



Indirect hemagglutination seropositivity and residential distribution in suspected cystic echinococcosis: a tertiary care hospital study

Eurasian Clinical and Analytical Medicine Original Research

Cystic echinococcosis seropositivity

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Abstract

Aim: Cystic echinococcosis (CE) is one of the major zoonotic infections of public health importance in Türkiye. This study aimed to evaluate the distribution of indirect hemagglutination assay (IHA) seropositivity among patients with suspected CE and to investigate its relationship with the Socio-Economic Development Ranking (SEDR) levels of districts in Ankara.

Methods: This study included 2,725 patients who underwent IHA testing for suspected CE between 2024 and 2025. The demographic and geographical distribution of seropositivity and its association with SEDR levels across Ankara districts were analyzed.

Results: Of the 2,725 patients included in the study, 43.2% were male, and the median age was 52 years. The overall IHA seropositivity rate was 11.0% (300/2,725). Seropositivity rates were 10.9% in males and 11.1% in females, with no significant difference between genders ($P = .85$). Seropositivity was lowest in the 0–17 years group (7.3%) and highest in the 18–40 years group (15.5%) ($P < .001$). Among patients residing in Ankara, the IHA seropositivity rate was 9.3%. SEDR rankings were not associated with seropositivity in Ankara ($\rho = 0.038$, $P = .07$).

Conclusion: The observed seropositivity rate of 11.0% is consistent with hospital-based data reported from Türkiye. In this hospital-based cohort, the absence of a significant association between district-level SEDR rankings and IHA seropositivity suggests that CE seropositivity among tested patients cannot be explained solely by socioeconomic development indicators. These findings support the need for a broader evaluation of environmental and epidemiological factors in patients with suspected CE. However, they should not be interpreted as reflecting population-level risk or disease prevalence.

Keywords

echinococcosis, hemagglutination tests, serologic tests, socioeconomic factors, Türkiye

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Introduction

Cystic echinococcosis (CE) is a zoonotic helminth infection that poses a significant threat to both human and animal health and causes substantial economic losses and reduced workforce productivity.¹ The causative agent is the larval stage of *Echinococcus granulosus*, whose adult form inhabits dogs and other carnivores.^{1,2} In its life cycle, dogs serve as the definitive hosts, whereas livestock such as sheep and cattle, as well as humans, act as intermediate hosts.^{1,3} Infection occurs through the fecal-oral ingestion of parasite eggs shed into the environment via dog feces and transmitted through contaminated food, water, or hands.⁴ Following intestinal hatching, oncospheres enter the portal circulation and subsequently form cysts in various organs, predominantly the liver (75%) and lungs (15%).² Molecular studies have demonstrated that the G1 genotype, commonly referred to as the sheep strain, is responsible for the majority of human infections.⁵

CE is widely distributed worldwide and remains a major public health concern, particularly in regions where animal husbandry is common. Globally, the incidence of CE was reported to be approximately 2.6 per 100,000 population between 1990 and 2019, and the number of cases is projected to increase by more than 13% by 2030.⁶ A recent meta-analysis conducted in children reported incidence rates ranging from 0.12 to 17.86 per 1,000 across countries, with a rate of 1.48 per 1,000 children in Türkiye.⁶

Türkiye, together with the Middle East and Central Asia, is considered one of the major endemic regions for *E. granulosus* infection.^{7,8} Community-based ultrasonographic screening studies conducted in Türkiye have reported an abdominal cyst prevalence of approximately 0.6%, indicating that nearly one in every 163 individuals is infected with CE.⁸ In addition, laboratory-based serological studies from different regions have reported seropositivity rates ranging from 2.7% to 54.1%.⁴ Historical data indicate that the Central Anatolia Region accounted for the highest disease burden in Türkiye, representing 38.57% of all reported cases.⁹ These findings highlight the need for updated epidemiological evaluations of CE in large urban centers such as Ankara.

Clinically, CE is characterized by slowly growing cystic lesions and may remain asymptomatic for prolonged periods. Clinical manifestations vary according to the size and anatomical location of the cysts. Hepatic involvement may present with abdominal pain and nausea, whereas pulmonary involvement may result in symptoms such as cough and chest pain.^{4,10}

Due to its broad clinical spectrum, early and accurate diagnosis is of great importance. The diagnosis of CE relies on the combined evaluation of clinical findings, imaging techniques, and serological tests.^{11,12} Abdominal ultrasonography is considered the primary diagnostic modality in both clinical practice and population-based screening programs, while chest radiography is commonly used in cases of suspected pulmonary involvement. Computed tomography and magnetic resonance imaging are reserved for more detailed evaluations when necessary.⁸ Although imaging methods are currently regarded as the diagnostic gold standard, serological tests provide valuable support, particularly in atypical lesions, small cysts, and situations requiring differential diagnosis.^{13,14}

Serological methods used for diagnostic purposes include the indirect hemagglutination assay (IHA), enzyme-linked immunosorbent assay (ELISA), dot-ELISA, and western blot (WB) techniques.^{15,16} Among these, the IHA test is widely utilized because of its ease of application, low cost, and availability in routine diagnostic laboratories. Previous studies have reported that the sensitivity and specificity of the IHA test range from

78.1–90.0% and 93.9–97.5%, respectively.¹⁷ However, the performance of serological tests is influenced by several factors, including cyst stage, cyst localization, cyst number, and the host immune response. Serological sensitivity is higher in active cyst stages and substantially lower in inactive stages.^{13–16} Therefore, serological findings should not be interpreted in isolation but rather in conjunction with imaging results.¹²

Despite the ongoing global and local burden of CE, important gaps remain in the literature due to difficulties in determining the true prevalence of the disease, limitations in reporting systems, and uncertainties regarding the correlation between serological findings and clinical manifestations. Furthermore, contemporary data are needed to clarify the relationship between serological results and demographic and residential characteristics. Therefore, the aim of this study was to evaluate IHA test results in patients with suspected CE who presented to a tertiary care center in Ankara and to analyze the distribution of seropositivity according to demographic characteristics and urban residential areas. The findings are expected to contribute updated epidemiological data on CE in the region and facilitate the interpretation of serological findings within the diagnostic workflow.

Materials and Methods

Study Population

Patients who underwent IHA testing for suspected CE or for the follow-up of a previous CE diagnosis between January 1, 2024, and December 31, 2025, at Ankara Etlik City Hospital were included in the study. Serum samples had been submitted from various hospital departments to the Microbiology Laboratory. Data were retrospectively retrieved from the Laboratory Information Management System (LIMS) and the Hospital Information Management System (HIMS).

Only patients with complete demographic and laboratory data were included. In cases where multiple serum samples were available from the same patient, only the first sample was considered. For patients with both negative and positive results during follow-up, the first sample demonstrating seropositivity was included in the analysis. Patients with incomplete demographic data, unavailable laboratory reports, invalid test results due to technical reasons, or serum samples unsuitable for analysis because of hemolysis, lipemia, or insufficient sample volume were excluded.

This study was a retrospective cross-sectional study.

Serological Analysis

Serological evaluation of CE was performed using a commercial indirect hemagglutination assay (ELI.H.A *Echinococcus*®, ELITech Microbio, Signes, France), which semi-quantitatively detects serum antibodies directed against *E. granulosus*. All tests were performed manually according to the manufacturer's instructions.

The principle of the assay is based on the agglutination of sheep erythrocytes sensitized with *E. granulosus* antigens in the presence of specific antibodies contained in patient sera. When specific antibodies are present, sensitized erythrocytes form a diffuse and irregular lattice pattern across the bottom of the well. In the absence of specific antibodies, erythrocytes sediment as a compact button at the center of the well. The kit also contains non-sensitized erythrocytes to identify potential nonspecific reactions caused by naturally occurring anti-sheep erythrocyte antibodies.

All assays were performed using U-bottom microplates. Serum samples were serially diluted according to the manufacturer's recommendations, and titers ranging from 1:160 to 1:10,240 were evaluated. Positive and negative controls supplied with the kit were included in each run to verify assay performance. Following the addition

of the sensitized erythrocyte suspension, microplates were incubated at room temperature for approximately two hours and subsequently interpreted visually.

A diffuse distribution of erythrocytes with a characteristic lace-like appearance was considered a positive reaction, whereas a compact button-shaped sedimentation pattern was considered negative. According to the manufacturer's recommendations, antibody titers $\geq 1:160$ were interpreted as positive and titers $< 1:160$ as negative. In routine laboratory practice, titers of 1:160 and above were considered indicative of seropositivity. According to the manufacturer, the ELI.H.A Echinococcus assay has a diagnostic sensitivity of 93.0% and a specificity of 94.9%.

Demographic and Geographic Data Analysis

Patient demographic characteristics, including age, gender, and place of residence, were obtained from the HIMS database. Age was categorized into four groups: 0–17, 18–40, 41–64, and ≥ 65 years. IHA seropositivity rates were calculated for each age group and gender.

For geographic analysis, residential addresses of seropositive patients were evaluated and classified at both provincial and district levels. The geographic distribution of seropositive cases throughout Türkiye was examined according to province of residence. A more detailed district-level analysis was performed for patients residing within the borders of Ankara Province.

Districts of Ankara were categorized into six socioeconomic development levels according to the Socio-Economic Development Ranking (SEDR) published by the Republic of Türkiye Ministry of Industry and Technology. This index is based on a comprehensive scoring system incorporating 56 variables across eight dimensions, including demographics, employment, education, health, and quality of life. In the present study, level 1 represented the highest socioeconomic development category, whereas level 6 represented the lowest.¹⁸

Ethical Approval

The study was approved by the Scientific Research Ethics Committee of Ankara Etilik City Hospital [Date: 17.06.2026, Decision No: 521].

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for

Windows, Version 27.0 (IBM Corp., Armonk, New York, United States of America). The distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. Continuous variables not conforming to a normal distribution were presented as medians [interquartile ranges (IQRs)], as appropriate. Categorical variables were expressed as numbers (n) and percentages (%).

Seropositivity rates were reported with 95% confidence intervals (CIs), calculated using the Wilson score method. Comparisons of seropositivity rates across age groups and between sexes were performed using Pearson's chi-square test or Fisher's exact test when appropriate. The relationship between seropositivity rates and socioeconomic development levels was assessed using Spearman's rank correlation analysis. A two-sided *P* value $< .05$ was considered statistically significant.

Reporting Guidelines

This study was reported in accordance with the STROBE guideline.

Results

Demographic Characteristics

A total of 2,725 individuals were included in the study. Of these, 1,176 (43.2%) were male, and 1,549 (56.8%) were female. According to age-group distribution, 259 (9.5%) participants were aged 0–17 years, 594 (21.8%) were aged 18–40 years, 1,256 (46.1%) were aged 41–64 years, and 616 (22.6%) were aged ≥ 65 years.

Table 1. Cystic echinococcosis seropositivity rates by districts of Ankara

District	Positive Cases / Total Cases	Seropositivity Rate [%]	%95 CI
Akyurt	1/18	5.6	1.0–25.8
Altındağ	25/270	9.3	6.4–13.3
Ayaş	2/5	40.0	11.8–76.9
Bala	3/14	21.4	7.6–47.6
Beypazarı	1/15	6.7	1.2–29.8
Çamlıdere	0/8	0.0	0.0–32.4
Çankaya	11/122	9.0	5.1–15.4
Çubuk	7/69	10.1	5.0–19.5
Elmadağ	6/16	37.5	18.5–61.4
Etimesgut	7/82	8.5	4.2–16.6
Evren	0/2	0.0	0.0–65.8
Gölbaşı	2/35	5.7	1.6–18.6
Güdül	1/6	16.7	3.0–56.4
Haymana	2/15	13.3	3.7–37.9
Kahramankazan	0/16	0.0	0.0–19.4
Kalecik	3/16	18.8	6.6–43.0
Keçiören	58/664	8.7	6.8–11.1
Kızılcahamam	0/13	0.0	0.0–22.8
Mamak	17/207	8.2	5.2–12.8
Nallıhan	0/2	0.0	0.0–65.8
Polatlı	3/16	18.8	6.6–43.0
Pursaklar	8/116	6.9	3.5–13.0
Sincan	19/70	27.1	18.1–38.5
Şereflikoçhisar	0/5	0.0	0.0–43.4
Yenimahalle	23/342	6.7	4.5–9.9
Total	199/2144	9.3	8.1–10.6

CI, confidence interval.

Table 1. Demographic characteristics of the study population (n=2725)

Variable	n [%]
Gender	
Male	1176 (43.2)
Female	1549 (56.8)
Age Group (years)	
0–17	259 (9.5)
18–40	594 (21.8)
41–64	1256 (46.1)
≥ 65	616 (22.6)
Place of Residence (Geographical Region)	
Central Anatolia	2377 (87.2)
Black Sea	138 (5.1)
Eastern Anatolia	64 (2.3)
Aegean	51 (1.9)
Marmara	36 (1.3)
Mediterranean	33 (1.2)
Southeastern Anatolia	26 (1.0)
Total	2725 (100.0)

The overall median age was 52 years (IQR: 35–63). The median age was 51 years (IQR: 31–64) among males and 53 years (IQR: 38–63) among females ($P = .01$) (Table 1).

Evaluation of the geographical distribution revealed that 87.2% of all participants resided in the Central Anatolia Region. Of the patients with suspected CE, 2,144 were residents of Ankara, including 900 males and 1,244 females (Table 1).

Overall Seropositivity and Distribution According to Age and Gender

Among the 2,725 patients included in the study, 300 tested positive by IHA, yielding an overall seropositivity rate of 11.0% [95% CI: 9.8%–12.2%].

The IHA seropositivity rate was 10.9% (128/1,176) among males and 11.1% (172/1,549) among females.

No statistically significant association was found between gender and IHA seropositivity ($P = .85$) (Table 1).

When evaluated according to age groups, IHA seropositivity rates were 7.3% (19/259) in the 0–17 years age group, 15.5% (92/594) in the 18–40 years age group, 10.4% (131/1,256) in the 41–64 years age group, and 9.4% (58/616) in the ≥65 years age group. The highest seropositivity rate was observed in the 18–40-year age group, whereas the lowest rate was observed in the 0–17-year age group. A statistically significant association was identified between age group and IHA seropositivity ($P < .001$) (Table 1).

In the gender-stratified analysis, IHA seropositivity among males was 7.3% (11/150) in the 0–17 years age group, 15.3% (40/262) in the 18–40 years age group, 11.1% (54/488) in the 41–64 years age group, and 8.3% (23/276) in the ≥65 years age group. Seropositivity rates differed significantly across age groups among males ($P = .02$).

Among females, the corresponding seropositivity rates were 7.3% (8/109), 15.7% (52/332), 10.0% (77/768), and 10.3% (35/340), respectively. Similarly, significant differences in seropositivity rates were observed across age groups among females ($P = .02$).

Geographic and Urban Distribution

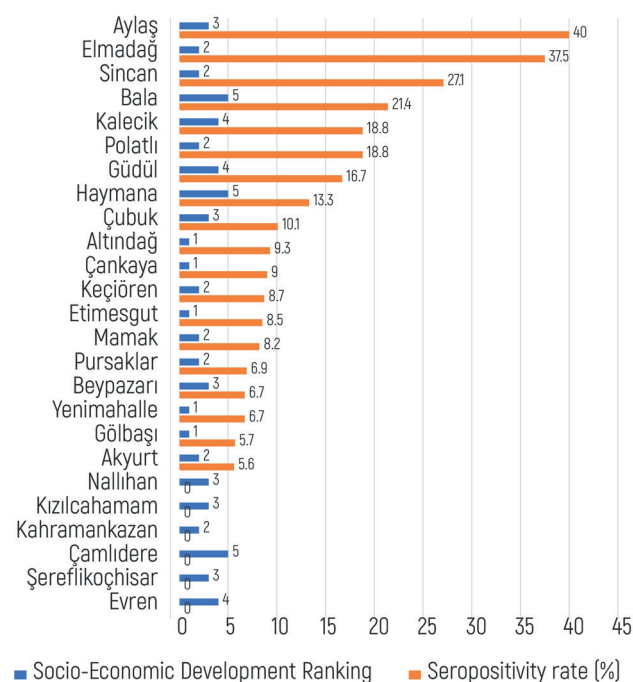


Figure 1. Cystic Echinococcosis Seroprevalence and Socioeconomic Development in Ankara's Districts.

Orange bars represent the IHA seropositivity rates (%), while blue bars indicate the district Socio-Economic Development Ranking (SEDR) categories (Levels 1–6; level 1 = highest and level 6 = lowest socioeconomic development).

Ankara consists of 25 districts. Among the 2,144 patients residing in these districts, IHA seropositivity was detected in 199 cases, corresponding to an overall seropositivity rate of 9.3% [95% CI: 8.1%–10.6%].

District-level analysis demonstrated the highest seropositivity rates in Ayaş (40.0%), Elmadag (37.5%), and Sincan (27.1%), whereas no seropositive cases were detected in Çamlidere, Kahramankazan, Kızılcahamam, Nallıhan, and Şereflikoçhisar (Table 2).

When the distribution of Ankara districts according to the SEDR-2022 classification was examined, most districts were concentrated within socioeconomic development levels 1 to 5, whereas no district was classified as level 6. The potential association between the socioeconomic development levels of Ankara's 25 districts and CE seropositivity rates was evaluated using Spearman's rank correlation analysis. No statistically significant correlation was identified between SEDR level and seropositivity rate (Spearman's rho = 0.038, $P = .07$). Figure 1 illustrates the distribution of CE seropositivity rates across Ankara districts according to their SEDR-2022 socioeconomic development levels.

When the place of residence of patients who underwent IHA testing was evaluated, the majority were found to reside in Ankara ($n = 2,144$, 78.7%). Patients residing outside Ankara accounted for 21.3% ($n = 581$) of the study population. Among the 300 seropositive cases, 66.3% ($n = 199$) were residents of Ankara, whereas 33.7% ($n = 101$) resided in provinces outside Ankara (Figure 2).

When the regional distribution of seropositivity was evaluated, the highest rates were observed in the Southeastern Anatolia (26.9%) and Eastern Anatolia (20.3%) regions, whereas the lowest seropositivity rate was found in the Central Anatolia region (10.2%). Seropositivity rates in the remaining regions ranged from 11.8% to 18.2%. The distribution of seropositive cases and seropositivity rates by geographical region in Türkiye is shown in Figure 3.

Discussion

In the present study, 2,725 patients who underwent IHA testing for



Figure 2. Geographic distribution of IHA seropositivity by province in Türkiye (Seropositive cases/Total tested cases).

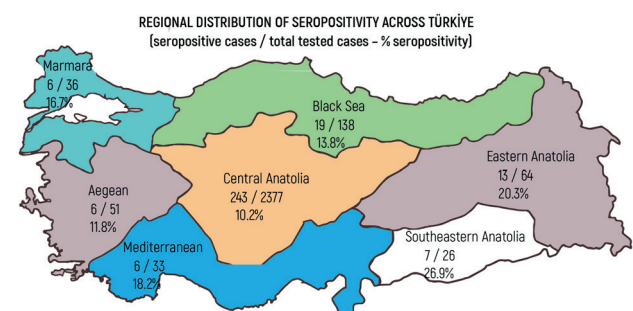


Figure 3. Regional distribution of cystic echinococcosis seropositivity rates in Türkiye.

suspected CE at a tertiary care hospital in Ankara were evaluated, and the overall seropositivity rate was found to be 11.0%. Seropositivity was further analyzed according to age, gender, geographic region, and district-level socioeconomic development characteristics. While similar seropositivity rates were observed in males and females, the highest seropositivity rate was detected in the 18–40 years age group.

In the present study, the relationship between IHA seropositivity for CE and the SEDR classification was evaluated. This classification is based on 56 variables representing eight fundamental dimensions, including demography, employment, education, health, finance, accessibility, innovation capacity, and quality of life.¹⁸ In contrast, the Socio-demographic Index used by Yang et al. comprises only three indicators: income per capita, educational attainment, and total fertility rate among women younger than 25 years. This methodological difference may partly explain why Yang et al. reported an association between sociodemographic development and disease burden at the global level, whereas no significant relationship was observed between district-level SEDR categories and CE seropositivity in our study.⁶ Our findings suggest that the epidemiology of CE cannot be explained solely by socioeconomic indicators and that local factors, such as environmental exposure, livestock farming practices, and other region-specific determinants, may play a more important role in shaping disease distribution.

Globally, the seroprevalence of human CE has been reported to vary considerably across regions. Seroprevalence rates are generally estimated to range between 1% and 3% in Africa, 2% and 6% in Asia, 7% and 11% in the Middle East and Eastern Mediterranean region, 5% and 7% in Latin America, and below 1% in most European countries.^{19–21} In the Eastern Mediterranean region, the pooled seroprevalence has been reported as 74% in the general population and 10.7% among high-risk groups.¹⁹ By contrast, very low prevalence rates have been reported from European countries such as Italy (0.2%) and Slovakia (0.6%).²⁰ The 11.0% seropositivity rate was comparable to rates reported among high-risk populations in the Eastern Mediterranean region.^{19–21} However, such comparisons should be interpreted cautiously because of differences in study populations and methodologies.

Hospital-based studies conducted in Türkiye have reported CE seropositivity rates ranging from 6.9% to 32.0%.^{22,23} The seropositivity rate observed in our study falls within the lower range of these reported values and is generally consistent with previous findings from the country. Regionally, reported seropositivity rates range from 6.9% to 32.0% in the Aegean region,^{22,23} 15.5% to 19.9% in the Marmara region,^{24,25} and 15.0% to 21.6% in the Central Anatolia region.^{26–28} Rates reported from Eastern Anatolia range between 9.5% and 22.5%,^{29,30} whereas values between 15.2% and 28.7% have been reported from Southeastern Anatolia.^{4,31,32}

The overall seropositivity rate identified in the present study was lower than many of the rates reported from Southeastern Anatolia and Central Anatolia and was close to the lower end of the range reported for Eastern Anatolia.^{4,22,29} Nevertheless, the highest seropositivity rates in our cohort were observed among patients residing in Southeastern and Eastern Anatolia. Although the retrospective design of the study prevented the evaluation of individual risk factors such as livestock farming, contact with infected dogs, rural living conditions, and slaughtering practices, these findings are consistent with previous reports identifying these regions as areas with a higher burden of CE.

The studies included in the literature have used various serological techniques, including IHA, ELISA, indirect fluorescent antibody testing, WB, and rapid immunochromatographic assays.^{4,22,27,29} ELISA

and WB methods are generally considered more sensitive than IHA. Indeed, the highest seropositivity rate reported in Türkiye (32.0%) was obtained using ELISA in a study conducted in Aydın.²³ Therefore, direct comparison of seropositivity rates obtained using different serological methods should be approached with caution.

Differences among studies are not limited to diagnostic techniques. Study populations and sampling strategies may also substantially affect reported seropositivity rates. While some investigations included only clinically suspected patients, others were conducted in specific risk groups or as community-based screening programs.

In our study, CE seropositivity was highest among individuals aged 18–40 years, whereas no significant gender-related differences were observed. This finding may be related to the prolonged latent course of CE and the increased exposure of economically active adults to environmental and occupational risk factors associated with livestock farming. In a study conducted in Gaziantep between 2015 and 2022, the highest seropositivity rate was reported among individuals older than 50 years (29.3%), followed by the 20–30 years (23.1%) and 30–40 years (22.9%) age groups. Nevertheless, both studies indicate that seropositivity is concentrated in adult age groups, which is consistent with the long incubation and growth period of hydatid cysts. Although female patients constituted the majority of seropositive cases in the study by Özbeklikçi et al.,⁴ the overall evidence suggests that gender alone is not a major determinant of infection risk and should be interpreted together with age and environmental exposure factors.

One of the notable strengths of the present study is the district-level evaluation performed within Ankara. The highest seropositivity rates were observed in Ayaş (40.0%), Elmadağ (37.5%), and Sincan (27.1%), whereas lower rates were detected in central districts such as Çankaya, Yenimahalle, and Keçiören. In addition, district-level socioeconomic development was assessed using the SEDR, a comprehensive index published by the Ministry of Industry and Technology of Türkiye.^{18,33,34} No significant association was identified between SEDR levels and CE seropositivity rates. To our knowledge, no previous study has evaluated human CE seroprevalence together with district-level SEDR classifications in Türkiye, making this one of the novel aspects of the present study.

Previous studies have identified rural residence, livestock farming, dog contact, and uncontrolled slaughtering practices as the principal risk factors for CE.^{22,23} The absence of a significant relationship between socioeconomic development level and seropositivity in our study suggests that CE cannot be explained solely by socioeconomic indicators and that environmental and epidemiological factors may also play important roles.³⁵

Limitations

This study has several limitations. First, its retrospective and single-center design may limit the generalizability of the findings. Furthermore, only patients who underwent testing because of suspected CE were included, and therefore the results cannot be interpreted as representing the true prevalence of CE in the general population.

Another important limitation is the lack of comprehensive clinical and radiological data. Information regarding imaging findings, cyst localization, cyst stage, and individual risk factors such as livestock exposure, dog contact, occupational history, and rural residence was not consistently available and therefore could not be included in the analyses.

In addition, serological evaluation was based solely on the IHA method, and results could not be confirmed using other serological assays such as ELISA or WB. Although the manufacturer reports a sensitivity

of 93.0% and a specificity of 94.9% for the ELI.H.A Echinococcus assay, independent studies have reported sensitivity values ranging from 78.1% to 90.0%.¹⁷ Consequently, the true seropositivity rate may have been slightly underestimated.

Conclusion

The observed seropositivity rate of 11.0% was consistent with previous hospital-based studies from Türkiye. District-level SEDR rankings were not associated with IHA seropositivity, suggesting that environmental and epidemiological factors may play a greater role than socioeconomic development indicators in suspected CE cases. However, these findings should not be interpreted as reflecting population-level risk or prevalence.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments, or comparable ethical standards.

Informed Consent

Not applicable.

Data Availability

The datasets used and/or analyzed during the current study are not publicly available due to patient privacy reasons but are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

Funding

None.

Author Contributions (CRediT Taxonomy)

Conceptualization: C.Ç., E.T.G.

Methodology: C.Ç.

Resources: C.Ç.; E.T.G.

Data curation: E.T.G.

Formal Analysis: C.Ç.; E.T.G.

Investigation: C.Ç.

Writing-original draft: C.Ç.; E.T.G.

Writing-review and editing: C.Ç.; E.T.G.

AI Usage Disclosure

The authors declare that no AI-assisted technologies were used.

Abbreviations

CE: Cystic echinococcosis

CI: Confidence interval

ELISA: Enzyme-linked immunosorbent assay

IBM: International business machines

IHA: Indirect hemagglutination assay

IQR: Interquartile range

SEDR: Socio-economic development ranking

References

- Mathivathani C, Ajaykumar VJ, Bora CAF. Epidemiology and public health significance of hydatidosis: a review. *Curr J Appl Sci Technol*. 2023. doi:10.9734/cjast/2023/v4i254182
- Mobarak A, Abd-Ellah OH, Abuelwafa EA, Barakat A. Update of the diagnosis of zoonotic hydatidosis disease in human. *Egypt J Vet Sci*. Published online November 12, 2025. doi:10.21608/ejvs.2025.425071.3133
- Tautanova A, Kiyan V, Dusmagambetov M, Almysheva T, Dusmagambetova A. Three decades of research on molecular genetic characteristics of *Echinococcus* spp.: a bibliometric study. *Folia Parasitol*. 2026;73:2026.001. doi:10.14411/fp.2026.001
- Özkeklikçi A, Cirit OS. Investigation of the prevalence of cystic echinococcosis in Gaziantep-Türkiye by ELI.H.A Echinococcus ELITech between 2015-2022. *Trakya Univ J Nat Sci*. 2024;25(1):91-96. doi:10.23902/trkjnat.1366489
- Staudacher M, Hotz JF, Ramharter M, Lagler H. Cystic echinococcosis (hydatid disease):

- current insights into epidemiology, diagnosis, therapy, and prophylaxis. *Br Med Bull*. 2026;157(1). doi:10.1093/bmb/ldag008
- Alansari AN, Zaazouee MS, Messaoud M, Mani S, Amine K. Incidence of hydatid disease in children: a systematic review and meta-analysis. *Qatar Med J*. 2025;2025(4):115. doi:10.5339/qmj.2025.115
 - Yang Z, Liu K, Wen B, et al. Changes in the global epidemiological characteristics of cystic echinococcosis over the past 30 years and projections for the next decade: findings from the Global Burden of Disease Study 2019. *J Glob Health*. 2024;14:04056. doi:10.7189/jogh.14.04056
 - Ok ÜZ, Kilimcioğlu AA, Özkol M. Cystic echinococcosis in humans in Turkey. *Mikrobiyol Bul*. 2020;54(3):510-522.
 - Yazar S, Taylan Özkan A, Hökelek M, et al. Türkiye'de 2001-2005 yılları arasında kistik ekinokokkosis. *Türkiye Parazit Derg*. 2008;32(3):208-220.
 - Nasralla HA, Abdalla BA, Abdullah HO, et al. Current perspectives on cystic echinococcosis: a systematic review. *Judi Clin J*. 2025;1(1):12-26.
 - Oussaga J, Et-Tahouri Z, Lmimouni BE, Sbail M, El Mezouari EM, Moutaj R. The contribution of hydatid serology in the diagnosis and monitoring of hydatid cyst in the parasitology and mycology department at the Avicenna Military Hospital of Marrakesh, Morocco. *Int J Med Pharm Sci*. 2022;12(6):10-13. doi:10.31782/ijmps.2022.12601
 - Çiçek C, Güner ET, Kavak RP, Bakır A, Aral M. Correlation between serological tests and radiological imaging in the diagnosis of hydatid disease. *Parasitol Int*. 2026;113:103231. doi:10.1016/j.parint.2026.103231
 - Can B, Capin BBO, Kursun M, Cimsit C, Yagci AK. Comparative analysis of radiological and serological methods for diagnosis of cystic echinococcosis. *Rev Bras Parasitol Vet*. 2025;34(4). doi:10.1590/s1984-29612025073
 - Bohard L, Brumpt E, Tissot N, et al. Unexplained subcutaneous swelling: keep echinococcosis in mind! Report of two primary extrahepatic subcutaneous echinococcosis cases and literature review. *PLoS Negl Trop Dis*. 2025;19(9). doi:10.1371/journal.pntd.0013511
 - Skhal D, Abbady AQ, Chaban H, Al Nahhas S. Crude protoscolex antigens of *Echinococcus granulosus* as serological markers for human hydatidosis detection. *Sci Rep*. 2025;15(1):31972. doi:10.1038/s41598-025-17798-1
 - Caushi F, Tashi E, Tanka A, et al. The role of ELISA IgG antibodies in diagnosis of cystic echinococcosis of lung: a retrospective study of a single centre activity in Albania. *J Cardiothorac Surg*. 2025;20(1):145. doi:10.1186/s13019-024-03308-3
 - Gholami S, Tanzifi A, Sharif M, et al. Demographic aspects of human hydatidosis in Iranian general population based on serology: a systematic review and meta-analysis. *Vet World*. 2018;11(10):1385-1396. doi:10.14202/vetworld.2018.1385-1396
 - Republic of Türkiye Ministry of Industry and Technology. Socio-Economic Development Ranking Studies (SEGE). Published 2022. Accessed July 1, 2026.
 - Galeh TM, Spotin A, Mahami-Oskouei M, et al. The seroprevalence rate and population genetic structure of human cystic echinococcosis in the Middle East: a systematic review and meta-analysis. *Int J Surg*. 2018;51:39-48. doi:10.1016/j.ijsu.2018.01.025
 - Karshima SN, Ahmed MI, Adamu NB, Magaji AA, Zakariah M, Mohammed K. Africa-wide meta-analysis on the prevalence and distribution of human cystic echinococcosis and canine *Echinococcus granulosus* infections. *Parasit Vectors*. 2022;15(1):357. doi:10.1186/s13071-022-05474-6
 - Mohemmi N, Khodayari MT, Karamati SA, et al. Update on the seroepidemiology of human cystic echinococcosis and associated risk factors in Iran: a systematic review and meta-analysis. *Health Sci Rep*. 2025;8(4). doi:10.1002/hsr.2.70699
 - Akalın S, Kutlu SS, Caylak SD, et al. Seroprevalence of human cystic echinococcosis and risk factors in animal breeders in rural communities in Denizli, Turkey. *J Infect Dev Ctries*. 2014;8(9):1188-1194. doi:10.3855/jidc.4343
 - Ertabaklar H, Yıldız İ, Malatyalı E, Tileklioğlu E, Çalışkan SÖ, Ertuğ S. Retrospective analysis of cystic echinococcosis results in Aydın Adnan Menderes University Training and Research Hospital Parasitology Laboratory between 2005 and 2017. *Türkiye Parazit Derg*. 2019;43(3):118-122. doi:10.4274/tpd.galenos.2019.6218
 - Eryıldız C, Tarladaçalısır T, Kuyucuklu G, Çakmakçı B, Sakru N. Serological follow-up of human cystic echinococcosis in the Thrace Region, Turkey. *Iran J Parasitol*. 2022;17(4):517-524. doi:10.18502/ijpa.v17i4.11279
 - Alver O, Payaslioğlu AM, Özakin C, et al. Laboratory results of cystic echinococcosis in 2017 and 2018. *Türkiye Parazit Derg*. 2021;45(3):207-210. doi:10.4274/tpd.galenos.2021.43434
 - Beyhan YE, Babür C, Mungan M, et al. Evaluation of cystic echinococcosis suspected patients applied to National Parasitology Reference Laboratory of Public Health Institution of Turkey between 2009 and 2013. *Türkiye Parazit Derg*. 2015;39(1):17-21. doi:10.5152/tpd.2015.3646
 - Başer S, Ismayıl A, Maçın S. Evaluation of the seropositivity of patients with cystic echinococcosis in Konya, Turkey. *J Contemp Med*. 2021;11(2):139-141.
 - Yürük M, Yaman O, Sivcan E, Erdoğan E. Retrospective determination of the prevalence of anti-*Echinococcus granulosus* antibodies in cystic echinococcosis pre-diagnosed patients at Erciyes University Faculty of Medicine. *Türkiye Parazit Derg*. 2022;46(2):133-139. doi:10.4274/tpd.galenos.2022.32032
 - Yılmaz A, Uslu H, Aktaş F. Evaluation of patients suspected with cystic echinococcosis by indirect hemagglutination methods at Regional Hospital of Erzurum between 2009 and 2013.

- Gumushane Univ J Health Sci. 2016;5(1):23-32.
30. Kara M, Davarci İ, Dabanlioglu B. Prevalence of cystic echinococcosis in humans in Erzincan Province. *Ann Med Res*. 2021;27(1):128-132.
31. Çelik M, Baran Aİ, Altındağ D, et al. Retrospective evaluation of adult hydatid cyst cases. *Genel Tıp Derg*. 2024;34(2):166-170. doi:10.54005/geneltip.1271990
32. Samancı Aktar G, Ayaydin Z, Rahmanalı Onur A, et al. Retrospective evaluation of cases with the pre-diagnosis of cystic echinococcosis admitted to the microbiology laboratory of Diyarbakır Health Sciences Gazi Yaşargil Training and Research Hospital between 2014 and 2017. *Türkiye Parazitoloj Derg*. 2020;44(4):207-210. doi:10.4274/tpd.galenos.2020.6592
33. Aydoğdu M, Tuncer B. Muğla ilinde nüfusun gelişimi ve ilçeler bazında mekânsal dağılışı analizi. *Int Geogr Geogr Educ*. 2022;(47):300-320.
34. Kuvvetli U, Dolu A. Türkiye'de kentlerin sosyo-ekonomik gelişmişlik düzeylerinin karşılaştırılması. *Int J Public Finance*. 2023;8(1):85-106.
35. Possenti A, Manzano-Román R, Sánchez-Ovejero C, et al. Potential risk factors associated with human cystic echinococcosis: systematic review and meta-analysis. *PLoS Negl Trop Dis*. 2016;10(11). doi:10.1371/journal.pntd.0005114