

Epidemiology, burden, and geographical distribution of cystic echinococcosis in Central Iran

Abedin Saghafipour¹, Masoumeh Divband², Leyli Zanjirani Farahani³, Hadi Hamidi Parsa⁴ and Hossein Golabchi Fard⁴

1. Department of Public Health, Faculty of Health, Qom University of Medical Sciences, Qom, Iran; 2. Student Research Committee, Qom University of Medical Sciences, Qom, Iran; 3. Department of Medical Parasitology and Mycology, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran; 4. Master of Sciences in Medical Economics, Qom University of Medical Sciences, Qom, Iran.

Corresponding author: Abedin Saghafipour, e-mail: abed.saghafi@yahoo.com

Co-authors: MD: m.divband.1997@gmail.com, LZ: leyli.zfarahani@gmail.com, HHP: hadihamidiparsa@gmail.com, HGF: hossein.golabchi@gmail.com

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Abstract

Background and Aim: Human cystic echinococcosis (CE) is an important, neglected zoonotic disease with worldwide distribution which has been reported in different regions of Iran, including the central areas (e.g. Qom Province). The disease is caused by the *Echinococcus granulosus* parasite living in the intestine of dogs and other canids as definitive hosts. This study aimed to investigate the epidemiology, burden, and geographical distribution of CE in Qom Province, Central Iran.

Materials and Methods: In this descriptive-analytic study, the data of patients with diagnosed CE during 2011-2018 were collected from all urban and rural areas of Qom Province. The data of the epidemiological status of CE cases were extracted from the CE surveillance system in the Centers for Disease Control and Prevention in the Qom University of Medical Sciences which is owned and run by Iran's Ministry of Health and Medical Education. In addition, the economic burden of the disease was evaluated by Azaraksh and Roozamad financial software; the geographical distribution of CE was obtained by ArcGIS 10.3 software (IBM Corp., Chicago, USA).

Results: The results reveal that the incidence rate of CE was 6.81/100,000 people over the 8-year period of the study. More than half of the cases were females (57.95%), housewives (57.47%), and residents (89.77%). The majority of the cases were Iranian (88.77%) and the rest were from the two neighboring countries: Afghanistan and Pakistan. The economic burden of the human CE in the 8 years was estimated to be 3,761,352,526 rials (75,227 \$). In terms of spatial distribution, the highest incidence rate of CE was observed in Salafchegan District in the southwest of Qom Province.

Conclusion: The economic burden of human CE infection provided by governmental health-care systems or as out-of-pocket expenses is relatively high, and housewives, especially those living in Salafchegan District, are more likely to be affected. More studies are recommended on different epidemiological aspects and the definitive hosts of the parasite; besides, people at risk need to be warned and educated so that the incidence rate of the disease is reduced.

Keywords: cystic echinococcosis, hydatidosis, Iran.

Introduction

Cystic echinococcosis (CE), also known as hydatid disease or hydatidosis, is a zoonotic parasitic disease caused by the larval stage of *Echinococcus granulosus*. According to the WHO reports in 2017, the parasite has spatial and temporal distribution globally, and more than 1 million people are affected with CE in the world [1]. *E. granulosus* has different strains that can impact the epidemiology and distribution of CE infection. The most important strain associated with human CE is the common sheep G1 strain [2]. The canids including dogs, wolves, foxes, and jackals

are the main host of the parasite, infected by the ingestion of the infected viscera. After the infection, small mature worms, 2-7 mm long, develop in the animals' intestine and release the eggs. Infected canids pass the parasite eggs through their feces to the soil, water, and vegetables. The eggs are very resistant and live from 3 to 8 months at an appropriate temperature and humidity levels. Farm animals, as the main hosts, are easily infected by eating the contaminated foods, while humans, as accidental hosts, get the infection by ingesting the eggs existing in the contaminated water and vegetables or direct contact with the infected dogs [3,4]. The most commonly affected organs are the liver and lungs of humans, and the clinical and pathological symptoms depend on factors such as the infection severity, the number and size of cysts, and the involved organ in the body [5].

The disease diagnosis is conducted by imaging techniques and some current treatments such as surgical operations and chemotherapy. The CE infection

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leads to severe economic and public health issues that are cared for by governmental health-care systems or out-of-pocket expenses in all endemic foci of the countries around the world every year. The economic burdens of the disease are not limited to the animal products and include the costs paid for the diagnosis, treatment, out-of-work days, or the absenteeism of the patients [6,7]. The disease is globally distributed in the areas where livestock is found, especially those areas, in which dogs are kept to protect the livestock [8]. In the endemic areas, the annual incidence rate (AIR) of CE reaches more than 50/105 populations; the prevalence rate can also reach as high as 5-10% in some parts of Argentina, Peru, East Africa, Central Asia, and China. In Turkey, the incidence rate of CE has been reported as 18-20/10⁵ as an endemic country [2].

The CE infection is a neglected parasitic infectious disease in Iran. The prevalence rate of the disease is estimated to be between 2 and 20% in the intermediate hosts in Iran, and the prevalence rate of human hydatidosis is 0.6 up to 1.2/10⁵ [8]. Many studies have been conducted on CE in Iran. For instance, the findings of Tavakoli *et al.*'s study on the CE prevalence in Iran, from 2002 to 2007, indicated that the disease was prevalent in all provinces of the country while the highest incidence, near 0.61/105 populations, was reported in Khorasan Province, Northeastern Iran, and the lowest prevalence rate was observed in Hormozgan Province, Southern Iran [9].

Considering the number of CE reports in Qom Province, Central Iran, a comprehensive study on the disease can determine the high-risk groups and help health planners manage and control the disease

distribution in the area. Therefore, this study aimed to investigate the epidemiology, burden, and geographical distribution of CE in Qom Province, Central Iran, over 8 years (2011-2018).

Materials and Methods

Ethical approval and Informed consent

The researchers followed Helsinki ethical principles throughout the study. The retrospective data on CE patients with surveillance were used in this study and approved by the Ethics Committee of the Qom University of Medical Sciences (IR.MUQ.REC.1398.147). Furthermore, informed consent of the parents or legally authorized representatives of participants was obtained.

Study area and data collection

Qom Province is one of the 31 provinces of Iran, geographically located between 50° 06' -51° 58' E and 34° 09' -35° 11' N in the central region of the country [10]. It has five rural districts and one city (Figure-1). In this descriptive-analytic study, the data on CE patients with surveillance during 2011-2018 were collected in all urban and rural areas of Qom Province.

Study design

The data on demographic and clinical status of CE patients, including age, gender, nationality, occupation, urban/rural residence, educational level, the potential sources of contamination, human infected organs, the number of cysts, and clinical symptoms, were extracted from the CE surveillance system in the Centers for Disease Control and Prevention in the Qom University of Medical Sciences which is owned and run by Iran's Ministry of Health and Medical Education.

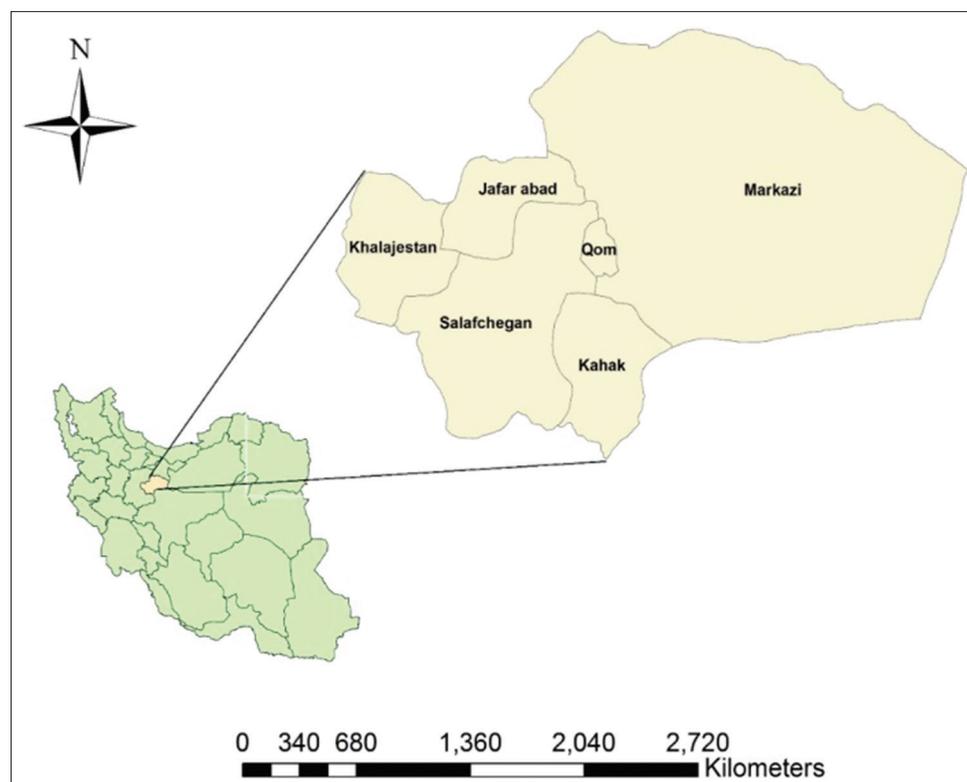


Figure-1: The location of Qom Province in Iran.

The human CE cases with incomplete epidemiological data registration forms were excluded from the study. The inclusion criteria for the study were the residence of cases in one area of Qom Province, having a confirmed disease detection certificate and having completed epidemiological data registration forms. All the patients whose data were fully documented were included in the study. The patients' data remained confidential and were used through the given code, without patients' names, or other identifying information.

Statistical analysis

The epidemiological data analysis was done using SPSS software Ver. 21 and the Chi-square test. Moreover, the economic burden of the disease was evaluated by Azarakhsh and Roozamad financial software. The special distribution of the CE in all areas of Qom Province was also obtained by ArcMap 10.4.1 software (Esri, California, USA).

Results

Epidemiology of CE

A total of 88 cases of hydatid cyst were reported in Qom Province from 2011 to 2018, with the mean age of 41.69 ± 18.26 . The patients were mostly over 50 years of age (30.68%) followed by the 31-40 years of age group (25%). The findings showed that the 8-year incidence rate of CE was 6.81/100,000 population. In addition, the highest and lowest AIR was 1.61 in 2014 and 0.16 in 2017, respectively. These trends during 2011-2018 were 0.60, 1.61, 0.93, 1.69, 1.44, 0.59, 0.16, and 0.38/100,000 people, respectively.

Of all cases, 57.95% were female with the mean age of 46.74 ± 17.53 . The mean age of male patients was 34.72 ± 17.11 , and a significant relationship was observed between the mean age of women and men ($p=0.002$). The findings indicated that 88.77% of reported cases were Iranian and the rest were from the two neighboring countries of Afghanistan and Pakistan. Regarding living areas, 89.77% of cases were residing in urban areas and 57.47% were housewives (Table-1). The epidemiological and clinical characteristics of patients are shown in Table-2. In addition, 30.68% of patients had contact with dogs. In terms of washing vegetables, 68.18% used water, 25% used detergents, and 6.82% used disinfectants. More than half (56.82%) had one hydatid cyst, 29.55% had two cysts, 2.27% had three cysts, and 4.55% had more than three cysts. In terms of the diagnostic method, 45.45% of the patients were diagnosed with ultrasound, 23.86% were diagnosed with radiology, and 14.77% were diagnosed by surgery. Cysts mostly existed in the liver (64.77% of the patients) and 22.73% of cases had lung involvement (Table-2).

There were no significant relationships among the number of cysts and gender ($p=0.76$), living area ($p=0.72$), and contact with the dogs ($p=0.09$).

Economic burden of CE

The economic burden of the human CE in the 8-year period was estimated to be 3,761,352,526

Table-1: Demographic characteristics of hydatid cyst in hospitals in Qom Province, Central Iran, over 8 years (2011-2018).

Characteristics	Number	Percentage
Sex		
Male	37	42.05
Female	51	57.95
Age		
>10	3	3.41
11-20	8	9.09
21-30	14	15.91
31-40	22	25.00
41-50	14	15.91
<50	27	30.68
Nationality		
Iran	79	88.77
Other countries	9	10.23
Living area		
Urban	79	89.77
Rural	9	10.23
Occupation		
Housewife	50	57.47
Student	6	6.90
Worker	9	10.34
Other jobs	23	25.29

Table-2: Epidemiologic and clinical characteristics of hydatid cyst in hospitals in Qom Province, Central Iran, over 8 years (2011-2018).

Characteristics	Number	Percentage
Contact with dogs		
Yes	27	30.68
No	61	69.32
Way of using vegetables		
Only washing with water	60	68.18
Washing with detergents	22	25.00
Washing with calcium hypochlorite	6	6.82
Number of cysts		
One	50	56.83
Two	26	29.55
Three	2	2.27
>3	4	4.55
Organs involved		
Liver		64.77
Lung		22.73
Others		12.50
Detection method		
Sonographic diagnosis	40	45.45
Radiology	21	23.86
Surgery	13	14.77
Other	1	1.13

rials (75,227 \$). The direct, indirect (overhead), and governmental costs spent for all the CE cases were 3,031,687,463 rials (60,634 \$), 443,822,640 rials (8876 \$), and 3,475,510,103 rials (69,510 \$), respectively. The out-of-pocket expenses were 285,842,421 rials (5717 \$) in total. The total costs (governmental and out-of-pocket expenses) in the 8-year period were estimated to be 42,742,642 rials (855 \$) expenditure per capita (Table-3 and Figure-2). Moreover, the lost workdays for all cases equaled to 121,972,587 rials (2439 \$), and expenditure per capita was estimated to be 1,386,052 rials (27.71 dollars).

Geographical distribution of CE in Central Iran

Figure-3 depicts the spatial distribution of CE incidence in Qom Province in the study period. Based on the map, the highest incidence of CE was observed in Salafchegan District (20.12/100,000) followed by Markazi District (Table-4).

Discussion

The findings showed that the 8-year incidence rate of CE in Qom Province was 6.81/100,000 population (88/1,200,000 population). The special distribution of CE disease revealed that the highest incidence rate of CE was observed in Salafchegan District. It should be noted that the real number of CE patients might be more than the available and registered data

in the study period because of the incomplete hospital documents, and the fact that some of the patients may be treated in neighboring cities, such as Tehran. Hence, the registered cases of patients in Qom Province hospitals may be fewer than the actual numbers in some years of the 8-year period.

The latest study on CE in Iran indicated that the prevalence rate of human hydatidosis was estimated to be 4.2%, and the majority of cases were reported in Southern Iran [11]. The frequency of CE in women was 1.38 times higher than in men. Previously, Zeinali's study conducted in different geographical zones of Iran during 1995-2014 reported that human CE could affect females more than males [12]. Besides, this ratio was reported to be 1.35-1 in the study carried out by Ahmadi in Tehran [13]. The higher prevalence rate of CE in women in comparison to men is also in agreement with the results of similar studies in Jordan [14], Basrah Province in Iraq [15], Cairo in Egypt [16], Zanjan Province in Northwestern Iran [17], and Khuzestan Province in the south of Iran [18]. This result is justifiable given that CE depends on exposure to the parasite eggs. Likewise, it seems that more contact with contaminated vegetables may be the cause of more CE frequency in women. However, the results are not consistent with the findings of the study in Alborz Province, Western Iran, which reported a higher incidence rate of the disease in males [19].

Based on the results of the study, it was observed that the frequency of the disease fluctuated from 2011 to 2018 but increased in 2014 and 2018. The comparison of the results with other areas of the country shows that the number of CE patients in Qom Province is

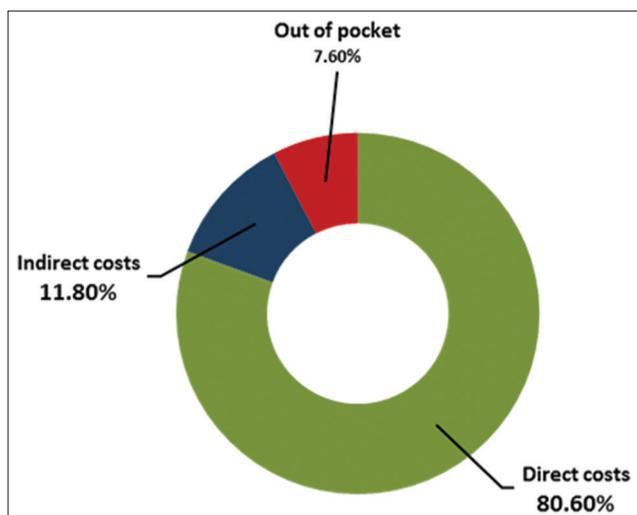


Figure-2: The contribution of each health-care cost item for human cystic echinococcosis health-care cases.

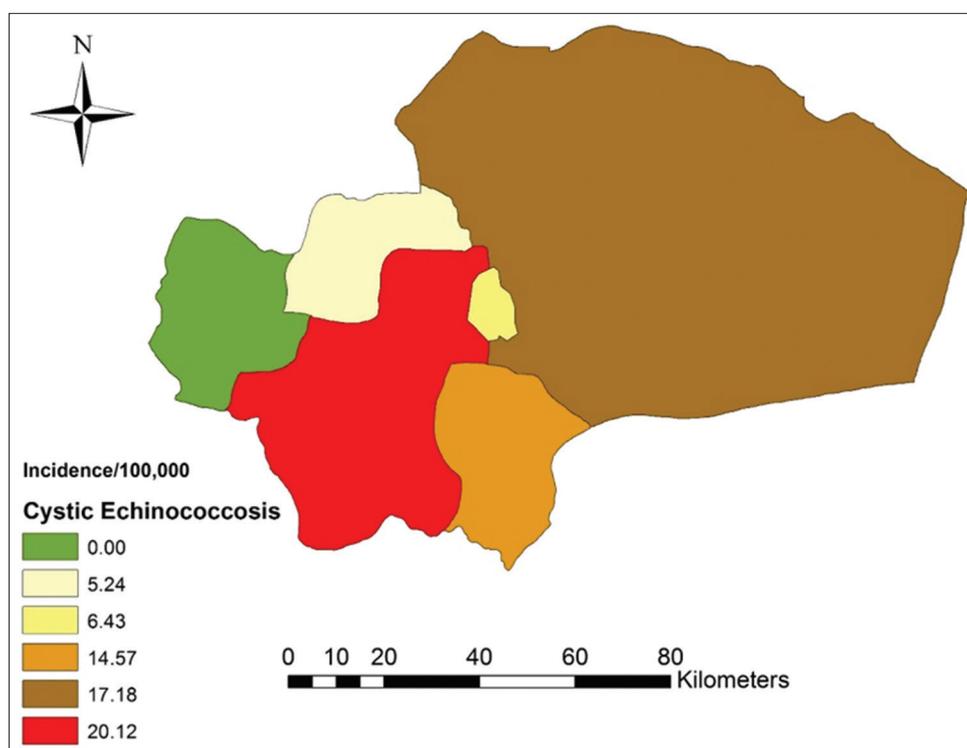


Figure-3: Special distribution of cystic echinococcosis in Qom Province, Central Iran, over a period of 8 years in 2011-2018.

Table-3: Estimation of economic burden of human cystic echinococcosis in Qom Province, Central Iran, over 8 years (2011-2018).

Health care costs	Total costs of cases (88/1,292,283) rials (\$)*	% out of total costs	Expenditure per capita rials (\$)
Major costs groups			
Direct costs	3,031,687,463 (60,634)	80.60	34,450,994 (689)
Indirect costs (overhead)	443,822,640 (8876)	11.80	5,043,439 (101)
Governmental (direct+indirect) costs	3,475,510,103 (69,510)	92.40	39,494,433 (790)
Out of pocket	285,842,421 (5717)	7.60	3,248,209 (65)
Total costs (governmental+out of pocket)	3, 761,352,526 (75,227)	100	42,742,642 (855)

*One dollar=50,000 rials

Table-4: The 8-year incidence rate of CE disease based on different districts of Qom Province, Central Iran.

Area	Total population	Cystic echinococcosis	
		n (%)	Incidence/100,000
Qom City	1,212,214	78 (88.64)	6.43
Markazi District	23,273	4 (4.54)	17.18
Kahak District	20,588	3 (3.41)	14.57
Salafchegan District	9938	2 (2.27)	20.12
Khalajestan District	7207	0 (0.00)	0.00
Jafarabad District	19,063	1 (1.14)	5.24
Total area	1,292,283	88 (100)	6.81

lower than the number in some provinces and higher in some others. According to the findings of a study conducted in Ilam Province, Western Iran, 140 patients (91 females and 49 males) were treated for hydatidosis within 10 years, and from 1200 human sera, 2.25% (27 patients) were seropositive for hydatidosis [20]. In the review article by Yousefi, 1759 cases of CE patients were diagnosed and underwent surgery in 20 years from 1985 to 2005 in Mashhad hospitals [21]. According to the results of this study, most CE cases in both men and women (40.91%) happened in patients who were in their thirties and forties. People in these age groups are the economically active members of the community, especially in rural areas, taking part in the agricultural and animal husbandry, and they are expected to be at a higher risk for zoonotic diseases.

As for the age of the patients, the hydatid cyst was reported in all age groups and no one was immune to this disease; however, the maximum infection occurred in the 15-35 years of age group [21]. The liver was the involved organ in more than 64% of the patients. In most studies on CE in Iran and the other endemic areas of the world, hydatid cysts were reported in the liver more than in any other organs [22,23]. Nevertheless, lung involvement has been reported more than the liver in Tabriz and Shiraz Provinces which are located in the northwest and south of Iran [24,25]. In the present study, about 90% of the CE cases resided in urban areas, which is similar to the result of the previous study in Kashan [12] but not consistent with the results of the studies conducted in Alborz Province [19]. Hydatidosis is transferred to humans by close contact with the parasite eggs passed

by infected dog feces or eating contaminated vegetables, water, or food, and it occurs in both urban and rural areas [26,27]. It should be mentioned that more than 94% of the population of Qom Province reside in urban areas, so it is expected that the majority of human CE cases happen in urban areas.

The findings of this study also demonstrated that the economic burden of human CE was estimated to be 855 \$ expenditure per capita. This finding shows that human CE can impose high costs on health-care systems and out-of-pocket expenses in comparison to other zoonotic diseases in Iran. For instance, in a study on the economic burden of cutaneous leishmaniasis in all endemic foci in Iran, Salimi *et al.* [28] reported that around 412 \$ was spent. One of the limitations of this study was the incomplete information of some epidemiological forms provided by the hospitals, which is a common limitation in the studies based on previously recorded data; however, it seems that the results of this study are reliable enough for disease management and control planning and can properly reveal the prevalence rate of hydatid cyst in Qom Province.

Conclusion

The highest frequency of hydatid cyst in Qom Province was reported in the 31-50 years of age group. Based on the results, it can be concluded that housewives are more likely to be affected by the disease than any other occupations. Moreover, the economic burden of CE is restively high, and it can consequently have an additional economic impact on health-care systems and patients. More comprehensive studies are recommended focusing on different epidemiological aspects and the definitive sources of contamination

in the future. Besides, housewives, especially in Salafchegan District, need to be warned and educated so that the incidence rate of the disease is reduced.

Authors' Contributions

AS and MD designed the study. AS, MD, HHP, LZP, and HGF gathered the data. AS, MD, and HHP interpreted the results and analyzed the data. AS, LZP and MD prepared the manuscript. All authors read and approved the final manuscript.

Acknowledgments

We used retrospective data for this study, which was coded and the patients' demographic information remained confidential. In the end, the authors would like to express their special gratitude to Dr. Sheikholeslami, a specialist in disease infections in Kamkar Hospital in Qom, for her kind cooperation and also to the staff in all Qom Health Centers who collaborated on the implementation of this study. This research was financially supported by Qom University of Medical Sciences, Qom, Iran, under the Grant number 981062.

Competing Interests

The authors declare that they have no competing interests.

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