

Echinococcus granulosus in humans associated with disease incidence in domestic animals in Kermanshah, west of Iran

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Abstract Hydatidosis is one of the important zoonotic diseases that cause considerable economic losses and public health problems worldwide. This study was conducted to determine the prevalence *Echinococcus granulosus* in people and slaughtered animals in Kermanshah province, west of Iran. Hospitals data and meat-inspection records in Kermanshah abattoir were used in this study. A total number of 32,130 slaughtered livestock (7000 cattle, 19,950 sheep and 5180 goats) was inspected in the 3-year period and overall 2043 (6.35 %) were infected. The highest and lowest prevalence was recorded in cattle and goats, respectively. In human, Cystic echinococcosis affected more females (54 %) than males (46 %) with a 1.17 male to female ratio. Rate of disease in urban and rural regions were 46 and 54 %, respectively. The youngest and the oldest patient operated were 7 and 87 years old, respectively, and the age group 21–40 years (41.2 %) were the most affected. A significantly higher number of hydatid cysts were recorded in the liver than in other sites. The ratio of hepatic hydatidosis to pulmonary hydatidosis was 2.46. The results showed that hydatidosis is of great importance in this area and serious attention is needed to prevent and control the disease.

Keywords Echinococcosis · Hydatidosis · Prevalence · Slaughtered animals · Kermanshah · Iran

Introduction

Cystic echinococcosis (CE), also known as hydatidosis, is one of the most important zoonotic parasitic diseases of human and mammals caused by the larval stage of dog tapeworm *Echinococcus granulosus*. Hydatidosis has great economic and public health significances with a worldwide distribution (Rokni 2009).

The disease is highly endemic in the Mediterranean zone, including North Africa and the Middle East countries (Rostami Nejad et al. 2007). Although sheep, goats, cattle, camels, buffaloes, pigs, and donkeys have been repeatedly found infected with hydatid cysts in the Middle East countries, the domestic dog as a definitive host for *E. granulosus* plays an important role in the spread of infection via contamination of the environment (Arbabi and Hooshyar 2006).

Similar to most Mediterranean countries, hydatidosis is endemic in Iran and is maintained in three distinct cycles; a dog/livestock domestic cycle, a dog/camel desert cycle, and a sylvatic cycle between wild carnivores and wild ruminants (Ahmadi and Hamidi 2008).

In Iran, livestock are still slaughtered traditionally and carcass wastes are easily accessible to scavenging dogs and other wild carnivores (Eslami and Hosseini 1998).

The prevalence of *E. granulosus* has been reported in Iran from 3.3 to 63.3 % in dogs, 5.1 to 74.4 % in sheep, 1.7 to 20 % in goats, 3.5 to 38.3 % in cattle, and 11.4 to 70 % in camels (Eslami and Hosseini 1998; Ahmadi 2005; Ansari-Lari 2005; Rokni 2009; Shahbazi et al. 2014). Sheep and camel (with 88 and 70 % of fertile cysts, respectively) are the most important intermediate hosts, and cattle (with 19 % fertile cysts) have been considered as the weakest intermediate host of *E. granulosus* in Iran (Eslami and Hosseini 1998; Rokni 2009).

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Humans are encountered as incidental (dead-end) hosts for *Echinococcus* spp. (Radfar and Iranyar 2004). The studies in many parts of Iran (Ahmadi and Hamidi 2008; Yousefi Darani et al. 2003; Dalimi et al. 2006; Pezeshki et al. 2007; Rostami Nejad et al. 2007; Rokni 2009; Sarkari et al. 2010; Ahmadi and Badi 2011) have indicated that hydatidosis is an important clinical disease which is associated with significant economic losses and social welfare of the people in Iran.

In Iran, CE is responsible for approximately 1 % of admission to surgical wards (Ahmadi and Hamidi 2008; Sarkari et al. 2010). Therefore, analysis of retrospective hospital records can provide a useful tool to evaluate the regional epidemiological situation of the disease in human (Ahmadi and Hamidi 2008; Ahmadi and Badi 2011).

Kermanshah province of Iran has the potential of high prevalence of echinococcosis/hydatidosis due to the existence of sheep and goats husbandry jobs and presence of numerous stray dogs. In spite of this fact, there is not adequate information about this disease in carnivores, herbivores and humans in this area.

Therefore, this survey was designed to estimate the prevalence of echinococcosis/hydatidosis in abattoir populations of ruminants and patients hospitalized at two medical centers in Kermanshah province, west of Iran.

Materials and methods

Field study area

The study was carried out in Kermanshah, the western provinces of Iran, from 2009 to 2014 during the wet and dry seasons. Kermanshah province is located between latitude 33°35' N and longitude 45°47' E with altitude 1350 m above sea level. Kermanshah has a moderate and mountainous climate and the annual rainfall is 500 mm. The average temperature in the hottest months is above 22 °C. The population of the area is approximately 1800,000 inhabitants, 60 % of them live in urban areas. Inhabitants living in rural area are farmers actually involved in animal production. The dogs either live with herds of sheep and goats or look after the house or farm. Additionally, stray dogs and some other carnivores, may enter the human houses and farms in search of food. In some regions, the animals are still slaughtered traditionally and carcass wastes are easily accessible to scavenging dogs and other wild carnivores.

Examination of slaughtered animals

A total of 7000 cattle, 19,950 sheep and 5180 goats were examined for hydatid cyst infection at slaughterhouses of

Kermanshah during 2011–2014. As part of an ongoing surveillance system, each slaughtered animal was examined individually by a meat inspector (veterinarian) in the course of his routine duties. Diagnosis of hydatidosis was done macroscopically either by visual inspection or palpation and, where necessary, one or more incisions were made. The reasons for condemnation of organs were recorded on prepared data sheets.

Hospitalized patients

A retrospective study was carried out at Imam-Reza and Imam-Hosseini hospitals which are general hospitals in Kermanshah, the center of Kermanshah province, west of Iran between 2009 and 2011. People from different parts of the province are referred to these hospitals for general surgery. All medical documents of patients with hydatid cyst were reviewed. Data such as age at the time of surgery, gender, place of residence, number of cysts and the anatomic location of cysts were recorded. The ratios between male and female cases and ratios between liver and lung involvement were calculated. The collected data were statistically analyzed using SPSS software. Values of $P < 0.05$ were accepted as significant.

Results

A total number of 32,130 slaughtered livestock (7000 cattle, 19,950 sheep and 5180 goats) was inspected in this study. The overall prevalence of hydatidosis in slaughtered livestock was 2043 (6.35 %). In total, 307 (59 %), 962 (76.6 %) and 189 (71 %) lungs and 125 (24 %), 203 (16.2 %) and 52 (19.7 %) livers were condemned in slaughterhouses due to hydatid cysts in cattle, sheep and goats, respectively. Additionally, hydatid cysts were observed in both organs in 12 % of cattle, 5.5 % of sheep and 6.6 % of goats. In all animal species, the condemnation rate in the lungs was more than that in livers (Table 1).

To determine the types of cysts in different animals, 558, 1305 and 275 cysts were inspected carefully in cattle, sheep and goats, respectively. The category of cysts by animal species and location is summarized in Table 2. In cattle, 10.7 % of cysts were fertile, whereas the number of fertile cysts was 33.5 % in sheep and 30.1 % in goats. The fertility rates of pulmonary cyst of cattle, sheep and goats were 11.6, 29.1 and 30.6 %, respectively, and the fertility rates of hepatic cyst of cattle, sheep and goats were 9, 50.2 and 29 %, respectively.

A total number of 172 CE positive (79 male and 93 female) was observed among studied medical records over a 5-year period in Kermanshah (Table 3). Rate of disease in rural and urban regions were 54 and 46 %, respectively.

Table 1 The total number of animals slaughtered, and lung and liver condemned (%) due to hydatid disease during 2011–2014

	Years			Total
	2011–2012	2012–2013	2013–2014	
Cattle				
Animal slaughtered	2400	2328	2272	7000
Infected animals	189 (7.9 %)	172 (7.4 %)	160 (7 %)	521 (7.4 %)
Lung hydatid	110 (58.2 %)	97 (56.4 %)	100 (62.5 %)	307 (59 %)
Liver hydatid	43 (22.7 %)	44 (25.6 %)	38 (23.7 %)	125 (24 %)
Lung + Liver	26 (13.8 %)	22 (12.8 %)	15 (9.4 %)	63 (12 %)
Other organs	10 (5.3 %)	9 (5.2 %)	7 (7 %)	26 (5 %)
Sheep				
Animal slaughtered	6721	6539	6690	19,950
Infected animals	451 (6.7 %)	402 (6.1 %)	403 (6 %)	1256 (6.3 %)
Lung hydatid	341 (75.6 %)	316 (78.6 %)	305 (75.7 %)	962 (76.6 %)
Liver hydatid	74 (16.4 %)	61 (15.2 %)	68 (16.9 %)	203 (16.2 %)
Lung + Liver	27 (6 %)	20 (5 %)	23 (5.7 %)	70 (5.5 %)
Other organs	9 (2 %)	5 (1.2 %)	7 (1.7 %)	21 (1.7 %)
Goat				
Animal slaughtered	1790	1682	1708	5180
Infected animals	96 (5.3 %)	82 (4.9 %)	88 (5.2 %)	266 (5.1 %)
Lung hydatid	68 (70.8 %)	59 (72 %)	62 (70.4 %)	189 (71 %)
Liver hydatid	17 (17.7 %)	17 (20.7 %)	18 (20.4 %)	52 (19.7 %)
Lung + Liver	7 (7.3 %)	5 (6.1 %)	5 (5.7 %)	17 (6.6 %)
Other organs	4 (4.2 %)	1 (1.3 %)	3 (3.5 %)	8 (3 %)

Table 2 Category of cyst by organs of origin

Animal	Organ	Cyst status			Total
		Fertile	Sterile	Calcified	
Cattle	Lung	43 (11.6 %)	201 (54.3 %)	126 (34.1 %)	370
	Liver	17 (9 %)	105 (55.9 %)	66 (35.1 %)	188
	Total	60 (10.7 %)	306 (54.8 %)	192 (34.4 %)	558
Sheep	Lung	300 (29.1 %)	283 (27.4 %)	449 (43.5 %)	1032
	Liver	137 (50.2 %)	55 (20.1 %)	81 (29.7 %)	273
	Total	437 (33.5 %)	338 (25.9 %)	530 (40.6 %)	1305
Goats	Lung	63 (30.6 %)	49 (23.8 %)	94 (45.6 %)	206
	Liver	20 (29 %)	24 (34.8 %)	25 (36.2 %)	69
	Total	83 (30.1 %)	73 (26.5 %)	119 (43.2 %)	275

Table 3 Prevalence of *E. granulosus* infection in human during 2009–2014 at two medical centers in Kermanshah, Iran

Years	Prevalence of CE		
	Male	Female	Total (%)
2009–2010	24	20	44 (25.58)
2010–2011	19	19	38 (22.09)
2011–2012	13	24	38 (22.09)
2012–2013	14	15	29 (16.86)
2013–2014	8	15	23 (13.37)
2009–2014	79	93	172 (100)

Table 4 Age and gender distribution of surgically confirmed cystic echinococcosis cases at two medical centers in Kermanshah, Iran (2009–2014)

Age (years)	Number and (%) of surgical cases			Male/female ratio
	Male	Female	Total (%)	
<20	14 (8.1)	6 (3.4)	20 (11.6)	2.3
21–40	33 (19.1)	38 (22)	71 (41.2)	0.8
41–60	13 (7.5)	27 (15.6)	40 (23.2)	0.48
>61	19 (11)	22 (12.7)	41 (23.8)	0.86
Total	79 (45.9)	93 (54)	172 (100)	0.84

Table 5 Location of hydatid cyst with single and multiple organ involvement

Cyst location	Male (%)	Female (%)	Total (%)
Single-organ involvement			
Liver	31 (23.4)	48 (36.3)	79 (59.8)
Lung	16 (12.1)	16 (12.1)	32 (24.2)
Spleen	–	3 (2.2)	3 (2.2)
Brain	1 (0.7)	1 (0.7)	2 (1.5)
Pelvis	1 (0.7)	–	1 (0.7)
Omentum	1 (0.7)	–	1 (0.7)
Abdomen	1 (0.7)	–	1 (0.7)
Total	51 (38.6)	68 (51.5)	119 (90.1)
Multiple-organ involvement			
Liver + lung	5 (3.7)	4 (3)	9 (6.8)
Lung + mediastinum	1 (0.7)	–	1 (0.7)
Liver + spleen	–	1 (0.7)	1 (0.7)
Spleen + pancreas	–	1 (0.7)	1 (0.7)
Liver + kidney	–	1 (0.7)	1 (0.7)
Total	6 (4.5)	7 (5.3)	13 (9.8)
Overall	57 (43.1)	75 (56.8)	132 (100)

Table 6 Distribution of surgically confirmed cystic echinococcosis cases according to age groups and site of cysts

Age (years)	Liver			Lung			Other organs			Ratio
	Male	Female	Total (%)	Male	Female	Total (%)	Male	Female	Total (%)	
<20	3	2	5	4	4	8	2	–	2	0.62
21–40	14	22	36	7	9	16	6	5	11	2.25
41–60	7	12	19	3	3	6	1	3	4	3.16
>61	7	12	19	2	–	2	1	3	4	9.5
Total	31 (23.4 %)	48 (36.3)	79 (59.8)	16 (12.1)	16 (12.1)	32 (24.2)	10 (7.5)	11 (8.3)	21 (15.9)	2.46

From 172 patients, 132 cases were operated in the medical centers. Age, gender distribution and the male/female ratio by age groups are shown in Table 4. The youngest and the oldest patient operated were 7 and 87 years old, respectively. In the 21–40 years old group there was a high rate of hydatid cysts (41.2 %), compared with other age groups. An overall analysis of gender and

age of the CE cases revealed that the number of females infected was higher than that of males with a 0.84 male to female ratio.

Hydatid cyst distribution in various anatomical sites is shown in Table 5. The most common involved organs were the liver (59.8 %) and lung (24.2 %), respectively. The incidence of hepatic CE was significantly higher than that

of CE in other organs ($P < 0.001$), and was higher in females (36.3 %) than males (23.4 %). The prevalence of lung hydatidosis was 12.1 % in both sexes. A single organ involvement was found in 90.1 % of the patients, and was more frequent in females (51.5 %) than in males (38.6 %).

The age-group distribution of the patients with liver and/or lung cysts is shown in Table 6. The ratio of hepatic hydatidosis to pulmonary hydatidosis was 2.46. Pulmonary hydatidosis was more prevalent in the <20 age group, whereas hepatic hydatid disease was predominant in the other age-groups.

Discussion

Hydatidosis is an important socioeconomic and public health problem in many areas of the world. Therefore, it is justifiable to find reliable data for monitoring epidemiologic aspects of disease in human and animals and also prepare a baseline data for future comparison (Ansari-Lari 2005). Previous studies from different parts of Iran confirm the fact that Iran is an endemic or a hyper endemic area for *E. granulosus* (Oryan et al. 1994; Ahmadi and Hamidi 2008; Eslami and Hosseini 1998; Mehraban et al. 1999; Ahmadi 2005; Ansari-Lari 2005; Arbabi and Hooshyar 2006; Daryani et al. 2007; Fakhari and Sadjjadi 2007; Pezeshki et al. 2007; Rostami Nejad et al. 2007; Ghazani et al. 2008; Sarkari et al. 2010; Ahmadi and Badi 2011; Shahbazi et al. 2014).

Based on the literature, hydatidosis is prevalent in livestock in many parts of Iran. According to abattoir surveys, the mean prevalence of hydatidosis of sheep in different parts of the country has been reported to be 8.1 %, which varies from 1 to 27.5 %, while the mean prevalence of infection in goats was 6.5 % (0.5–20 %). The corresponding feature for cattle has been reported as 12 %, (1–28 %) (20).

In the present study, 7.4 % of cattle, 6.3 % sheep and 5.1 % of goats were infected with hydatid cyst. The prevalence of *E. granulosus* infection recorded in the present study was generally lower than those reported from other regions of Iran (Moghaddar et al. 1992; Oryan et al. 1994; Dalimi et al. 2002; Akhlaghi et al. 2005; Ansari-Lari 2005; Arbabi and Hooshyar 2006; Daryani et al. 2007) and its neighbor countries, i.e., Saudi Arabia, Iraq and Jordan (Kamhawi et al. 1995; Saeed et al. 2000; Ibrahim 2010).

The differences in prevalence of hydatidosis may arise due to variations in environmental conditions that are conducive for the perpetuation of the parasite, abundance of infected definitive hosts, livestock husbandry, stocking rate, the nature of the pasture and grazing patterns of animals. Other factors like difference in culture, social

activities and attitudes to dogs may contribute to this variation (Ernest et al. 2009; Shahbazi et al. 2014).

In this study, there was a difference in the prevalence of hydatidosis between studied animals with higher prevalence in cattle than sheep, and the lowest prevalence in goats. This difference could be attributed to the fact that cattle are slaughtered at old age, while sheep and goats are slaughtered at a relatively early age compared to cattle. Aging can increase the risk of exposure to eggs of *E. granulosus* in cattle (Getaw et al. 2010).

Additionally, lower incidence of caprine hydatidosis is probably due to the feed of goats. Since goats feed mainly by browsing, rather than grazing, they usually show lower rates of infection (Ansari-Lari 2005).

Assessment of organ distribution of cysts showed that the lung was more frequently infected with hydatid cysts than the liver in all studied animals. This result is in agreement with previous studies in Shiraz (Southern Iran), Kashan (Central Iran), Northern Iran, Ethiopia, Italy and Morocco (Giannetto et al. 2004; Ansari-Lari 2005; Arbabi and Hooshyar 2006; Azlaf and Dakkak 2006; Getaw et al. 2010). In contrast, some researchers stated that the livers of cattle are more commonly infected with hydatid cysts than the lungs (Gusbi et al. 1990; Ibrahim 2010; Mansoor-lakooraj et al. 2011; Adinehbeigi et al. 2013).

In examining the condition of cyst fertility, it was revealed that 33.5 % of the cysts were sterile and moderate proportions were fertile (27.1 %). The cyst fertility rate was variable as high in sheep (33.5 %) and goats (30.1 %) and low in cattle (10.7 %). These findings were similar to those reported by other researchers (Dalimi et al. 2002; Kebede et al. 2008; Ernest et al. 2009).

According to these results, it seems that cattle are poor hosts for *E. granulosus* and may therefore not be an important source of infection for dogs. In contrast, the greater infectivity of hydatid cysts from sheep and goats and the common practice of backyard slaughter may reflect their importance as intermediate hosts for the perpetuation of the domestic cycle of *E. granulosus* in this area.

According to a literature review, Iran is one of the hyper endemic areas with a human infection rate of more than 1 % of the total population (Rostami Nejad et al. 2007). Humans are accidental intermediate hosts and are being exposed to the parasite by fecal-oral and hand to mouth spread ways (Smith and Rickman 2001).

In this study, 172 patients treated for CE at two medical centers in Kermanshah, namely Imam-Reza and Imam-Hosseini hospitals during 2009–2014. The highest number of CE cases (25.58 %) was recorded in 2009–2010 and the lowest (13.37 %) in 2013–2014.

In the current study, CE was most prevalent in the patients between 21 and 40 years old. Similar results have been reported from Hamedan, Kohgiluyeh and Boyer-

Ahmad, Kashan and Tehran provinces of Iran (Arbabi and Hooshyar 2006; Pezeshki et al. 2007; Sarkari et al. 2010; Ahmadi and Badi 2011).

Hydatidosis is a chronic disease with a long incubation period (might be 20–30 years) and hydatid cyst grows very slowly in human when compared to animals. This might explain the reason for the high rate of surgeries for CE in people who are in the age group 21–40 years old.

The highest prevalence of CE was observed in the women in this study with a male: female ratio of 1.17, similar to the results have been reported previously (Ahmadi and Hamidi 2008; Saeed et al. 2000; Al-Qaoud et al. 2003; Pezeshki et al. 2007; Ahmadi and Badi 2011).

The reason for this incidence is not quite clear, but it seems that the women have the highest chance of contact with sources of infection such as dog, soil and raw vegetable in some areas depending on the culture and social criteria (Rokni 2009).

However, in the other studies conducted in Khuzestan, East Azerbaijan and Sistan and Baluchistan provinces of Iran, the number of surgical cases in adult men was higher than in women (Talaiezhadeh and Maraghi 2006; Hosseinpour and Rahbani 2007; Sharifi-Mood et al. 2007).

Unlike adult cases, young males <20 years old showed higher prevalence of CE than females of comparable age at a ratio of 2.3. A similar difference between male and female (in <20 years) was noted in Hamedan and Tehran provinces of Iran (Ahmadi and Hamidi 2008; Ahmadi and Badi 2011), Bulgaria (Todorov and Boeva 2000) and Jordan (Al-Qaoud et al. 2003).

Our study showed that the different organs were involved with CE, but the liver was the most affected organ in both sexes, followed by lung. This observation is in agreement with reports from several other studies in Iran and other countries (Ahmadi and Hamidi 2008; Rostami Nejad et al. 2007; Pezeshki et al. 2007; Sarkari et al. 2010; Ahmadi and Badi 2011). The findings showed that the hepatic hydatid disease predominated in all age-group except <20 age-group.

However, pathophysiological influences on the anatomic location of cysts are still unknown, this is explained by the fact that livers and lungs possess the first great capillary sites encountered by the migrating echinococcus oncosphere (hexacanth embryo) which adopt the portal vein route and primarily negotiate hepatic and pulmonary filtering system sequentially before any other peripheral organ is involved (Kebede et al. 2009; Fathi et al. 2012).

According to the hospital data, the vast majority (90.1 %) of CE cases had only single-organ involvement. This result is similar to those reported by other researchers in Iran (Ahmadi and Hamidi 2008; Sarkari et al. 2010) and Argentina (Pierangeli et al. 2007).

The results showed that the prevalence of CE in the rural inhabitants (54 %) was higher than the urban inhabitants

(46 %). This result is consistent with reports from several other studies in Iran, Iraq, Jordan and Argentina (Ahmadi and Hamidi 2008; Saeed et al. 2000; Al-Qaoud et al. 2003; Pierangeli et al. 2007).

Rural dwellers have the highest chance of contact with the sources of infection such as contaminated vegetables, cleaning the house containing the dog faeces and desire to eat soil (Geophagy) as longing in pregnant (Rokni 2009).

However, the results of this survey indicated that the prevalence of ruminant's hydatidosis in Kermanshah is relatively lower than many parts of Iran, but the high fertility rates which was observed in all infected animal species highlights the hazards that these animals may pose indirectly to people in this region and possibly other parts of the country where the livestock industry and pastoralism are practiced.

Dogs play an important role in the transition of the hydatidosis. In our study area, a large number of households have dogs which are not dewormed regularly and are managed under free-range system. Moreover, survey of literature regarding the rate of infection to *E. granulosus* in stray dogs shows a prevalence of 5–49 % in different parts of Iran (Rokni 2009).

In rural areas, sheep and goats are commonly slaughtered on farms and the infected offal is available to scavenging dogs. Moreover, dogs may become infected by scavenging of dead animals in nearby fields or via local butchers and abattoirs or from houses in which sheep have been slaughtered for household consumption. Hence, a large number of parasites' eggs may be released continuously by dogs in the region (Eslami and Hosseini 1998).

It seems that dogs have a very important role in maintaining the parasite cycle not only in rural areas, but also in urban regions of Kermanshah province.

Local veterinarians assessed the dog populations of the urban area as 1 dog per 20 inhabitants in Kermanshah province. Therefore, many people in our study area may have had direct contact with dogs or may have been to locations contaminated by their feces.

In addition, some socio-cultural factors such as consumption of raw vegetables and the slaughter of Sheep and goats without the supervision of veterinary organization and also lack of attention to public health can play an important role in the incidence of human hydatidosis in our studied area.

Conclusion

Generally, the situation of the hydatidosis in the livestock and human in Kermanshah is similar to that of the other area in Iran. Owing to the presence of socioeconomic

conditions favorable for hydatidosis and high level of infection in livestock indicates that the disease is of great importance in our study area. Since hydatidosis is usually asymptomatic in human and also some cases do not require surgical intervention or hospitalization, retrospective hospital survey data cannot give an accurate picture of the prevalence of infection. However, despite such limitations, survey of hospital records provides a useful indication of infection expressed as an annual rate of hospitalized cases and also prepares a baseline data for future comparison.

Certainly, improving the slaughter slabs, restrict backyard slaughter, enforce legislation on meat inspection and improve veterinary services can help to control and prevention of the disease in this area. Furthermore, public health education about the disease is highly recommended to the community.

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Conflict of interest The authors declare no conflicts of interest.

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