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# Community surveys and risk factor analysis of human alveolar and cystic echinococcosis in Ningxia Hui Autonomous Region, China

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**Objective** To determine the true community prevalence of human cystic (CE) and alveolar (AE) echinococcosis (hydatid disease) in a highly endemic region in Ningxia Hui, China, by detecting asymptomatic cases.

**Methods** Using hospital records and "AE-risk" landscape patterns we selected study communities predicted to be at risk of human echinococcosis in Guyuan, Longde and Xiji counties. We conducted community surveys of 4773 individuals from 26 villages in 2002 and 2003 using questionnaire analysis, ultrasound examination and serology.

**Findings** Ultrasound and serology showed a range of prevalences for AE (0–8.1%; mean 2%) and CE (0–7.4%; mean 1.6%), with the highest prevalence in Xiji (2% for CE, 2.5% for AE). There were significant differences in the prevalence of CE, AE and total echinococcosis between the three counties and villages (with multiple degrees of freedom). While hospital records showed 96% of echinococcosis cases attributable to CE, our survey showed a higher prevalence of human AE (56%) compared to CE (44%). Questionnaire analysis revealed that key risk factors for infection were age and dog ownership for both CE and AE, and Hui ethnicity and being female for AE. Drinking well-water decreased the risk for both AE and CE.

**Conclusions** Echinococcosis continues to be a severe public health problem in this part of China because of unhygienic practices/habits and poor knowledge among the communities regarding this disease.

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Voir page 719 le résumé en français. En la página 719 figura un resumen en español.

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## Introduction

Echinococcosis is caused by adult or larval stages of cestodes belonging to the genus *Echinococcus* (Taeniidae). Larval infection (hydatid disease; hydatidosis) is characterized by long-term growth of metacestode (hydatid) cysts in the intermediate host.

*Echinococcus granulosus* and *E. multilocularis* — the two major species of medical and public health importance — cause cystic echinococcosis (CE) and alveolar echinococcosis (AE), respectively. While both CE and AE are serious diseases, AE has a high fatality rate and poor prognosis if managed inappropriately.

China is endemic for both CE and AE, with a greater prevalence in the north and north-west.<sup>1</sup> Human cases of CE reported from 33 provinces/autonomous regions in China account for more than 98% of echinococcosis cases with Gansu, Ningxia Hui Autonomous Region (NHAR), Qinghai, Sichuan, and Xingjiang being co-endemic for CE and AE.<sup>1,2</sup> Red foxes and small mammals are the main definitive and intermediate hosts, respectively, for *E. multilocularis* in the NHAR.<sup>3</sup> *E. granulosus* is primarily transmitted between domestic dogs and sheep. CE is present throughout the NHAR, whereas AE occurs in three confluent mountainous counties (Guyuan, Haiyuan, Xiji) in southern NHAR.

We undertook a community survey in 2002 and 2003, using ultrasound and serology, to detect asymptomatic cases for assessing the true prevalence of human CE and AE among rural communities in Guyuan, Longde and Xiji. We also sought to identify risk factors for both these diseases.

## Methods

### Study area and population

Guyuan, Longde and Xiji counties are situated on the Liupan mountains (average altitude 2200 m above sea level). The socioeconomic structure, land-use and population density of these counties are representative of rural mountainous

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Table 1. Population structure and echinococcosis prevalence, by gender and ethnicity, in three counties in Ningxia Hui Autonomous Region, surveyed in 2002 and 2003

Name of county	Gender (Female / Male)			Total		Ethnicity (Hui/Han)			
	No. of individuals	CE <sup>a</sup>	AE <sup>b</sup>	AE/CE <sup>c</sup>	Echino-coccosis	No. of individuals	CE	AE	AE/CE
Guyuan	471/512	3/0 (0.6/0)	2/3 (0.4/0.6)	1/0 (0.2/0)	9 (0.9)	279/702	2/2 (0.7/0.3)	2/2 (0.7/0.3)	1/0 (0.4/0)
	983	3 (0.3) <sup>d</sup>	5 (0.5)	1 (0.1)					
Longde	77/84	0/1 (0/1.2)	0/0 (0/0)	0/0 (0/0)	1 (0.6)	0/161	0/1 (0.6)	0/0 (0/0)	0/0 (0/0)
	161	1 (0.6)	0 (0)	0 (0)					
Xiji	1720/1909	41/30 (2.4/1.6)	55/33 (3.2/1.7)	2/0 (0.1/0)	161 (4.6)	2045/1584	37/34 (1.8/2.1)	54/34 (2.7/2.1)	1/1 (0.04/0.06)
	3629	71 (1.96)	88 (2.4)	2 (0.05)					
Total	2268/2505	44/31 (1.9/1.2)	57/36 (2.5/1.4)	3/0 (0.1/0)	171 (3.6)	2324/2447	39/37 (1.7/1.5)	56/36 (2.4/1.5)	2/1 (0.08/0.04)
	4773 <sup>e</sup>	75 (1.6)	93 (1.95)	3 (0.06)					

<sup>a</sup> AE = alveolar echinococcosis.

<sup>b</sup> CE = cystic echinococcosis.

<sup>c</sup> Mixed lesions of AE and CE in liver.

<sup>d</sup> Single figures in parentheses are percentages.

<sup>e</sup> Though 4778 subjects were surveyed, 4 originated from Yongning county and Yinchuan city, NHAR, and 1 from Huining county in Gansu province; therefore, we analysed 4773 individuals who were domiciled in the surveyed counties.

regions of NHAR. People in this region are poor; subsistence agriculture and livestock herding (sheep, goats, cattle) are the main income sources. During the course of the community surveys and searches of local government records, it became evident that the dog population had decreased dramatically by 1997 due to poisoning as the secondary effect of a poison-bait rodent control programme.

Half the population of Guyuan and Xiji is Han while the other half is Hui Chinese (a minority ethnic group, with their distinct religion (Islamic), lifestyle and customs). Though the majority (91%) living in Longde county are Han, their lifestyle is comparable to those from

Guyuan and Xiji. Village populations ranged from 200 to 1900 people (average, 400). We also surveyed three local primary and middle schools in Xiji.

### Community surveys

We used hospital records and "AE-risk" landscape profiles<sup>4</sup> to select village communities in Guyuan, Longde and Xiji counties predicted at risk of human CE and/or AE. We received approval for the surveys from the Ethics Committee of Ningxia Medical College, and obtained written consent from all adult participants and parents of minors five years or older who agreed to participate. We conducted participant interviews using a questionnaire to collect demographic,

epidemiological and risk factor data. We took a small blood sample from the ear lobe of each participant for specific antibody testing by enzyme linked immunosorbent assay (ELISA) using *E. granulosus* cyst fluid antigen B (AgB) and *E. multilocularis* crude protoscolex extract (EmP).<sup>5,6</sup> We performed an abdominal ultrasound (US) scan on each participant, using a portable ultrasonograph (Aloka, Japan, model 3.5 MG67N-35F2.4) to differentiate advanced AE from CE in the liver.<sup>7</sup> We used serum (prepared from 5 ml venous blood samples) from individuals with a surgical history of CE or AE, an abnormal US image and those with no cystic lesions detected by US during the surveys, as negative controls. We transported serum samples at 4 °C and later stored them at -20 °C before processing for ELISA.

We employed the WHO recommended US classification for CE<sup>8</sup> and the PNM system, proposed by the European Network for Concerted Surveillance for classification of AE.<sup>9</sup>

### Statistical analysis of data

We used Epi-Info and SPSS 11.5 to analyse data from interviews/questionnaires, US scanning and serology. Differences among groups were compared using the  $\chi^2$  test. Odds ratios and 95% confidence intervals for the multivariate analysis were calculated using multiple logistic regression models.

Table 2. Age structure of individuals diagnosed with CE<sup>a</sup> and AE<sup>b</sup> in three counties in Ningxia Hui Autonomous Region, surveyed in 2002 and 2003

Age (years)	CE/individuals	AE/individuals	Echinococcosis <sup>c</sup> /individuals
0-10	0/121	0/121	0/121
11-20	1/1629 (0.06) <sup>d</sup>	2/1629 (0.12)	3/1629 (0.18)
21-30	10/774 (1.38)	3/774 (0.3)	13/774 (1.68)
31-40	16/930 (1.6)	20/930 (2.2)	36/930 (3.9)
41-50	14/602 (2.5)	31/602 (5.0)	45/602 (7.5)
51-60	18/453 (4.1)	22/453 (4.8)	34/453 (8.9)
61	16/264 (6.0)	18/264 (6.8)	34/264 (12.8)
All	75/4773 (1.6)	96/4773 (2.0)	171/4773 (3.6)

<sup>a</sup> CE = cystic echinococcosis.

<sup>c</sup> Combined AE and CE.

<sup>b</sup> AE = alveolar echinococcosis.

<sup>d</sup> Figures in parentheses are percentages.

## Results

### Structure of the surveyed populations

The sex ratios (female:male) in the three counties were 1:1.09 in Guyuan and Longde (Table 1) and 1:1.11 in Xiji. The age range was 5–83 years (average, 32 years; females, 34 years, males, 30 years). Age structures were similar, except for peaks in the age group of 11–20 years in Guyuan and Xiji, and 31–40 years in Longde (Table 2). Surveyed subjects were of both Han and Hui nationality in Guyuan and Xiji counties, but in Longde, the residents were all Han (Table 1). The residents were mainly farmers (64%) or students (31%), with the remainder (5%) comprising businessmen, village leaders, civil servants, teachers, public health workers and military personnel.

Of the 4778 who participated in our 2002 and 2003 surveys, 4773 were residents of the surveyed areas and belonged to 26 communities within 16 townships in the three counties (Table 3). We surveyed approximately 25% of the total rural population from Guyuan, 80% from Longde and 12.5% from Xiji. Within Xiji, 2.3% of the population was urban and 73% rural. The average rural population coverage was 36%.

### CE and AE prevalence determined by US

The overall echinococcosis prevalence determined by US was 3.6% (171/4773); 0–8.1% (mean 2%) for AE and 0–7.4% (mean 1.6%) for CE. The highest prevalence of echinococcosis was 4.5% in Xiji (2% for CE, 2.5% for AE), while Guyuan and Longde counties had prevalences of 0.9% (0.3% for CE, 0.6% for AE) and 0.6% (CE only), respectively (Table 1). There were significant differences in prevalence of CE, AE and total echinococcosis infections between Guyuan and Xiji ( $\chi^2 = 12.4$ ,  $P < 0.001$ ;  $\chi^2 = 11.9$ ,  $P < 0.001$ ;  $\chi^2 = 24.6$ ,  $P < 0.001$ ), of AE between Xiji and Longde ( $\chi^2 = 2.9$ ,  $P < 0.05$ ) and of total echinococcosis infections ( $\chi^2 = 4.3$ ,  $P < 0.05$ ) (Table 1). There were no significant differences between Guyuan and Longde for CE and total echinococcosis infections, or between Xiji and Longde for CE infection, but a comparison of the three counties for CE, AE and total echinococcosis showed significant differences ( $\chi^2 = 14.2$ ,  $P < 0.001$ ;  $\chi^2 = 16.6$ ,  $P < 0.001$ ;  $\chi^2 = 30.3$ ,  $P < 0.001$ ).

Table 3. Echinococcosis prevalence in communities of the three counties in Ningxia Hui Autonomous Region, surveyed in 2002 and 2003

Communities <sup>a</sup>	Population	Individual (%) <sup>b</sup>	CE <sup>c</sup> (%)	AE <sup>d</sup> (%)	Total echinococcosis cases (%)
1. Zhangyi	700	200 (28)	0	1 (0.7)	1 (0.7)
1. Maozhu	380	91 (21)	1 (1)	0	1 (1)
1. Wangtao	320	61 (19)	0	0	0
1. Shangmaquan	370	66 (18)	1 (1.5)	0	1 (1.5)
1. Shangtan	330	90 (20)	0	1 (1.5)	1 (1.5)
1. Hetao	390	64 (16)	0	0	0
2. Hongzhuang	600	156 (32)	0	4 (2)	4 (2)
2. Chengou	300	78 (26)	0	0	0
3. Zhonghe	600	177 (30)	1 (0.6)	0	1 (0.6)
<b>Sub-total Guyuan</b>	<b>3990</b>	<b>983 (25)</b>	<b>3 (0.3)</b>	<b>6 (0.6)</b>	<b>9 (0.9)</b>
4. Nanwan-yumu	350	221 (63)	10 (4.5)	18 (8.1)	23 (13)
4. Chelugou	655	200 (31)	5 (2.5)	4 (2)	9 (4.5)
5. Haoziwan	350	132 (38)	2 (1.5)	4 (3)	6 (4.5)
5. Xinying	1900	474 (25)	22 (4.6)	27 (5.7)	49 (10)
6. Longpu	220	138 (63)	2 (1.4)	0	2 (1.4)
6. Xiaohu	500	261 (52)	0	0	0
7. Huoshizhai	600	270 (45)	4 (1.5)	0	4 (1.5)
7. Saozhulin	481	199 (41)	2 (1)	0	2 (1)
8. Longwangba	470	221 (47)	1 (0.5)	0	1 (0.5)
9. Maqigou	360	221 (61)	1 (0.5)	3 (1.3)	4 (1.8)
10. Majian	524	242 (46)	6 (2.5)	2 (0.8)	8 (3.3)
11. Dazhuang	476	176 (37)	2 (1.1)	2 (1.1)	4 (2.2)
12. Zhuanyao	300	74 (25)	0	6 (8.1)	6 (8.1)
13. Zhangcunpu	270	176 (64)	2 (1.1)	11 (6.3)	13 (7.3)
14. Baicheng	1250	134 (11)	10 (7.4)	0	10 (7.4)
<b>Total rural (Xiji)</b>	<b>8655</b>	<b>3139 (36)</b>	<b>69 (2.2)</b>	<b>77 (2.5)</b>	<b>146 (4.7)</b>
County city	21000	490 (2.3)	1 (0.2)	0	1 (0.2)
Xiji hospital <sup>e</sup>	—	—	1	13	14
<b>Sub-total Xiji</b>	<b>29 000</b>	<b>3629 (12.5)</b>	<b>71 (2)</b>	<b>90 (2.5)</b>	<b>161 (4.4)</b>
Dazhuang (Longde)	200	161 (80)	1 (0.6)	0	1 (0.6)
<b>Total</b>	<b>33 000</b>	<b>4773 (14.5)</b>	<b>75 (1.6)</b>	<b>96 (2)</b>	<b>171 (3.6)</b>

<sup>a</sup> The numbers represent administrative township: 1, Zhangyi township; 2, Hongzhuang; 3, Zhonghe; 4, Xiapu; 5, Xinying; 6, Xiaohu; 7, Houshizhai; 8, Chengjiao; 9, Malian; 10, Majian; 11, Piancheng; 12, Bai'ai; 13, Xitan; 14, Baicheng townships.

<sup>b</sup> The number in parentheses represents the percentage of the total population of a village community.

<sup>c</sup> CE = cystic echinococcosis.

<sup>d</sup> AE = alveolar echinococcosis.

<sup>e</sup> Patients came from Hongyao, Jiantai and Bai'ai.

Some villages, especially in Xiji county, had a higher AE prevalence than CE. Some had either high or low prevalences of both diseases, and in some no cases were detected. We compared prevalences using a  $\chi^2$  test with multiple degrees of freedom as many villages had low or zero prevalence for CE or AE. Our results showed a high degree of heterogeneity in prevalences among communities and villages within/between counties (Table 3). We found highly significant ( $P < 0.01$ ) differences for CE, AE and total echinococcosis for village communities within Xiji county and between Xiji and Guyuan. However,

there were no significant differences in echinococcosis prevalences within villages in Guyuan county.

We found no significant gender associations; AE cases occurred in 62.5% (60/96) females ( $\chi^2 = 7.8$ ,  $P < 0.01$ ) and CE cases occurred in 58.6% (44/75) females ( $\chi^2 = 3.2$ ,  $P = 0.07$ ) (Table 1). There was a highly significant difference between the Hui and Han ethnic groups for AE ( $\chi^2 = 5.2$ ,  $P < 0.05$ ) (Table 1).

The ages of AE and CE patients ranged from 19–73 years and from 18–79 years, respectively (Table 2). Age-prevalences increased from 0.12% in those aged 20 years or less to 6.8% for



those above 61 years for AE and from 0.06% in those 20 years or less to 6.0% for those above 61 years for CE.

### Seroprevalence among schoolchildren

Of the 121 females and 148 males (age 7–15 years) tested serologically using EmP and AgB antigens for antibody detection by ELISA (Table 4), we found significantly more EgB seropositive individuals ( $\chi^2 = 24.2$ ,  $P < 0.01$ ) among Hao-Zi-Wan school students, all of whom were Han. Significantly more students from Nan-Wan school displayed sero-reactivity for EmP ( $\chi^2 = 8.3$ ,  $P < 0.01$ ), all of whom were Hui. Seropositive students from Huo-Shi-Zhai local schools were predominantly of Hui ethnicity, in whom anti-EmP reactivity was significantly higher than for EgB ( $\chi^2 = 5.6$ ,  $P < 0.05$ ). Seropositive rates between boys and girls in the different schools were not significantly different.

### Questionnaire and relative risk analysis

We evaluated 4773 participants and estimated prevalence odds ratios, with  $P$ -values, for each potential risk factor for CE and AE obtained by univariate analysis as a preliminary screen (Table 5; web version only, available from <http://www.who.int/bulletin>). The risk of having either AE or CE significantly increased among individuals older than 30 years, farmers and dog owners (especially those who had owned a dog for over 5 years). Increased risk for AE was associated with Hui ethnicity, female gender and drinking spring-water. There was decreased risk for AE infection among those who drank well-water and decreased risk for CE infection among those who drank unboiled water.

To allow for confounding effects we carried out a multivariate analysis using a logistic regression model (Table 6) to further investigate the risk factors, including those that had shown associations with disease in the univariate analysis. The possibility of AE or CE infection increased among individuals older than 30 years and dog owners, but not among farmers. Increased risk for AE was also associated with Hui ethnicity and being female, but not with drinking spring-water. Drinking well-water decreased the risk for AE and CE, while drinking unboiled water did not decrease the probability of being

Table 4. Age, ethnicity and gender of surveyed school children in Xiji and their seropositivity rates by gender, Ningxia Hui Autonomous Region, 2002 and 2003

Schools	Individuals			EmP <sup>a</sup> -positive	AgB <sup>b</sup> -positive
	Hui / Han	F/M <sup>c</sup>	A-age <sup>d</sup>	F/M (%)	F/M (%)
Hao-Zi-Wan primary school	0/87	46/41	12	3/3 (6.9)	16/12 (28)
Nan-Wan primary school	81/0	30/51	11	10/14 (30)	0/6 (7.4)
Huo-Shi-Zhai middle school and primary school	101/0	45/56	13	16/14 (30)	9/3 (12)
<b>Total</b>	<b>182/87</b>	<b>121/148</b>	–	<b>29/31 (22)</b>	<b>25/21 (16)</b>

<sup>a</sup> EmP = crude antigen extracted from *E. multilocularis* protoscoleces.

<sup>b</sup> AgB = *E. granulosus* hydatid cyst fluid lipoprotein antigen.

<sup>c</sup> F/M = female/male.

<sup>d</sup> A-age = average age.

infected with CE.

### Discussion

Despite the establishment of extensive and successful control programmes for CE and AE, *E. granulosus* and *E. multilocularis* continue to have a wide geographical distribution. This is a cause for concern as they are likely to persist or re-emerge in many endemic areas worldwide and also readily spread from endemic to non-endemic areas, causing severe disease and considerable economic loss.<sup>1,10</sup> Our study provides an update on a highly endemic focus for AE and CE in NHAR, China and exemplifies the serious public health problem that echinococcosis presents, particularly in poor rural communities.

A previous retrospective clinical study of echinococcosis incidences in southern NHAR identified highly endemic foci and a highly heterogeneous distribution of both CE and AE cases.<sup>2</sup> This survey of hospital records for the period 1994–2001 showed the incidence of combined cases of CE and AE to be 7 per 100 000 for southern NHAR, compared with 1 per 100 000 for the northern zone, represented by the capital city, Yinchuan. Human AE cases were only recorded in a confluent area comprising the three southern counties of Guyuan, Haiyuan and Xiji despite CE cases occurring over the whole of NHAR.<sup>2</sup> While the hospital records showed an overall majority (96%) of cases resulting from CE, our community survey results revealed a higher prevalence of human AE (56%) compared to CE (44%), thereby demonstrating that hos-

pital records though relevant for CE are grossly inaccurate for AE case detection, particularly in this rural under-developed region. Although the overall human echinococcosis prevalence detected by US was 3.6%, the distribution was heterogeneous between counties, and also within Xiji. We found that while a retrospective survey of hospital records was beneficial for identifying regions of endemicity,<sup>2</sup> active community surveys revealed far more detailed information in rural areas, especially for AE.

The asymptomatic period for human AE and CE is 5–15 years, but CE is much more likely to be detected by the patients themselves and confirmed by local or regional health centres. Human echinococcosis is endemic in regions with poor economic conditions, accompanied by low education levels and poor medical facilities,<sup>11</sup> thus resulting in these predominantly rural people often failing to seek medical attention.<sup>12</sup> Therefore, active identification of human echinococcosis cases at the community level, especially in rural areas, is a necessary step for accurately evaluating the true extent of the disease in a given endemic focus.<sup>1</sup>

The risk factors we identified for AE and CE — poor hygienic practices, female gender, low income, limited education and dog ownership — were similar to those reported in previous studies.<sup>13–17</sup> Although dogs from the neighbouring Gansu Province were known to be infected with *E. multilocularis*, this was not confirmed for dogs in Ningxia.<sup>3,18</sup> In Gansu Han communities, dog ownership was a risk factor for AE.<sup>19</sup> In contrast to a previous study,<sup>20</sup> in our survey echino-

Table 6. Multiple logistic regression analysis of the relationships of dog ownership/livestock ownership and echinococcosis, controlling for potential confounding factors, among participants from three<sup>a</sup> surveyed counties in Ningxia Hui Autonomous Region, 2002 and 2003

Risk factor	Cystic echinococcosis (CE)		Alveolar echinococcosis (AE)		Combined CE and AE	
	Odds ratio (95% CI) <sup>b</sup>	P-value <sup>c</sup>	Odds ratio (95% CI)	P-value	OR (95% CI)	P-value
<b>Exposure variables</b>						
Does not own a dog	0.45 (0.26–0.77) <sup>d</sup>	<0.01	0.54 (0.33–0.89) <sup>d</sup>	<0.05	0.49 (0.34–0.72) <sup>d</sup>	<0.01
Livestock-owner	0.91 (0.42–2.04)	0.81	0.67 (0.28–1.60)	0.36	0.78 (0.43–1.43)	0.41
<b>Other risk factors</b>						
Sex (female)	1.37 (0.83–2.27)	0.22	1.69 (1.06–2.69) <sup>d</sup>	<0.05	1.52 (1.07–2.17) <sup>d</sup>	<0.05
Age <30 years	0.40 (0.19–0.84) <sup>d</sup>	<0.05	0.13 (0.05–0.34) <sup>d</sup>	<0.01	0.24 (0.13–0.43) <sup>d</sup>	<0.01
Ethnicity (Han)	0.72 (0.42–1.24)	0.24	0.53 (0.32–0.88) <sup>d</sup>	<0.05	0.62 (0.42–0.91) <sup>d</sup>	<0.05
Killed animals <sup>e</sup>	1.24 (0.73–2.09)	0.42	1.10 (0.69–1.76)	0.68	1.15 (0.80–1.67)	0.44
<b>Occupation</b>						
Farmer	0.53 (0.18–1.47)	0.09	0.67 (0.20–2.20)	0.51	0.60 (0.27–1.35)	0.22
Student	0.09 (0.009–0.84) <sup>d</sup>	<0.05	0.32 (0.03–3.57)	0.35	0.16 (0.03–0.85) <sup>d</sup>	<0.05
<b>Water supplies</b>						
Others <sup>f</sup>	1.42 (0.39–5.21)	0.59	1.44 (0.49–4.25)	0.50	1.42 (0.59–3.43)	0.44
Tap	1.97 (0.76–5.11)	0.16	0.86 (0.29–2.52)	0.78	1.26 (0.61–2.61)	0.83
Well	0.55 (0.32–0.96) <sup>d</sup>	<0.05	0.37 (0.23–0.59) <sup>d</sup>	<0.01	0.44 (0.30–0.64) <sup>d</sup>	<0.01
Spring	0.69 (0.23–2.04)	0.50	0.70 (0.19–2.59)	0.59	0.71 (0.29–1.71)	0.44
Unboiled water	1.11 (0.63–1.96)	0.72	0.78 (0.45–1.35)	0.38	0.94 (0.63–1.42)	0.77
<b>Other risk factors</b>						
Uncooked food	1.10 (0.48–2.54)	0.82	1.90 (0.92–3.92)	0.08	1.48 (0.84–2.60)	0.18
No knowledge of <i>Echinococcus</i> or echinococcosis	0.16 (0.083–0.32) <sup>d</sup>	<0.01	0.08 (0.04–0.18) <sup>d</sup>	<0.01	0.12 (0.07–0.19) <sup>d</sup>	<0.01
<b>Counties</b>						
Xiji	2.47 (0.30–20.3)	0.40	–	–	3.72 (0.48–28.6)	0.20
Guyuan	0.60 (0.06–5.69)	0.65	–	–	1.09 (0.13–8.97)	0.93

<sup>a</sup> The Longde County case numbers were too low to undertake an analysis as a possible risk factor on its own and therefore not given in the table.

<sup>b</sup> CI = confidence interval.

<sup>c</sup> P-value determined using multiple logistic regression analysis.

<sup>d</sup> Indicates a significant association.

<sup>e</sup> Killed animals included domestic animals and large wild mammals.

<sup>f</sup> Other water supplies that included river water and pool collected water.

coccosis was not significantly associated with uncooked food collected from the field or garden, livestock ownership, or home slaughtering. Our results revealed some unexpected results, such as increased risk related to having some knowledge of human echinococcosis, probably due to misunderstanding of the true risk factor situation. This emphasizes the necessity for investigators to be aware of the possibility of bias in answers by interviewees or in the interpretation of risk factor data.

In contrast to another study,<sup>21</sup> farming was not an important risk factor for echinococcosis in our analysis, probably because the majority of our participants came from a rural population, and were thus farmers.

As reported in another study<sup>22</sup> our results showed that use of well-water decreased the risk of contracting either

AE or CE. The wells in our study area were deep (because of the low water table), sturdy and less likely to be contaminated by faeces from wild animals or livestock, as protective lids covered the majority of wells.

Within the surveyed zone, vegetation and wildlife, including foxes used to be more abundant in this mountainous area in the past and *E. multilocularis* infections in animals were well documented in the 1980s.<sup>3,23–25</sup> During the past 50 years, the natural landscape (such as forest, pasture) in NHAR has been modified to an artificial landscape of farmland and urban areas thus increasing soil erosion and changing local climatic conditions with more frequent droughts, floods and pests, thereby affecting wildlife biodiversity.<sup>19,26</sup> The variable prevalence of human AE and CE among communities may be associated with

different micro-environmental features of various localities, including a range of biotic and abiotic factors.<sup>27–30</sup>

Our results showed a predominance of AE and CE infections in females in NHAR probably because women are more involved in farming and herding livestock, as well as more likely than men to come in contact with dogs. Increased susceptibility to *Echinococcus* infection, however, may also be affected by physiological and genetic factors.<sup>31,32</sup> The lack of gender differences in *Echinococcus* seropositivity among teenage schoolchildren suggests that there is a similar level of exposure to infection for boys and girls. The higher prevalence of infection in adult females may be the effect of physiology and farming or increased contact with dogs.<sup>19</sup>

In concordance with previous reports,<sup>13,14,33</sup> our survey revealed some

association between infection prevalence and unhygienic behaviour or lifestyle. In one of the villages, where teenagers showed higher EmP than EgB sero-reactivity, tap water had replaced spring water in 1997 and the numbers of wild and owned dogs had also decreased considerably. We have evidence that foxes (susceptible rodent species for AE) occur in areas (identified by faeces) close to this community,<sup>34</sup> suggesting current continued transmission of AE. However, the combined effects of the change in water source and the reduction in definitive hosts (dogs) may explain the apparent interruption of CE transmission to humans in this locality. Although, current use of tap water seems safer than the previous use of unprotected spring or river water, the lifestyle of these rural people has not changed thus continuing AE transmission.

## Conclusions

Unhygienic practices and habits emphasize the poor knowledge that NHAR communities have about echinococcosis, thus sustaining active transmission of *E. granulosus* and *E. multilocularis*. Since infection occurs through accidental ingestion of contaminated (with *Echinococcus* eggs released in dog or fox faeces) garden vegetables, water or soil,<sup>35,36</sup> residents in endemic areas should be educated about careful washing of hands and food, and the importance of drinking clean, uncontaminated water. Feeding of livestock offal to dogs should be avoided as it is a starting point for the *E. granulosus* life cycle.<sup>35</sup> We suggest that health education programmes integral to echinococcosis control be initiated early because most infections are acquired

during childhood.<sup>37,38</sup> Control measures for CE and AE should focus on decreasing dog numbers and active anthelmintic dosing of owned dogs.<sup>28,39</sup> ■

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## Résumé

### Enquêtes en communauté et analyse des facteurs de risque pour les échinococcoses alvéolaire et cystique humaines dans la région autonome du Ningxia Hui, Chine

**Objectif** Déterminer la prévalence réelle dans les communautés des échinococcoses cystique (EC) et alvéolaire (EA) humaines (hydatidose) dans une région chinoise de forte endémicité (Ningxia) par détection des cas asymptomatiques.

**Méthodes** A partir des registres hospitaliers et des types paysagers associés à un risque d'EA, on a sélectionné, dans les comtés de Guyuan, Longde et Xiji, une série de communautés à étudier, pour lesquelles on prévoyait un risque accru d'échinococcosse humaine. Des enquêtes en communauté ont été effectuées en 2002 et 2003 sur 4773 individus issus de 26 villages, par application d'un questionnaire, exploration par ultrasons et analyse sérologique.

**Résultats** Les explorations par ultrasons et les analyses sérologiques ont mis en évidence les valeurs de prévalence suivantes pour l'EA (0 - 8,1 %, moyenne : 2 %) et la CE (0 - 7,4 %, moyenne : 1,6 %), les niveaux de prévalence les plus élevés étant atteints dans le comté du Xiji (2 % pour l'EC et 2,5 % pour l'EA).

On a constaté des différences importantes dans la prévalence de l'EC, de l'EA et de l'ensemble des échinococcoses entre les trois comtés et les villages (plusieurs degrés de liberté étant relevés). Bien que les registres hospitaliers recensent une proportion des cas d'échinococcosse attribuables à l'EC de 96 %, la présente enquête a fait ressortir une plus forte prévalence de l'EA (56 %) par rapport à l'EC (44 %). L'analyse par questionnaire a révélé que les principaux facteurs de risque d'infection étaient l'âge et la possession d'un chien pour l'EC et l'EA, et l'appartenance à l'ethnie Hui et au sexe féminin pour l'EA. La consommation d'eau provenant d'un puits semblait réduire le risque d'EA et d'EC.

**Conclusions** L'échinococcosse reste un grave problème de santé publique dans cette partie de la Chine en raison des pratiques et des habitudes peu hygiéniques et du manque de connaissances sur la maladie parmi les communautés.

## Resumen

### Encuestas comunitarias y análisis de los factores de riesgo de la equinococosis alveolar y quística humana en la Región Autónoma de Ningxia Hui, China

**Objetivo** Determinar la verdadera prevalencia comunitaria de la equinococosis (hidatidosis) alveolar (EA) y quística (EQ) humana en una región de alta endemidad de la enfermedad en Ningxia, China, detectando para ello los casos asintomáticos.

**Métodos** A partir de registros hospitalarios y patrones de paisaje de la EA, seleccionamos varias comunidades de estudio con riesgo probable de equinococosis humana en los cantones de Guyuan, Longde y Xiji. En 2002 y 2003 realizamos encuestas comunitarias entre 4773 personas de 26 aldeas, utilizando cuestionarios, ecografías y análisis serológicos.

**Resultados** La ecografía y la serología revelaron un intervalo de prevalencias de EA (0% - 8,1%; media: 2%) y EQ (0% - 7,4%; media: 1,6%), con la prevalencia más alta en Xiji (2% para la EQ, 2,5% para la EA). Había diferencias importantes de la prevalencia

de EQ, EA y equinococosis total entre los tres cantones y aldeas (con varios grados de libertad). Aunque los registros hospitalarios mostraron un 96% de casos de equinococosis atribuibles a EQ, nuestra encuesta mostró una prevalencia de EA humana (56%) superior a la de EQ (44%). El análisis de los cuestionarios reveló que los factores de riesgo de infección más importantes eran la edad y el hecho de tener perro, tanto para la EQ como para la EA; y la pertenencia al grupo étnico Hui y el sexo femenino para la EA. Beber agua de pozo reducía el riesgo tanto de EA como de EQ.

**Conclusión** La equinococosis sigue siendo un grave problema de salud pública en esa parte de China, debido a unos hábitos y prácticas poco higiénicos y al escaso conocimiento de la enfermedad entre las comunidades.

## ملخص

## المسوحات وتحليل عوامل الخطر في المجتمع لداء المشوكات الكيسية والمُنخَرَبَة لدى البشر في منطقة نينجكسيا المستقلة، الصين

ولوحظ وجود فروق كبيرة في معدلات انتشار كل من داء المشوكات الكيسية والمُنخَرَبَة وفي إجمالي معدلات داء المشوكات بين المقاطعات الثلاث وقراها، مع السماح بدرجات متفاوتة من الحرية. وفي حين أن سجلات المستشفيات تظهر أن 96% من حالات داء المشوكات تعزى إلى داء المشوكات الكيسية، فإن دراستنا المسحية هذه أظهرت أن داء المشوكات المُنخَرَبَة البشري ذو معدل انتشار (56%) أعلى من معدل انتشار داء المشوكات الكيسية (44%). كما أظهر تحليل الاستبيان أن العوامل الرئيسية للعدوى بداء المشوكات الكيسية والمُنخَرَبَة هي العمر وامتلاك الكلاب، والانحدار من عرق هوي والأثوثة للعدوى بداء المشوكات المُنخَرَبَة، أما شرب مياه الآبار فينقص من خطر الإصابة بداء المشوكات الكيسية والمُنخَرَبَة.

**الاستنتاج:** لايزال داء المشوكات أحد المشكلات الوخيمة في الصحة العمومية في هذا الجزء من الصين، نتيجة للعادات والممارسات المنافية للصحة ونقص المعارف بين المجتمعات حول هذا الداء.

**الهدف:** التعرف على المعدلات الحقيقية لانتشار داء المشوكات الكيسية والمُنخَرَبَة لدى البشر في منطقة شديدة التوطن بها في نينجكسيا، في الصين، وذلك بالكشف عن الحالات غير المصحوبة بالأعراض.

**الطريقة:** قمنا بانتقاء مجتمعات الدراسة باستخدام سجلات المستشفيات ونماذج لعوامل خطر الإصابة بداء المشوكات المُنخَرَبَة والتي تتوقع أن تكون معرضة لأخطار الإصابة بداء المشوكات الكيسية في مقاطعات غويوان ولونج وزيجي. وقمنا عام 2002 و2003 بدراسات مسح مجتمعية شملت 4773 فرداً موزعين على 26 قرية، وذلك باستخدام تحليل للاستيبيانات وبالفحص بالأموح فوق الصوت وبالاختبارات السيرولوجية.

**الموجودات:** أظهرت الفحوص بالأموح فوق الصوت وبالاختبارات السيرولوجية مجالاً من معدلات انتشار داء المشوكات المُنخَرَبَة تراوح بين 0% و8% وبمعدل وسطي 2%، ومعدلات انتشار داء المشوكات الكيسية تتراوح بين 0% و7.4% وبمعدل وسطي 1.6%، وكان أكثر المعدلات في مقاطعة كزيجي (2% لداء المشوكات الكيسية و2.5% لداء المشوكات المُنخَرَبَة).

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Table 5. Frequency of cystic and alveolar echinococcosis and measures of association with potential risk factors determined by univariate analysis, Ningxia Hui Autonomous Region, China, 2002 and 2003

Risk factor	Cystic echinococcosis (CE)				Alveolar echinococcosis (AE)				Combined CE and AE	
	Yes/ individuals (%)	No/ individuals (%)	Odds ratio <sup>a</sup> (95% CI <sup>b</sup> )	P- value <sup>c</sup>	Yes (%)	No (%)	Odds ratio (95% CI)	P- value	Odds ratio (95% CI)	P- value
≤ 30 years old	10/2524 (0.4)	65/2249 (2.9)	0.14 (0.07–0.27) <sup>d</sup>	<0.01	6 (0.2)	90 (4.0)	0.06 (0.03–0.14) <sup>d</sup>	<0.01	0.09 (0.09–0.16) <sup>d</sup>	<0.01
Ethnicity (Han) <sup>e</sup>	35/2447 (1.4)	40/2326 (1.7)	0.83 (0.51–1.34)	0.49	36 (1.5)	59 (2.5)	0.58 (0.37–0.90) <sup>d</sup>	<0.05	0.68 (0.49–0.94) <sup>d</sup>	<0.05
Female	44/2268 (1.9)	31/2505 (1.3)	1.48 (0.92–2.41)	0.07	60 (2.6)	36 (1.5)	1.76 (1.14–2.72) <sup>d</sup>	<0.01	1.63 (1.18–2.25) <sup>d</sup>	<0.01
Farmer	68/3068 (2.2)	7/1705 (0.4)	3.73 (1.85–7.75) <sup>d</sup>	<0.01	91 (3.0)	5 (0.3)	5.49 (2.67–11.8) <sup>d</sup>	<0.01	4.57 (2.77–7.62) <sup>d</sup>	<0.01
Livestock owner	62/4069 (1.5)	13/704 (1.8)	0.83 (0.44–1.59)	0.64	84 (2.1)	12 (1.7)	1.67 (0.78–3.74)	0.63	1.01 (0.64–1.59)	0.94
Killed animals <sup>f</sup>	35/2393 (1.5)	40/2380 (1.7)	0.87 (0.54–1.41)	0.63	50 (2.1)	46 (1.9)	1.08 (0.71–1.65)	0.78	0.87 (0.63–1.82)	0.97
Dog owner	33/1339 (2.5)	42/3435 (1.2)	2.02 (1.24–3.27) <sup>d</sup>	<0.01	41 (3.1)	55 (1.6)	1.91 (1.25–2.94) <sup>d</sup>	<0.01	1.96 (1.42–2.57) <sup>d</sup>	<0.01
≤ 5 years owner	11/716 (1.5)	22/585 (3.8)	0.41 (0.18–0.98) <sup>d</sup>	<0.05	11 (1.5)	31 (5.3)	0.29 (0.14–0.61) <sup>d</sup>	<0.01	0.34 (0.20–0.58) <sup>d</sup>	<0.01
Knowledge of echinococcosis	60/1476 (4.1)	15/3297 (0.5)	8.93 (4.92–16.46) <sup>d</sup>	<0.01	83 (5.6)	13 (0.4)	14.25 (7.70–26.9) <sup>d</sup>	<0.01	11.41 (7.45–17.6) <sup>d</sup>	<0.01
Uncooked food	64/4112 (1.6)	11/661 (1.7)	0.49 (0.48–1.89)	0.90	78 (1.9)	18 (2.7)	0.74 (0.42–1.30)	0.22	0.79 (0.52–1.21)	0.29
Unboiled water	47/3549 (1.3)	28/1224 (2.3)	0.58 (0.35–0.95) <sup>d</sup>	<0.05	65 (1.8)	30 (2.5)	0.75 (0.47–1.19)	0.23	0.67 (0.48–0.93) <sup>d</sup>	<0.05
Tap water	8/538 (1.5)	63/4036 (1.6)	0.95 (0.42–2.07)	0.95	5 (1.4)	87 (2.2)	0.44 (0.18–1.07)	0.08	0.65 (0.35–1.18)	0.17
Well water	37/2830 (1.3)	34/1744 (1.9)	0.67 (0.41–1.10)	0.12	42 (1.5)	50 (2.9)	0.53 (0.35–0.79) <sup>d</sup>	<0.01	0.58 (0.42–0.80) <sup>d</sup>	<0.05
Spring water	23/1115 (2.1)	48/3459 (1.4)	1.49 (0.87–2.52)	0.15	40 (3.6)	52 (1.5)	2.39 (1.54–3.69) <sup>d</sup>	<0.01	1.94 (1.39–2.71) <sup>d</sup>	<0.01

<sup>a</sup> Odds ratio for prevalence.

<sup>b</sup> CI = confidence interval.

<sup>c</sup> P-value = differences between groups were compared by the Chi-square ( $\chi^2$ ) test.

<sup>d</sup> Indicates a significant association.

<sup>e</sup> Ethnicity includes Han and Hui (only two persons belonging to other nationalities).

<sup>f</sup> Killed animals included domestic animals and large wild mammals.