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BRIEF COMMUNICATION

Prevalence of Cystic Echinococcosis in Slaughtered Sheep as an Indicator to Assess Control Progress in Emin County, Xinjiang, China

Shijie Yang[1], Weiping Wu[1,*], Tian Tian[1], Jiangshan Zhao[2], Kang Chen[3], Qinyan Wang[3], Zheng Feng[1,*]

[1]National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, WHO Collaborating Centre for Malaria, Schistosomiasis and Filariasis, Shanghai 200025, China; [2]Xinjiang Center for Disease Control and Prevention, Wulumuqi, Xinjiang 832003, China; [3]Emin County Center for Disease Control and Prevention, Xinjiang 834600, China

Abstract: Hydatid disease imposing serious threat on human health and great loss in live¬stock pastoralism remains a major public health problem in western China. To assess and monitor the effect of control program on transmission dynamics, we used the prevalence of cystic echinococcosis in slaughtered sheep at slaughterhouse as an indicator during the period of 2007 to 2013 in Emin County, Xinjiang Uygur Autonomous Region, China. The results showed a significant decline trend of prevalence in all age groups during the 7 years when the control program was implemented; particularly, the rate was reduced by 72% after first 3 years. Among the sheep slaughtered, the age distribution evidenced that the prevalence increased significantly as the sheep grew older. The baseline data indicated that the rate was 4.5% at the age <1, 6.7% at age 2~, and reached to the highest 17.9% at age ≥4 years. Earlier response to the intervention pressure was seen in the sheep at the younger age. Significant decline started from 2008 at the age <1, from 2009 at age of 1~, 2010 at 2~ to 3~, and the latest, in 2012 at age ≥4. This study demonstrated that the prevalence of cystic echinococcosis in slaughtered sheep may be used as an indicator to assess and monitor the transmission status during and after control program providing information for betterment of performance to sustain control strength.

Key words: *Echinococcus granulosus*, cystic echinococcosis, sheep, prevalence, transmission, Xinjiang, China

Cystic echinococcosis (CE), also termed hydatid disease, a worldwide zoonotic disease, is caused by larval *Echinococcus granulosus* posing serious threat to the health of human and livestock and leading to great economic loss [1-3]. It is a major public health risk in western China, a vast area of pastoral farming, affecting about 66 million people, which accounts for 5.1% of the country population [4,5]. The CE is endemic in Tibet, Gansu, Qinghai, Ningxia Hui Autonomous Region, Xinjiang Uygur Autonomous Region (Xinjiang), and western part of Inner Mongolia Autonomous Region and Sichuan in western and northwestern China with an average prevalence of 1.1% [4,6-8]. Recent report shows that there are about 30 million infected livestock with 7 million infected yearly; among the infected, more than 70% are sheep, causing a total economic loss of about 1 billion Yuan (RMB) [6,7]. In 2006, the government listed CE as one of the major parasitic diseases to be controlled in a national control program for echinococcosis. In 2007, echinococcosis was listed as one of the major parasitic diseases which can be treated free. In a long term, China plans to achieve virtual control of echinococcosis by 2020. The integrated measures in the national control program include (1) control of the source of infection by deworming dogs with praziquantel (PZQ), (2) strict management of slaughterhouses and quarantine of livestock to restrict feeding dogs with offal of infected animals, (3) health education for healthy habits comprising of washing hands before meals and drinking boiled water, and (4) treatment of patients [9,10].

To evaluate the effect of the control program on *E. granulosus* transmission in Emin County, we investigated the changes of the hydatid cyst prevalence in slaughtered sheep from October 2007 to November 2013. Emin County is located in the north border of Xinjiang, at latitudes 46°N and altitudes 83°E (Fig. 1). It consists of 11 administrative townships including 5 pas-

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* Corresponding author (wuweiping@hotmail.com; zfeng0909@163.com)

Fig. 1. Geographic location of Emin County, Xinjiang, China.

tures and 1 farm, covering 1,050 acres of natural grassland and a total population of 220 thousands with multiethnic groups. Xinjiang is one of the 5 major pastoral areas in the country, and a highly endemic area of CE. Implementing the national control program, deworming of dogs was carried out as a main component among other measures. In the county, all the domestic dogs were registered and monthly administered with PZQ at a dosage of 200 mg for the body weight under 15 kg and 400 mg for over 15 kg. The stray dogs were also dewormed by auto-feeding with PZQ-mixed food placed at assigned sites and checked regularly. After dosed, the dog feces were deep buried to avoid environment contamination [11]. To ensure implementation of the control program, each village appointed a resident to be responsible for deworming of dogs and delivering health education. The County Department of Quarantine strengthened inspection of the slaughterhouse, strictly restricting feeding dogs with offal and prohibiting sales of sick animals' offal.

The county slaughterhouse is authorized for all local livestock animals. There is only one authorized slaughterhouse at service in Emin County. In this region, the number of animals slaughtered usually reaches a peak in September-October each year before freezing season; therefore, we examined all the sheep slaughtered in October yearly from 2007 to 2013. A total of 17,215 slaughtered sheep were surveyed at the slaughterhouse by visual inspection and palpation for hydatid cysts in internal organs including the liver, lungs, spleen, heart, and kidneys. All the sheep investigated were raised outdoors locally. Among the sheep examined, 73.5% (12,649/17,215) were males, and 42.8% (7,363/17,215) at age <1 year, 91.4% (15,735/17,215) aged <3, while 1.6% were over 4 years old.

The data were analyzed with SPSS 17.0. For the group comparison, Chi-square test was used and the significance at $P<0.05$ was estimated.

In 2007, when the control program was initiated, the infection rate was 6.6%, and from 2008 through 2013 was 3.9%, 2.0%, 1.8%, 1.9%, 1.7%, and 2.0%, respectively, showing a significant declining trend ($\chi_{trend}^2=59.79$, $P<0.001$). Particularly, after the first 3 years, the rate was remarkably reduced by 72%. However, the changes from 2010 to 2013 were not significant ($P>0.05$), remaining at a level between 1.7% and 2.0% (Table 1).

As shown in Table 2, the age distribution of *E. granulosus* infection rate in the slaughtered sheep varied with age and the time of year during the control period. It was found that the infection rate of all age groups presented a significant reducing trend longitudinally as the dog deworming progressed. It is worth noticing that in comparison with the baseline in 2007, significant reduction started from 2008 at the age <1, from 2009 at age 1~, 2010 at the age 2~ to 3~ groups, and the latest, from 2012 at age ≥4 years old. The age distribution also showed that the infection rate was significantly increased as

Table 1. *E. granulosus* infection rate in slaughtered sheep from 2007 to 2013

Year	2007	2008	2009	2010	2011	2012	2013	Total
No. examined	1,083	1,002	2,194	6,545	3,144	2,652	595	17,215
No. with cysts	71	39	44	120	60	44	12	390
Infection rate (%)	6.6	3.9	2	1.8	1.9	1.7	2	

Table 2. Age distribution of *E. granulosus* infection rate in sheep during 2007-2013

Year	Age (year)					χ^2	*P*
	<1	1.0-1.9	2.0-2.9	3.0-3.9	≥4		
2007	4.46 (10/224)[a]	5.47 (21/384)	6.69 (18/269)	9.55 (17/178)	17.86 (5/28)	8.36	0.004
2008	1.42 (4/281)[b]	2.46 (6/244)	4.76 (12/252)	7.41 (16/216)	11.11 (1/9)	14.24	0
2009	1.58 (26/1649)	2.17 (5/230)[c]	4.05 (6/148)	5.63 (8/142)	8.00 (2/25)	19.6	0
2010	1.38 (43/3221)	1.49(31/2083)	3.24 (32/989)[d]	4.00 (9/225)[e]	7.41 (2/27)	20.12	0
2011	1.22 (11/900)	1.44 (15/1042)	2.25 (20/889)	3.90 (9/231)	6.10 (5/82)	13.34	0
2012	1.18 (11/932)	1.35 (9/667)	1.79 (14/784)	3.23 (6/186)	4.82 (4/83)[f]	7.2	0.007
2013	1.28 (2/156)	2.05 (3/146)	2.04 (5/245)	3.13 (1/32)	6.25 (1/16)	1.3	0.254
χ_{trend}^2	5.124	17.88	20.38	10.37	5.522		
P	0.024	0	0	0.001	0.036		

[a]Infection rate (%; no. infected/no. examined) Compared with 2007 baseline.
[b]$\chi^2=4.276$, $P<0.05$.
[c]$\chi^2=3.882$, $P<0.005$.
[d]$\chi^2=6.618$, $P<0.05$.
[e]$\chi^2=5.073$, $P<0.05$.
[f]$\chi^2=4.777$, $P<0.05$.

the sheep grew in the years from 2007 to 2012, but not in 2013.

Deworming of dogs is a main component in echinococcosis control program in China, as domestic dogs were reported as the predominant definitive host in CE endemic area. The highest prevalence was found in dogs owned by transhumant pastoralists. Domestic dogs are kept in large population in northwestern China for pastoralism and cultural reasons, typically 2-4 shepherd dogs per household, and they play the most important role in transmitting the disease to humans through close contact with local people and sharing water source [1,2,8].

The principal animal intermediate host in highly endemic regions of China is sheep, although yaks, pigs, goats, and cattle are commonly found infected with *E. granulosus*. Sheep have the highest infection rates and are slaughtered in greater numbers than other livestock species [2,9].

The survey results showed that the infection rate increased significantly when the sheep grew older. The baseline data indicated that the sheep infection rate was 4.5% at the age <1, 6.7% at age 2~, and reached to the highest 17.9% at age ≥4 years. The age distribution we observed was similar to a recent study in Xinjiang that the rate was 1.9% at the age <1, and 17.2% when the sheep were 5-6 years old [9]. It may be explained by the fact that the younger sheep might be exposed to transmission for a shorter time than the older.

Given that sheep, the major intermediate host, is a key factor in CE transmission, we used the prevalence of CE in slaughtered sheep as an indicator to assess the effect of control program on the transmission in the implementing period of 7 years in the county. To follow up the indicator during the control period, the data obtained in the initiative year 2007 was used as a baseline. In this region, control activity usually begins in May-June after freezing winter; the survey of this study was conducted in October. Therefore, a few months of intervention would not affect the transmission chain status in 2007. Another reason for the study design is that after the government launched a control program for echinococcosis in 2006, it is administratively and ethically infeasible to reserve one county as a paired control site in forthcoming 6 years long staying out of control activities.

This investigation showed that after the first 3 years of control, the infection rate reduced by 72%, followed by remaining at a marginal level from 2010 afterward. Several factors may be attributable to the changing profile. First, it may be related to the sheep age. Analyzing the age distribution, the infection rate of all age groups showed a declining trend longitudinally, but significant reduction occurred earlier in younger ages, as shown in Table 2. The earliest significant decline occurred from 2008 at the age <1 group, and the latest, 2012 at age ≥4. On an average in the first 3 years, the number of slaughtered sheep aged <3 accounted for 83.6% (81-92%) of the total slaughtered. The local people usually raise sheep for about 2-3 years, since lambs would favorably meet the demands of the consumer market. Though the number of slaughtered is not from a population-based sampling, it may mirror a general status of the population. The earlier occurrence of significant reduction of prevalence in younger sheep may imply that the response of younger group is more sensitive to the intervention on CE transmission. This decline pattern may also be related to the strength of control practice. As a community-based intervention program, the deworming of domestic and stray dogs, burying dog feces, and health education might be difficult to be sustained at a high coverage as the control program is carried on. Furthermore, nomadic sheep, home slaughtered and a small number of sheep possibly slaughtered in neighboring counties might not be covered by the survey.

To interrupt the transmission cycles in dogs and sheep is essential for control of CE; thus, the effect of intervention on transmission could be evaluated by examining the infection in dogs and sheep. A decline in canine infection may be followed by a reduction of prevalence in sheep and young cattle and a decreasing annual incidence of human cases [12]. Obviously, estimating the prevalence in humans is a direct way to evaluate a control program, but it will involve a huge amount of work in a large area with households scatteredly distributed, often in remote areas. To examine the infection in dogs is an option, but in ethnic communities in western China, Buddhist practice forbids killing any animals, including dogs, leaving a large number of stray dogs in pastures and townships [8]. Using coproantigen detection approach to estimate the prevalence in dogs encounters difficulties not only due to the high cost for feces sample collection in a large area, but also the low sampling coverage of a large number of stray dogs, which are mostly beyond reach.

The CE prevalence in domestic animals, particularly in sheep, may provide a reliable indicator of infection source to dogs and transmission force to humans [9,12]. Some earlier studies reported the use of sentinel lamb or sheep prevalence to evaluate the CE control effect. A study in Xinjiang used sentinel lambs purchased for examination 4 years after the CE control effort, but no prevalence change was recorded due to the limited number of samples and low coverage of dog deworming [13]. Sentinel lambs purchased from farms were used to identify *E. granulosus* infection in sheep, to provide an early indication of the progress of the South Powys Hydatidosis Control Scheme, and it was concluded that within 1 year of dog treatment every 6 weeks the transmission to sheep could be ceased [14].

A nationwide random sampling survey of 2,035 sheep from slaughterhouses in Uruguay was reported using the prevalence of larval echinococcosis as an indicator of control progress and existing status 4 years after implementation of the national hydatidosis control program [15]. The results showed a significant decrease of prevalence in the sheep examined [15]. Random sampling survey may have an advantage for large scale evaluation, but the sampling size and stratum would be of critical importance. Purchasing sentinel sheep would significantly increase the cost. Therefore, using the prevalence in slaughtered sheep at slaughterhouse as an indicator may be a feasible and economic way to assess and monitor the effect of CE control program. Although it has limitations that it is not a population-based random sampling survey and unable to cover all slaughtered animals at the site investigated [16], the merit of the survey on slaughtered sheep is apparent. In the case of Emin County, the indicator data suggested that the control program is progressing effectively in reducing the transmission, but after the preceding 3 years, the field performance should be reviewed and possible weak points be improved to ensure a high coverage of intervention measures. For future practice, a yearly monitoring of the indicator amid the control may not be necessary, but 3 years after the control efforts may be an advisable time to estimate the progression in impacting the transmission, and find possible weakness of the control activity.

In conclusion, CE prevalence in slaughtered sheep may be used as an optional indicator at a lower cost to assess and monitor the effect of control program on the disease transmission, and to provide information for betterment of performance to sustain the control strength.

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CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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