

Demographics of cystic echinococcosis patients treated surgically in Lahore, Pakistan: A single centre study from 2007 – 2018

Q. RASIB¹, A. KHAN¹, H. AHMED^{1*}, S. NIZAMUDDIN², F. ASIF³, M. S. AFZAL⁴, S. SIMSEK⁵, F. KHURSHID², S. IRUM¹, N. HUSSAIN¹, S. RIAZ¹, S. S. KHAN¹, C. M. BUDKE⁶

¹Department of Biosciences, COMSATS University Islamabad (CUI), Islamabad, Pakistan, *E-mail: haroonahmad12@yahoo.com;

²Consultant Microbiologist, Pathology, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore, Pakistan; ³Clinical Research Administrator, Clinical Research Office, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore, Pakistan;

⁴Department of Lifesciences, University of Management & Technology (UMT), Lahore, Pakistan; ⁵Department of Parasitology, Faculty of Veterinary Medicine, University of Firat, Elazig, Turkey; ⁶Department of Veterinary Integrative Biosciences, College of Veterinary Medicine & Biomedical Sciences, Texas A & M University, College Station, Texas, United States of America

Article info

Received June 17, 2020
 Accepted December 22, 2020

Summary

Cystic echinococcosis (CE) is a zoonotic disease caused by the larval stage of *Echinococcus granulosus* tapeworms. These parasites have a worldwide geographic distribution and pose a serious threat to livestock industry as well as human health in the endemic areas. CE is widely distributed in Pakistan. However, very few reports are available related to the regional transmission of *E. granulosus*. A retrospective analysis was conducted of surgically confirmed CE patients who were treated at Shoukat Khanum Memorial Cancer Hospital and Research Centre in Lahore, Punjab Province, Pakistan from 2007 – 2018. In total, 536 CE patients were evaluated during the study period. Cases originated from the provinces of Khyber Pakhtunkhwa (n=336), Punjab (n=147), Baluchistan (n=18), Sindh (n=3), Islamabad (n=2), Gilgit Baltistan (n=1), and Azad Jammu and Kashmir (n=1). An additional 28 cases were from Afghanistan. The highest number of CE cases was reported in 2013 (n=90). Females made up a larger proportion of cases (n=310; 57.8 %) than males (n=226; 42.2 %). Most patients were members of the Pashtun (n=197; 36.7 %), Hindku (n=142; 26.5 %), and Punjabi (n=118; 22.0 %) ethnic groups. The largest number of cysts was obtained from the liver (137/536; 25.6 %). This study showed that CE is likely present throughout Pakistan. In order to control the disease, a comprehensive control program and regional surveillance are needed.

Keywords: Cystic echinococcosis; epidemiology; human; Pakistan

Introduction

Cystic echinococcosis (CE) is a zoonotic parasitic disease. According to the World Health Organization (WHO), worldwide economic losses due to CE exceed three billion US dollars annually (WHO, 2020). Globally, most human CE cases are caused by *E. granulosus sensu stricto*, sheep strain (G1 and G3) (Agudelo Hi-

guita *et al.*, 2016). The adult worms reside in the small intestines of the definite host, which are mainly dogs or other canids. Parasite eggs are then released in the feces and consumed by intermediate hosts, which are commonly sheep or other ruminants. Humans can become aberrant intermediate hosts if they ingest substances, such as water or vegetables that are contaminated with *Echinococcus* eggs (Otero-Abad *et al.*, 2013). Cystic lesions typically

* – corresponding author

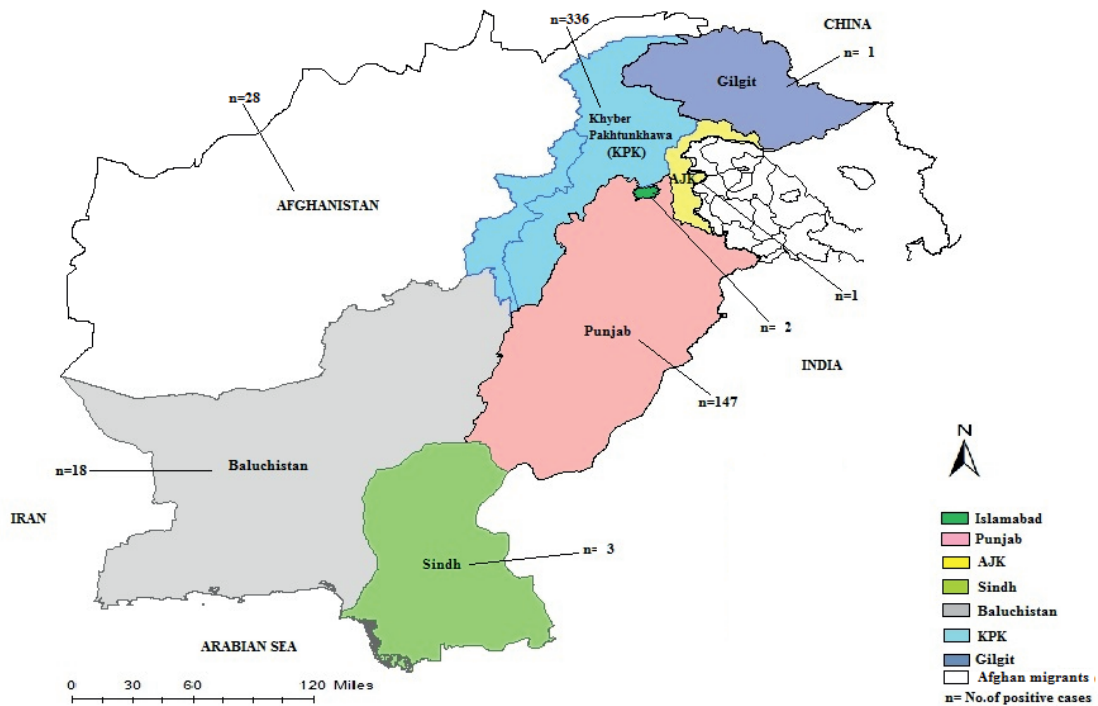


Fig. 1. Province level distribution of 536 CE cases treated surgically at Shoukat Khanum Memorial Cancer Hospital and Research Centre in Lahore, Pakistan from 2007 – 2018.

occur in the liver, lungs or both, but can develop in other organs (Engin *et al.*, 2000). Infected individuals may remain asymptomatic for months or years (Almulhim & John, 2019).

In Pakistan, CE is considered an endemic disease (Ahmed *et al.*, 2017). However, the burden of CE on Pakistan has been poorly studied due to a general lack of awareness (Khan *et al.*, 2019a). In addition to long-term residents of Pakistan, immigrants from Afghanistan with CE are also commonly treated in Pakistan (Khan *et al.*, 2019b). The current study describes the demographic characteristics of CE patients who were treated surgically at Shaukat Khanum Memorial Cancer Hospital and Research Centre (SKMCH & RC) in Lahore, Punjab Province, Pakistan from 2007 to 2018.

Materials and Methods

Study area

Pakistan is located in South Asia and is the fifth most populated country in the world. In 2019, the population of Pakistan was approximately 211.2 million, with 61.4 % of the population 15 – 64 years of age, 22.1 % of the population 5 – 14 years of age, 12.1 % of the population 4 years of age and younger, and 4.4 % of the population 65 years of age and older (GOP, 2020). Males make up 51 % of the population (GOP, 2020). Most of Pakistan's population lives in rural and peri-rural areas (GOP, 2020). Due to a lack of medical facilities, in rural areas, most of the population must visit larger cities for medical treatment. Pakistan is a largely agricultural

Table 1. Age and sex of 536 CE cases treated surgically at Shoukat Khanum Memorial Cancer Hospital and Research Centre in Lahore, Pakistan from 2007 – 2018.

Age (years)	Male (%)	Female (%)	Total Cases (%)
1 – 10	32 (14.1)	20 (6.4)	52 (9.7)
11 – 20	41 (18.1)	52 (16.7)	93 (17.3)
21 – 30	52 (23)	83 (26.7)	135 (25.2)
31 – 40	37 (16.3)	68 (21.9)	105 (19.6)
41 – 50	27 (11.9)	49 (15.8)	76 (14.2)
51 – 60	17 (7.5)	25 (8.1)	42 (7.8)
61 ≥	20 (8.8)	13 (4.2)	33 (6.2)
	226 (42.2)	310 (57.8)	536 (100)

Table 2. Province or region of origin for 536 CE cases treated surgically at Shoukat Khanum Memorial Cancer Hospital and Research Centre in Lahore, Pakistan from 2007 – 2018.

Province or Region	2007 – 2010	2011 – 2014	2015 – 2018	Total Cases (%)
Khyber Pakhtunkhwa	65	158	113	336 (62.7)
Punjab	45	53	49	147 (27.4)
Afghanistan	5	16	7	28 (5.2)
Baluchistan	2	8	8	18 (3.3)
Sindh	2	-	1	3 (0.6)
Islamabad	-	1	1	2 (0.4)
Gilgit Baltistan	-	-	1	1 (0.2)
Azad Jammu and Kashmir	-	1	-	1 (0.2)
	119 (22.20%)	237 (44.22%)	180 (33.58%)	536 (100)

country with a semi-arid landscape and a subtropical climate (Ahmed *et al.*, 2012). The country's economy relies heavily on livestock production, with a large part of the population involved with livestock husbandry. The livestock population of Pakistan consists of over 49 million cattle, 41 million buffaloes, 31 million sheep, 78 million goats, 5.5 million donkeys, 1.1 million camels, 400,000 horses, and 200,000 mules (GOP, 2020).

Punjab province is located in the southern part of the country, with fertile agricultural land and deserts (Khan *et al.*, 2020a). It has one of the largest provincial populations, with a 2017 census population of 110,012,615. The province also contains much of the country's livestock population, including 49 % of the country's cattle, 65 % of the country's buffaloes, 24 % of the country's sheep, 37 % of the country's goats, 22 % of the country's camels, 47 % of the country's horses, 41 % of the country's mules, and 52 % of the country's donkeys (GOP, 2006).

Patient Information

In current study, data was collected retrospectively for CE patients treated surgically at SKMCH & RC from 2007 to 2018 were included in this study. Pre-surgical diagnosis was performed via ultrasound (US), magnetic resonance imaging (MRI), or computed tomography (CT) scan. All cases were confirmed by histopathology

performed on surgically removed cysts. In addition to surgical management, all patients received antiparasitic treatment with albendazole (400 mg twice a day for 28 to 90 days). Patient medical charts were reviewed to collect demographic information, including age, sex, ethnicity, and place of residence. Cyst localization and number of cysts per organ were documented.

Statistical analysis

Frequencies of the assessed variables were recorded as percentages, with patient age presented using 10-year age categories.

Ethical Approval and/or Informed Consent

This study was approved by the SKMCH & RC Institutional Ethics Committee under EXMPT-22-06-18-01. Informed consent for the use of medical records for future research was obtained from all patients at the time of treatment.

Results

In total, 536 surgically confirmed CE cases were treated at SKMCH & RC from 2007 to 2018. Out of the 536 patients, 226 (42.2 %) were male and 310 (57.8 %) were female. Patient age ranged from

Table 3. Ethnicity for 536 CE cases treated surgically at Shoukat Khanum Memorial Cancer Hospital and Research Centre in Lahore, Pakistan from 2007 – 2018.

Ethnicity	Total cases (%)
Pashtun	197 (36.7)
Hindku	142 (26.5)
Punjabi	118 (22.0)
Afghani	28 (5.2)
Saraiki	26 (4.9)
Balochi	18 (3.4)
Other*	7 (1.3)
Total	536 (100)

*Gilgit, Kashmiri, Muhajir, Sindhi

Table 4. Treatment year, anatomic cyst location, and imaging technique used for 536 CE cases treated surgically at Shoukat Khanum Memorial Cancer Hospital and Research Centre in Lahore, Pakistan from 2007 – 2018.

Parameter	Number of Cases	Percentage (%)
Year		
2007	24	4.5
2008	28	5.2
2009	41	7.6
2010	30	5.6
2011	52	9.7
2012	51	9.5
2013	90	16.8
2014	51	9.5
2015	48	9.0
2016	48	9.0
2017	38	7.1
2018	35	6.5
Cyst location		
Liver	137	25.6
Lungs	86	16.0
Brain	43	8.0
Abdomen	41	7.6
Uterus and ovary	26	4.9
Chest	25	4.7
Spleen	24	4.5
Kidney	14	2.6
*Other	88	16.4
Site not mentioned	52	9.7
Imaging technique		
Computed tomography scan	405	75.6
Ultrasound	223	41.6
Magnetic resonance imaging	107	20.0
Radiography	87	16.2
Data not available	52	9.7

*Heart, gallbladder, pancreas, face, neck, thigh, intestines, back, femur, shoulder, thyroid, pituitary, eye, pelvic region, liver + spleen, liver + gallbladder, spleen + lung, pancreas + spleen

1 to 82 years of age (Table 1). Males made up 50.3 % of cases 20 year of age or younger, 36.7 % of cases aged 21 – 50 years, and 49.3 % of cases 51 years of age and older. Patients were from throughout Pakistan, with 336 cases (62.7 %) from the province of Khyber Pakhtunkhwa, 147 cases (27.4 %) from Punjab, 18 cases (3.3 %) from Baluchistan, 3 cases (0.6 %) from Sindh, 2 cases (0.4 %) from Islamabad, 1 case (0.2 %) from Gilgit, and 1 case (0.2 %) from Azad Jammu and Kashmir. An additional 28 cases (5.2 %) were from the neighboring country of Afghanistan (Fig. 1; Table 2). A further breakdown by city of origin is presented as supplementary material (Table S1). Most patients were members

of the Pashtun (n=197; 36.7 %), Hindku (n=142; 26.5 %), and Punjabi (n=118; 22.0 %) ethnic groups (Table 3).

The highest number of CE cases was reported in 2013 (n=90), with the lowest number of cases in 2007 (n=24) (Table 4). The largest number of cysts was obtained from the liver (137/536; 25.6 %), followed by the lungs (86/536; 16.0 %), brain (43/536; 8.0 %), abdomen (41/536; 7.6 %), uterus and ovaries (26/536; 4.9 %), chest (25/536; 4.7 %), spleen (24/536; 4.5 %), and kidneys (14/536; 2.6 %), with anatomical location not available for 52 (9.7 %) cysts (Table 4). Twenty-six (4.8 %) patients presented with multiple cysts. Data on World Health Organization Informal Working Group

Table S1. City and province of origin for 536 CE cases treated at Shoukat Khanum Memorial Cancer Hospital and Research Centre Lahore, Pakistan from 2007 – 2018.

City	Province	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Afghanistan	Afghanistan	1												1
Islamabad	Islamabad			3	1	14	2	1		1	2	1	3	28
Bagh	AJK							1	1					2
Abbottabad	KPK						1		1					1
Bajaur	KPK	1						1					1	2
Bannu	KPK					2	2	1	1					3
Bara	KPK	1		2				1		2		1		6
Charsada	KPK			2	1	2		1	1		1			7
Dassu	KPK			2		1		1						8
Dera Ismail Khan	KPK			1		1		1	2					1
Daggar	KPK		1											5
Hangu	KPK		1			1		1						1
Jamrud	KPK		1					1						3
Kohat	KPK						1		1	1	2		1	2
Kurram	KPK							1						5
Karak	KPK			1		1		1			2	1	2	1
Khar Bajaur	KPK							1		1		2	1	4
Khyber	KPK												1	1
Kabal	KPK							22	2		1		1	28
Landi Kotal	KPK						3				1			1
Lakki Marwat	KPK	1			1						1		3	5
Lower Dir	KPK				1		1					1	1	4
Malakand	KPK						1	1	1	1	2	1		7
Mansehra	KPK										1			1
Mardan	KPK		1	1		1		3		2	1	1	2	12
Miran Shah	KPK						1	1						3
Mohmand	KPK												1	1
N.Waziristan	KPK										1		2	3
Nowshera	KPK			2					2	1	1	3		9
Peshawar	KPK	3	11	15	14	15	19	25	4	9	10	6	9	140
Parachinar	KPK										1			1
Razmak	KPK											1	1	2
Sawabi	KPK									1				1
Swat	KPK				1	1	5	3	20	14	9	3	2	58
Upper Dir	KPK					1					1			2
Waziristan	KPK			1			1							1
Arifwala	Punjab													1
Attock	Punjab	1						1		1				3

on Echinococcosis (WHO-IWGE) ultrasound-based cyst staging were not available. A detailed breakdown of cases by age, sex, ethnicity, and cyst location is provided as supplementary material (Table S2).

Discussion

CE is considered a neglected tropical disease (NTD) of global concern (Khan *et al.*, 2019b). As there have been few studies conducted in Pakistan while it is known that CE is endemic in this region. Therefore, studies evaluating the distribution of human cases are needed. In the present study, there were more female than male cases, which concurs with the findings of other studies (Khan *et al.*, 2018, 2019c). In some locations, females are believed to be of higher risk due to increased interaction with dogs as well as gardening. However, this does not appear to be globally applicable since in some areas the condition appears to be more common in males (Aksu *et al.*, 2013; Sharma *et al.*, 2013; Torgerson *et al.*, 2013; Khan *et al.*, 2019c).

In the current study, the highest numbers of cases were in young and middle age adults. However, of note, is the large number of patients under 11 years of age ($n=52$; 9.7 %), indicating recent parasite transmission. This finding concurs with another study conducted in Pakistan where 10.5 % of reported cases were in children less than 11 years of age (Khan *et al.*, 2019c). Younger individuals may be at higher risk due to greater exposure to dogs, especially in an agricultural setting (Khan *et al.*, 2019c). In the current study, the 21 – 30-year age group made up of 25.2 % of the evaluated cases. Similar observations were found by Muqaddas *et al.* (2019) who reported 29.8 % of cases in this age group in the cities of Lahore, Karachi, and Multan. Comparable outcomes have been reported in other countries, including Iraq (Abdulhameed *et al.*, 2018), Nepal (Ghartimagar *et al.*, 2013), and Ethiopia (Kebede *et al.*, 2010). Clinical disease in young adults can have detrimental impacts on the local workforce and economy (Amini *et al.*, 2008; Mousavi *et al.*, 2012).

The largest numbers of cysts were obtained from the liver and lungs, which is in line with studies from other geographic locations in Pakistan (Khan *et al.*, 2018; Khan *et al.*, 2019c; Muqaddas *et al.*, 2019; Butt *et al.*, 2020). These findings are also similar to those found in Turkey (Akalin *et al.*, 2014), Iran (Mahmoudi *et al.*, 2019; Khazaei *et al.*, 2016; Aliabadi *et al.*, 2015), Tanzania (Ernest *et al.*, 2010), Kyrgyzstan (Torgerson *et al.*, 2003), and Italy (Conchedda *et al.*, 2010). While liver and lung cysts were most common, the large number of cysts found in other organ systems is likely due to more complicated cysts and unusual presentations of CE being surgically treated at SKMCH & RC. Therefore, it is unlikely that the distribution of cyst locations found in the current study is applicable to all CE cases in the country. Overall, the number of CE cases treated surgically at the SKMCH & RC appears to have risen somewhat during the last half of the study period. This increase is likely due to improvements in the hospital's data management

system rather than a true increase in the number of treated cases. The large number of reported surgical cases in 2013 was likely due to the establishment that year of the new Ministry of National Health Services, Regulation, and Coordination, which may have increased the likelihood that surgeons appropriately documented CE cases. Since surgical CE case data were collected from a single hospital, it would not be appropriate to try extrapolate CE incidence to a larger geographic area.

The majority of cases presenting to SKMCH & RC during 2007 – 2018 were from Khyber Pakhtunkhwa Province, which is a neighboring province to Punjab. A recent retrospective study conducted on hospital records from five major metropolitan cities located in Pakistan showed that the majority of treated patients were from Sindh Province (67.5 %), with 32.4 % of the patients from Punjab (Muqaddas *et al.*, 2019). However, there has yet to be a study that evaluates the regional frequency of human CE cases in Pakistan. Hospitals in Pakistan treat a large immigrant population. While in European countries, many of the CE cases among immigrants come from countries such as Turkey, Greece, Bulgaria, Afghanistan, Kosovo, Macedonia, Morocco, Syria, and Iraq, almost all immigrants treated for CE in Pakistan are from Afghanistan (Khan *et al.*, 2019b; Anonymous, 2017). In addition to acting as a strain on the healthcare system, a secondary concern is that these immigrants may also bring infected dogs and livestock with them into the country.

Demographically, in Pakistan, the largest ethnic group is Punjabi (44.7 %), followed by Pushtun (15.4 %), Sindhi (14.1 %), Sarai-ki (8.4 %), Muhajir (7.6 %), Hindku (6.2 %), and Balochi (3.6 %) (Misachi, 2019). The current findings showed that most CE cases treated in the hospital in Lahore were Pashtun (36.7 %), followed by Hindku (26.5 %), and Punjabi (22.0 %). In comparison, a study by Khan *et al.* (2018) found that 93.4 % of cases seen in north-eastern Punjab Province were Punjabi, while only 6.6 % were Pashtun (6.6 %) (Khan *et al.*, 2018). These findings likely represent the geographic distribution of these ethnic groups in Pakistan. Additional studies are needed to evaluate any sociocultural risk factors for CE within the various ethnic groups.

This study described the epidemiological characteristics of CE cases managed surgically at a single reference hospital in the city of Lahore. While these cases don't portray the full spectrum of cases seen in the country, most CE patients in Pakistan continue to be treated surgically despite WHO-IWGE guidelines indicating that certain cases are best managed medically or using a watch-and-wait approach (Brunetti *et al.*, 2010). As a result, CE likely results in higher costs to the Pakistan healthcare system than if a cyst stage-specific approach was taken. Albendazole drug appears to be commonly used, although primarily in association with surgery (Khan *et al.*, 2020b). According to Khan *et al.*, (2020c; 2020d), albendazole is commonly recommended to all CE patients, while the combination of albendazole and praziquantel or albendazole and nitazoxanide is occasionally prescribed (Bygott *et al.*, 2009; Lötsch *et al.*, 2016; Monge-Maillo *et al.*, 2017). As of now, there does not

Table S2. Sex, ethnicity, and cyst location by age group for CE patients (n=546) treated at Shoukat Khanum Memorial Cancer Hospital and Research Centre Lahore, Pakistan from 2007 – 2018.

Parameters	Age (in years)											Total
	<7	7-12	13-18	19-24	25-30	31-36	37-42	43-48	49-54	55-60	61+	
Sex												
Female	4	26	27	34	64	36	40	29	18	20	13	311
Male	11	28	28	20	38	27	12	15	11	16	19	225
Ethnicity												
Pashtun	8	20	19	22	33	27	18	12	16	15	7	197
Hindko	5	18	13	16	32	14	15	8	7	9	5	142
Punjabi		8	14	8	22	14	13	17	3	7	12	118
Afghani	1	3	6	2	2	4	2	3	2	1	2	28
Saraiki		3	2	4	4	2		4		2	5	26
Balochi	1	2	1	1	8	2	2		1	1	1	18
Other				1	1		2		1	1		7
Cyst location												
Liver	4	9	14	16	22	17	11	11	9	15	9	137
Lung	3	17	10	9	18	13	7	3	1	2	3	86
Brain	3	4	8	6	9	6	3	4				43
Abdomen		2	3	4	7	6	4	3	3	4	5	41
Uterus and ovary			1	1	2	7	7	4	2	1	1	26
Chest	1	4	1		9	3	2		3	1	1	25
Spleen		2	1	6	2	4	5	1	1	2		24
Kidney		2	2		3			2	1	1	3	14

appear to be a system in place to share best practices for treating CE in Pakistan. Healthcare centers could contribute to combatting CE by sharing patient data and treatment strategies (Junghanss *et al.*, 2008; Brunetti *et al.*, 2010; Khan *et al.*, 2020b).

Conclusion

This study showed that CE continues to be a problem throughout the country of Pakistan. There is an urgent need for community-based US screening following WHO-IWGE international guidelines to ensure the timely diagnosis and appropriate cyst stage-based management of the disease (WHO-IWGE, 2003; Brunetti *et al.*, 2010). These studies would also assist in determining the extent of non-healthcare seeking cases. In addition, surveys to estimate the CE burden in humans and animals would help direct public health efforts, similar to the work done by the HERACLES project in Balkan countries (Tamarozzi *et al.*, 2018). Overall, a well-organized surveillance system is needed to help inform decision-makers on how to best approach CE control.

Conflict of Interest

The authors declare that there are no conflicts of interest or financial disclosures related to this publication.

Funding

Not applicable.

Acknowledgements

The authors are thankful to staff members of SKMCH & RC for their support during data collection.

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 Trop*, 178: 130 – 133. DOI: 10.1016/j.actatropica.2017.11.011

AHMED, H., ALI, S., AFZAL, M.S., KHAN, A.A., RAZA, H., SHAH, Z.H., SIMSEK, S. (2017): Why more research needs to be done on echinococcosis in Pakistan. *Infect Dis Poverty*, 6: 90. DOI: 10.1186/s40249-017-0309-z

AHMED, H., KHAN, M.R., PANADERO-FONTAN, R., LÓPEZ SANDEZ, C., IQBAL, M.F., NAQVI, S.M.S., QAYYUM, M. (2012): Geographical distribution of hypodermosis (*Hypoderma* sp.) in Northern Punjab, Pakistan. *Kafkas Univ Vet Fak Derg*, 18: A215 – A219

AKALIN, S., KUTLU, S.S., CAYLAK, S.D., ONAL, O., KAYA, S., BOZKURT, A.I. (2014): Seroprevalence of human cystic echinococcosis and risk factors in animal breeders in rural communities in Denizli, Turkey. *J Infect Dev Ctries*, 8: 1188 – 1194. DOI: 10.3855/jdc.4343

ANDALIB ALIABADI, Z., BERENJI, F., FATA, A., JARAHI, L. (2015): Human Hydatidosis/Echinococcosis in North Eastern Iran from 2003 – 2012. *Iran J Parasitol*, 10: 658 – 662.

AMINI, M., BAHADOR, M., MALEKHOSEYNI, M. (2008): Evaluation of hydatid cyst manifestations in patients admitted to Shaheed Modarres Hospital, 1984 – 2004. *Arch Clin Infect Dis*, 2: 177 – 180.

AGUDELO HIGUITA, N.I., BRUNETTI, E., MCCLOSKEY, C. (2016): Cystic Echinococcosis. *J Clin Microbiol*, 54:518 – 523. DOI: 10.1128/JCM.02420-15

FREE PMC ARTICLE

ALMULHIM, A.M., JOHN, S. (2014): Echinococcus granulosus (Hydatid Cysts, Echinococcosis) [Updated 2019 May 4]. In: StatPearls [Internet]. Treasure Island (FL): Stat Pearls Publishing; 2020 Jan.

Available from: <https://www.ncbi.nlm.nih.gov/books/NBK539751/>

ANONYMOUS. (2017): *The infectious disease epidemiology annual report. 2017*. Retrieved on July 12 from <https://www.gatestoneinstitute.org/10676/germany-migrants-Infectious>.

BRUNETTI, E., KERN, P., VUITTON, D.A. (2010): Expert consensus for the diagnosis and treatment of cystic and alveolar echinococcosis in humans. *Acta Trop*, 114: 1 – 16. DOI: 10.1016/j.actatropica.2009.11.001

Free article

BYGOTT, J. M., CHIODINI, P. L. (2009): Praziquantel: Neglected drug? ineffective treatment? or therapeutic choice in cystic hydatid disease? *Acta Trop*, 111: 95 – 101. DOI: 10.1016/j.actatropica.2009.04.006

BUTT, A., KHAN, J.A. (2020): Cystic echinococcosis: a 10-year experience from a middle-income country. *Trop Doct*, 50: 117 – 121. DOI: 10.1177/0049475519891338

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 to 2005. *Parasitol Int*, 59: 454 – 459. DOI: 10.1016/j.parint.2010.06.008

ENGIN, G., ACUNAŞ, B., ROZANES, I., ACUNAŞ, G. (2000): Hydatid disease with unusual localization. *Eur Radiol*, 10:1904 – 1912. DOI: 10.1007/s003300000468

ERNEST, E., NONGA, H.E., KYNSIERI, N., CLEVELAND, S. (2010): A retrospective survey of human hydatidosis based on hospital records during the period 1990 – 2003 in Ngorongoro, Tanzania. *Zoonoses Public Health*, 57: 8 – 14. DOI: 10.1111/j.1863-2378.2009.01297.x

GOVERNMENT OF PAKISTAN (GOP) (2020): Pakistan economic survey 2019-20. http://www.finance.gov.pk/survey/chapter_20/PES_2019_20.pdf (Data accessed on; 11th september, 2020).

GOVERNMENT OF PAKISTAN (GOP) (2006): Livestock Census, Agriculture Census Organization, Pakistan Bureau of Statistics, Islamabad, 2006.

GHARTIMAGAR, D., GHOSH, A., SHRESTHA, M.K., TALWAR, O.P., SATHIAN, B. (2013): A 14 years hospital based study on clinical and morphological spectrum of hydatid disease. *JNMA J Nepal Med Assoc*, 52:349 – 353. DOI: 10.31729/jnma.2115

JUNGHANSS, T., DA SILVA, A.M., HORTON, J., CHIODINI, P.L., BRUNETTI, E. (2008): Clinical management of cystic echinococcosis: State

- of the art, problems, and perspectives. *Am J Trop Med Hyg*, 79, 301 – 311
- KHAN, A., ZAHOR, S., AHMED, H., MALIK, U., BUTT, R.A., MUZAM, M.S., KILINC, S.G., NOOR, N., ZAHOR, S., AFZAL, M. S., MANSUR, H., IRUM, S., SIMSEK, S. (2018): A retrospective analysis on the cystic echinococcosis cases occurred in Northeastern Punjab Province, Pakistan. *Korean J Parasitol*, 56: 385 – 390. DOI: 10.3347/kjp.2018.56.4.385
- KHAN, A., AHMED, H., BUDKE, C.M (2019a): Echinococcosis in Pakistan: a call for research. *Lancet Infect. Dis.*, 19: 581. DOI: 10.1016/S1473-3099(19)30221-X
- KHAN, A., AHMED, H., SIMSEK, S. (2019b): War, migration and cystic echinococcosis. *Travel Med Infect Dis*, 28:111 – 112. DOI: 10.1016/j.tmaid.2018.09.012
- KHAN, A., AHMED, H., SIMSEK, S., GONDAL, M.A., AFZAL, M.S., IRUM, S., MUHAMMAD, I., MANSUR, H., FATIMA, A., ALI, M.S., RIAZ, N., AKBAR, A., WEIPING, W., YAYI, G. (2019c): Poverty-associated emerging infection of cystic echinococcosis in population of Northern Pakistan: A hospital based study. *Trop Biomed*, 36: 324 – 334
- KHAN, A., AHMED, H., SIMSEK, S., LIU, H., YIN, J., WANG, Y., SHEN, Y., CAO, J. (2020a): Molecular characterization of human Echinococcus isolates and the first report of *E. canadensis* (G6/G7) and *E. multilocularis* from the Punjab Province of Pakistan using sequence analysis. *BMC Infect Dis*, 20: 262. DOI: 10.1186/s12879-020-04989-6
- KHAN, A., AHMED, H., KHAN, H., SALEEM, S., SIMSEK, S., BRUNETTI, E., AFZAL, M.S., MANCIULLI, T., BUDKE, C.M. (2020b): Cystic Echinococcosis in Pakistan: A review of reported cases, diagnosis, and management. *Acta Trop*, 212: 105709. DOI: 10.1016/j.actatropica.2020.105709
- KHAN, A., AHMED, H., NAZ, K., GUL, S., ISHAQUE, S.M., ZAIDI, S., AFZAL, M.S., ALI, M.S., BOKARI, S.A., BUDKE, C.M. (2020c): Surgically confirmed cases of cystic echinococcosis from Baluchistan Province, Pakistan for the years 2011 – 2018. *Acta Trop*, 205: 105354. DOI: 10.1016/j.actatropica.2020.105354
- KHAN, A., AHMED, H., KHAN, H., SIMSEK, S., KILINC, S.G., KESIK, H.K., YAYI, G., CELIK, F., AFZAL, M.S., BUDKE, C.M. (2020d): First report of Echinococcus canadensis (G6/G7) by sequence analysis from the Khyber Pakhtunkhwa province of Pakistan. *Acta Trop*, 209: 105559. DOI: 10.1016/j.actatropica.2020.105559
- KEBEDE, N., MITIKU, A., TILAHUN, G. (2010): Retrospective survey of human hydatidosis in Bahir Dar, northwestern Ethiopia. *East Med-iterr. Health J.*, 16: 937 – 941
- KHAZAEI, S., REZAEIAN, S., KHAZAEI, Z., GOODARZI, E., KHAZAEI, S., MOHAMMADIAN, M., SALEHINIYA, H., AYUBI, E., MOHAMMADIAN-HAFSHEJANI, A. (2016): Epidemiological and clinical characteristics of Patients with Hydatid Cysts in Khorasan Razavi Province, from 2011 to 2014. *Iran J Parasitol*, 11: 364 – 367
- LÖTSCH, F., NADERER, J., SKUHALA, T., GROGER, M., AUER, H., KACZIREK, K., WANECK, F., RAMHARTER, M. (2016): Intra-cystic concentrations of albendazole-sulphoxide in human cystic echinococcosis: a systematic review and analysis of individual patient data. *Parasitol Res*, 115: 2995 – 3001. DOI: 10.1007/s00436-016-5054-x
- MAHMOUDI, S., MAMISHI, S., BANAR, M., POURAKBARI, B., KESHAVARZ, H. (2019): Epidemiology of echinococcosis in Iran: a systematic review and meta-analysis. *BMC Infect. Dis*, 19: 929. DOI: 10.1186/s12879-019-4458-5
- MISACHI J. (2019): *Ethnic groups in Pakistan*. Retrieved on 4th October, 2020 from <https://www.worldatlas.com/articles/ethnic-groups-in-pakistan.html>
- MONGE-MAILLO, B., CHAMORRO TOJEIRO, S., LÓPEZ-VÉLEZ, R (2017): Management of osseous cystic echinococcosis. *Expert Rev Anti Infect Ther*, 15:1075 – 1082. DOI: 10.1080/14787210.2017.1401466
- MOUSAVI, S.R., SAMSAMI, M., FALLAH, M., ZIRAKZADEH, H. (2012): A retrospective survey of human hydatidosis based on hospital records during the period of 10 years. *J Parasit Dis*, 36: 7 – 9. DOI: 10.1007/s12639-011-0093-9
- MUQADDAS, H., ARSHAD, M., AHMED, H., MEHMOOD, N., KHAN, A., SIMSEK, S. (2019): Retrospective study of cystic echinococcosis (CE) based on hospital record from five major metropolitan cities of Pakistan. *Acta Parasitol*, 64:866 – 872. DOI: 10.2478/s11686-019-00109-w
- OTERO-ABAD, B., TORGERSON, P.R. (2013): A systematic review of the epidemiology of echinococcosis in domestic and wild animals. *PLoS Negl. Trop. Dis*, 7:e2249. DOI: 10.1371/journal.pntd.0002249
- SHARMA, M., SEHGAL, R., FOMDA, B.A., MALHOTRA, A., MALLA, N. (2013): Molecular characterization of *Echinococcus granulosus* cysts in north Indian patients: identification of G1, G3, G5 and G6 genotypes. *PLoS Negl Trop Dis*, 7: e2262. DOI: 10.1371/journal.pntd.0002262
- TORGERSON, P.R. (2013): The emergence of echinococcosis in central Asia. *Parasitology*, 140: 1667 – 1673. DOI: 10.1017/S0031182013000516
- TAMAROZZI, F., AKHAN, O., CRETU, C.M., VUTOVA, K., AKINCI, D., CHIPEVA, R., CIFTCI, T., CONSTANTIN, C.M., FABIANI, M., GOLEMANOV, B., JANTA, D., MIHAILESCU, P., MUHTAROV, M., ORSTEN, S., PETRUTESCU, M., PEZZOTTI, P., POPA, A.C., POPA, L.G., POPA, M.I., VELEV, V., CASULLI, A. (2018): Prevalence of abdominal cystic echinococcosis in rural Bulgaria, Romania, and Turkey: a cross-sectional, ultrasound-based, population study from the HERACLES project. *Lancet Infect. Dis.*, 18: 769 – 778. DOI: 10.1016/S1473-3099(18)30221-4
- TORGERSON, P.R., KARAEVA, R.R., CORKERI, N., ABDYJAPAROV, T.A., KUTTUBAEV, O.T., SHAIKENOV, B. S. (2003): Human cystic echinococcosis in Kyrgyzstan: an epidemiological study. *Acta Trop.*, 85: 51 – 61. DOI: 10.1016/s0001-706x(02)00257-7
- WHO-IWG (2003): International classification of ultrasound images in cystic echinococcosis for application in clinical and field epidemiological settings. *Acta Trop.*, 85: 253 – 261. DOI: 10.1016/s0001-706x(02)00223-1
- WORLD HEALTH ORGANIZATION (WHO) (2020): *Echinococcosis*. Retrieved April 9, 2020 from <https://www.who.int/news-room/factsheets/detail/echinococcosis>