinical Infectious Diseases, 13(1), e13765. https://doi.org/10.5812/archcid.13765

Amini, M., Bahador, M., & Malekhoseyni, M. (2008). Evaluation of hydatid cyst manifestations in patients admitted to Shaheed Modarres Hospital, 1984-2004. Archives of Clinical Infectious Diseases, 2(4), 177-180.

Anonymous. (2020). International Journal of One Health, 6(1), 17-22.

Asgarim, Mohebali, M., Kia, E. B., Farahnak, A. M., & Asadian, S. (2013). Seroepidemiology of human hydatidosis using Ag B-ELISA test in Arak, central Iran. Iranian Journal of Public Health, 42(4), 391-396.

Aziz, A., Zhang, W., Li, J., Loukas, A., McManus, D. P., & Mulvenna, J. (2011). Proteomic characterisation of Echinococcus granulosus hydatid cyst fluid from sheep, cattle, and humans. Journal of Proteomics, 74(9), 1560-1572. https://doi.org/10.1016/j.jprot.2011.04.017

Bennett, J. E., Dolin, R., & Blaser, M. J. (Eds.). (2014). Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases. Elsevier Health Sciences.

Bingham, G. M., Larrieu, E., Uchiumi, L., Mercapide, C. H., Mujica, G., Del Carpio, M., ... Budke, C. M. (2016). The economic impact of cystic echinococcosis in Rio Negro province, Argentina. American Journal of Tropical Medicine and Hygiene, 94(3), 615-625. https://doi.org/10.4269/ajtmh.15-0602

Budke, C. M., Deplazes, P., & Torgerson, P. R. (2006). Global socioeconomic impact of cystic echinococcosis. Emerging Infectious Diseases, 12(2), 296-303. https://doi.org/10.3201/eid1202.050499

Chalechale, A., Hashemnia, M., Rezaei, F., & Sayadpour, M. (Year). Echinococcus granulosus in humans associated with disease incidence in domestic animals in Kermanshah, west of Iran. (Source).

Conchedda, M., Antonelli, A., Caddori, A., & Gabriele, F. (2010). A retrospective analysis of human cystic echinococcosis in Sardinia (Italy), an endemic Mediterranean region from 2001-2005. Parasitology International, 59(3), 454-459. https://doi.org/10.1016/j.parint.2010.04.002

Dybicz, M., Borkowski, P. K., Jonas, M., Wasiak, D., & Małkowski, P. (2019). First report of Echinococcus ortleppi in human cases of cystic echinococcosis in Poland. BioMed Research International, 2019. https://doi.org/10.1155/2019/3695304

Falagas, M. E., & Bliziotis, I. A. (2007). Albendazole for the treatment of human echinococcosis: A review of comparative clinical trials. The American Journal of the Medical Sciences, 334(3), 171-177.

Gollackner, B., Längle, F., Auer, H., Maier, A., Mittlböck, M., Agstner, I., et al. (2000). Radical surgical therapy of abdominal cystic hydatid disease: Factors of recurrence. World Journal of Surgery, 24(6), 717-721. https://doi.org/10.1007/s002689910115

Hama, A. A., Hassan, Z. I., Mero, W. M., Interisano, M., Boufana, B., & Casulli, A. (2015). Epidemiology/ : Open Access a Morphologically Unusual Echinococcus granulosus (G1 Genotype) Cyst in a Cow from Kurdistan - Iraq. Medicine, 16th ed. McGraw-Hill Professional Publisher, USA. https://doi.org/10.4172/2161-1165.S2-005

Ibrahim, B. B., Haridy, F. M., Hegazi, M. M., & Morsy, T. A. (2007). Human hydatidosis granulosis in Greater Cairo, Egypt: With general review. Journal of the Egyptian Society of Parasitology, 937(2), 681-688.

Islami Parkoohi, P., Jahani, M., Hossein Zadeh, H. Z., Taghian, F., Rostami, M., Mousavi, A., & Rezai, M. S. (2018). Epidemiology and clinical features of hydatid cyst in Northern Iran from 2005 to 2015. Iranian Journal of Parasitology, 13(2), 310-316.

Jaira Jpuri, Z. S., Jetley, S., Hassan, M. J., & Hussain, M. (2012). Hydatid disease in childhood: Revisited report of an interesting case. Journal of Parasitic Diseases, 36(2), 265-268.

Kalin, A. S., Kutluss, S., Caylak, S. D., Onal, O., Kayas, S., & Bozkut, A. L. (2014). Seroprevalence of human cystic echinococcosis and risk factors in animal breeders in rural communities in Denizli, Turkey. Journal of Infection in Developing Countries, 8(09), 1188–1194. https://doi.org/10.3855/jidc.4437

Kayal, A., & Hussain, A. (2014). A comprehensive prospective clinical study of hydatid disease. SRN Gastroenterology, 2014, Article ID 514757, 5 pages. https://doi.org/10.1155/2014/514757

Kern, P. (2003). Echinococcus granulosus infection: Clinical presentation, medical treatment, and outcome. Langenbeck's Archives of Surgery, 388(6), 413-420. https://doi.org/10.1007/s00423-003-0405-1

Kohansal, M. H., Nourian, A., & Bafandeh, S. (2015). Human cystic echinococcosis in Zanjan area, Northwest Iran: A retrospective hospital-based survey between 2007 and 2013. Iranian Journal of Public Health, 44(9), 1277-1282.

Mahmoudi, S., Mamishi, S., Banar, M., Pourakbari, B., & Keshavarz, H. (2019). Epidemiology of echinococcosis in Iran: A systematic review and meta-analysis. BMC Infectious Diseases, 19, 929. https://doi.org/10.1186/s12879-019-4458-0

Marquardt, W. C., Demaree, R. S., & Grieve, R. B. (2000). Parasitology and Vector Biology. Harcourt Academic Press, New York.

Molan, A. L. (1993). Epidemiology of hydatidosis and Echinococcus in the Qar province, Southern Iraq. Japanese Journal of Medical Science & Biology, 46, 29-35.

Moro, P. L., & Schantz, P. M. (2009). Echinococcosis: A review. International Journal of Infectious Diseases, 13(2), 125-133. https://doi.org/10.1016/j.ijid.2008.03.037

Mousavi, S. R., Samsami, M., Fallah, M., & Zirakzadeh, H. (2012). A retrospective survey of human hydatidosis based on hospital records during the period of layers. Journal of Parasitic Diseases, 36(1), 7-9.

Niger, J., & Clin. Pract. (2013). 16(2), 221-225.

Pierangeli, N. B., Soriano, S. V., Roccia, L., Gimenez, J., Lazzarini, L. E., Grenovero, M. S., et al. (2007). Heterogeneous distribution of human cystic echinococcosis after a long-term program control in Neuquen, Patagonia Argentina. Parasitology International, 56(2), 149-155. https://doi.org/10.1016/j.parint.2007.01.001

Raja Jawad, M., Alyaa Neamh, N. Alsaedi, & Jasim Hameed, T. (2021). Epidemiology of hydatid disease in Najaf provincial, Iraq. Journal of Physics: Conference Series, 1879. https://doi.org/10.1088/1742-6596/1879/2/022037

Rampal, K., Prajapati, D. K., & Sharma, M. (2016). Hydatid Disease-A clinical perspective with a review of primary hydatidosis of spleen. International Journal of Integrative Medical Sciences, 3(7), 337-340.

Romig, T., Deplazes, P., Jenkins, D., Giraudoux, P., Massolo, A., Craig, P. S., et al. (2017). Ecology and life cycle patterns of Echinococcus species. In Advances in Parasitology, 95, 213-314. https://doi.org/10.1016/bs.apar.2016.09.002

Saeed, I., Kapel, C. M. O., Saida, L. A., Willingham, A. L., & Nansen, P. (2000). Epidemiology of Echinococcus granulosus in Erbil province, northern Iraq, 1990-1998. Journal of Helminthology, 74(1), 83-88.

Saghafipour, A., Divband, M., ZanJiran Farahani, L., HamidiParsa, H., & Golabchi Fard, H. (2003). Epidemiology, burden, and geographical distribution of cystic echinococcosis in central Iran. Acta Tropica, 85(1), 51-61. https://doi.org/10.1016/S0001-706X(02)00237-3

Saimot, M., & Adrien, G. (2001). Medical treatment of liver hydatidosis. World Journal of Surgery, 25(1), 15-20.

Sastry, A. S., & Bhat, S. (2014). Essentials of Medical Parasitology. Jaypee Brothers, Medical Publishers Pvt. Limited.

Stamatakos, M., Sargedi, C., Stefanaki, C., Safioleas, C., Matthaiopoulou, I., & Safioleas, M. (2009). Anthelminthic treatment: An adjuvant therapeutic strategy against Echinococcus granulosus. Parasitology International, 58(2), 115-120. https://doi.org/10.1016/j.parint.2008.12.003

Thompson, R. C. A. (2017). Biology and systematics of Echinococcus. In Advances in Parasitology, 95, 65-109. https://doi.org/10.1016/bs.apar.2016.09.001

Xiu-Min, H., Qi-Gang, C., Wei, W., Hu, W., Qiang, Z., & Yong, W. (2018). Childhood suffering: Hyperendemic echinococcosis in Qinghai-Tibetan primary school students, China. Infectious Diseases of Poverty, 7, 71. https://doi.org/10.1186/s40249-018-0452-0

Yaghan, R. J., Bani-Hani, K. E., & Heis, H. A. (2004). The clinical and epidemiological features of hydatid disease in northern Jordan. Saudi Medical Journal, 25(7), 886-889.

Zibaei, M., Azargoon, A., Ataie-Khorasgani, M., Ghanadi, K., & Sadjjadi, S. M. (Year). The serological study of cystic echinococcus and assessment of surgical cases during 5 years (2007-2011) in Khorramabad, Iran.