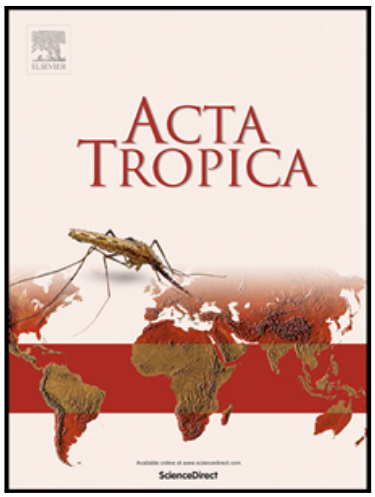

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Disease burden of echinococcosis in Tibetan communities-a significant public health issue in an underdeveloped region of western China

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Abstract

Echinococcosis is considered by the World Health Organization (WHO) to be a neglected zoonotic disease in the world. Some Tibetan communities were found to be highly endemic for echinococcosis just 20 years ago. Until recently, we were able to understand the overall disease burden of echinococcosis in Tibetan communities after prevalence data being available from nationwide investigations from 2012 to 2016. Data were abstracted from 9 publications regarding to echinococcosis prevalence between 2016-2018; from 10 data bases on echinococcosis prevalence for 151 Tibetan counties; and statistics of population, Gross Domestic Product (GDP) and health staff from 44 local statistic bureaus and government websites at provincial, prefecture and county level, and 2 books of provincial yearly statistics. These data were used to estimate the Disability Adjusted Life Years (DALYs) due to cystic echinococcosis (CE) and alveolar echinococcosis (AE). The distribution of DALYs was presented

geographically and economically. The echinococcosis DALYs in the Tibetan communities were estimated to be 126,159 (95%UI 122,415-137,675) annually using the method recommended by WHO. Echinococcosis affects people more in underdeveloped areas. There was a tendency that a higher echinococcosis DALYs were usually correlated a higher altitude. Health services are also poorly provided in terms of number of health staff of 5.05 per 1,000 population in comparison with the national average of 5.8 per 1,000 population. The data suggest that the echinococcosis burden in the center region of Qinghai-Tibet plateau is higher than that of other regions, and consequently more control and health services should be provided to the region.

Key words: echinococcosis, disease burden, DALYs, Tibetan communities

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1.Introduction

The World Health Organization (WHO) listed echinococcosis, including both cystic echinococcosis (CE) and alveolar echinococcosis (AE), as a neglected tropical disease in 2010 (WHO, 2011). Two types of echinococcosis, CE and AE, caused by *Echinococcus granulosus* and *Echinococcus multilocularis*, respectively, are endemic in China (Wang G.Q., 2016). It was reported that China was responsible for 40% of the global CE Disability Adjusted Life Years (DALYs) (Budke et al.,2004) and 91% of global AE DALYs (WHO,2011). It was estimated that there were 380,000 patients in western China by a national investigation in 2004 (Xu et al., 2005), which covered

the Tibet Autonomous Region (TAR), Sichuan, Qinghai, Xinjiang, Gansu, Ningxia and Inner Mongolia. Another national investigation during 2012-2016 estimated the figure to be some 166,000 (Wu et al., 2018). The estimated echinococcosis DALYs based on the latter figure was 322,398 (Zhang et al., 2017). The prevalences of echinococcosis in Tibetan communities of Sichuan province, Qinghai Province and TAR were 1.08%, 0.63% and 1.66% (Wu et al., 2018). These figures were the top three in the nation, and indicated the Qinghai-Tibet Plateau to be the most endemic region in China.

The Qinghai-Tibet Plateau in western China is located at 26°00′12″N~39°46′50″N and 73°18′52″E ~ 104°46′59″E. The plateau covers Tibet Autonomous Region and Qinghai Province, and extends to western Sichuan Province, southern Gansu Province, and west-northern Yunnan Province. It is bordered by the Hengduan Mountains to the east, by the Himalayan range to the south, by the Pamir Mountains to the west, by the Kunlun range to the north, and by the Qilian range to the northeast. There are 151 Tibetan counties on the plateau (ChinaNet, 2016; SEAC, 2010). The estimated Tibetan population was 6.28 million in 2010 in the Tibetan counties (SEAC, 2010). Due to the endemic of echinococcosis in western China, Chinese government has been increasing the financial support to the echinococcosis control programme to contain the transmission of the disease since 2006. The resources allocation largely depends on the control options with consideration of disease burden, economic development level and the availability of professional staff. Therefore, it is timely to understand the distribution of the disease burden with reference to geography, economy and health human resources on the Qinghai-Tibet Plateau.

2. Materials and methods

Data and literature selection criteria

Medline, CNKI, Google Scholar, Baidu, Bing and government websites were

searched for literature published between 2012 and 2018. Search terms included one word and/or phrase from each of following 3 categories: the name of the disease, including hydatidosis, hydatid disease, echinococcosis, and echinococcus; county statistics, including population, gross domestic product (GDP), income, location, altitude, the number of health staff; Geographic or province names,including Tibet, Qinghai, Qinghai-Tibet Plateau, Tibet Plateau, western China, Sichuan, Gansu and Yunnan. The languages of the literature were restricted to Chinese and English. A list of Tibetan counties is given by a relevant authority (SEAC, 2010). Prevalence investigation of echinococcosis should be based on positive findings by abdominal ultrasound examinations and complemented by confirmatory serological tests, as recommended by WHO (Pawłowski et al., 2001). Selected publications on prevalence investigation were original researches rather than reviews. Fig 1 shows a visualized strategy for the literature retrieval.

Data analysis

DALYs was employed to describe the burden of echinococcosis, and were calculated respectively for AE, CE, and AE and CE combined. The method was recommended by WHO (WHO, 2017; Torgerson et al., 2015). DALYs were calculated as the sum of the Years of Life Lost (YLL) and the Years Lost due to Disability (YLD). The formulas are described below:

$$DALY = YLL + YLD$$

$$YLL = N \times L$$

$$YLD = P \times DW$$

Where: N = number of deaths, L = standard life expectancy at age of death in years, P = number of prevalent cases, DW = disability weight.

The standard life expectancy at age of death was from the life table used in the WHO Global Health Estimates (WHO, 2017).It was reported that AE patients had a

fatality rate of 94% within 10 years (Eckert J., et al, 2001) and CE patients have a fatality rate of 2.2% within 5 years (Ammann R. W. et al., 1996). It was assumed that annual mortality due to AE was similar to its incidence in the Tibetan communities (Torgerson et al., 2010), a similar assumption was also applied to CE. Therefore, annual fatality rate was assumed to be 9.4% for AE and 0.44% for CE. The annual death number was obtained by multiplying the number of patients by the annual fatality rate, for AE and CE respectively.

Zhang et al. (2018) classified the symptom severity of echinococcosis as asymptomatic, mild, moderate and severe, and reported the proportions of each severity (see Table 1). We assigned DWs to these health state in accordance with the WHO Global Health Estimates (WHO, 2017) (See Table 1).

Monte Carlo simulations were conducted for 10,000 times to calculate 95% uncertainty intervals (UI) of prevalence, mortality and DALYs. A beta distribution was used to model prevalence. The proportions for CE case suffering asymptomatic, mild, moderate and severe loss were modeled using a Dirichlet distribution with parameters of 121, 101, 22 and 6. The same procedure was done for AE, using a Dirichlet distribution with parameters of 18, 39, 16 and 14.

Total DALYs, DALYs per 10,000 population (10,000 * total DALYs divided by local population), prevalence, mortality, population size, GDP per capita, and number of health staff and institutions were described for cities and prefectures. Top 20 counties with higher disease burden were presented with total DALYs, DALYs per 10,000 population, prevalence, mortality, and population size. The geographic distribution of disease burden was mapped along with GDP per capita at county level using QGIS (formerly known as Quantum GIS). The correlations between DALYs per 10,000 population and GDP per capita and county average altitude at county level were analyzed with Spearman correlation using R version 3.2.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Data from 9 publications (Wang et al., 2016; Baimayangjin et al., 2018; Cirenlamu et al., 2018; Danzhenwangjiu et al., 2018; Gongsangquzhen et al., 2018; Wang et al., 2018; Wu et al. 2018; Xiao et al., 2018; Bianmazhuoma et al., 2018) and 10 databases regarding echinococcosis for 151 Tibetan counties were used to calculate DALYs. Statistics of population, GDP, altitude and number of health staff and institution were accessed from 44 local statistic bureaus and government websites at provincial, prefecture and county level, and 2 books of yearly statistics (TSB, 2015; QHSB, 2016).

Echinococcosis prevalence data of all 151 Tibetan counties were accessed, which included 9, 33, 32, 74 and 3 counties from Gansu, Qinghai, Sichuan, Tibetan autonomous region（TAR）and Yunnan respectively. Among the 151 Tibetan counties (See appendix) defined by relevant authority (SEAC, 2010), 140 counties were endemic with echinococcosis. Among these 140 counties, 70 Tibetan counties were endemic with both CE and AE, and the remaining 70 counties had CE patients only. CE and AE DALYs were calculated for the 140 counties accordingly.

The disease burden of echinococcosis was estimated at 126,159 DALYs (95%UI 122,415-137,657). Qinghai Province had the highest echinococcosis burden (49,149 DALYs, 95%UI 46,197-55,785) among the Tibetan communities in the 5 provinces. Sichuan Province and TAR ranked second and third with 39,701 DALYs (95%UI 36,909-44,374) and 36,343 DALYs (95%UI 32,448-40,520) respectively. AE DALYs (105,828, 95%UI 101,969-117,090) were higher than CE DALYs (20,330, 95%UI 19,690-21,581) (See Table 2). At county level, Shiqu county of Sichuan province, Dari and Chenduo counties of Qinghai province were the top 3 with the most echinococcosis DALYs. The top 20 counties for echinococcosis DALYs were all from Qinghai, TAR and Sichuan Province (See Table 3). Shiqu county of Sichuan Province, Zuogong and Baqing counties of TAR were the top three with highest CE DALYs. Shiqu county of Sichuan Province, Dari and Chenduo counties of Qinghai Province were the top three with highest AE DALYs (See Table 3).

The GDP per capita of the Tibetan communities of China was 33,480 RMB (5,040US$) in 2016. Number of health staff and number of health institutions per 1,000 population were 5.05 and 0.81 respectively (See Table 2). The geographic distribution of the echinococcosis DALYs was typically centered in the middle of Qinghai-Tibet plateau (Map 1). There was a tendency that a higher echinococcosis DALYs were usually correlated a higher altitude (Spearman correlation: $p<0.001$, r=0.512) (Fig.1). The echinococcosis DALYs seemed to occur more in less developed counties (Spearman correlation: $p=0.001$, r=-0.304) (Fig.2).

Discussion and conclusions

China has some 368 counties known to be endemic for human CE, in which 115 counties are also endemic for human AE (Wu et al., 2018). We were able to investigate the echinococcosis DALYs of all 151 Tibetan counties. The counties were defined by the relevant authority (SEAC, 2016). We found that 140 Tibetan counties were affected by echinococcosis, constituting 38% of all 368 endemic counties in China. Furthermore, among the 140 counties, 70 counties were endemic for both CE and AE, and the remaining 70 counties were endemic for CE only. The 70 AE endemic Tibetan counties constituted 69% of all 115 AE endemic counties in China.

The national investigation (Wu et al.,2018) from 2012-2018 found that CE was more widely distributed geographically than AE. The estimated number of CE patients (86,291 cases) was larger than that of AE patients (21,085 cases) among the Tibetan population. But in terms of DALYs, it appears that AE DALYs (105,828; UI 101,969-117,090) outnumbered CE DALYs (20,330; UI 19,690-21,581) in the Tibetan counties. One of the reasons could be a much higher YLL of AE (See Table 4), which is due to more death of AE patients than CE patients (See Appendix).

Geographically, the echinococcosis disease burden is higher in the central area of the Qinghai-Tibetan plateau (Map 1), where the 3 counties with the highest echinococcosis DALYs are located. They are Shiqu county of Sichuan Province, and

Dari and Chenduo counties of Qinghai province, with high average altitude of 4000-4200 m. We also found a positive association between DALYs and altitude (Fig. 2), which suggests that the disease caused more burden in high altitude areas compared with that in low altitude areas. High altitude regions are harmful to human health due to factors such as low density of oxygen, however, it is not well understood the reasons behind the positive association between echinococcosis prevalence and altitude, although Li Wei (2006) assumed climate, life style and animal diversity to be possible explanations.

The GDP per capita in the endemic Tibetan counties was 33,480 RMB (5,040US$), which is far less than 54,000 RMB (8,130US$, NBS China, 2018) for the whole China in 2016. Our research found a negative association between echinococcosis DALYs and GDP per capita in Tibetan counties (Fig.3), which supports the notion that echinococcosis is an infectious disease of poverty. Although the poverty is not the direct cause of the echinococcosis DALYs, the low GDP per capita would affect the population access to public services. Surgery is a major treatment for echinococcosis (Pawlowski et al., 2001), which is very costly. A review found that the cost for echinococcosis surgery hospitalization in a Tibetan region was averagely 47,146 RMB (7,098US$) in 2015 (Zhang et al., 2017), which is even higher than the GDP per capita of 33,480(5,040$) of 2016. Another study found that indirect cost for hospitalization of echinococcosis reached 2,341 RMB (352US$, Duan Xinyu, 2014). Therefore, low GDP per capita in the region appears not beneficial to the prevention and treatment of echinococcosis.

Health staff are responsible for screening, diagnosis, treatment, management of echinococcosis patients, and health education for echinococcosis prevention. Sufficient number of health workers is the key to provide quality health services in the remote areas. In 2015, the number of health staff per 1,000 population was 5.05 in 96 Tibetan counties; which is lower than that of national level (5.8 per 1,000 population, NSB China, 2018) (Table 2). This makes the provision of adequate echinococcosis health services more difficult.

Historically, major parasitic diseases, such as schistosomiasis, malaria, leishmaniasis and filariasis, were mostly endemic in tropical or subtropical areas of eastern and southern China (Yu et al., 1994). These tropical or subtropical areas are located in the developed and low altitude part of China where health services are also better provided. The endemic areas of echinococcosis are in contrast located mostly in pastoral areas which are usually located in high plateau with underdeveloped economy and infrastructures, and poor health services as well, which will make it more difficult to apply control measures and reduce the public health impact of the disease.

Our study revealed that echinococcosis is a major public health issue in Tibetan counties in China. However, it is still a diseases that is lack of adequate diagnosis technique and good effective medicine in China and around the world (Qian et al.,2017). Dogs were found be the definitive hosts for both *E. granulosus* and *E. multilocularis* in Qinghai-Tibet plateau, and foxes also were the definitive hosts of *E. multilocularis* (Cai et al., 2018). However, only dogs, owned dogs in particular were found to be most significant risk factor for both human CE and human AE in Tibetan communities (Wang et al., 2014). Deworming dogs is a major strategy to control in the Tibetan communities and it was a proved effective way to control the transmission of the CE/*E. granulosus*. However, it remains to see if a dog targeted control strategy will work for controlling CE/*E.multilocularis* in Tibetan communities where foxes also could play a role as definitive hosts. If fruit and mushrooms were also considered as possible risk factors as they were in Europe, would make the situation more complicated on the plateau (Torgerson, 2016). Therefore, more researches are needed to understand the control measures and their effectiveness in such a remote and broad Qing-Tibet plateau.

In conclusion, AE causes more DALYs than CE does in Tibetan communities. Echinococcosis DALYs affects people more in underdeveloped areas. Health staff per 1,000 population are also less than the national average level. The data suggests that the focus of echinococcosis control should be in the center region of Qinghai-Tibet

plateau where the echinococcosis DALYs is higher, and consequently more control and health services should be provided to these communities.

Conflict of Interest

The authors declare no conflict of interest concerning the MS "Disease burden of echinococcosis in Tibetan communities-a significant public health issue in an underdeveloped region of western China".

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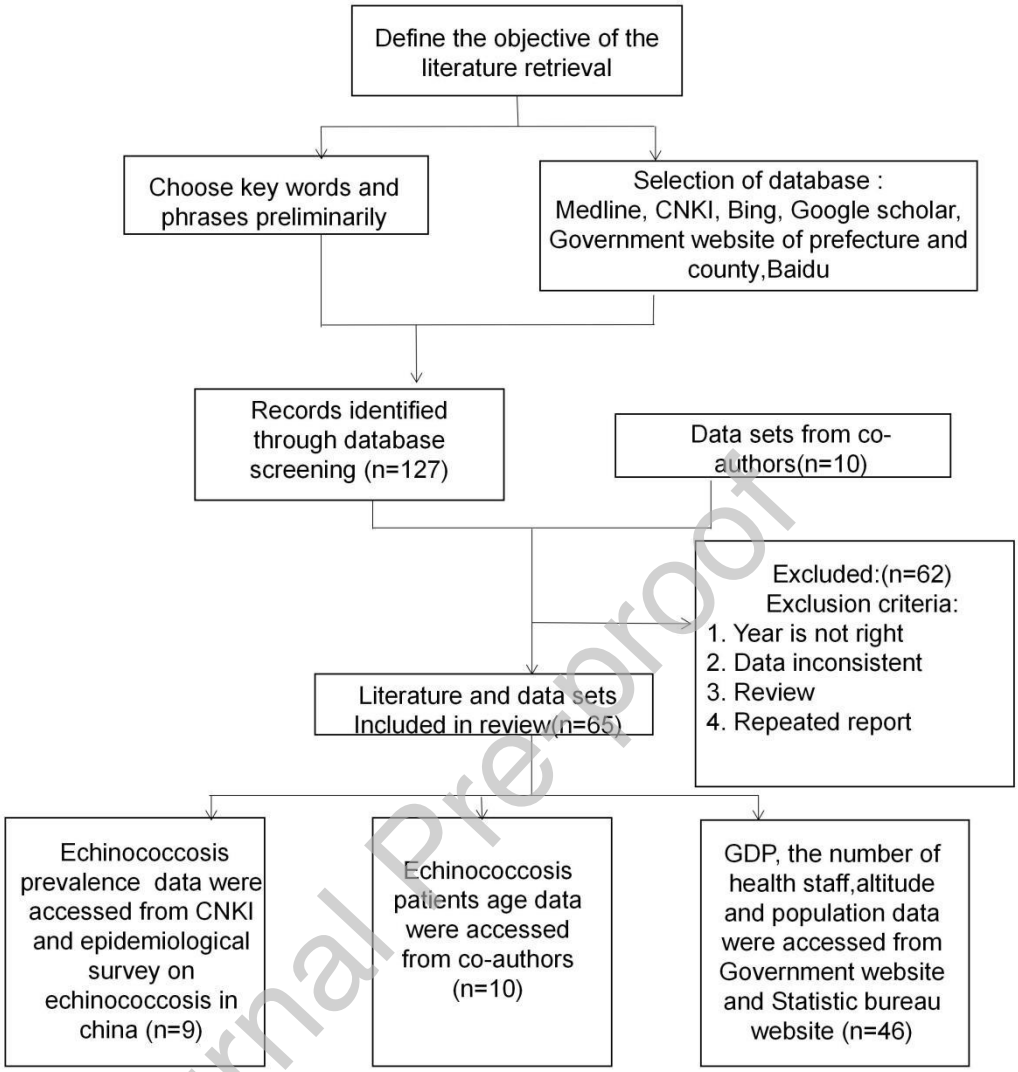
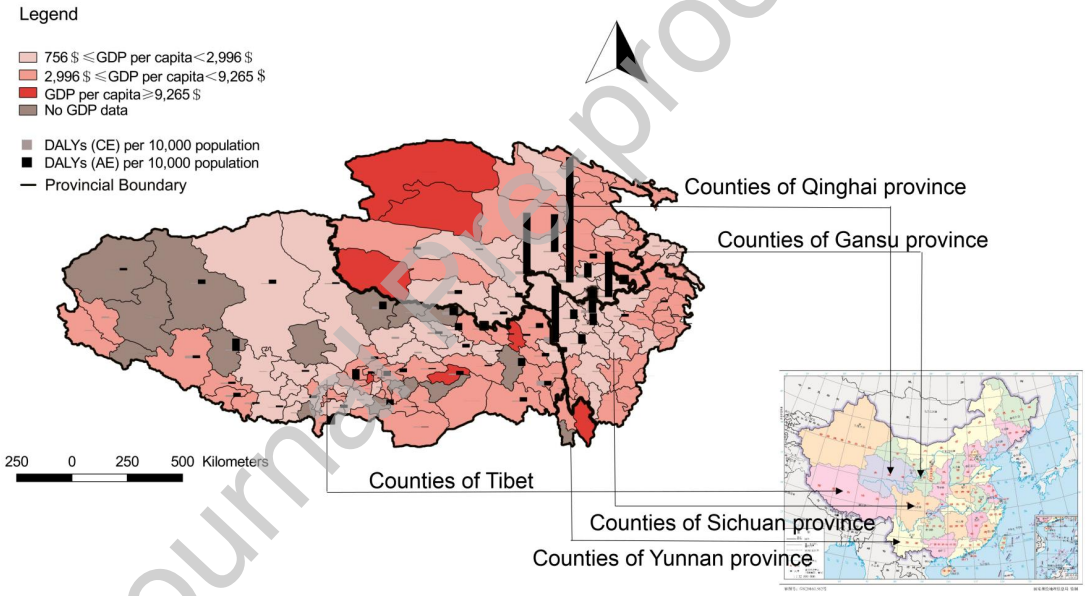
Fig. 1 Strategy for literature retrieval



Map 1 Geographic distribution of CE and AE DALYs in relation to GDP per capita



Reference for classification of GDP: World Bank, 2001.

Table 1 Proportions and DWs for AE and CE

Severity levels	Proportion of AE(%)	Proportion of CE(%)	DW
Asymptomatic	20.48	48.78	0
Mild	45.78	40.65	0.011
Moderate	18.07	8.54	0.114
Severe	15.66	2.03	0.324

Note : values assigned to DW according to WHO Global Health Estimates (WHO, 2017)

Table 2 Prevalence, mortality, DALYs, GDP and health resources in Tibetan region

Province	City/prefecture/county	No.counties	Population size	CE prevalence(‰) （95%UI）	Estimated CE mortality （95%UI）	AE prevalence(‰) （95%UI）	Estimated AE mortality （95%UI）	Echinococcosis DALYs（95%UI）	CE DALYs （95%UI）	AE DALYs（95%UI）	Echinococcosis DALYs per 10,000 population （95%UI）	CE DALYs per 10,000 population （95%UI）	AE DALYs per 10,000 population （95%UI）	GDP per capita* (RMB)	No.health staffs per 1,000 population*	No. health institutions per 1,000 population*
All Tibetan counties	Overall	151	8,178,601	105 (102-109)	380 (366-393)	26 (24-28)	1,982 (1,848-2,122)	126,159 （122,415-137,675）	20,330 （19,690-21,581）	105,828 （101,969-117,090）	154（150-168）	25（24-26）	129（125-143）	33,480	5.05	0.81
Gansu	Overall	9	863,925	50(43-58)	19(16-22)	0(0-2)	3(1-14)	1,027(903-1,486)	933(812-1,111)	95(21-498)	12(10-17)	11(9-13)	1(0-6)	20,965	5.9	0.54
	Gannan	8	689,132	46(39-54)	14(12-16)	0(0-2)	3(1-13)	763(667-1,177)	668(589-827)	95(21-452)	11(10-17)	10(9-12)	1(0-7)	19,213	6.02	0.24
	Tianzhu	1	174,793	66(45-96)	5(3-7)	0(0-0)	0(0-0)	264(250-1,717)	264(250-1,717)	0(0-0)	15(10-22)	15(10-22)	0(0-0)	28,296	5.44	1.77
Qinghai	Overall	33	1,790,023	98 (91-105)	77 (72-83)	44 (40-49)	744 (674-826)	49,149 (46,197-55,785)	4,360 (4,246-4,939)	44,789 (41,618-51,191)	275 (258-312)	24 (24-28)	250 (233-286)	40,000	4.35	0.22
	Haibei	4	273,304	13(8-21)	2(1-2)	0(0-0)	0(0-0)	94(60-154)	94(60-154)	0(0-0)	3(2-6)	3(2-6)	0(0-0)	34,033	4.5	0.23
	Huangnan	4	256,716	60(48-76)	7(5-9)	1(0-5)	2(1-12)	423(353-740)	365(293-473)	58(14-348)	16(14-29)	14(11-18)	2(1-14)	27,499	4.14	0.24
	Hainan	5	441,691	20(14-28)	4(3-5)	1(0-4)	2(1-15)	256(191-697)	182(127-257)	74(23-509)	6(4-16)	4(3-6)	2(1-12)	32,754	3.7	0.11

	Guoluo	6	181,682	209 (188-232)	17 (15-19)	244 (221-270)	417 (378-461)	27,235 (24,796-29,976)	1,001 (916-1,138)	26,234 (23,775-28,957)	1,499 (1,365-1,650)	55 (50-63)	1,444 (1,309-1,594)	18,378	3.65	0.38
	Yushu	6	378,439	283 (248-326)	47 (41-54)	91 (71-117)	323 (254-415)	21,072 (17,911-27,486)	2,648 (2,353-3,093)	18,424 (15,211-24,771)	557 (473-726)	70 (62-82)	487 (402-655)	1,5280	3.4	0.21
	Haixi	8	258,191	11(7-17)	1(1-2)	0(0-0)	0(0-0)	69(44-109)	69(44-109)	0(0-0)	3(2-4)	3(2-4)	0(0-0)	95,314	6	0.27
Sichuan	Overall	32	2,122,306	97 (91-104)	91 (85-97)	34 (31-38)	682 (614-758)	39,701 (36,909-44,374)	4,938 (4,608-5,292)	34,762 (31,972-39,448)	187 (174-209)	23 (22-25)	164 (151-186)	25,035	6.08	2.16
	Aba	13	898,708	75(67-84)	30(27-33)	4(2-6)	32(20-53)	3,051(2,390-4,062)	1,384(1,232-1,551)	1,666(1,025-2,664)	34(27-45)	15(14-17)	19(11-30)	30,594	6.62	1.79
	Ganzi	18	1,091,872	126 (117-136)	61 (56-65)	63 (57-70)	650 (586-720)	36,621 (34,066-40,914)	3,525 (3,272-3,812)	33,096 (30,534-37,368)	335 (312-375)	32 (30-35)	303 (280-342)	19,596	5.64	2.47
	Muli	1	131,726	9(3-27)	1(0-2)	0(0-0)	0(0-0)	29(11-90)	29(11-90)	0	2(1-7)	2(1-7)	0	21,254	/	/
Tibet	Overall	74	3,002,165	145 (138-154)	191 (182-203)	20 (17-23)	554 (477-648)	36,343 (32,448-40,520)	10,069 (9,463-10,729)	26,274 (22,411-30,383)	121 (108-135)	34 (32-36)	88 (75-101)	35,143	4.62	0.66
	Lhasa	8	559,423	105(87-126)	26(21-31)	22(15-33)	116(78-172)	6,001(4,495-8,407)	1,279(1,031-1,500)	4,722(3,254-7,141)	107(80-150)	23(18-27)	84(58-128)	59,223	8.81	0.54
	Rikeze	18	703,292	100(87-114)	31(27-35)	10(6-15)	65(42-98)	4,731(3,613-6,256)	1,599(1,410-1,849)	3,132(1,986-4,628)	67(51-89)	23(20-26)	45(28-66)	23,724	1.72	0.21

	Changdu	11	657,505	122 (106-139)	35 (31-40)	28 (21-37)	170 (130-231)	11,080 (8,789-14,088)	1,935 (1,673-2,206)	9,146 (6,883-12,146)	169 (134-214)	29 (25-34)	139 (105-185)	/	/	/
	Shannan	12	328,990	131 (112-154)	19 (16-22)	4 (1-9)	12 (4-28)	1,373 (998-1,867)	883 (745-1,032)	490 (156-970)	42 (30-57)	27 (23-31)	15 (5-29)	35,038	5.08	2.06
	Linzhi	7	195,109	134 (108-168)	12 (9-14)	20 (12-36)	37 (21-66)	2,284 (1,642-3,878)	565 (459-715)	1,720 (1,077-3,287)	117 (84-199)	29 (24-37)	88 (55-168)	50,117	6.23	2.76
	Naqu	11	462,381	299 (271-331)	61 (55-67)	30 (21-41)	129 (92-177)	9,189(7,078-10,728)	3,355 (2,918-3,600)	5,834 (3,887-7,440)	199 (153-232)	73 (63-78)	126 (84-161)	18,939	3.31	0.36
	Ali	7	95,465	195 (158-238)	8 (7-10)	27 (16-47)	24 (14-42)	1,685 (1,196-2,626)	454 (366-553)	1,231 (747-2,167)	177 (125-275)	48 (38-58)	129 (78-227)	/	/	/
Yunnan	Overall	3	400,182	5(2-20)	1(0-4)	0(0-10)	0(0-37)	31(10-113)	31(10-113)	0	1(0-3)	1(0-3)	0	44,153	5.23	0.73
	Diqing	3	400,182	5(2-20)	1(0-3)	0(0-0)	0(0-0)	31(10-114)	31(10-114)	0	1(0-3)	1(0-3)	0	44,153	5.23	0.73

* Data source: 46 local statistics bureaus and government websites at provincial, prefecture and county level in Qinghai, Sichuan, Tibet, Gansu and Yunnan.

Table 3 Top 20 counties for echinococcosis DALYs in Tibetan communities

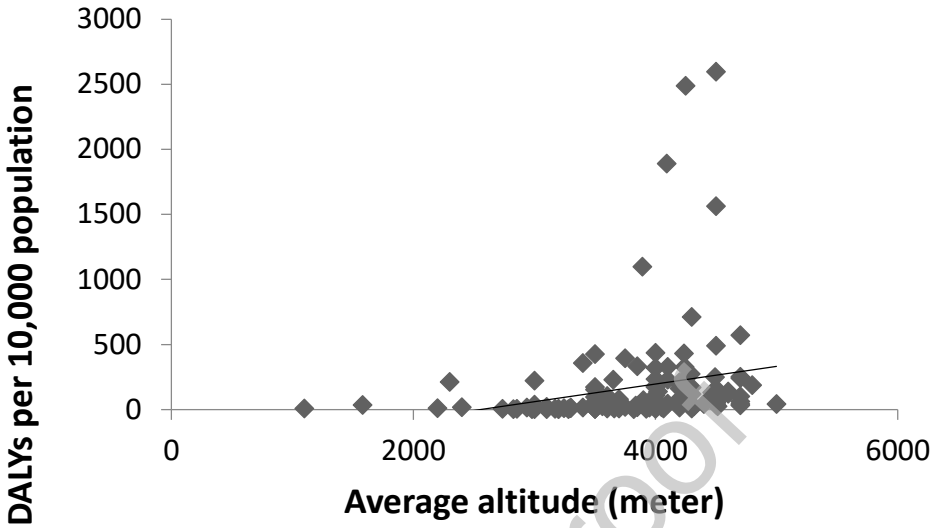
County	Province	Population size	CE prevalence (‰) (95%UI)	Estimated CE mortality (95%UI)	AE prevalence (‰) (95%UI)	Estimated AE mortality (95%UI)	Total DALYs (95%UI)	CE DALYs (95%UI)	AE DALYs (95%UI)	Total DALYs per 10,000 population (95%UI)	CE DALYs per 10,000 population (95%UI)	AE DALYs per 10,000 population (95%UI)
Shiqu	Sichuan	80,834	746(663-845)	27(24-30)	467(397-546)	355(302-415)	20,102(17,384-23,221)	1,643(1,458-1,877)	18,459(15,729-21,562)	2,487(2,151-2,873)	203(180-232)	2,284(1,946-2,667)
Dari	Qinghai	30,995	384(324-450)	5(4-6)	854(766-952)	249(223-277)	15,964(14,418-17,730)	309(262-365)	15,655(14,115-17,425)	5,150(4,652-5,720)	100(85-118)	5,051(4,554-5,622)
Chenduo	Qinghai	55,619	447(369-533)	11(9-13)	447(371-536)	234(194-280)	14,432(12,079-17,200)	656(547-792)	13,776(11,413-16,535)	2,595(2,172-3,092)	118(98-142)	2,477(2,052-2,973)
Seda	Sichuan	58,606	448(382-526)	12(10-14)	202(160-259)	111(88-143)	6,424(5,230-8,060)	635(542-750)	5,789(4,596-7,414)	1,096(892-1,375)	108(93-128)	988(784-1,265)
Banma	Qinghai	27,185	198(152-260)	2(2-3)	337(274-416)	86(70-106)	5,131(4,155-6,306)	140(107-186)	4,991(4,015-6,159)	1,887(1,528-2,320)	51(39-69)	1,836(1,477-2,266)
Ganzi	Sichuan	68,523	143(109-192)	4(3-6)	109(79-152)	70(51-98)	3,547(2,665-4,812)	241(184-324)	3,306(2,412-4,561)	518(389-702)	35(27-47)	482(352-666)
Dege	Sichuan	81,503	146(110-193)	5(4-7)	82(55-118)	63(42-91)	3,489(2,453-4,946)	283(216-379)	3,206(2,158-4,647)	428(301-607)	35(27-47)	393(265-570)
Yushu	Qinghai	120,447	241(168-354)	13(9-19)	39(15-86)	44(17-108)	2,974(1,582-6,339)	677(472-998)	2,297(888-5,639)	247(131-526)	56(39-83)	191(74-468)
Gande	Qinghai	34,840	470(403-549)	7(6-8)	89(62-129)	29(20-42)	2,476(1,856-3,368)	439(377-516)	2,037(1,418-2,929)	711(533-967)	126(108-148)	585(407-841)
Baiyu	Sichuan	56,290	89(60-127)	2(1-3)	76(50-111)	40(27-59)	2,392(1658-3455)	141(97-201)	2,251(1,511-3,310)	425(294-614)	25(17-36)	400(268-588)
Baqing	Tibet	48,284	537(400-712)	11(8-15)	60(27-141)	27(12-64)	2,361(1,443-4,553)	729(542-975)	1,632(719-3,810)	489(299-943)	151(112-202)	338(149-789)

Dingqing	Tibet	69,888	105(66-166)	3(2-5)	62(34-112)	41(22-74)	2,306(1,362-4,054)	187(119-298)	2,119(1,172-3,855)	330(195-580)	27(17-43)	303(168-552)
Maduo	Qinghai	11,336	131(47-523)	1(0-3)	214(79-631)	23(8-67)	1,769(706-5,198)	40(14-159)	1,730(642-5,136)	1,561(623-4,585)	35(12-140)	1,526(566-4,530)
Zuogong	Tibet	44,320	748(597-942)	15(12-18)	34(12-99)	14(5-41)	1,738(1,163-3,476)	874(693-1,104)	863(314-2,584)	392(262-784)	197(156-249)	195(71-583)
Jiangda	Tibet	760,26	137(91-204)	5(3-7)	41(21-84)	29(15-60)	1,722(984-3,381)	198(132-297)	1,524(780-3,170)	227(129-445)	26(17-39)	200(103-417)
Anduo	Tibet	37,802	528(397-701)	9(7-12)	72(34-154)	26(12-55)	1,663(1,035-3,064)	483(363-644)	1,180(564-2,556)	440(274-810)	128(96-170)	312(149-676)
Chengguan	Tibet	27,9074	88(61-125)	11(7-15)	11(5-31)	29(13-81)	1,653(1,015-3,675)	520(366-746)	1,133(511-3,118)	59(36-132)	19(13-27)	41(18-112)
Zaduo	Qinghai	58,268	492(373-651)	13(10-17)	31(12-93)	17(6-51)	1,581(1,010-3,453)	681(518-908)	900(341-2,737)	271(173-593)	117(89-156)	154(58-470)
Nangqian	Qinghai	85,825	207(133-308)	8(5-12)	26(10-83)	21(8-67)	1,456(850-3,725)	469(300-700)	988(396-3,231)	170(99-434)	55(35-82)	115(46-376)
Suoxian	Tibet	43,621	148(85-254)	3(2-5)	86(43-178)	35(17-73)	1,424(787-2,806)	142(82-248)	1,282(634-2,649)	327(180-643)	33(19-57)	294(145-607)

Table 4 YLD, YLL and DALYs

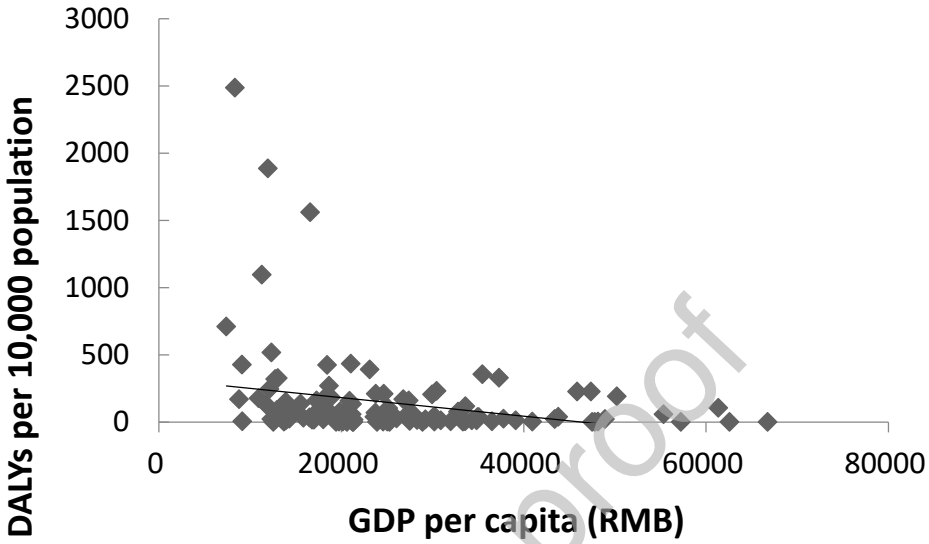
	Total (UI)	CE (UI)	AE (UI)
YLD	3,414(2,847-4,432)	1,812(1,393-2,594)	1,602(1,173-2,230)
YLL	122,744(119,154-133,892)	18,518(18,009-19,337)	104,226(100,549-115,256)
DALYs	126,159（122,415-137,675）	20,330（19,690-21,581）	105,828（101,969-117,090）

Fig.1 Distribution of county DALYs per 10,000 population in relation with county average altitude (above sea level: meters)



Spearman correlation:r=0.512 p<0.001

Fig.2 Distribution of county echinococcosis DALYs per 10,000 population in relation with GDP per capita (RMB)



Spearman correlation r=-0.304 p=0.001