

# Effectiveness over 10 years (2004-2014) of the echinococcosis control programme in China: Impact on humans and dogs population

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## Research

**Keywords:** Control programme, Effectiveness, Echinococcosis, humans and dogs

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# Abstract

## Background

A national control program for echinococcosis has been in effect since 2005 in China. This program has applied a comprehensive strategy, and good control results have been achieved. The objective of this study is focusing on the effectiveness of the programme with two indices, including patients treatment and registered dogs deworming, in endemic areas of echinococcosis control over the period of 10 years (2004-2014) in China.

## Methods

The study was conducted in the pastoral and farming-pastoral regions of project counties in 10 provinces and autonomous regions, a database was established that included demography at county and township levels, grouping available patients into those subjected to surgery and those receiving drug treatment after population screening. Information was given regarding the diagnosis (CE, AE, co-infection or unclassified) and the number of registered dogs and that of those dewormed. All statistical analyses were performed using SPSS software version 18 (SPSS Institute, Chicago, IL, USA). The results are shown as percentages with the corresponding 95% confidence intervals (95% CIs). The situation with respect to humans and dogs were described using epidemiological descriptive analyses and the direct costs calculated after discount.

## Results

Our study showed that over the 10-years period, the coverage rate for the patients treatment had increased 32.4% on surgical treatment as well as 81.3% on medical treatment, meanwhile, it had increased by 58.6% for registered dog deworming since 2007. The accumulated costs of US 27.03 \$ million after discount on patients and registered dog treatment, it has account for 1/4 on total accumulated inputs (110.67 \$ million) by Chinese government, in addition, it was by 57-fold on the annual inputs whereas 368-fold on accumulated inputs since the national program implementation.

## Conclusions

As found through this study, it is suggested that sustainable follow-up evaluations are crucial for success and continued implementation of the national program, which will be necessary until the disease is under control and has been eliminated in all endemic areas of China. Based on the results obtained through this study, we recommend that more attention should be paid to controlling stray dogs during the ongoing program period. Keywords: Control programme; Effectiveness, Echinococcosis, humans and dogs

# Background

Echinococcosis (hydatid disease) is one of the 17 neglected tropical diseases (NTDs) recognized by the World Health Organization (WHO) and its continued spread is a severe public health concern (1). Echinococcosis is mainly endemic in areas of central, eastern and western Asia, South America, Oceania and southern, northern and eastern Africa. Infection in humans/livestock/small mammals is caused by the larval stage of the parasite. Canines (i.e. dogs, foxes, and wolves) are the definitive hosts and play a key role in the transmission and dissemination of the adult stage of this tapeworms belonging to genus *Echinococcus*. The two most important zoonotic species, *E. granulosus* (the causative agent of cystic echinococcosis - CE) and *E. multilocularis* (the causative agent of alveolar echinococcosis - AE), are a serious threat to over 1 million people and responsible for over US\$ 3 billion in expenses every year. Expressed in global disability-adjusted life years (DALYs), losses of between 0.3-1million DALYs for CE and 0.65 million DALYs for AE, respectively, have been reported (2-5). China has a high prevalence of human CE and one of the highest prevalence levels of human AE, accounting for 40% of global DALYs lost worldwide (5,6,8,11). Both diseases are widely endemic in the pastoral and farming-pastoral regions of Inner Mongolia, Sichuan, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang provinces (autonomous regions) covering 350 counties, with 120,000 people infected and 50 million people estimated at risk according to the national prevalence survey of echinococcosis initiated by the National Health and Family Planning Commission in 2012 (13). Notably, canine infectious sources in wild environments in the above endemic areas play important roles in the transmission dynamics of both diseases (7, 9,10,12). A national program for echinococcosis control with comprehensive approaches was launched in 2005. This program has developed well, particularly thanks to the national control action plan (2010-2015) implemented by the Chinese Central Government, as evidenced by the human echinococcosis prevalence rate, which has shown a remarkable decrease from 1.08% in 2004 to 0.24% in 2012 (13-14). The key measures were monthly praziquantel oral treatment (reported to have 99.9% efficacy by WHO) of registered dogs in addition to large-scale human surgical interventions and oral treatment in the endemic regions (7). Clearly, control of CE and AE will have important economic consequences. An evaluation of the costs of the human intervention and deworming of the dog population is essential and should be part of any program aimed at the control of parasitic zoonoses (15). The objective of this study was to assess progress and costs for the national echinococcosis control program at the central government level over a 10-year period up to 2014. This assessment includes a comprehensive, epidemiological description and a cost analysis with estimates for human and dog interventions in the endemic areas of China for the period 2004-2014. Due to the limitation of data confidentiality, we only collected data approved by the National Health and Family Planning Commission up to 2014, so the four years data after that were not covered. Moreover, although the national control programme was led by National Health and Family Planning Commission, the livestock management and vaccination were the responsibility of the Ministry of Agriculture and the outcomes will depend on their reports. In addition, the national surveillance system for echinococcosis was established in 2016, as there were hardly any historical data for analysis to fully reflect the prevalence or incidence for patients and dogs, except for the two national surveys in 2004 and 2012.

## Methods

### Study area

The study was conducted in the pastoral and farming-pastoral regions of project counties in 10 provinces and autonomous regions (Inner Mongolia, Sichuan, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang and the Xinjiang Production and Construction Corps (XPCC)) where the echinococcosis control measures were implemented and supported by budgeted annual financial requirements by the Chinese Central Government covering the period 2004–2014 (Figure. 1, Figure. 2).

## Data collection

All data were obtained in the form of echinococcosis control statistics from the disease-endemic areas approved by the National Health and Family Planning Commission for each year of the 10-year period. Data involving patient privacy were not involved. Based on the collected information, a database was established that included demography at county and township levels, grouping available patients into those subjected to surgery and those receiving drug treatment after population screening. Information was given regarding the diagnosis (CE, AE, co-infection or unclassified) and the number of registered dogs and that of those dewormed. The situation with respect to humans and dogs were described using epidemiological descriptive analyses and the direct costs calculated after discount.

## Statistical analysis

All statistical analyses were performed using Microsoft Excel software, version 2010 (Microsoft Office, CA, USA) and SPSS software version 18 (SPSS Institute, Chicago, IL, USA). The maps were generated using ArcGIS software, version 10 (ESRI, Redlands, CA, USA). The results are shown as percentages with the corresponding 95% confidence intervals (95% CIs). The annual numbers of dewormed dogs were not directly acquired for the period 2012–2014 due to a change in the statistical criterion adjustment in these years; instead the expectation-maximization (EM) method for missing value filling ([https://en.wikipedia.org/wiki/Expectation-maximization\\_algorithm](https://en.wikipedia.org/wiki/Expectation-maximization_algorithm)) was used to estimate the number of dewormed dogs statistically with reference to the annual total of the registered dog variable and the human prevalence rate for 2004–2011.

Additionally, the direct costs after discount of each documented surgical and treatment patient was in accordance with the national available direct financial inputs approved by the State Ministry of Finance as follows (using the exchange rate of 1 US\$=6.5 RMB Yuan): the annual financial inputs calculated with bank discount average changes of 2.3–3.3%: US\$1,230 per surgical case; and US\$1.20 per treatment case at the beginning of 2006. All costs data were statistically analyzed and calculated after the corresponding discount in accordance with annual bank interest rates during the years used for the costs analysis. (20).

## Results

### Humans

During the period 2004–2014, the total number of human echinococcosis cases reported in the endemic areas ranged from 1,749 – 31,507 among 56.7–79.7 million inhabitants at the county level and 19.3–39.1 million inhabitants at the township level. The grand total included individuals identified by annual mass screening [4.8% (959/20,168)-18.2% (318/1749)], the number of patients subjected to surgical intervention [38.1% (938/2461)-91.1% (12,572/24,733)] and patients receiving treatment [53.4% (1313/2461)-98.0% (20,196/20,624)]. The statistical analysis of the patients showed that although the average rate of surgical operations for 2005–2006, i.e. before the implementation of the national control program, was greater than 10%, the rate declined to 5.7% in 2007 (95% CI, 5.0-6.9%) and remained stable until 2014. The average coverage rate of patients under treatment was 69.4% (95% CI, 56.8–82.0%) in 2007, while the total coverage rate was 76.7% (95% CI, 67.5–87.9%) in 2014; these rates were stable over the whole study period (Table. 1, Figure. 3).

Additionally, the number of surgical cases changed from 318 (1,749\*18.2%) to 2,379 (31,507\*7.55%) from 2004 to 2014 (Table 1). A total of 121 patients (with co-infections) underwent surgical operations since 2010, and 513 unclassified cases were recorded since 2008. Moreover, 134,249 person-hours (the total time used for surgical treatment and drug treatment) were reported since 2010, including 74,145 person-hours for CE, 28,833 for AE and 1802 for co-infection. However, 29,469 person-hours remained unclassified since 2008, particularly within the 2-year period 2011–2012 when the accumulated total person-hours were greater than 10,000. During these years, the mean incidence for surgical patients after diagnosis as the patients at the county level (the project county) were 2.7 (CE), 0.1 (AE), 0.02(with co-infections) and 0.1 (unclassified) per 10,000 persons, respectively, while those at the township level were 2.9, 0.2, 0.04 and 0.13, respectively. It should be noted that some patients were not suitable for surgery. The person-hours for the patients having received treatment were 10.2 (CE), 3.9 (AE), 0.3(with co-infections) and 4.4 (unclassified) at the county level, respectively, while the corresponding figures at the township level were 21.8, 8.5, 0.6 and 7.4, respectively (Table 2, Figure. 4, Fig. 5, Figure.6, Figure.7).

Table 1  
Patient interventions undertaken by the national echinococcosis control program during 2004–2014

Year	Project county <sup>a</sup>	Project township <sup>b</sup>	Population examined <sup>c</sup>	Available patients	Proportion of patients subjected to surgical interventions (%)					Proportion of patients treated with albendazole (%)		
					CE	AE	Co-infection	Unclassified	Average	CE	AE	Co-infection
2004	10	70	2.8	1,749	17.7	0.5	–	–	18.2	36.5	10.2	–
2005	25	116	4.9	2,461	14.9	0.4	–	–	15.2	27.7	10.4	–
2006	38	192	12.0	3,920	9.5	0.5	–	–	10.0	28.0	15.5	–
2007	67	370	39.1	7,399	5.6	0.1	–	–	5.7	41.2	27.7	–
2008	103	591	52.8	14,227	4.4	0.2	–	0.2	4.8	39.3	25.8	–
2009	118	899	83.4	18,108	3.1	2.1	–	0.0	5.1	49.8	28.7	–
2010	120	904	90.0	20,168	4.3	0.0	0.4	0.05	4.8	57.2	19.4	6.0
2011	175	1,455	152.2	20,624	5.9	0.1	0.0	0.7	6.8	27.8	4.5	0.1
2012	214	2,270	166.6	24,733	4.8	0.1	0.02	0.8	5.7	28.8	4.5	0.2
2013	230	2,333	183.8	28,652	6.9	0.3	0.02	0.2	7.4	50.9	17.9	0.9
2014	247	2,624	213.0	31,507	6.9	0.3	0.1	0.3	7.6	47.9	18.5	0.9

<sup>a</sup> number of counties subjected to control activities

<sup>b</sup> number of townships subjected to control activities

<sup>c</sup> (× 10000)

<sup>d</sup> proportion of patients treated by surgical interventions + patients treated with albendazole.

Table 2  
Patient interventions at different administrative levels in the areas endemic for echinococcosis for the period 2008–2014

Types	Mean prevalence (per 10 <sup>5</sup> population)							
	Patients subjected to surgery (Number of cases)				Patients treated with albendazole (Number of person-hours)			
	Case	Proportion (%)	County level (95% CI)	Township level (95% CI)	Case	Proportion (%)	County level (95% CI)	Township level (95% CI)
CE	10,053	88.4	2.71 (1.32–4.11)	2.94 (1.50–4.49)	74,145	55.2	0.23 (4.85–15.61)	21.79 (9.44–31.43)
AE	685	6.0	0.11 (0-0.24)	0.21 (0-0.46)	28,833	21.5	3.93 (1.75–6.09)	8.52 (3.51–13.52)
Co-infection <sup>a</sup>	513	4.5	0.02 (0-0.06)	0.04 (0-0.09)	29,469	22.0	0.25 (0-0.63)	0.56 (0-1.40)
Unclassified <sup>b</sup>	121	1.7	0.07 (0-0.15)	0.1 (0.01–0.3)	1,802	1.3	4.36(0-9.75)	7.41 (0-16.08)

<sup>a</sup> statistics from 2010–2014. <sup>b</sup> statistics from 2008–2014. Person-hours: the total times after treatment for patients (surgical cases included)

## Registered Dogs

Over the 10-year period from 2004–2014, the number of registered dogs tended to increase, i.e. reaching 28 times the previous annual number with a medium value of 115.0 (95% CI, 83.779-226.0), while the annual number of registered dogs already subjected to deworming increased 49 times with a medium value of 46.8 (95% CI, 35.9-151.1), respectively. In addition, the deworming coverage rate increased 73% in 2014 in comparison to 2005 with dogs being dewormed 6, 10 and 12 times per year based on an estimation according to the number of registered dogs during the period of 2012–2014 (Table 3, Fig. 8). Because disease surveillance was not performed in the endemic regions due to the uneven development of disease control, the actual and accurate data of the dogs in

which infection was not reported until 2012, with the exception of large-scale treatment schemes of the dog population using praziquantel tablets, whereas unpublished data based on Echinococcus coproantigen ELISA tests for the average dog infection rates (available via the national pilot surveillance system) ranged between 3.4% (2013) and 2.9% (2014), in the endemic areas. Dogs are definitive hosts in the semi-domestic life cycle of E. multilocularis and play a key role due to their close association with E. granulosus throughout parasite transmission in the endemic areas of western China (9,10,23,26). Since 2005, the echinococcosis control initiative in China provides complete data for the management of registered dogs including deworming of infected dogs. Over the 7-year period of 2005–2011, the number of registered dogs increased 9-fold, but the deworming coverage rate only increased 8-fold in 2011 compared to the rate in 2005. However, according to the complete data records of registered dogs from 2012 to 2014, the coverage rate remained near 70% and exhibited an estimated 7-fold increase compared to 2005. These results were similar to those of the 2012–2014 period. Additionally, monthly anthelmintic treatment for dogs was more effective compared to previous studies (28,29).

Table 3  
The situations for registered dogs deworming by the national echinococcosis control program from 2004–2014

Year	Registered dogs (× 10000)	Deworming cases (× 10000)	Coverage rate (%)	Single deworming (× 10000)
2004	9.6	3.7	38.2	–
2005	23.0	2.4	10.2	–
2006	76.2	7.9	10.4	–
2007	93.2	38.9	41.5	–
2008	109.5	44.5	40.7	–
2009	115.0	46.8	40.7	–
2010	203.3	118.9	58.5	–
2011	216.0	176.9	81.9	–
2012	325.6	240.5 <sup>a</sup>	73.9	1,332.0
2013	263.1	170.3 <sup>a</sup>	64.7	1,714.2
2014	269.0	178.0 <sup>a</sup>	66.2	2,304.5

<sup>a</sup> Based on statistical estimation. Coverage rate = deworming cases/registered dogs·100

## Costs Analysis

The national echinococcosis control program led by National Ministry of Health was implemented in sectoral collaboration with 13 other ministries, e.g., the Ministry of Agriculture and the Ministry of Water Resources. The activities consisted of health education, ultrasound screening of the human population, surgical interventions and treatment with albendazole, including management and deworming of the dog population. In addition, a pilot study on comprehensive measures, capacity building for the local CDC and other approaches was carried out (18,19). The annual financial outlays for the control activities were allocated at the province and county level by the Chinese Central Government. Over the 10-year period, a total costs of US\$110.7 million after discount was estimated for the national program by the National Health and Family Planning Commission, a sum that was verified by the health administration departments of the endemic areas. The direct costs, ranging from albendazole treatment and surgical operations to deworming the dog population with oral praziquantel, were calculated at US\$ 12.3 for humans and US\$ 15.8 million for dogs after discount. This means that in 2014, compared to 2005, the annual and accumulated intervention costs with respect to humans and dogs had increased 2,840 times and 21.8 times, respectively. The annual cost proportion increased by 190% [(31.58–10.88)/10.88] and the accumulated costs proportion increased by 187% [(24.42–8.51)/ 8.51] in comparison to 2006, respectively.(Table 4).

Table 4  
Analysis of input-cost at the national level for patient and dog interventions from 2004–2014

Total input			Cost for patient and dog interventions				Proportion (%)	
Year	Annual	Accumulated	Patients	Dogs	Annual	Accumulated	Annual	Accumulated
2004	–	–	–	–	–	–	–	–
2005	30.1	30.1	–	–	–	–	–	–
2006	108.2	138.3	0.1	11.7	11.8	11.8	10.9	8.5
2007	392.3	530.6	51.0	55.6	106.6	118.3	27.2	22.3
2008	1038.4	1569.0	82.3	63.7	146.0	264.3	14.1	16.9
2009	1119.9	2688.9	112.5	67.6	180.01	444.9	16.1	16.5
2010	1709.3	4398.1	115.6	171.3	286.9	731.2	16.8	16.6
2011	1683.0	6081.1	168.2	254.3	422.6	1153.8	25.1	19.0
2012	1571.0	7652.1	168.7	346.2	515.0	1668.8	32.8	21.9
2013	1710.1	9362.2	252.0	243.6	495.6	2164.4	29.0	23.1
2014	1705.6	11067.9	284.0	254.7	538.7	2703.1	31.6	24.4
State inputs and costs are expressed in US\$ ·10,000.								

## Estimated Gaps

We carried out a financial input gap estimate for patient treatments and dogs deworming by for the 2006-2014 period at the national level. The formulas were expressed as follows:

1. The annual gap for treatment of patients (A1) = the annual number of available patients in need of treatment – the actual annual cost for patient treatment based on cost, actual number of patients and treatment (CAT);
2. The annual gap for dog deworming (A2) = the annual number of registered dogs needing deworming – the cost for annual actual dogs deworming based on cost, actual number of dogs and deworming (CAD);
3. The accumulated gap for patient treatment (A3) = The accumulated number of available patients in need of treatment – the actual accumulated cost for patient treatment based on cost, actual number of accumulated patients and treatment (CAAT);
4. The accumulated gap for dog deworming (A4) = the accumulated number of registered dogs needing deworming) – the actual accumulated cost for dog deworming based on cost, actual number of accumulated dogs and deworming (CADD);
5. Grand annual proportion =  $A1 + A3 / CAT + CAD$ ; and
6. Grand accumulated proportion =  $A2 + A4 / CAAT + CADD$ .

Table 5 shows that although the current financial inputs did not fully adapt to the emerging number of patients and dogs in need of treatment and deworming, the gap narrowed by 68% in 2014, while it narrowed by 66% with respect to the accumulated costs in comparison to 2006, which is in accordance with the annual increases by China's Central Government.

Table 5  
Input gap by estimation for patient and dog interventions 2006–2014

Year	Input gap for patients		Input gap for dogs		Grand total proportion (%)	
	Annual	Accumulated	Annual	Accumulated	Annual	Accumulated
2006	0.3	0.3	100.8	100.8	90.0	90.0
2007	16.8	17.1	77.6	178.5	47.0	62.3
2008	17.0	34.1	92.9	271.4	43.0	53.6
2009	17.0	51.1	98.5	369.9	39.1	48.5
2010	9.3	60.4	121.6	491.5	31.3	43.0
2011	5.7	66.1	56.2	547.7	12.8	34.7
2012	20.0	86.1	122.4	670.1	21.7	31.3
2013	75.4	161.5	132.8	802.9	29.6	30.8
2014	89.4	250.9	130.1	933.0	29.0	30.5
Inputs are expressed in US\$ ·10,000						

## Discussion

Echinococcosis transmission mainly occurs in the pastoral and farming-pastoral regions of western China due to the complex animal populations and *Echinococcus* spp., which involve a wide range of intermediate and definitive hosts, Human epidemiological surveys may be carried out by serology, and ultrasonography is regarded as a simple, safe and reliable diagnostic tool for screening for internal cysts. Importantly, relatively safe and effective chemotherapy is available (21,22).

The data in this study demonstrate that the grand total person-hours spent on surgical interventions and treatment (including postoperative treatment) was 76.6% of the corresponding grand total proportion for the year of 2014, which was 1.2-fold compared to 2005. These results show a high disease burden in terms of DALYs in the endemic areas, which indicates that echinococcosis is a serious threat in parts of China. However, the patient numbers increased 18-fold in 2014 compared to 2004, while the prevalence per 100,000 population rate increased 17-fold at the county level and 10.8 times at the township level during the same time. Moreover, 1.5 as many new cases were found, and the cumulative cases (expressed in person-hours) for surgical operations increased 4.2 times, which was 3.8 times the value for CE and 8.1 times the value for AE. For treatment (expressed in person-hours), the cumulative cases increased 5.7 times the value for the CE cases and 3.3 times the value for the AE cases for the last 5 years (2009-2014) compared to the former 5 years (2004-2008). In addition, increases of 0.6 times co-infection with surgical interventions and 0.5 times the co-infection cases with treatment for the last 3 years (2012- 2014) were sustained compared to the former 3 years (2010-2011). For the unclassified cases, the cumulative cases were 13.7 times the value obtained with respect to surgical interventions and 6.3 times the value obtained for treatment for the last 4 years (2011- 2014) compared to the former 3 years (2008-2010).

According to the mean prevalence rate at the county and township level, more diagnosed patients will be reported with a higher prevalence following a large-scale population screening; however, the characteristics of the co-infection cases and the unclassified cases treated during an additional 3-year period decreased by one-half. The results indicate that patients with co-infection and unclassified cases display an annual decreasing trend. Moreover, the patient treatments varied widely due to improvement of the diagnostic accuracy through ultrasound screening for the entire exposed population in high-risk areas. Therefore, patient diagnosis and management, including surgery and treatment with albendazole in endemic areas, are sustainable, whereas established surveillance systems for population prevalence and relevant factors need improvement at different levels, including compliance with respect to albendazole treatment, clinical follow-up, personal information and timely treatment updates of record.

Data for the annual number of dogs deworming with dog-time calculated for large-scale deworming for the registered dogs increased 1.7-times in 2014 compared to 2012 and was estimated at 12 times per dog per year for 2014. In conclusion, the estimation of dog management and treatment over this period was performed at completely different levels on an annual timeline and helped reduce the parasite load to control the disease.

The national echinococcosis control program demonstrates that mass human population screening of echinococcosis, early detection and prompt treatment of human cases and large-scale dog deworming are valuable (particularly with respect to coverage) based on the cost proportion changes, with the exception of limitations of minor values based on the estimation. The results of the simple cost analysis show that over the 10-year period, a total cost of US\$ 27.0 million after discount on patients treatment and registered dogs deworming was accumulated. It reached 24.4% accounting for 1/4 of the total financial input, though currently they have not adapted to the emerging numbers of patients in need of treatment and dogs that should be dewormed. The annual and the accumulated costs increased 57-fold and 368-fold compared to those in 2005 respectively, and the grand total proportion narrowed by 70% with respect to annual or accumulated gaps, which is in accordance with the annual increase of the cost for patients and anti-parasite treatment of registered dogs. Notably, a strong relationship exists between patients and dogs, which means that there is a high risk that humans ingest parasite eggs directly through contact with infectious dogs or indirectly from contaminated environments. Studies also reveal that *E. granulosus* eggs remain viable and infective after 41 months that include warm summer and cold winter conditions (1,4,7,9).

In this study, we found that a positive correlation ( $R=0.97$ ,  $P < 0.01$ ) between registered dogs with the available patients after Spearman's correlation analysis of the present data. Currently, the management of stray dogs is particularly difficult in some regions where cultural acceptance is prevalent, several studies indicate that distribution of anthelmintic baits against wild and stray definitive hosts results in significant reductions in AE prevalence, particularly if innovative bait delivery is used (30,32). According to WHO reports regarding endemic regions, the human prevalence rates for CE can reach more than 50 per 100,000 person-years with prevalence levels as high as 5%-10% worldwide; similar rates have been reported in regions of western China (1,8,33,34).

## Conclusion

China has a high prevalence of human cystic echinococcosis (CE) and one of the highest prevalence on human alveolar echinococcosis (AE) worldwide. A national control program for echinococcosis has been in effect since 2005. This program has applied a comprehensive strategy and good control results have been achieved. With increased focus on patients and dog interventions by the Chinese Government, as found through this study, it is suggested that sustainable follow-up evaluations are crucial for success and continued implementation of the national program, which will be necessary until the disease is under control and has been eliminated in all endemic areas of China. Based on the results obtained through this study (though we were unable to include the distribution of stray dogs through the national program, which is a critical for blocking parasitic egg transmission), we recommend that more attention should be paid to controlling stray dogs during the ongoing program period.

## Abbreviations

CE: cystic echinococcosis ; AE: alveolar echinococcosis; NTD: neglected tropical diseases; WHO: World Health Organization.

## Declarations

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### Authors' contributions

QY designed, together with SH and TT wrote the manuscript, NX revised and NXZ reviewed and finally edited the manuscript. All authors read and approved the final manuscript.

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### Availability of data and materials

The supporting data in this paper are included in the context.

### Ethics approval and consent to participate

The study has been reviewed and approved by the Ethical Review Board of National Institute of Parasitic Diseases. The study does not involve the use of any animal or human samples.

### Consent for publication

All participants consented for publication.

### Competing interests

The authors declare they have no competing interests.

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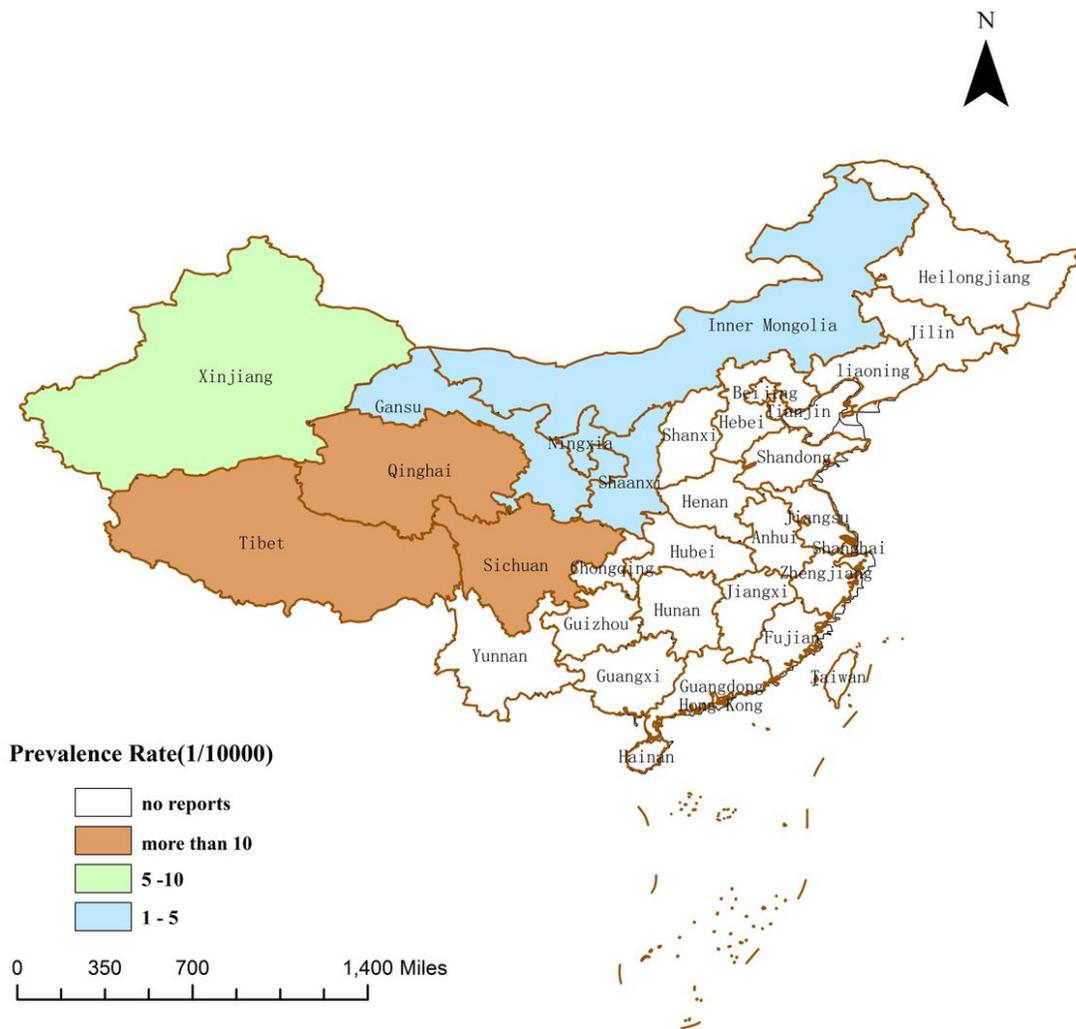
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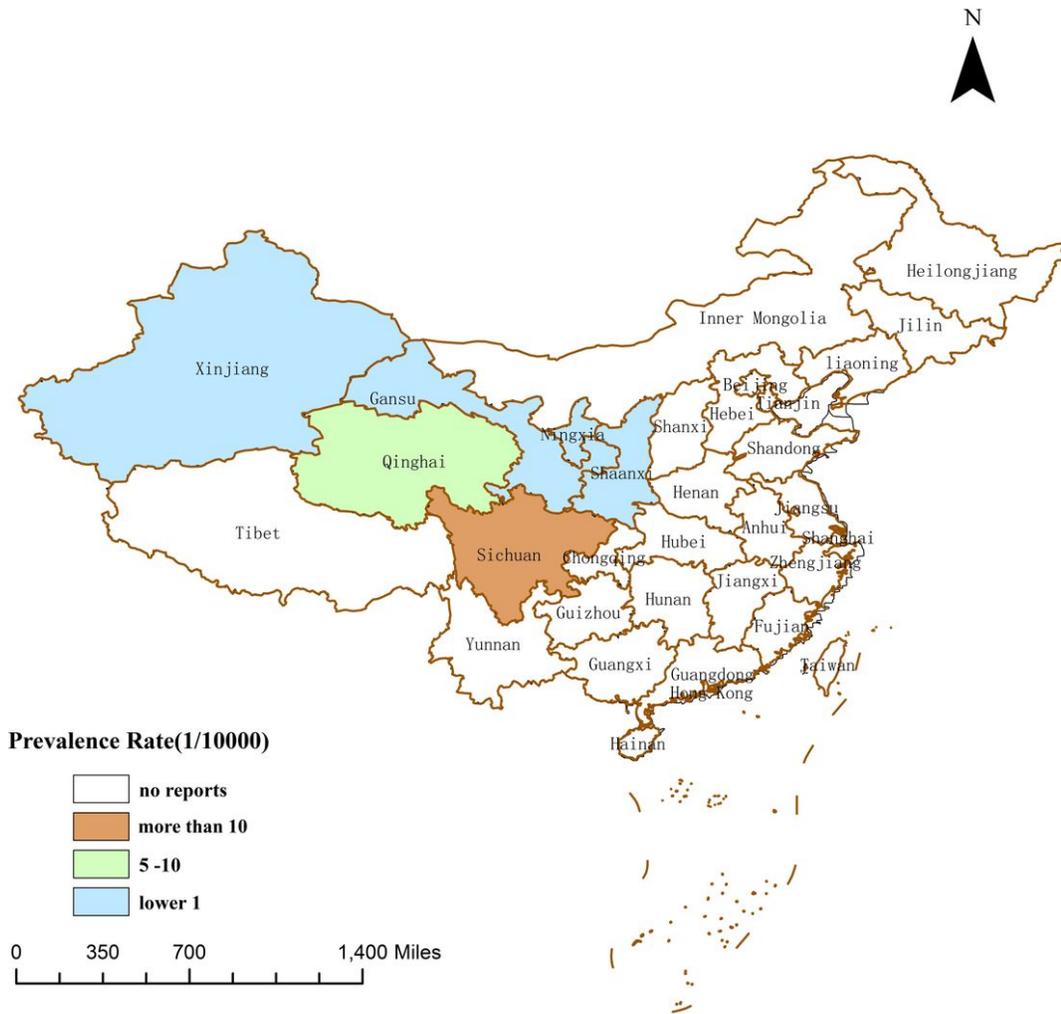
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## Figures

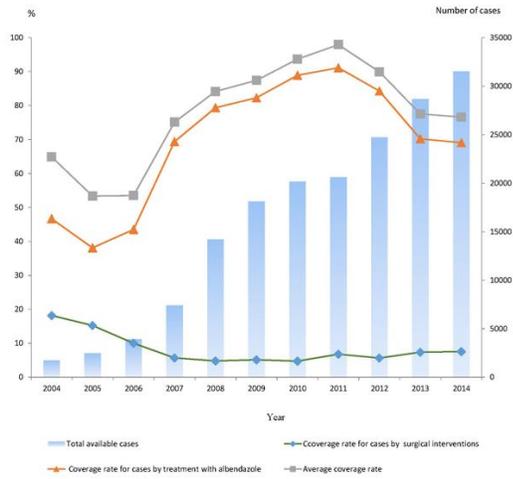


**Figure 1**

Geographic distribution of human cases of cystic echinococcosis (CE) reported by the Chinese system for infectious diseases surveillance in 2014. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

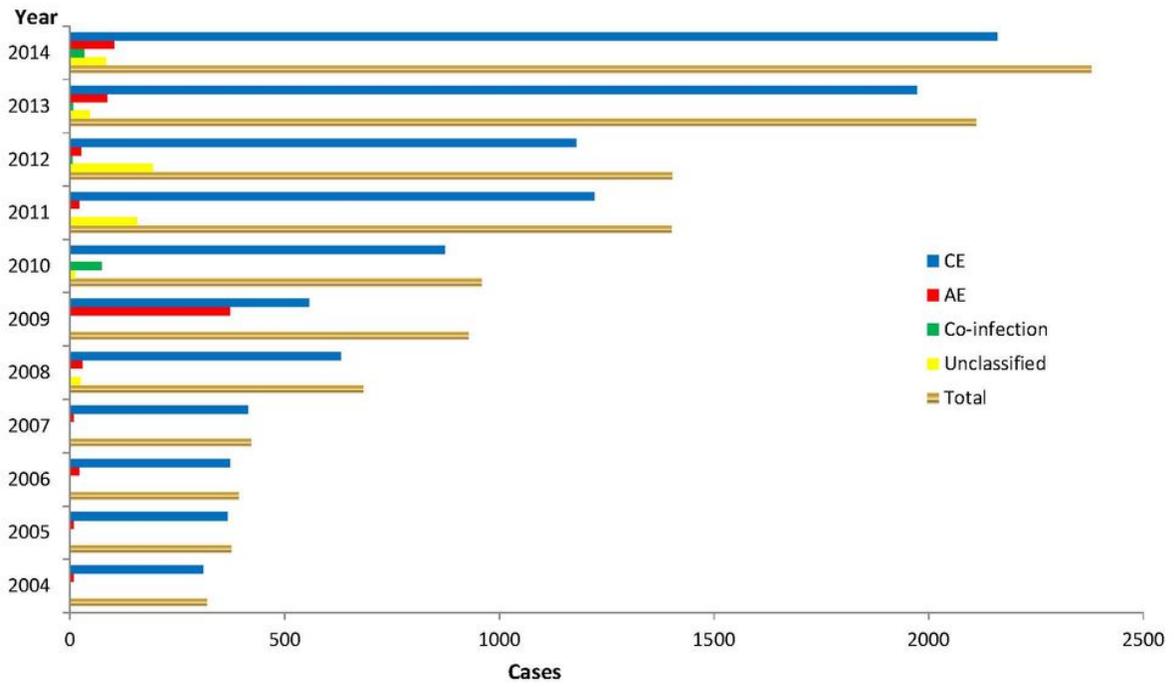


**Figure 2**  
 Geographic distribution of human cases of alveolar echinococcosis (AE) reported by the Chinese system for infectious diseases surveillance in 2014. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.



**Figure 3**

Trend for coverage of patients drug treatment and surgical interventions from 2004-2014 (These coverage rate refer to the patient groups with the average coverage rate being the sum of the rates shown for the group receiving surgery and that given albendazole treatment.)



**Figure 4**

Classification of patients subjected to surgical interventions in the period 2004-2014

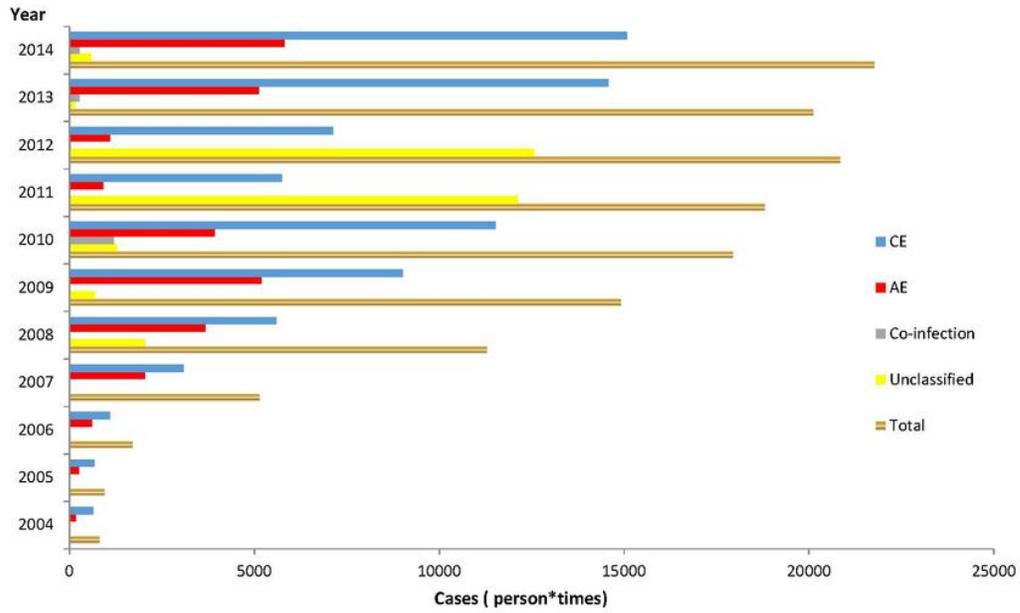
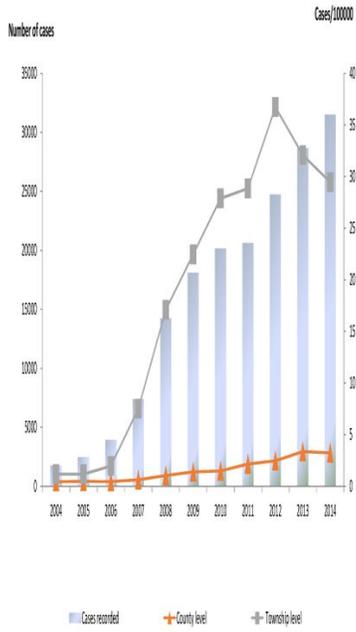


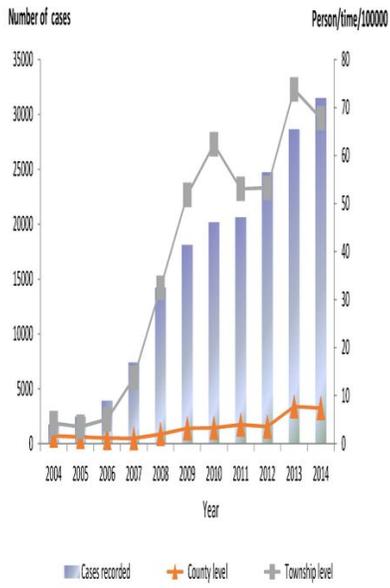
Figure 5

Classification of patients receiving albendazole treatment in the period 2004-2014



**Figure 6**

Distribution of patients by surgical interventions at different levels for 2004-2014



**Figure 7**

Patients treatment with albendazole at different levels for 2004-2014

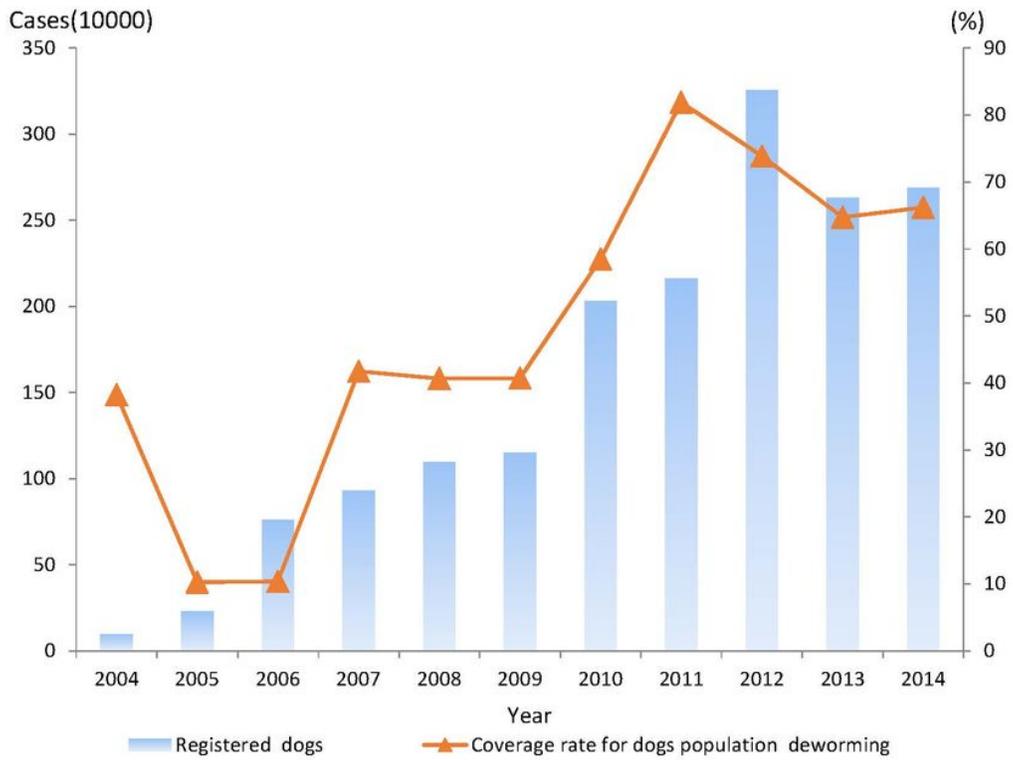


Figure 8

Change of coverage rate for registered dog deworming for the period 2004-2014