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PARASITIC DISEASE ISSUE

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Cover Photo: An ultrasound doctor screening for echinococcosis in monastic monks, Xizang (Tibet) Autonomous Region, 2016.

This week's issue was organized by Guest Editor Xiao-nong Zhou.

Preplanned Studies

A Knowledge Survey on Health Education of Echinococcosis Among Students — Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China, 2020

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Summary

What is already known about this topic?

Previous surveys have mainly focused on how well residents and primary school students have understood the core knowledge of echinococcosis control and are limited in terms of the comprehensiveness of the knowledge category and respondents.

What is added by this report?

There were some shortcomings in related knowledge of echinococcosis among students, which showed a tendency to know methods but not the rationale. The differences among regions indicated a lack of a unified system for training educators and allocating comprehensive educational material.

What are the implications for public health practices?

The results of this study provide evidence to potentially help improve health education programs in the new phase of echinococcosis prevention and control in China.

Health education (HE) is considered an essential component of the control program for echinococcosis (*1*). In this study, a questionnaire survey was conducted among 2,075 junior high school students in Ganzi Tibetan Autonomous Prefecture to evaluate their knowledge regarding echinococcosis. The overall passing rate of students, i.e., passing the knowledge threshold required by the questionnaire, was 82.89%. The students had good knowledge of echinococcosis control, prevention, and treatment, but many were unacquainted with the risks and theoretical details of echinococcosis. The differences in awareness about echinococcosis knowledge among students from different regions were significant, and there were clear differences between counties and between schools. The results support the formulation and adjustment of corresponding HE programs that were based on local echinococcosis prevention and control stages and characteristics. The results also encourage the establishment of a unified echinococcosis HE system, the launching and promotion of various forms of pilot HE programs, and the application of a gradual and dynamic education model for local students.

Echinococcosis is a public health problem that seriously threatens human health and restricts economic development (*2*). It is widespread in pastoral and semi-pastoral areas in western China, of which the Ganzi is an important endemic area with a prevalence of 1.05% in humans (*3*). The echinococcosis prevention and control in Sichuan has experienced 4 different periods since 1980 and the basic goal of control was achieved by 2019; educational strategies matching the conditions of different times provided a key impetus in this accomplishment (*4*). Especially for students, it is valuable if HE can be efficiently accepted, and thus, not only promote changes in behavior with positive effects, but also be spread to families and family-based communities (*5*).

From September to October 2020, we conducted a questionnaire survey on the knowledge of echinococcosis in Ganzi, relying on the Ganzi Workstation for Echinococcosis of China CDC (*6*). Considering various factors such as geographical location (GL), production mode (PM), economic level (EL), and total population (TP) of 18 counties in Ganzi (*7*), we selected Shiqu County (GL: north, PM: mainly husbandry, EL: low, TP: 104,600), Daofu County (midlands, semi-agricultural and semi-husbandry, middle, 55,997), and Daocheng County (south, mainly agriculture and tourism, high, 31,678) as representative counties. Note that Daofu County is one of the five national-level comprehensive intervention areas of echinococcosis in Sichuan Province and that a demonstration project focusing on the children's HE of echinococcosis was launched here, meaning various activities were implemented and extended to middle schools before this survey (*8*). All eighth graders from these counties were included in the survey. To ensure authenticity, the participants' tests were administered closed-book and independently. Microsoft Office Excel 2016 (version 16.0.4266.1001, Microsoft Corporation, Redmond, US), EpiData (version 3.1, EpiData Association, Odense, Denmark) and SPSS Statistics (version 22.0, IBM Corporation, Armonk, US) were used for statistical analysis. The Hiplot website based on R language script or function was used for plotting (https://hiplot.com.cn).

Of the 2,190 questionnaires collected, 2,075 (94.75%) were considered valid. Among these, 1,720 were considered as passing (passing rate [PR]=82.89%), with at least 18 of 30 questions (60%) correct. The median score (MS) was 22 points (one point for each question). The age of the 8th graders ranged from 11 to 21 years in the surveyed areas, and the PR and MS among different age groups showed statistical significance, both decreasing with age (Table 1). The item with the highest awareness rate (AR), i.e., answering the question correctly, was Q1, of which the correct answer was "Yes" to the question "Human and livestock are infected with echinococcosis mainly through contact with infected dogs," while the lowest was Q30 "Echinococcosis is a category C infectious disease in *Law of the People's Republic of China on prevention and control of infectious diseases* (Yes)." In some of the key questions related to infection, control and prevention, and treatment (e.g., Q4, Q5, Q10, Q12, and Q16), the students' answers did not reach or just reached passing levels (Table 2). The PR of type 3 questions (Control & Prevention) was the highest at 90.41%. The other types of questions in descending order of PR were types 2 (Treatment), 5 (Assistance policies), 1 (Infection), 4 (Risks), and 6 (Theoretical knowledge) (Table 2). The students had good knowledge of the infection, treatment, and assistance policies but an insufficient understanding of echinococcosis risks, and an even worse awareness of theoretical knowledge.

We statistically analyzed the students' answers to each question. The results showed that the differences in AR of all 30 questions were statistically significant. The students of Daofu County performed the best, with the highest AR of 21 questions (Figure 1A), and

TABLE 1. Passing rate and median score of echinococcosis knowledge survey among eighth graders in Ganzi Prefecture in autumn, 2020.

Characteristic	Group	No. of surveyed	No. of passing	Passing rate*, % (95% CI)	Test†	Median of score with interquartile range§	Test¶
Sex	Male	888	737	83.00 (80.52–85.47)	χ^2=0.120, P>0.05	22 (19, 25)	Z=–0.350, P>0.05 (Wilcoxon Signed Rank test)
	Female	1,187	983	82.81 (80.67–84.96)		22 (19, 25)	
Age (years)	≤13	265	226	85.28 (81.02–89.55)	χ^2=26.053, P<0.001**; χ^2_{Trend}=17.318, P<0.001;	23 (20, 25)	H=31.134, P<0.001†† (Kruskal–Wallis test); R=–0.098, P<0.001 (Pearson correlation analysis);
	14	637	542	85.09 (82.32–87.85)		22 (20, 25)	
	15	602	487	80.90 (77.76–84.04)		22 (19, 24)	
	16	367	302	82.29 (78.38–86.19)		22 (18, 24)	
	≥17	204	143	70.10 (63.82–76.38)		21 (18, 24)	
Nationality	Tibetan	2,063	1,710	82.89 (81.26–84.51)	χ^2=0.002, P>0.05	22 (19, 25)	Z^2=–0.700, P>0.05 (Wilcoxon Signed Rank test)
	Others	12	10	83.33 (62.25–100.00)		23 (20, 25)	
Total		2,075	1,720	82.89 (81.27–84.51)		22 (19, 25)	

Abbreviations: CI=Confidence interval.

* It was considered as passing when it had at least 20 correct answers.

† The chi-squared (χ^2) tests were used to infer the significance levels between passing rates.

§ Students' test scores were not considered to be normal distribution after the normality tests were performed; therefore, medians were used for data descriptions.

¶ Correspondingly, because the scores did not conform to the normal distribution, the nonparametric tests were used for statistical analyses.

** The post-hoc pairwise tests for passing rates of all age groups were performed, there were no significant differences of any pair between each age groups ≤13 years, 14 years, 15 years, 16 years, but the differences of passing rates between these groups and group ≥17 years were statistically significant. P values were adjusted by Bonferroni correction and compared with 0.05 level.

†† The post-hoc pairwise tests for scores of all age groups were performed, except that there were significant differences within 3 pairs: between age group ≤13 years and 15 years, between ≤13 years and 16 years, and between ≤13 years and ≥17 years, there were no statistically significances of pairwise comparison between the other paired age groups. P values were adjusted by Bonferroni correction and compared with 0.05 level.

TABLE 2. Awareness rate of answering questions correctly and passing rate for categories of questions regarding echinococcosis knowledge survey among eighth graders in Ganzi Prefecture in Autumn, 2020.

Type	Question (answer)	No. of known	Awareness rate, % (95% CI)	No. of passing*	Passing rate, % (95% CI)
Type 1-infection	Q01. Humans and livestock are infected with echinococcosis mainly through contact with infected dogs. (Yes)	2,020	97.35 (96.66−98.04)	1,729	83.33 (81.72−84.93)
	Q02. Infected livestock can transmit echinococcosis directly to human. (No)	916	44.14 (42.01−46.28)		
	Q03. There is a risk of echinococcosis infection in all people in the endemic area. (Yes)	1,635	78.80 (77.04 -80.55)		
	Q04. Echinococcosis can spread from person to person. (No)	1,442	69.49 (67.51−71.48)		
	Q05. Patients with echinococcosis will not recur or be reinfected after being cured. (No)	1,221	58.84 (56.73−60.96)		
Type 2-treatment	Q06. People in endemic areas of echinococcosis should take the initiative to perform regular B-ultrasound examinations for early detection and treatment. (Yes)	1,684	81.16 (79.47−82.84)	1,859	89.59 (88.28−90.90)
	Q07. Treatment methods for echinococcosis include medication and surgery. (Yes)	2,001	96.43 (95.64−97.23)		
	Q08. Patients with echinococcosis can take albendazole for treatment. (Yes)	1,213	58.46 (56.34−60.58)		
	Q09. Patients should adhere to standardized medication and accept follow-up management by township health centers. (Yes)	1,649	79.47 (77.73−81.21)		
	Q10. Patients with echinococcosis should be treated in isolation. (No)	1,271	61.25 (59.16−63.35)		
Type 3-control & prevention	Q11. Diseased organs of livestock should be buried deep or burned. (Yes)	1,733	83.52 (81.92−85.11)	1,876	90.41 (89.14−91.68)
	Q12. Dog management should be strengthened, and dogs should be dewormed regularly. (Yes)	1,514	72.96 (71.05−74.87)		
	Q13. Dog feces should be collected and treated in a harmless manner. (Yes)	1,714	82.60 (80.97−84.23)		
	Q14. To develop the good personal hygiene habits. (Yes)	1,717	82.75 (81.12−84.37)		
	Q15. Washing hands before eating is the simplest and most effective way to prevent echinococcosis. (Yes)	1,763	84.96 (83.43−86.50)		
Type 4-risks	Q16. Being infected with echinococcosis causes a decline in physical function. (Yes)	1,421	68.48 (66.48−70.48)	1,622	78.17 (76.39−79.95)
	Q17. The initial symptoms of the echinococcosis infection are not obvious, that is why it can be easily ignored and can aggravate physical trauma at the time of onset. (Yes)	1,556	74.99 (73.12−76.85)		
	Q18. Echinococcosis is a lethal parasitic disease. (Yes)	1,914	92.24 (91.09−93.39)		
	Q19. The epidemic of echinococcosis affects the economic development of animal husbandry. (Yes)	1,144	55.13 (52.99−57.27)		
	Q20. Patients and their families are impoverished due to echinococcosis. (Yes)	1,081	52.10 (49.95−54.25)		
Type 5-assistance policies	Q21. Free B-ultrasound examinations for people in epidemic areas of echinococcosis. (Yes)	1,264	60.92 (58.82−63.02)	1,778	85.69 (84.18−87.19)
	Q22. Free medication for echinococcosis patients. (Yes)	1,740	83.86 (82.27−85.44)		
	Q23. Patients can take treatment drugs at the local CDC or township health centers. (Yes)	1,801	86.80 (85.34−88.25)		
	Q24. To provide subsidies to patients undergoing surgical treatment. (Yes)	1,602	77.20 (75.40−79.52)		
	Q25. To include patients in poverty alleviation and assistance targets. (Yes)	1,084	52.24 (50.09−54.39)		
Type 6-theoretical knowledge	Q26. Livestock is the intermediate host of *Echinococcus*. (Yes)	1,419	68.39 (66.38−70.39)	1,477	71.18 (67.76−71.71)†
	Q27. Dogs are the definitive host of *Echinococcus*. (Yes)	1,613	77.73 (75.94−79.52)		
	Q28. *Echinococcus* eggs are highly resistant and can survive in the natural environment for a long time. (Yes)	1,204	58.02 (55.90−60.15)		
	Q29. The echinococcosis is mainly divided into CE and AE in China. (Yes)	1,416	68.24 (66.24−70.24)		
	Q30. Echinococcosis is a category C infectious disease in *Law of the People's Republic of China on prevention and control of infectious diseases*. (Yes)	808	38.94 (36.84−41.04)		

Note: The post-hoc pairwise tests for passing rates of all types were performed, except that there were no statistical significances between Type 1 and 5, and between Type 2 and 3, there were significant differences between the other paired types. *P*-values were adjusted by Bonferroni correction and compared with 0.05 level.

Abbreviations: CI=confidence interval; CE=cystic echinococcosis; AE=alveolar echinococcosis.

* In each type, it was considered as passing to answer 3 or more questions correctly.

† The chi-squared (χ^2) test of passing rate of 6 types was performed and the result was: χ^2=396.228, P<0.001.

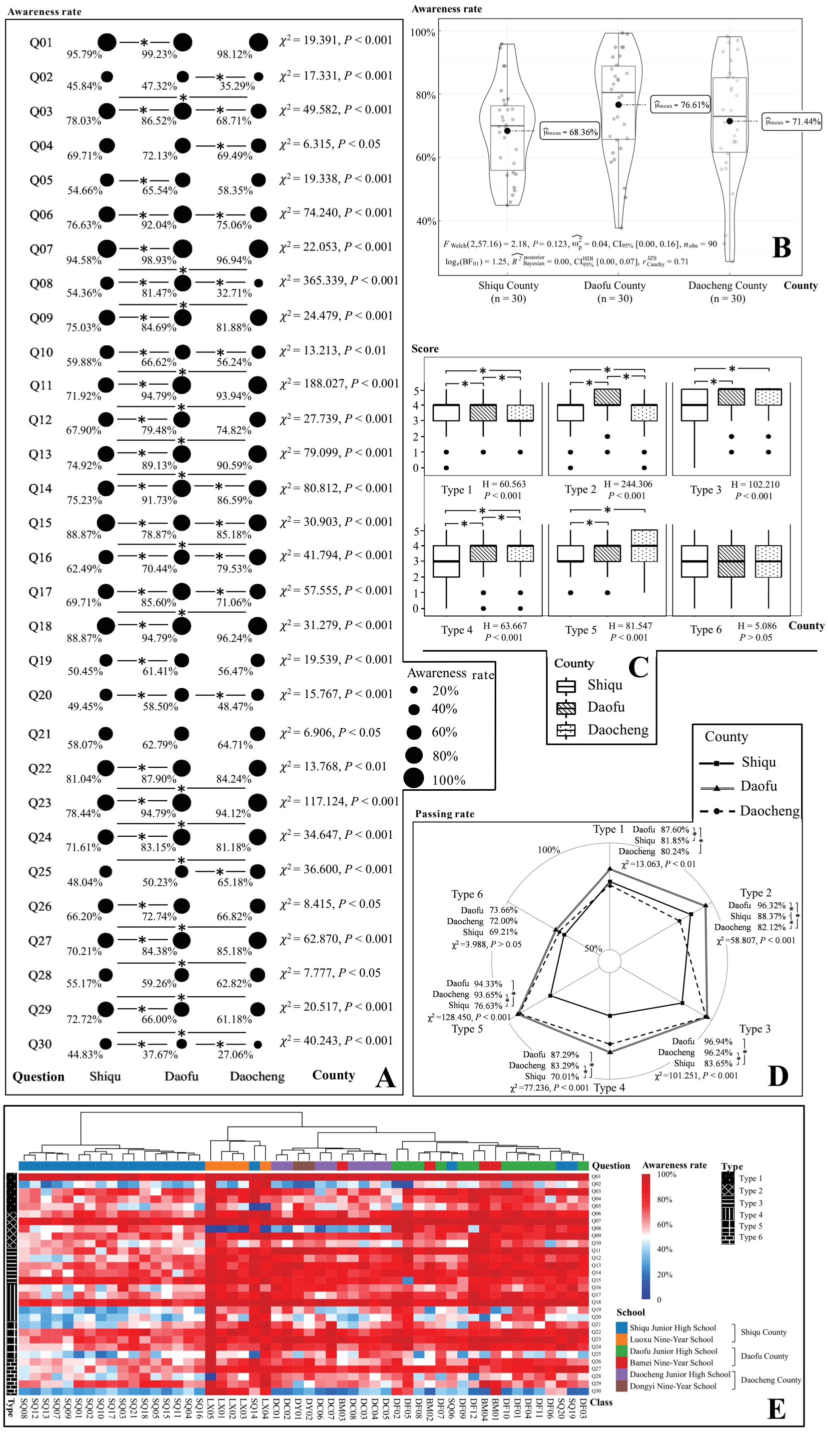

FIGURE 1. Comparison of awareness rate, score and passing rate of echinococcosis knowledge survey (n=2,075) among eighth graders of Shiqu, Daofu, and Daocheng counties in Ganzi Prefecture in autumn 2020. (A) A matrix-bubble figure for awareness rate of 30 questions with the Pearson Chi-Square (χ^2) test among three counties. (B) A stats-violin figure shows the distribution of awareness rate among the three counties. (C) A box-scatter figure for the median score of the six types of questions with Kruskal-Wallis H-test among three counties. (D) A radar-chart figure shows the qualified rate of the six types of questions among three counties. (E) The inter-heatmap was drawn to show the clustering of awareness rate from 52 classes based on Ward's minimum variance method (Ward. D2).

* In Graph (A), (C), and (D), it indicates that there was a statistical significance between two counties after the post-hoc tests were performed, P values were adjusted by Bonferroni correction and compared with 0.05 level. In Graph (B), the Y-axis and X-axis indicate the range and density, respectively, of the awareness rate.

the highest average AR (76.61%) (Figure 1B). However, Shiqu County was the most evenly distributed county in the distribution of AR level between highest and lowest, followed by Daofu County, while Daocheng County had the largest gap (Figure 1B). Comparing the scores for each type among 3 counties, Daofu County performed better in types 1, 2, 3 and 4 according to their MS (the full score was 5 points per type); Daocheng County was better in types 3 and 5; and Shiqu County was better in type 1 (Figure 1C). Daofu County ranked the highest in terms of PR in all types and achieved more than 90% PR in types 2, 3, and 5 (Figure 1D). Overall, Daofu County showed obvious advantages over the other two counties in all aspects. Moreover, based on the AR level of 30 questions, 52 classes of 6 schools from 3 counties were clustered into 4 branches on a tree-structured clustering framework, and the classes could basically be mapped to the branches of their corresponding school or county by the differentiation on awareness of each item (Figure 1E).

DISCUSSION

The following characteristics of the current HE were derived from the above results. 1) There were differences in individual awareness rates in a group; for example, older students had poor responses in the same grade. 2) There were differences in students' awareness of different types of knowledge. There was a tendency to know how to do things but not to know why. 3) There were some key issues in the HE processes that might have been ignored or misunderstood by the students. For example, some students thought that echinococcosis could be transmitted human-to-human because they were not aware of the biological life cycle of *Echinococcus*. 4) The unevenness of the students' awareness of echinococcosis among different regions should be noted. In this study, the highest overall scoring students from Daofu County indicated that the specific HE model did have a positive impact. 5) The distribution difference and preference clustering of AR among regions and schools revealed the lack of a unified and comprehensive echinococcosis-related HE system.

In addition, we compared the results of other surveys from primary school students (*9–10*). The high AR of core knowledge was similar to that of junior high school students in this survey, assessed through questions such as Q01, Q11, Q13, and Q15. This showed that some key knowledge points have been strengthened and fixed in the student population. However, we also found that the answers were not satisfactory for some questions, especially regarding the risks and theoretical knowledge of echinococcosis. Junior high school students generally had higher levels of education due to more years in schools and were likely better able to understand related information than primary school students. Therefore, the breadth and depth of previous HE were limited and lacked some coverage for junior high school students.

We put forward the following suggestions. First, unified teaching materials should be formulated or designated. This requires the cooperation of health and education departments to launch educational materials suitable for students and provide education at the corresponding acceptance levels for different age groups. Second, school health educators should receive more professional and comprehensive training to have an in-depth understanding of echinococcosis. This way, teachers can bring their personal initiative into lessons and pay attention to the disadvantaged members with insufficient knowledge of echinococcosis. Third, relevant pilot testing and promotion strategies should be encouraged. Daofu County's educational system is a model that attracts attention and has adopted a variety of educational methods to enable students to understand knowledge and accept behavior changes. Fourth, a regular health education evaluation is necessary to help policymakers or program planners to correct the gaps in the current work.

This study was subject to some limitations. First, the study focused on eighth grade students and did not involve other grades; therefore, the current levels of echinococcosis awareness among junior high school students needs further investigation. Second, due to the large number of respondents, the length of the study period was extended as the survey of Shiqu County was carried out first in early September, and Daofu County was last to be surveyed in mid-October. Therefore, the variation in survey timing may impact the results.

The health education strategy of spreading echinococcosis prevention and control knowledge to the surrounding population, starting with students as the focal point, is helpful to realize the bidirectional combination of infection source control and population active prevention. This study found some problems in the current HE project of echinococcosis and provided some targeted suggestions. However, the improvement of the HE program is still a long, gradual, and localized process that needs more attention and effort.

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Preplanned Studies

Intestinal Protozoan Infections in Patients with Diarrhea — Shanghai Municipality, Zhenjiang City, and Danyang City, China, 2011–2015 and 2019–2021

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Summary

What is already known about this topic?

Intestinal protozoa are common pathogens of diarrhea globally. However, the etiology of diarrhea due to intestinal protozoan infections in China is not known.

What is added by this report?

Based on active syndromic surveillance in Shanghai, Zhenjiang, and Danyang during 2011–2015 and 2019–2021, 89 (1.67%) patients were infected with intestinal protozoa (*Cryptosporidium* spp., *Giardia duodenalis*, *Enterocytozoon bieneusi*, and *Cyclospora cayetanensis*), and positivity rates statistically differed by region and age.

What are the implications for public health practice?

This was the most comprehensive data collection in investigating parasitic diarrheal diseases in humans. Identification of these protozoa in diarrhea will provide new perspectives for detecting hidden etiological agents of diarrhea as early as possible.

Diarrhea is the most common symptom of disease and the eighth leading cause of death worldwide with more than 1.6 million attributed deaths in 2016. Although syndromic surveillance as a type of active surveillance has been widely applied to safeguard activities of mass gatherings in past years (*1*), it is now being used to monitor diarrheal disease trends for the early detection of emergent public health events. Furthermore, due to numerous foodborne and waterborne outbreaks of intestinal protozooses, such as cryptosporidiosis (*2*), giardiasis (*3*), microsporosis (*4*), and cyclosporiasis (*5*) worldwide, interest in these pathogens related to diarrheal disease has increased. However, epidemiological status and characteristics of intestinal protozoan infections in diarrheal populations have not been studied in detail in China. This study aimed to understand the etiology and epidemiological characteristics of these intestinal protozoan infections in patients with diarrhea from study areas, including Shanghai Municipality, Zhenjiang City, and Danyang City, during the implementation results in 12th Five-Year Plan period and 13th Five-Year Plan period. The results showed that *G. duodenalis*, *E. bieneusi*, and *C. cayetanensis* were detected in these study areas, and *Cryptosporidium* spp. was detected in Shanghai and Danyang, with increases in intestinal protozoan infections during 2011–2015 and 2019–2021. The syndromic surveillance and laboratory surveillance network for testing the capacity of protozoan infections should be jointly strengthened to provide a basis for establishing prevention and control strategies.

Based on an active, prospective study of the National Key Science and Technology Project on Infectious Disease Surveillance Technical Platform, study areas were chosen to represent various administrative levels, economies, population sizes, and geographical areas. A structured questionnaire assessing demographic data and clinical symptoms was administered to each participant. Selection criteria for diarrheal cases were defined as ≥3 passages of watery, loose, mucoid, or bloody stools within a 24-hour period. Patients referred from other hospitals or patients not initially diagnosed at sentinel sites were excluded from this study. The protocol of this study was evaluated and approved by the ethical committee of the National Institute of Parasitic Diseases, China CDC (2015011, 2019003).

One fecal specimen was collected from each patient, transported to the laboratory within 24 hours in a cooler with ice packs and stored at −20 °C. Following the manufacturer's instructions, genomic DNA was directly extracted from 180–200 mg of fecal specimens using a QIAamp DNA stool mini kit (QIAgen 51504, QIAGEN, Hilden, Germany), eluted in 200 μL of elution buffer, and stored at −20 °C for pending polymerase chain reaction (PCR) analysis.

Cryptosporidium spp., *G. duodenalis*, *E. bieneusi,* and *C. cayetanensis* were identified by nested PCR amplifications and sequencing of gene fragments at around 830 bp of the small subunit (SSU) rRNA gene, around 530 bp of the triosephosphate isomerase (*tpi*) gene, around 600 bp of the SSU rRNA gene, and around 500 bp of the SSU rRNA gene, respectively (*6*). The positivity rates of intestinal protozoan infections in patients with diarrhea were determined, and possible risk factors related to intestinal protozoan infections were assessed by region, age, and sex with the chi-squared (χ^2) test using GraphPad Prism (version 5.0, GraphPad Software, San Diego, CA, USA). Differences were considered statistically significant at $P<0.05$.

From January 1, 2011 to June 30, 2021, an epidemiological investigation on intestinal protozoan infections was conducted among 5,341 patients under surveillance of diarrheal illnesses through the established diarrheal syndromic surveillance network. Among the 5,341 patients, 1,645 patients (1,087 patients during 2011–2015 and 558 patients during 2019–2021) were recruited at the Shanghai Sixth People's Hospital; 1,498 patients (1,032 patients during 2011–2015 and 466 patients during 2019–2021) were recruited at the Affiliated Hospital of Jiangsu University in Zhenjiang; 2,198 patients (1,578 patients during 2011–2015 and 620 patients during 2019–2021) were recruited at the Danyang Hospital.

A total of 89 (1.67%) out of 5,341 diarrheal patients were confirmed to be infected with intestinal protozoa, including *Cryptosporidium* spp. (0.69%), *G. duodenalis* (0.45%), *E. bieneusi* (0.28%), and *C. cayetanensis* (0.24%) (Table 1). The highest positivity rate of intestinal protozoan infections was recorded in Shanghai (2.31%), followed by Danyang (1.87%) and Zhenjiang (0.67%). Differences in positivity rate were observed among the study areas ($P<0.01$), but no statistical difference was observed due to age or gender (Table 1).

The positivity rates of the 4 intestinal protozoa differed during 2011–2015 and 2019–2021; they were 0.70% *vs.* 0.67% for *Cryptosporidium* spp. (Table 2 and Figure 1A), 0.35% *vs.* 0.67% for *G. duodenalis*, 0.24% *vs.* 0.28% for *E. bieneusi*, and 0.27% *vs.* 0.18% for *C. cayetanensis*. Different positivity rates were observed in the study areas during the 2 periods (Figure 1B): 2.21% *vs.* 2.51% in Shanghai, 0.58% *vs.* 0.86% in Zhenjiang, and 1.77% *vs.* 2.10% in Danyang.

DISCUSSION

The results of this study revealed the changes in positivity rate and epidemiological characteristics of patients with protozoan-related diarrhea in the study areas during 2011–2015 and 2019–2021. Overall, in these 4 intestinal protozoa, the positivity rate of protozoa-related diarrhea was 1.67% by PCR detection. Further analysis of data showed that particular attention was paid to the observation of the increasing positivity rate from 1.57% (2011–2015) to 1.89% (2019–2021). To support this finding, a recent national surveillance study on morbidity analysis of notifiable infectious diseases reported that infectious diarrheal cases have increased from 200,000 (2015–2017) to 1,282,270 (2018) (*7*). Future research efforts should prioritize diarrheal disease control and prevention, as well as etiology identification. These findings will increase stakeholder's awareness and ability to reduce the risk of infection of parasitic diseases caused by intestinal protozoa.

The findings on intestinal protozoan infections showed wide variations in positivity rate across the study areas — 2.31% in Shanghai, 0.67% in Zhenjiang, and 1.87% in Danyang. These positivity rates of intestinal protozoan-related diarrhea were lower than those of towns in Ethiopia (16.61%) (*8*) and cities in Pakistan (41.61%) (*9*). Meanwhile, the positivity rate of each of these four intestinal protozoa was lower than the positivity rate of diarrhea in patients. For *Cryptosporidium* spp., the positivity rate of diarrheal diseases attributable to this protozoan was lower in the present study (0.69%) than in Canada (15.74%) (*10*). The low positivity rates of intestinal protozoan infections in these geographical areas might be related to local habits of drinking boiled water and eating cooked food/vegetables. Personal hygiene habits, among multiple related factors, affect the positivity rates of intestinal protozoan infections.

The study was subject to some limitations. First, these study areas were in the Yangtze River Delta, which were not representative of the country. Second, data on possible influence factors for intestinal protozoan infections were not collected. These could include drinking boiled water, washing hands before meals and after using toilets, eating unwashed vegetables and fruits, and patterns of animal feeding. Collecting this data could provide evidence for early warning and prediction.

Since numerous animal species have been reported to be infected with *Cryptosporidium* spp., *G.*

TABLE 1. Positivity rates of intestinal protozoa among patients with diarrhea from 3 study areas in China, 2011–2015 and 2019–2021.

Variable	Pathogen									
	Intestinal protozoa		*Cryptosporidium* spp.		*G. duodenalis*		*E. bieneusi*		*C. cayetanensis*	
	No. Positive / No. Examined (%)	χ^2/P value	No. Positive / No. Examined (%)	χ^2/P value	No. Positive / No. Examined (%)	χ^2/P value	No. Positive / No. Examined (%)	χ^2/P value	No. Positive / No. Examined (%)	χ^2/P value
Total	89/5,341 (1.67)		37/5,341 (0.69)		24/5,341 (0.45)		15/5,341 (0.28)		13/5,341 (0.24)	
Region		13.81 (<0.01)		20.39 (<0.01)		0.80 (0.70)		0.97 (0.61)		3.00 (0.22)
Shanghai	38/1,645 (2.31)		22/1,645 (1.34)		6/1,645 (0.36)		4/1,645 (0.24)		6/1,645 (0.36)	
Zhenjiang	10/1,498 (0.67)		0/1,498 (0)		6/1,498 (0.40)		3/1,498 (0.20)		1/1,498 (0.07)	
Danyang	41/2,198 (1.87)		15/2,198 (0.68)		12/2,198 (0.55)		8/2,198 (0.36)		6/2,198 (0.27)	
Age (years)		3.87 (0.14)		0.73 (0.69)		6.14 (0.046)		12.73 (<0.01)		2.85 (0.24)
Children (≤14)	20/1,437 (1.39)		10/1,437 (0.70)		8/1,437 (0.56)		1/1,437 (0.07)		1/1,437 (0.07)	
Teenagers (15–17)	4/102 (3.92)		0/102 (0)		2/102 (1.96)		2/102 (1.96)		0/102 (1.96)	
Adults (≥18)	65/3,802 (1.71)		27/3,802 (0.71)		14/3,802 (0.37)		12/3,802 (0.32)		12/3,802 (0.32)	
Gender		1.71 (0.19)		3.53 (0.06)		1.34 (0.25)		2.84 (0.09)		0.23 (0.63)
Male	55/2,935 (1.87)		26/2,935 (0.89)		16/2,935 (0.55)		5/2,935 (0.17)		8/2,935 (0.27)	
Female	34/2,406 (1.41)		11/2,406 (0.46)		8/2,406 (0.33)		10/2,406 (0.42)		5/2,406 (0.21)	

Note: The three cities are: Shanghai, Zhenjiang, and Danyang. Based on the economic development level and population distribution, they represented the large city, the medium city and the small city, respectively. The positive rates of intestinal protozoa in diarrheal patients were determined, and possible risk factors related to intestinal protozoan infection were assessed by region, age, and sex by Chi-square (χ^2) test using GraphPad Prism 5.0 (GraphPad Software, San Diego, CA, USA).

TABLE 2. Change in the positivity rates of intestinal protozoa in patients with diarrhea from study areas in China during 2011–2015 and 2019–2021.

Period	Region	Pathogen, No. of positive/No. of examined (%)				
		Intestinal protozoa	*Cryptosporidium* spp.	*G. duodenalis*	*E. bieneusi*	*C. cayetanensis*
2011–2015*	Shanghai	24/1,087 (2.21)	11/1,087 (1.01)	4/1,087 (0.37)	3/1,087 (0.28)	6/1,087 (0.55)
	Zhenjiang	6/1,032 (0.58)	0/1,032 (0)	2/1,032 (0.19)	3/1,032 (0.29)	1/1,032 (0.10)
	Danyang	28/1,578 (1.77)	15/1,578 (0.95)	7/1,578 (0.44)	3/1,578 (0.19)	3/1,578 (0.19)
	Total	58/3,697 (1.57)	26/3,697 (0.70)	13/3,697 (0.35)	9/3,697 (0.24)	10/3,697 (0.27)
2019–2021†	Shanghai	14/558 (2.51)	11/558 (1.97)	2/558 (0.36)	1/558 (0.18)	0/558 (0)
	Zhenjiang	4/466 (0.86)	0/466 (0)	4/466 (0.86)	0/466 (0)	0/466 (0)
	Danyang	13/620 (2.10)	0/620 (0)	5/620 (0.81)	5/620 (0.81)	3/620 (0.48)
	Total	31/1,644 (1.89)	11/1,644 (0.67)	11/1,644 (0.67)	6/1,644 (0.28)	3/1,644 (0.18)

Note: The study areas were Shanghai, Zhenjiang, and Danyang.
* Implementation results of 2011–2015 points out the 12th Five-Year Plan period.
† Implementation results of 2019–2021 points out the 13th Five-Year Plan period.

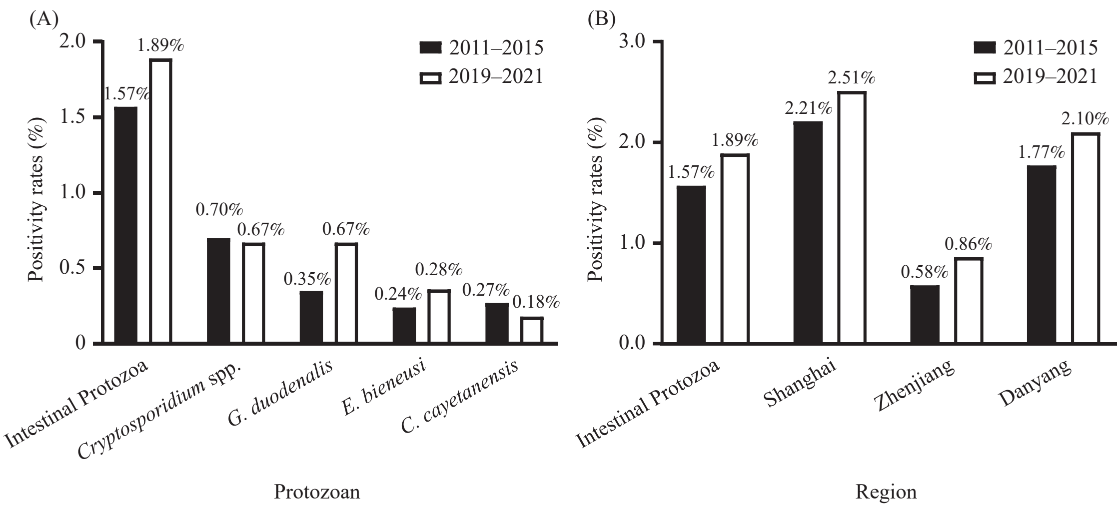

FIGURE 1. Etiology and distribution of intestinal protozoa infection in patients with diarrhea among the study areas, China, 2011–2015 and 2019–2021. (A) Comparison of positivity rates of intestinal protozoan infection during 2011–2015 and 2019–2021 by protozoa; (B) Comparison of positivity rates of intestinal protozoan infection during 2011–2015 and 2019–2021 by region.

duodenalis, and *E. bieneusi*, a One Health approach to intestinal protozooses prevention, surveillance, monitoring, control, and mitigation, as well as environmental conservation, should be adopted broadly.

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Preplanned Studies

Transmission Risks of Mountain-Type Zoonotic Visceral Leishmaniasis — Six Endemic Provincial-Level Administrative Divisions, China, 2015–2020

Xinyi Wang[1]; Shang Xia[1,2]; Jingbo Xue[1,2]; Zhengbin Zhou[1]; Yuanyuan Li[1]; Zelin Zhu[1]; Yi Zhang[1,2]; Qiang Wang[1]; Shizhu Li[1,2,#]

Summary

What is already known about this topic?

Mountain-type zoonotic visceral leishmaniasis (MT-ZVL) cases in China have increased significantly between 2015 and 2020. A total of 25 regions had re-emerged yielding 88 MT-ZVL indigenous cases, while the total number of visceral leishmaniasis cases declined.

What is added by this report?

The transmission risk of MT-ZVL showed a trend of patchy dissemination centered on major endemic areas and medium-high risk occurrence areas of *Phlebotomus chinensis* with discrete foci. Multi-point re-emergence and local outbreaks of MT-ZVL were trending in historically endemic areas.

What are the implications for public health practice?

Risk identification and early warnings of MT-ZVL are essential in formulating precise prevention and control strategies in China. More frequent monitoring, establishing a mechanism of joint prevention and control, and highlighting health education are recommended.

After large-scale control and treatment efforts, visceral leishmaniasis (VL) was well controlled in China by the 1960s and eliminated in the early 1980s as a major public health problem (*1*). However, the number of mountain-type zoonotic visceral leishmaniasis (MT-ZVL) cases has been increasing significantly in recent years. Conducting timely identification of this disease and implementing an early warning of MT-ZVL transmission risks are fundamental premises of generating targeted intervention measures. To identify the key risk areas, a risk-matrix was used to assess the transmission risk of MT-ZVL in six endemic provincial-level administrative divisions (PLADs) in China. Data such as the indigenous cases (2015–2020) and the occurrence probabilities of the main vector *Phlebotomus chinensis* (*Ph. chinensis*) were collected, and the comprehensive scores were calculated. The transmission risk areas showed a trend of patchy dissemination centered on major endemic areas and medium-high risk occurrence areas of the vector with discrete foci. Multi-point re-emergence and local outbreaks of MT-ZVL appeared in historically endemic areas. In the medium-high risk areas identified, the recommended strategies are more frequent monitoring of sandflies, canines, and mobile population, establishing a mechanism of joint prevention and control, and highlighting health education to the public.

The indigenous cases reported in 6 endemic PLADs were collected from the National Notifiable Disease Reporting System between 2015 and 2020 (Figure 1A). The data were verified by epidemiological investigations on individual cases and vector investigations conducted by county-level CDCs. According to the working guidelines of VL prevention and control, the endemic county-level administrative divisions (CLADs) were categorized into three classes with the number of reported cases based on experts' experiences of onsite prevention and control. Class I CLADs were those with a cumulative case number of not less than 10. Class II and Class III CLADs had 3–9 and less than 3 cases, respectively. Non-endemic CLADs were those that have no indigenous case. The scores were 3, 2, 1, 0, from more cases to less.

The historical distribution of the vector, bioclimatic, and geographical environmental data were collected. MaxEnt software (version 3.4.1, American Museum of Natural History, New York, NY, USA) was used to calculate the occurrence probabilities of *Ph. chinensis* in a previous study (*2*). The continuous value of occurrence probabilities ranged from 0–1 (minimal–maximal probability). In this study, the

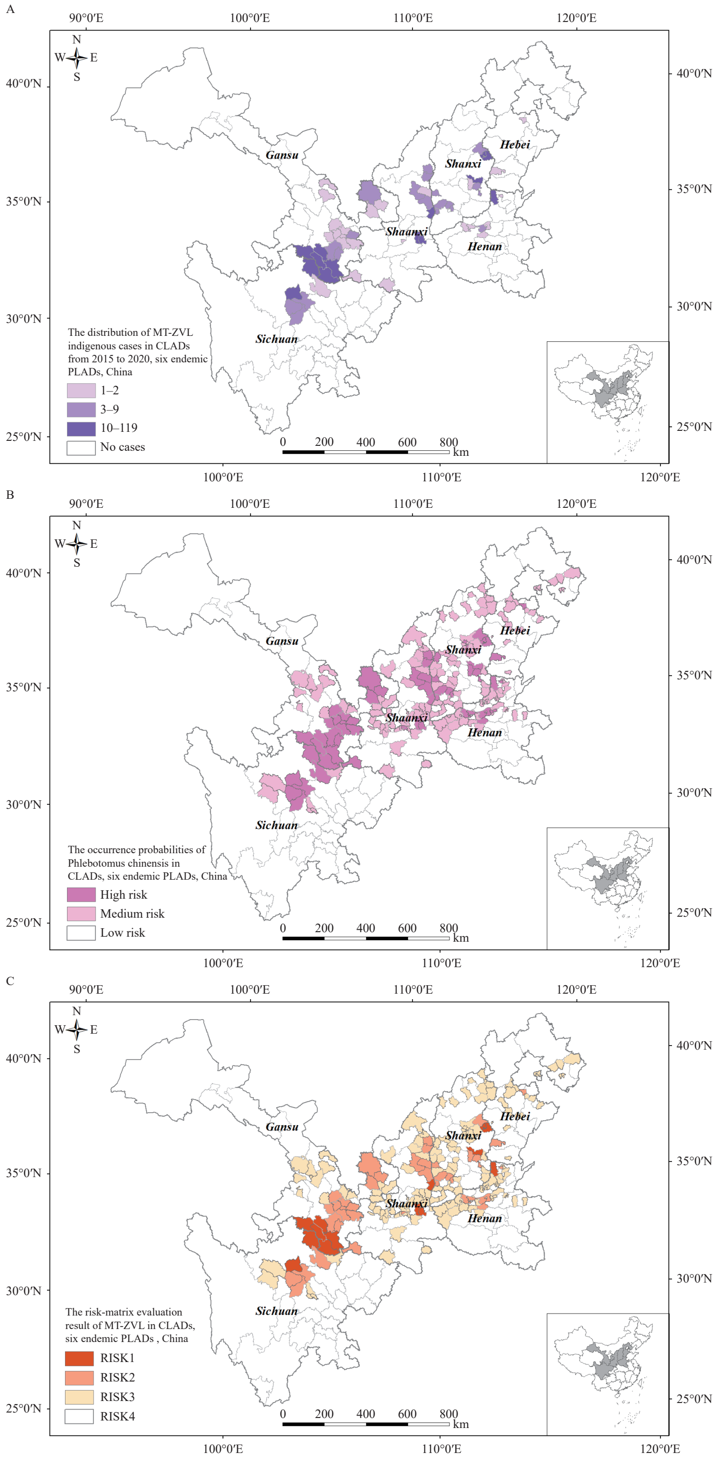

FIGURE 1. Transmission risks of mountain-type zoonotic visceral leishmaniasis in six endemic PLADs, China. (A) The distribution of MT-ZVL indigenous cases in CLADs from 2015 to 2020; (B) The occurrence probabilities of *Phlebotomus chinensis* in CLADs; (C) The risk-matrix evaluation result of MT-ZVL in CLADs.

Note: The occurrence probabilities of *Phlebotomus chinensis* were calculated using the distribution data of the vector, and bioclimatic and geographical environment data in previous studies. The sandfly distribution data was derived from a national field survey and historical literature; the environment data was derived from the WorldClim database (https://www.worldclim.org/data/worldclim21.html) and Resource and Environment Science and Data Center database (http://www.resdc.cn/).

Abbreviations: MT-ZVL=mountain-type zoonotic visceral leishmaniasis; PLADs=provincial-level administrative divisions; CLADs=county-level administrative divisions.

occurrence probabilities were re-extracted by mean value based on CLADs and further categorized into three ranks. A 0.60–1.0 value was a high risk for the occurrence of *Ph. chinensis*, 0.30–0.59 was medium risk, and 0–0.29 was low risk, and these were assigned 3, 2, and 1 points, respectively.

The cumulative value of the comprehensive scores was calculated and presented in the transmission risk-matrix (Table 1). The assessment was under expert guidance and the results were already included in the investigation of vectors in potential MT-ZVL endemic areas. The data of indigenous cases and the vectors, and the risk warning assessment scores were analyzed by Microsoft Excel (version 2016, Microsoft, Redmond, WA, USA). The visual maps were made by ArcGIS (version 10.1, ESRI, Redlands, CA, USA).

The number of MT-ZVL indigenous cases and its proportion of total VL cases increased significantly between 2015 and 2020, although the annual number of VL cases showed an overall downward trend. Re-emerged cases were defined as indigenous cases after epidemiological investigations that currently re-occurred in an area where local transmission was interrupted in the past 10 years, according to the literature (*3*). A total of 25 MT-ZVL re-emergent CLADs appeared between 2015 and 2020, with 88 re-emergent cases reported. The number of class Ⅰ, Ⅱ, and Ⅲ CLADs were 16, 20, and 23 in the study area, respectively. They were scattered in southern Gansu, northern Sichuan, and the mountainous cross-border areas of Shaanxi, Shanxi, Hebei, and Henan, showing significant local aggregation characteristic (Figure 1A). The occurrence probabilities map of *Ph. chinensis* showed 66 high risk areas, 154 medium risk areas, and 592 low risk areas on a county basis (Figure 1B).

According to the risk assessment results, RISK 1, RISK 2, RISK 3, and RISK 4 areas contained 16, 41, 143, and 592 CLADs, corresponding to super-high risk, high risk, moderate risk, and low risk, respectively. RISK 1 and RISK 2 areas included all major MT-ZVL endemic CLADs and the majority of high-risk areas for *Ph. chinensis* occurrence, while most of the RISK 3 areas were the vector's medium risk occurrence areas. The risk areas showed a trend of patchy dispersion centered on major endemic CLADs and medium-high risk occurrence areas of the vectors. Multi-point re-emergence and local outbreaks appeared in historically endemic areas. Medium-high risks appeared in the suburbs of some large urban regions and their surrounding areas. The distribution of risk areas was concentrated in the Qinling Range in southern Gansu and Shaanxi, the northern Hengduan Range in northern Sichuan, the Lvliang Range and the extended region of Loess Plateau at the cross-border areas of Shaanxi and Shanxi, and hilly areas of the Yanshan-Taihang Range across the Shanxi, Henan, and Hebei (Figure 1C).

DISCUSSION

Between 2015 and 2020, the number of MT-ZVL cases increased significantly in China, and a total of 25 CLADs had re-emerged with 88 cases reported, while the total number of VL cases declined (*1*,*3*). A risk-matrix evaluation on the transmission risks of MT-ZVL was conducted on account of the classification scores of the endemic CLADs and the occurrence probabilities of *Ph. chinensis.* Results showed a trend of patchy dissemination centered on major endemic areas and medium-high risk occurrence areas of *Ph. chinensis* with discrete foci. Multi-point re-emergence and local outbreaks of MT-ZVL are trending in historically endemic areas. A medium-high risk appeared in the suburbs of some large urban regions and their surrounding areas. Timely risk identification and early warning of transmission risks in particular areas lay a

TABLE 1. Risk-matrix evaluation on the transmission risk of mountain-type zoonotic visceral leishmaniasis in 6 endemic PLADs in China, 2015–2020.

Classification of Occurrence probabilities of *Phlebotomus chinensis*	Classification of MT-ZVL endemic CLADs			
	Class Ⅰ (cases ≥10, 3)	Class Ⅱ (cases 3–9, 2)	Class Ⅲ (cases <3, 1)	Non-endemic (no case, 0)
High risk (0.60–1, 3)	6, RISK 1	5, RISK 2	4, RISK 2	3, RISK 3
Medium risk (0.30–0.59, 2)	5, RISK 2	4, RISK 2	3, RISK 3	2, RISK 3
Low risk (0–0.29, 1)	4, RISK 2	3, RISK 3	2, RISK 3	1, RISK 4

Note: MT-ZVL scores were calculated by the summation of the scores of endemic CLADs classification and the scores of occurrence probabilities of *Phlebotomus chinensis*. The corresponding risk levels were evaluated comprehensively by the scores and opinions of experts.

Abbreviations: MT-ZVL=mountain-type zoonotic visceral leishmaniasis; PLADs=provincial-level administrative divisions; CLADs=county-level administrative divisions.

solid foundation for formulating precise prevention and control strategies. Therefore, it is essential to take targeted measures to move the prevention and control barriers forward in medium-high risk areas of MT-ZVL identified to reduce the transmission risk.

The region covering southern Gansu and northern Sichuan is a traditional MT-ZVL endemic area with 7 super-high-risk areas and 16 high-risk areas. In Shanxi, Shaanxi, Henan, and Hebei, a total of 9 super-high-risk areas and 25 high risk areas emerged. The multi-point re-emergence and local outbreaks of MT-ZVL were significant in historically endemic provinces, especially in Yangquan City (Shanxi Province), Hancheng City (Shaanxi Province), and Anyang City (Henan Province) (*1*,*4*–*5*).

The geographical range of medium-high occurrence risk of *Ph. chinensis* was considerably large and likely to expand toward higher latitudes and elevations in the context of global warming (*6*). The walls of many buildings in rural areas become rough and porous after long-term exposure to sunlight and wind, which provides new breeding grounds for MT-ZVL vectors (*7*). Due to the weak flying ability of sandflies, the transmission rate of MT-ZVL decreases rapidly based on the distance from the transmission foci (*8*). The limited range and special ecological habits of *Ph. chinensis* were partly responsible for the focal transmission of MT-ZVL. Deeply understanding the environmental influences on the vectors is the key to controling them.

The rural areas of suburbs and the surrounding areas of several large cities presented as medium-high risk. The number of canines has soared in recent years since they have become the ideal animal for protection and companionship, hindering traditional management methods of mass culling. Investigations found that almost every family in rural areas raised dogs, and the dogs moved without restraint (*4*–*5*,*9*). Once in contact with wild animal sources of infection, MT-ZVL cases could be more prone to appear in rural areas than in cities. Frequent causes of population movement such as tourism and immigration increase imported risk in non-endemic areas. Additionally, the trading of canines has not been supervised by regulatory authorities in a timely manner, leading to greater imported risk (*9*). Historically, imported dogs in Sichuan have caused re-emergent cases (*10*).

This study was subject to some limitations. The monitoring data of canines was insufficient, and social factors such as population movement and economic conditions were not included in the assessment process. In the future, it is necessary to carry out more systematic investigations on the vectors and the infectious sources, supplemented by more sensitive detecting methods.

To effectively prevent and control MT-ZVL in China, it is necessary to identify key transmission areas and implement early warnings. In the medium-high risk areas identified in this study, more frequent monitoring of sandflies, canines, and mobile population, establishing joint prevention and control mechanisms, and highlighting health education to the public are recommended.

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Commentary

Ending the "Neglect" to End Neglected Tropical Diseases

Pin Yang[1]; Xiao-nong Zhou[1,2,#]

January 30, 2022 will mark the third World Neglected Tropical Diseases (NTD) Day. The slogan for this year World NTD Day is "A New Day in the fight against NTDs" (https://worldntdday.org/). While human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS), tuberculosis, and malaria were regarded as the three major infectious diseases and have received greater treatment and research funding, NTDs have almost disappeared in the global health policy agenda to gain recognition in 2015 with the Sustainable Development Goals (SDG target 3.3).

NTDs are a diverse group of tropical infections threatening more than 1.7 billion people living in the most marginal communities of the world. Worldwide, an estimated 200,000 deaths and 19 million disability-adjusted life years are annually attributed to NTDs. Every year, NTDs cause billions of US dollars loss in direct health costs, indirect costs of lost productivity, and socioeconomic attainment. In January 2021, the World Health Organization (WHO) launched the second 2021–2030 NTD roadmap to identify critical gaps and the actions required to reach the targets set for 2030. Discussing how to implement the NTDs control program in line with the new road map represented in "*Ending the neglect to attain the Sustainable Development Goals: a road map for neglected tropical diseases 2021–2030*" (*1*), is a research priority. In order to achieve the targets, there is urgent need for collaborative actions to combat NTDs through cooperation in the control activities, coherence of various resources, and coordination of different control programs in developing regions of Africa, Asia, and the Americas. The most important action would be to end the "neglect" to achieve the goal of ending the epidemic of NTDs under the framework of the One Health approach (*2*).

END THE "NEGLECT" BY BRINGING THE STAKEHOLDERS TOGETHER

NTDs are caused by a variety of pathogens, such as viruses, bacteria, protozoa, and parasitic worms. According to the global report on NTDs by the WHO, NTDs include 20 kinds of infectious diseases, caused by pathogens of viruses (n=3), bacteria (n=4), protozoa (n=4), helminths (n=8), fungi (n=2), ectoparasites (n=1), as well as one noncommunicable disease (*3*).

Due to different routes of transmission, the WHO recommends following an integrated control strategy for national NTDs control program. The control strategy to interrupt the transmission of NTDs relied on the following integrated approaches: preventive chemotherapy and vector control reducing the exposure risk, disease management ensuring early diagnosis and treatment, quality patient care in mental health and/or surgery and/or rehabilitation, and cross-cutting by the One Health approaches including water, sanitation, and hygiene. Through implementation of these integrated interventions, the NTDs burden causing poverty, disability, and stigmatization of affected population would be alleviated, especially in resource-limited areas.

To efficiently implement and sustain those integrated interventions, the World NTD Day is an appropriate opportunity for the following: 1) bringing civil society advocates, community leaders, global health experts, and policymakers together to discuss NTD control actions; 2) bringing all stakeholders working across the diverse NTD landscape together to unify partners behind the common goal of ending the epidemic of NTDs; and 3) bringing all resources together to reduce the burden of patients with NTDs and further decline inequity, such as loss of education, loss of productivity, and lack of access to healthcare.

END THE EPIDEMIC OF NTDS BY APPLYING THE ONE HEALTH APPROACH

In 2019, 3 international organizations including the WHO, Food and Agriculture Organization of the United Nations (FAO), and World Organization for

Animal Health (OIE) published "*Taking a Multisectoral, One Health Approach: A Tripartite Guide to Addressing Zoonotic Diseases in Countries*" (*4*). This document is a symbol that One Health will be a powerful weapon to fight infectious diseases of poverty, since One Health is a collaborative, multidisciplinary, and multisectoral approach that can address urgent, ongoing, or potential health threats at the human-animal-environment interface (ecosystem) at all levels, e.g., local, subnational, national, regional, and global levels.

The One Health approach claims to be the best choice for the NTDs control program because of the following reasons. First, NTDs are caused by multiple species of pathogens with a series of complexities, including complexity in routes of transmission, complexity in integration of intervention, and complexity in evaluation of the control program, etc. To solve such complexities in one framework, the One Health approach is able to uncover the original courses and provide solutions to those complexities. Second**,** the systems thinking approach have been exercised in the formulation of the new road map for beating NTDs by the WHO in 2020. Through the gap analysis for each NTD presented by heat map, the WHO has proposed three innovative ways of designing the intervention strategy to beat NTDs, i.e., accelerating programmatic actions, intensifying cross-cutting approaches, and changing operational models and culture to facilitate country ownership, based on the new road map for combating NTDs issued in '*Ending the neglect to attain the Sustainable Development Goals: a road map for neglected tropical diseases 2021–2030.'* Third, the benefits of applying the One Health approach to the NTDs control program can certainly achieve optimal outcomes such as the following: 1) to accelerate technical progress with more effective interventions targeting multiple NTDs in one approach; 2) to effectively implement the NTDs program systematically from strategy to service delivery and from implementation to evaluation; 3) to mobilize multisectoral action and collaboration for resources mobilization; 4) to integrate anti-NTDs activities on common health delivery platforms to make possible the targeting of a series of diseases together; 5) to integrate NTD control within national health systems under the framework of universal health coverage; and 6) to integrate with other sectors to improve the governance ability of the NTDs program.

ACHIEVEMENTS OF SCHISTOSOMIASIS CONTROL IN CHINA, A MODEL FOR IMPLEMENTING THE ONE HEALTH APPROACH

Schistosomiasis is transmitted by freshwater snails and has been listed as a neglected tropical disease by the WHO. The life cycle of schistosomes is complex, involving humans, various mammals, aquatic snails, and a variety of freshwater bodies. More than 200 million people are still suffering from schistosomiasis worldwide.

Schistosomiasis japonica is caused by *Schistosoma japonicum* and distributed in China, the Philippines, and Indonesia. It is a zoonosis with more than 40 species of mammals involved in transmission. Schistosomiasis is distributed in 12 provincial-level administrative divisions (PLADs) and has affected hundreds of millions of people in China. Great achievements of the national schistosomiasis control program have been gained with the help of the One Health concept, such as multisectoral cooperation, various regional coordination from local to provincial and national level communities, and disciplinary integration (*5*). The major lessons in the process of the One Health approach that improved the schistosomiasis control program are summarized as follows.

First, the government took leadership supported by multisectoral cooperation to improve the governance capacities. The national schistosomiasis control program of China launched in the 1950s, was initiated by a government leading group established under the leadership of the Chairman Mao Zedong. Then, the call for schistosomiasis elimination in all applicable areas by Chairman Mao Zedong became the final goal of the national schistosomiasis program in China. With the effort of generations of professionals from institutions/universities and residents from communities, remarkable achievements have been obtained in China. For example, all 450 endemic counties have reached the criteria of transmission control (prevalence <1% in humans and domestic animals) in 2015, and 435 out of 450 (96.7%) endemic counties have achieved the criteria of transmission interruption as of 2020 (*6*). These achievements were attributed to multisectoral cooperation, such as modification of snail habitats along the canals by agriculture irrigation engineering projects or water conservation projects, and control or reduction of snail densities in the forest or marshland through forest engineering projects or planting projects, which were performed by multiple sectors at the county, provincial, and national levels (*7*). Based upon the progress of schistosomiasis control program, the State Council launched in late 2014 the national schistosomiasis elimination program, with its goal to interrupt disease transmission by 2025 and totally eliminate schistosomiasis by 2030. Up to now, the governance mechanism with Inspection in Spring and Meeting in Autumn is still executed annually to ensure the national schistosomiasis control and elimination program moves forward to eradication by 2030; that is to say that schistosomiasis control and elimination efforts have never been neglected over seven decades.

Second, various regional coordination from local community to provincial and national levels improved efficiency of the program. The involvement of local communities in the national schistosomiasis control and elimination program ensures that all activities can be promptly performed at the community level, with coordination of the county CDCs. To ensure the quality of the activities, monitoring and evaluation have to be implemented by professional staff from county- or prefecture-level CDCs. The surveillance and response systems have been well established through coordination by the National Institute of Parasitic Diseases of China CDC, which formed the surveillance network covering all endemic counties, including passive surveillance network covering a total of 850 surveillance villages, an active surveillance network, and a sentinel surveillance network (*8*). In addition, two cross-region cooperative networks have been established. One is the cross-lake regional cooperative network on schistosomiasis control which involved five provinces, such as Jiangsu, Anhui, Jiangxi, Hunan, and Hubei. The other one is the cooperative network for PLADs surveillance, with all counties achieving elimination of schistosomiasis in 8 PLADs, including Guangdong, Guangxi, Fujian, Zhejiang, and Shanghai. Those two networks contribute to schistosomiasis elimination cooperatively by information exchanges and resource sharing, improving the efficacy of schistosomiasis elimination program by targeting mobile population, blocking snail spreading, etc. All of the aforementioned cooperative activities have been well implemented through coordination from the central government to local communities.

Third, disciplinary integration improved innovation from control to elimination. All the disease control programs could be further improved once innovative approaches are employed. The national schistosomiasis control program of China was integrated with implementation research since 1992 when the World Bank Loan Project on Schistosomiasis Control in China was launched. This has not only promoted the capacity to execute the program but also integrate the disciplinary knowledge or technology to accelerate the progress of the program. By applying knowledge from epidemiology, population genetics, modern biology, mathematic modelling, etc., an integrated strategy on schistosomiasis control with an emphasis of infectious source control has been developed and implemented since 2006, which greatly promotes the schistosomiasis control program marching from control toward elimination. Therefore, such an integrated strategy with infectious source control provides references to design the national schistosomiasis elimination program in order to achieve the final goal of schistosomiasis elimination in China by 2030. In addition, a lot of innovative research and development products, including fast diagnostics, drug candidates and their use in clinics, and new molluscicide approaches, facilitated by good governance mechanisms with multisectoral cooperation have been made possible and feasible, so that outcomes of the schistosomiasis elimination program have been accomplished with a higher cost-effectiveness (*9*). It is clearly illustrated that the positive bi-interaction between the program execution and implementation research could be significantly improved when disciplinary integration is performed. Therefore, the long-term impact to the schistosomiasis elimination program will certainly achieve the final goal of being schistosomiasis-free in China.

TAKING THE ONE HEALTH APPROACH TO ACHIEVE THE TARGETS FOR 2030

Substantial progress has been made in past years — 43 countries have eliminated at least one NTD, and 600 million people no longer require treatment for NTDs. However, many of the targets set for 2020 were not achieved. For the next decade, much work still needs to be done as at least 1.74 billion people require interventions against NTDs. Looking to the future years, the new WHO NTD roadmap set global targets and cross-cutting targets aligned with both the WHO's Thirteenth General Programme of Work, 2019–2023, and the SDGs. To achieve the targets, further multisectoral actions should be taken to beat all 20 diseases and disease groups through the application of the One Health approach. Chinese experience in eliminating some NTDs, in conjunction with poverty reduction, multisectoral cooperation, and disciplinary integration, can serve as a model for other countries or regions (*7*).

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