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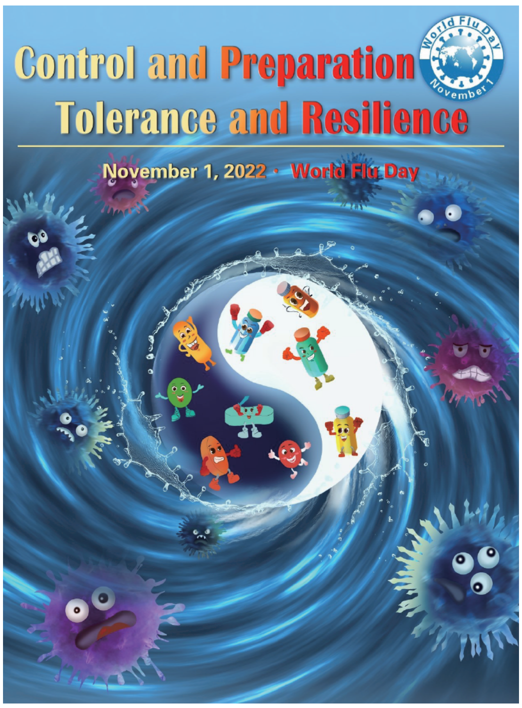

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Preplanned Studies

Prevalence and Determinants of Secondhand Smoke Exposure Among Adolescent Girls — China, 2019

Fulin Huang[1]; Xinying Zeng[1]; Xinbo Di[1]; Lin Xiao[1]; Shiwei Liu[1,#]

Summary

What is already known about this topic?

The rate of secondhand smoke (SHS) exposure among female junior high students in 2013–2014 in China was 69.9%.

What is added by this report?

The rate of SHS among adolescent girls in 2019 in China was 62.8%, with 60.8% in junior high and 65.3% in senior high school, meanwhile, higher SHS exposure was correlated to higher grade levels, senior high school over junior high school, urban areas, those with more pocket money, those who've attempted smoking, exposure to tobacco advertisements, those with parents who smoke, those with close friends who smoke, use of e-cigarettes, and belief that SHS exposure is detrimental to health.

What are the implications for public health practice?

The rate of SHS exposure among adolescent girls in China still remains extraordinarily high. Targeted public health initiatives to curb SHS exposure among adolescent girls are urgently needed in China.

Secondhand smoke (SHS) exposure is harmful to health: there is no risk-free level, and it negatively influences smoking behaviors as well (*1*–*2*). Girls are particularly vulnerable to the adverse health outcomes associated with SHS; a recent study indicated exposure to SHS increases the risk of developing breast cancer, especially when the exposure occurs in puberty when breast cell proliferation is most rapid (*3*). The prevalence of SHS exposure in China (69.9%) in 2013–2014 was much higher than that in 68 other low-income and middle-income countries (54.1%) in 2006–2013 for girls aged 12–15 (*4*). However, the prevalence of SHS exposure at the present is unknown, and the research on its determinants among adolescent girls is limited in China. This study aims to describe the status quo of SHS exposure and explore its determinants among adolescent girls.

The data for this study were extracted from the 2019 China National Youth Tobacco Survey (NYTS), in which a multi-stage, stratified, cluster random sampling design was used to acquire a nationally representative sample. First, 347 districts or counties were selected with a probability proportional to the population size sampling (PPS) method from 31 provincial-level administrative divisions (PLADs) in China. Second, 3 junior high schools and 3 senior high schools (2 academic and 1 vocational) were selected using PPS in each sampled district or county. Third, a class was selected randomly in every grade of each sampled school. All students of the selected class were invited to complete paper-based questionnaires distributed by well-trained investigators independently without the presence of teachers. A total of 154,287 junior high and 149,764 senior high school students were included, with the overall response rates being 95.5% and 94.1%, respectively. The average median age of students surveyed was 15 years old.

In the 2019 China NYTS, all the participants were asked: 1) In the past 7 days, how many days did someone smoke in your home in your presence? 2) In the past 7 days, how many days did someone smoke in any indoor public places in your presence, such as teaching buildings, indoor venues, gymnasiums, internet cafes, stores, restaurants, shopping malls, or cinemas? 3) During the past 7 days, how many days did someone smoke in any outdoor public places in your presence, such as playgrounds, sidewalks, stations, building entrances, or parks? and 4) How many days did someone smoke in your presence in public transportation such as trains, buses, or taxis over the past 7 days? Being exposed to SHS at any place (i.e., at home, in indoor public places, in outdoor public places, or on public transportation) on ≥1 day in the past 7 days was defined as SHS exposure.

All parameter estimations were weighted based on a complex sampling design. Multilevel modeling of complex survey data was used to explore determinants of SHS exposure, with individuals being level-1 units and schools being level-2 clusters. Point values with 95% confidence intervals (CI) were presented for each parameter, and the difference with no overlap in CIs was identified to be statistically significant between subgroups. All analyses were conducted by SAS software (version 9.4, SAS Institute Inc., Cary, USA).

In this study, 70,778 and 72,169 female students in junior high and senior high schools, respectively, accomplished the questionnaire, of which 62.8% (61.5, 64.1) on average overall [60.8% (59.3, 62.1) from junior high and 65.3% (63.7, 67.0) from senior high school] were exposed to SHS in any place — with 31.7% (30.6, 32.8) at home, 46.5% (45.4, 47.6) in indoor public places, 48.8% (47.5, 50.0) in outdoor public places, and 22.1% (21.1, 23.1) on public transportation. The prevalence of SHS exposure in indoor public and outdoor public places was significantly higher than that at home and on public transportation — despite smoking or not and across different types of schools. In terms of geographic location, be it at home or in public places, there was no significant difference observed in the rate of SHS exposure between urban and rural areas. However, more girls in rural areas were exposed to SHS in public transportation than those in urban areas. For female non-smokers, the SHS exposure rate of senior high school students [64.8% (63.1, 66.4)] was higher than that of junior high school students [60.2% (58.8, 61.6)], but no significant difference between schools in SHS exposure was observed for female smokers [91.6% (88.2, 95.0) *vs.* 91.7% (89.1, 94.3)]. (Table 1)

The null model in multilevel modeling showed a statistically significant random part of level-2 accounting for 12 percent of the total variance (P<0.0001) and indicated the hierarchical structure of the data in this study. As a result, the introduction of Multilevel modeling was needed.

The results of the Multilevel modeling showed that higher grade levels [grade one as reference, grade two: odds ratio (OR)=1.438; grade three: OR=1.456], senior high school status (junior high school as reference: OR=1.158), urban areas (rural as reference: OR=1.302), more pocket money (OR=1.334), current smoking behaviors (no as reference: OR=2.441), exposure to tobacco advertisements (none as reference, one venue: OR=2.047; two venues: OR=2.222; three venues: OR=3.639), parental smoking behaviors (no one as reference: OR=2.098), close friends' smoking behaviors (no one as reference: OR=1.950), use of e-cigarettes (no as reference: OR=1.654), and believing SHS exposure is detrimental to health (no as reference, maybe not: OR=1.504; maybe yes: OR=1.952; certainly: OR=2.430) were factors associated with higher SHS exposure (Table 2).

DISCUSSION

The prevalence of SHS exposure among Chinese adolescent girls (62.8%) in 2019 was similar to that among those aged 12 to 16 globally (62.9%) in 2010–2018 (*5*). The percentage of SHS exposure at home in China (32.0%) in 2019 was lower than that in Malaysia in 2016 (38.1%) but higher than that in the U.S. (25.3%) in 2019 (*6*–*7*).

In any place, be it at home (32.0%), indoor public places (43.4%), outdoor public places (46.3%), or public transportation (20.5%), the rate of SHS exposure among girls in junior high school in 2019 was markedly lower than that from 2013–2014 (42.1%, 53.9%, 55.3%, and 34.5%) (*8*). The fastest decline was observed for public transportation while the slowest was observed for outdoor public places. Both in 2013–2014 and 2019, the rates of SHS exposure in public places were critically higher than those at home, which is consistent with the results of another research (*5*). These findings not only highlight the improvement of tobacco control regulation but also showcase the importance of enhanced implementation of smoke-free public places and homes in conjunction with continuous efforts to implement tobacco control regulation in public transportation (*9*).

Despite the fact that tobacco use among adolescent girls is very low in China, more than half of non-smokers (62.2%) were affected by tobacco use. Moreover, non-smokers exposed to SHS at home and in other places were 1.4–2.1 and 1.3–1.8 times more likely to be vulnerable to initiating smoking than those not exposed, respectively (*1*). From January 2006, when the World Health Organization's Framework Convention on Tobacco Control (FCTC) came into force in China, to August 2019, 22 cities implemented local or government regulations for tobacco control (*9*). However, the people protected by these laws only account for 15% of the total population of the country. In order to protect more people from tobacco use, regulations need to be introduced in more cities as soon as possible (*9*).

According to the results of the Multilevel modeling, use of electronic cigarettes (e-cigarettes) was associated with secondhand smoke exposure. In other words, this study found that adolescent girls with experience of using e-cigarettes were more susceptible to SHS.

Among females, the odds of being exposed to SHS were higher among those with one or both parents

TABLE 1. Secondhand smoke exposure among adolescent girls in China, 2019.

Types of school	Region	Places of exposure, % (95% CI)				
		Home	Indoor public places	Outdoor public places	Public transport	Any place
Both						
Overall	Total	31.7 (30.6, 32.8)	46.5 (45.4, 47.6)	48.8 (47.5, 50.0)	22.1 (21.1, 23.1)	62.8 (61.5, 64.1)
	Urban	31.5 (29.9, 33.2)	45.8 (44.1, 47.5)	49.5 (47.3, 51.7)	19.5 (18.2, 20.7)	63.3 (61.1, 65.5)
	Rural	31.8 (30.3, 33.2)	46.8 (45.3, 48.3)	48.2 (46.7, 49.8)	23.9 (22.5, 25.4)	62.4 (61.0, 64.0)
Junior high school	Total	32.0 (30.9, 33.1)	43.4 (42.2, 44.6)	46.3 (45.0, 47.7)	20.5 (19.3, 21.6)	60.8 (59.3, 62.1)
	Urban	31.6 (30.2, 33.0)	43.4 (41.8, 45.0)	48.2 (46.0, 50.4)	18.5 (17.2, 19.8)	62.0 (60.0, 64.0)
	Rural	32.2 (30.6, 33.8)	43.5 (41.8, 45.1)	45.2 (43.6, 47.0)	21.7 (20.1, 23.4)	60.1 (58.2, 62.0)
Senior high school	Total	31.3 (29.8, 32.7)	50.2 (48.6, 51.8)	51.7 (50.1, 53.3)	24.0 (22.7, 25.4)	65.3 (63.7, 67.0)
	Urban	31.5 (29.1, 33.9)	48.5 (46.1, 51.0)	50.9 (48.2, 53.7)	20.5 (18.8, 22.2)	64.9 (62.0, 67.7)
	Rural	31.1 (29.4, 32.9)	51.3 (49.2, 53.4)	52.2 (50.2, 54.1)	26.8 (24.9, 28.7)	65.6 (63.7, 67.5)
Non-smoker						
Overall	Total	31.1 (30.0, 32.2)	45.8 (44.7, 47.0)	48.1 (47.0, 49.4)	21.6 (20.6, 22.6)	62.2 (61.0, 63.5)
	Urban	31.1 (29.4, 32.8)	45.3 (43.6, 47.0)	49.0 (46.8, 51.2)	19.1 (17.9, 20.3)	62.9 (60.7, 65.0)
	Rural	31.1 (29.7, 32.5)	46.1 (44.6, 47.6)	47.6 (46.1, 49.1)	23.4 (22.0, 24.8)	61.8 (60.3, 63.3)
Junior high school	Total	31.4 (30.3, 32.5)	42.8 (41.6, 43.9)	45.8(44.5, 47.1)	20.0 (18.9, 21.1)	60.2 (58.8, 61.6)
	Urban	31.2 (29.9, 32.6)	43.0 (41.3, 44.6)	47.8 (45.6, 50.0)	18.2 (16.9, 19.5)	61.6 (59.5, 63.6)
	Rural	31.5 (29.9, 33.1)	42.7 (41.1, 44.3)	44.6 (43.0, 46.3)	21.2 (19.6, 22.7)	59.4 (57.5, 61.2)
Senior high school	Total	30.7 (29.3, 32.1)	49.6 (48.0, 51.2)	51.1 (49.5, 52.7)	23.6 (22.2, 24.9)	64.8 (63.1, 66.4)
	Urban	31.0 (28.6, 33.4)	47.9 (45.5, 50.3)	50.3 (47.6, 53.1)	20.1 (18.4, 21.8)	64.3 (61.4, 67.2)
	Rural	30.5 (28.7, 32.3)	50.7 (48.6, 52.8)	51.6 (49.6, 53.5)	26.3 (24.4, 28.2)	65.1 (63.2, 67.0)
Smoker						
Overall	Total	61.8 (58.7, 64.9)	79.8 (76.4, 83.3)	78.5 (75.5, 81.4)	42.1 (38.7, 45.5)	91.6 (89.5, 93.8)
	Urban	56.4 (51.4, 61.5)	77.8 (73.4, 82.2)	79.5 (75.2, 83.8)	38.0 (34.0, 42.1)	91.2 (87.4, 95.0)
	Rural	64.4 (60.5, 68.3)	80.8 (76.2, 85.5)	78.0 (74.1, 81.8)	44.3 (39.5, 49.2)	91.9 (89.3, 94.5)
Junior high school	Total	64.4 (60.3, 68.5)	80.2 (75.5, 84.8)	77.1 (72.5, 81.7)	42.8 (37.3, 48.3)	91.7 (89.1, 94.3)
	Urban	61.4 (54.8, 68.0)	80.9 (77.2, 84.6)	82.2 (78.2, 86.1)	41.4 (34.5, 48.3)	92.8 (89.8, 95.8)
	Rural	65.3 (60.2, 70.3)	79.9 (74.0, 85.9)	75.5 (69.6, 81.5)	43.3 (36.1, 50.5)	91.4 (88.1, 94.6)
Senior high school	Total	59.0 (54.3, 63.7)	79.5 (75.3, 83.7)	80.0 (76.5, 83.4)	41.4 (37.4, 45.4)	91.6 (88.2, 95.0)
	Urban	53.5 (46.5, 60.5)	76.0 (69.7, 82.3)	78.0 (72.2, 83.8)	36.0 (30.5, 41.4)	90.2 (84.5, 96.0)
	Rural	63.1 (56.6, 69.6)	82.2 (76.5, 87.8)	81.5 (77.3, 85.7)	45.6 (39.5, 51.7)	92.6 (88.4, 96.8)

Abbreviation: CI=confidence interval.

smoking. This finding was also discovered in several other studies, one of which reported that parents were responsible for 90% of children's SHS exposure (*10–11*). Therefore, educating parents about the hazard of SHS and enforcing complete smoking bans at home is critical to keeping adolescents away from SHS (*3*). As demonstrated in another study, adolescent girls whose intimate friends were smokers had an increased likelihood of being exposed to SHS. Hence, parents should also be involved in the lives of adolescents and keep an eye on their close friends (*10*).

Exposure to tobacco advertisements increased the possibility of being exposed to SHS, suggesting that comprehensive bans on tobacco advertisements, sponsorships, and marketing were also effective in avoiding exposure to SHS in China (*12*). Girls who believed in the harm of SHS had significantly more SHS exposure than those who did not, which may be due to better health consciousness or higher sensitivity to secondhand smoke (*13*).

Limitations exist in this study. First, SHS exposure was collected by self-reporting rather than identified by

TABLE 2. Multilevel modeling for secondhand smoke exposure among adolescent girls.

Parameter	Estimate (95% CI)	SE	t	*P*	OR (95% CI)
Fixed effects					
Intercept	−1.952 (−2.339, −1.565)	0.198	−9.880	<0.001	
School types					
Junior high school					1.0
Senior high school	0.147 (0.035, 0.259)	0.057	2.570	0.010	1.158 (1.035, 1.295)
Grade					
One					1.0
Two	0.364 (0.214, 0.513)	0.076	4.760	<0.001	1.438 (1.238, 1.671)
Three	0.376 (0.256, 0.495)	0.061	6.150	<0.001	1.456 (1.292, 1.641)
Regions					
Rural					1.0
Urban	0.264 (0.141, 0.387)	0.063	4.220	<0.001	1.302 (1.152, 1.472)
Pocket money					
No					1.0
Yes	0.288 (0.139, 0.438)	0.076	3.770	0.001	1.334 (1.149, 1.550)
Smoking					
No					1.0
Yes	0.893 (0.138, 1.647)	0.385	2.320	0.021	2.441 (1.148, 5.193)
Others’ smoking does harm to you					
No					1.0
Maybe not	0.408 (−0.059, 0.876)	0.239	1.710	0.087	1.504 (0.942, 2.402)
Maybe yes	0.669 (0.328, 1.009)	0.174	3.850	0.001	1.952 (1.389, 2.743)
Certainly	0.888 (0.541, 1.234)	0.177	5.020	<0.001	2.430 (1.718, 3.436)
Exposure to tobacco advertisement					
None					1.0
One venue	0.717 (0.611, 0.822)	0.054	13.350	<0.001	2.047 (1.843, 2.274)
Two venues	0.798 (0.648, 0.949)	0.077	10.390	<0.001	2.222 (1.911, 2.583)
Three venues	1.292 (1.057, 1.527)	0.120	10.780	<0.001	3.639 (2.877, 4.603)
Tobacco use of parents					
No one					1.0
At least one	0.741 (0.637, 0.845)	0.053	13.990	<0.001	2.098 (1.891, 2.328)
Tobacco use of close friends					
No one					1.0
At least one	0.668 (0.537, 0.799)	0.067	9.970	<0.001	1.950 (1.711, 2.224)
Use of e-cigarette					
No					1.0
Yes	0.503 (0.288, 0.718)	0.110	4.590	<0.01	1.654 (1.334, 2.050)
Random effects					
Level 2 $\sigma_{u_0}^2$	0.577	0.060	9.652	<0.001	

Abbreviation: CI=confidence interval; SE=standard error; OR=odd ratio; $\sigma_{u_0}^2$=random coefficient.

biomarkers such as serum cotinine, which might lead to misreporting or recall bias. However, self-reported SHS exposure is widely adopted across similar epidemiological studies: making these results comparable to other research (*3*,*10*). Second, this study cannot analyze the changes in SHS exposure among senior high school students over time, as this was investigated for the first time in 2019.

In conclusion, SHS exposure among adolescent girls in China is still an important public health issue. In order to better curb SHS exposure, targeted public health initiatives need to be strengthened in China.

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REFERENCES

1. Bettcher DW, Peruga A, Baptiste J, El Awa F, Nikogosian H, Rahman K, et al. Exposure to secondhand smoke among students aged 13–15 years-worldwide, 2000–2007. MMWR Morb Mortal Wkly Rep 2007. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5620a2.htm#tab. [2021-12-20].
2. Okoli CT, Kelly T, Hahn EJ. Secondhand smoke and nicotine exposure: a brief review. Addict Behav 2007;32(10):1977–1988. https://www.sciencedirect.com/science/article/pii/S0306460307000020?via%3Dihub.
3. Schwartz J, Graham RB, Richardson CG, Okoli CT, Struik LL, Bottorff JL. An examination of exposure and avoidance behavior related to second-hand cigarette smoke among adolescent girls in Canada. BMC Public Health 2014;14:468. https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-14-468.
4. Xi B, Liang YJ, Liu YX, Yan YK, Zhao M, Ma CW, et al. Tobacco use and second-hand smoke exposure in young adolescents aged 12–15 years: data from 68 low-income and middle-income countries. Lancet Glob Health 2016;4(11):e795–805. https://www.sciencedirect.com/science/article/pii/S2214109X16301875?via%3Dihub.
5. Ma CW, Heiland EG, Li ZL, Zhao M, Liang YJ, Xi B. Global trends in the prevalence of secondhand smoke exposure among adolescents aged 12–16 years from 1999 to 2018: an analysis of repeated cross-sectional surveys. Lancet Glob Health 2021;9(12):e1667–1678. https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(21)00365-X/fulltext.
6. Ling MYJ, Lim KH, Hasani WSR, Rifin HM, Majid NLA, Lourdes TGR, et al. Exposure to secondhand smoke among school-going adolescents in Malaysia: Findings from the tobacco and e-cigarettes survey among Malaysian adolescents (TECMA). Tob Induc Dis 2020;18:96. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7694740/.
7. Walton K, Gentzke AS, Murphy-Hoefer R, Kenemer B, Neff LJ. Exposure to secondhand smoke in homes and vehicles among US youths, United States, 2011-2019. Prev Chronic Dis 2020;17:E103. https://www.cdc.gov/pcd/issues/2020/pdf/20_0107.pdf.
8. Liang XF. Survey Report on Youth Tobacco in China in 2014[M]. BeiJing: People's Medical Publishing House, 2014. (in Chinese)
9. Yang J, Li Q, Zhou S, Xi Z, Luo XW, Song LL. Tobacco control regulations in cities of China, 2006-2019. Cap J Public Health 2019;13(5):226 – 9. http://dx.doi.org/10.16760/j.cnki.sdggws.2019.05.001. (In Chinese).
10. Raute LJ, Pednekar MS, Mistry R, Gupta PC, Pimple SA, Shastri SS. Determinants of exposure to second-hand smoke at home and outside the home among students aged 11–17 years: results from the Mumbai student tobacco survey 2010. Indian J Cancer 2012;49(4):419-24. https://pubmed.ncbi.nlm.nih.gov/23442407/.
11. Environmental Protection Agency. FACT SHEET: National survey on environmental management of asthma and children's environmental tobacco smoke. (NSEMA/CEE). 2004. https://www.epa.gov/sites/default/files/2013-08/documents/survey_fact_sheet.pdf. [2021-12-20].
12. Zhu ZY, Zheng PP. Secondhand smoke exposure on campus and influencing factors among college students in Shanghai. J Environ Occup Med 2017;34(4):304 – 10. http://dx.doi.org/10.13213/j.cnki.jeom.2017.16774. (In Chinese).
13. Bayly JE, Bernat D, Porter L, O'Dare K, Choi K. Prevalence and characteristics of secondhand smoke and secondhand vapour exposure among youth. Tob Control 2019;28(3):305–10. https://tobaccocontrol.bmj.com/content/28/3/305.long.

Preplanned Studies

The First Detection of *Echinococcus Granulosus* DNA in Residents' Hands, Dogs' Hair, and Soil in Highly Endemic Region of Echinococcosis — Naqu City, Xizang Autonomous Region, China, 2020

Baixue Liu[1]; Chuizhao Xue[1]; Xu Wang[1]; Wenting Wu[2]; Shuai Han[1,#]; Weiping Wu[1]

Summary

What is already known about this topic?

Echinococcosis is a serious zoonotic parasitic disease that predominantly infects humans; domestic animals like cattle or sheep; as well as wild animals such as small rodents. To date, there is a lack of comprehensive information about all potential environmental transmission routes for *Echinococcus*.

What is added by this report?

This study assesses the importance of under-researched environmental factors for the transmission of *Echinococcus*. It concludes that hand hygiene is an important factor in the robust environmental transmission of *Echinococcus granulosus*.

What are the implications for public health practice?

This study suggests that residents are at risk of catching echinococcosis through hand-oral transmission routes. Health education given to local residents is thus a key intervention, as well as avoiding close contact with dogs and ensuring proper hand-washing practices are followed.

Echinococcosis is a zoonotic parasitic disease caused by the *Echinococcus* larvae (*1*) that seriously threatens human health and restricts local socioeconomic development. It is widespread in pastoral and semi-pastoral areas in northwestern China, particularly in the Qinghai-Tibet Plateau (*2*). Humans often become infected by the ingestion of *Echinococcus* eggs excreted from the feces of a host, such as by having water and food polluted by *Echinococcus* eggs accidentally, or by touching surrounding soil or dog hair contaminated with *Echinococcus* eggs (*3*). However, there is a lack of information so far about other environmental transmission routes for this parasite. Hence, this study aimed to investigate the presence of *E. granulosus* deoxyribonucleic acid (DNA) in the environment surrounding Daqian Town, Naqu City, Xizang (Tibet) Autonomous Region. The results showed that positive samples were detected via nucleic acid detection method from the environmental samples of residents' hand-eluent, dog hair, and surrounding soil. Sequencing confirmed that the obtained polymerase chain reaction (PCR) products represented mitochondrial cytochrome c oxidase subunit I (*COI*) gene fragments from *E. granulosus*. Thus, this study provides evidence to design targeted interventions as well as optimize existing prevention and control strategies to curb echinococcosis infections.

To understand transmission routes that risk contamination by *Echinococcus* in the environment surrounding human habitats, this study conducted a survey in Xizang (Tibet) Autonomous Region in August 2020. The first action item was the selection of survey sites: through considering the production mode (mainly husbandry) and high levels of echinococcosis in various areas, Daqian Town was resultantly selected (Figure 1). The second was sample collection: a total of 171 samples were collected randomly, including eluent samples from residents' hands (78 samples), hair samples from dogs (28 samples), topsoil samples from surrounding settings (37 samples), and grass samples from pasture areas (28 samples). The standard collection for samples was as follows: eluent samples from residents' hands were rinsed with 500 mL water after 1 mL 7X hand sanitizer and filtered through 500 mesh nylon silk cloth; 1 g of dogs' surface hair was collected; 25 g surface soil within 100 m^2 centered on the kennel was collected; and 25 g of surface grass samples were collected. Safety protocols were adhered to during the collection of all samples to avoid infection as infected host feces are the only source of eggs in such an environment.

The third step was nucleic acid detection. Prior to extracting nucleic acid from samples, the samples were processed as follows: soil samples of 15 g were

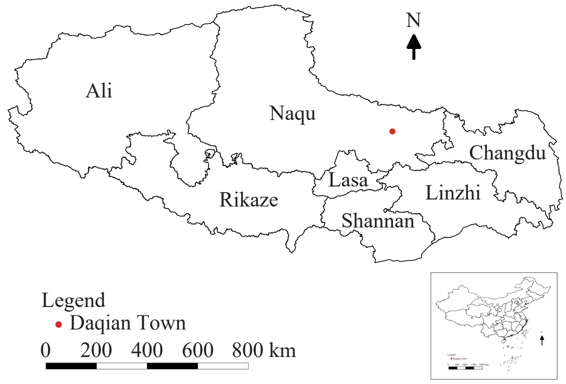

FIGURE 1. The site of sample collection in Xizang (Tibet) Autonomous Region in August 2020.

saturated in approximately 100 mL brine; and 200 mL of brine was added to each eluent, hair, and grass sample for the purpose of saturation. Next, samples were placed in a glass vessel on an automatic oscillator (ZWYR-D2403, ZHICHENG, China) for 30 min at 200 rpm and maintained at 25 °C for 40 min (without shaking). In total, 50 mL of supernatant was extracted and filtered by an electric vacuum pump (SHB-III, CHANGCHENG, China) (pore size was 0.22 μm). Extraction of nucleic acids from all samples was performed using the TIANNAMP Soil DNA Kit (No. DP336). After the concentrations of all samples were measured, they were stored at −20 °C for further analysis.

Fourthly, *COI* gene sequencing: the mitochondrial *COI* gene of *Echinococcus* was subjected to PCR analysis. The amplification was performed according to the protocol described by Guo ZH et al (*4*). The DNA isolated from adult *E. granulosus* and distilled water were used as positive and negative controls in the PCR experiments, respectively. The final PCR products of the positive samples were sequenced by Sangon Biotech (Shanghai). Sequencing results were compared with the *Echinococcus* sequence deposited in the GenBank database. Evolutionary analyses were conducted in MEGA 11 software (version 11.0.10, Mega Limited, Auckland, New Zealand) (*5*). Statistical analysis was performed using the SPSS software package (version 21.0, IBM, Armonk, USA). All data were transferred to Microsoft Excel software (version 2016, Microsoft, Redmond, USA) for data compilation.

The results showed that the positivity rates of nucleic acid in the eluent samples of residents' hands, hair samples from dogs, and topsoil samples were 8.97% (7/78), 7.14% (2/28), and 2.70% (1/37), respectively. All grass samples were negative in the detection of nucleic acid (Table 1). The sequencing of selected positive samples and comparison with the *Echinococcus* sequence deposited in the GenBank database confirmed that the PCR products obtained represented *E. granulosus* mitochondrial *COI* gene fragments, and showed 99.19%–100.00% similarity to the referential sequence (accession number: KX227125). Evolutionary analysis showed that the haplotypes may be closer to the G1 type of *E. granulosus* (Figure 2).

DISCUSSION

Overall, this study investigated the presence of *E. granulosus* DNA in environments surrounding both where husbandry is practiced and where there is a high rate of echinococcosis cases. This study thus evidences that residents' hands, dog hair, and topsoil from Daqian Town in Xizang (Tibet) Autonomous Region have been contaminated with this parasite and that local residents may have been infected by their surrounding environment. Notably, the nucleic acid positivity rate of eluent samples from residents' hands was 8.97% (7/78), indicating that the *E. granulosus* DNA easily adheres to people's hands, which is an

TABLE 1. 171 environmental sample information and test results, Daqian Town, Naqu City, Xizang (Tibet) Autonomous Region, 2020.

Sample type	Number of samples collected (n)	Positive samples		Test
		Number (n)	%	
Eluent from residents' hands	78	7	8.97	
Hair from dogs	28	2	7.14	
Soil	37	1	2.70	*P*=0.356
Grass	28	0	0.00	
Total	171	10	5.85	

Note: The post-hoc pairwise tests for positivity rates of all sample types were performed, and there were no statistical significances of any pair. *P* values were adjusted by Bonferroni correction and compared with the 0.05 level.

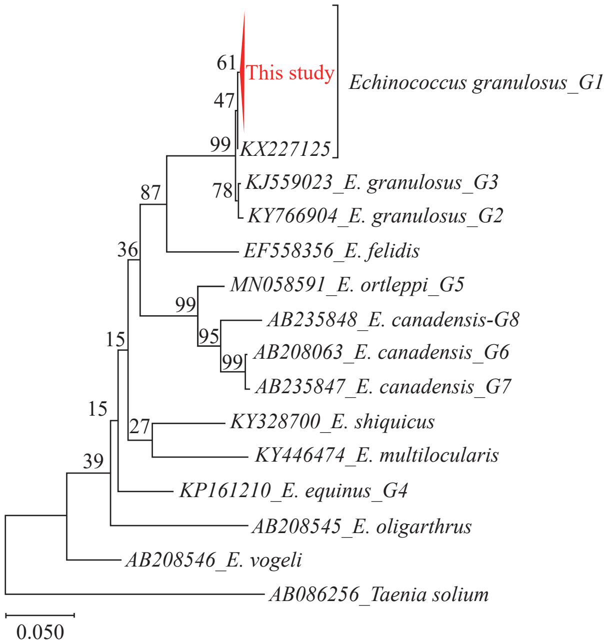

FIGURE 2. Phylogenetic tree of *Echinococcus* based on mitochondrial cytochrome c oxidase subunit I (*COI*) genes.

important transmission route of infection for local residents. The results of nucleotide sequence comparison showed fragments were from *E. granulosus*, which is consistent with the local prevalence (*6*). Against this background, understanding the presence of *E. granulosus* DNA in surrounding settings can help local communities control the transmission risk of echinococcosis more effectively. This study suggests that residents are at risk of catching echinococcosis through hand-oral transmission routes. Health education given to local residents is thus a key intervention with the central message being "*wash hands frequently and don't play with wild dogs.*"

Previous studies have shown that *Echinococcus* eggs may preserve their infectivity for a long time, which could have contributed to the distribution of infectious eggs present in the environment surrounding Daqian Town. The eggs of *E. granulosus* can be completely inactivated at −80 ℃ for at least 7 days. They can survive for more than 200 days at 7 ℃ and 50 days at 21 ℃ (*7*). General information regarding the distribution of eggs in the environment is fragmentary. Specifically, very few studies address the contamination of environmental matrices (*3,8–10*). In Poland, DNA from *E. multilocularis* eggs was detected in soil collected from forests, arable fields, kitchen gardens and farmyards (*9*). Similarly, environmental fruit, vegetable, and mushroom samples have also contained the presence of *E. multilocularis* eggs (*10*). In this study, samples were tested from dogs' feces, dog hair, and soil, which were collected in a highly endemic region of *Echinococcus* in Sichuan Province; the results showed that the positive rates of hair samples from dogs and soil samples were 13.1% (8/61) and 7.7% (3/39) (*3*). These results show that canine feces will indeed cause contamination to the surrounding environment, and surveillance of DNA from *Echinococcus* eggs in the environment is necessary. However, there is insufficient information about the occurrence of DNA from *Echinococcus* eggs on residents' hands as a result of contact with their environment. As well as providing an indication of hand-oral as a transmission route, this study is the first environmental survey of the presence of *E. granulosus* DNA from residents' hands in China. The evolutionary history was inferred using the Maximum Likelihood method and General Time Reversible model. Evolutionary analysis by Maximum Likelihood method in this study showed that the haplotype may be closer to the G1 type of *E. granulosus* (Figure 2).

However, this study was subject to some limitations. First, due to the large workload of sample collection, the number and variety of samples in this study are small. Our results suggest that more investigations should be performed in the future in order to obtain a clear picture. Second, the study focused on heavy endemic areas and did not involve other areas. We will enlarge the range of sample collection and do further investigations from this aspect in the future.

In conclusion, the results from this study provide scientific reference for the development of echinococcosis prevention and control strategies. As well as providing an indication of some environmental transmission routes of *E. granulosus* eggs, such a survey is of use in further health education efforts. These results should motivate professional prevention and treatment efforts against echinococcosis, help introduce informative and educational campaigns about the risk of infection, as well as aid in the development of methods for protecting the population — especially those living in at-risk areas.

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REFERENCES

1. Moro P, Schantz PM. Echinococcosis: a review. Int J Infect Dis 2009;13(2):125 – 33. http://dx.doi.org/10.1016/j.ijid.2008.03.037.
2. Yang YR, Williams GM, Craig PS, McManus DP. Impact of increased economic burden due to human echinococcosis in an underdeveloped rural community of the People′s Republic of China. PLoS Negl Trop Dis 2010;4(9):e801. http://dx.doi.org/10.1371/journal.pntd.0000801.
3. Yuan DB, Guo L, Hou W, Mo Q, Yin J, Zhou MZ, et al. Detection of *Echinococcous multilocularis*/*granulosus* eggs in soil and water in highly endemic region of *Echinococcosis*, Sichuan province. Chin J Vet Med 2018;54(6):93 – 5. https://d.wanfangdata.com.cn/periodical/zgsyzz2018 06030. (In Chinese).
4. Guo ZH, Kubo M, Kudo M, Nibe K, Horii Y, Nonaka N. Growth and genotypes of *Echinococcus granulosus* found in cattle imported from Australia and fattened in Japan. Parasitol Int 2011;60(4):498 – 502. http://dx.doi.org/10.1016/j.parint.2011.09.002.
5. Tamura K, Stecher G, Kumar S. MEGA11: molecular evolutionary genetics analysis version 11. Mol Biol Evol 2021;38(7):3022 – 7. http://dx.doi.org/10.1093/molbev/msab120.
6. Shu K, Qiong D, Wang L, Zhang YL. Investigation on the prevalence of hepatic echinococcosis in Naqu County, Tibet, 2014. Chin J Rural Med Pharm 2015;22(11):63 – 4. https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjIwOTAxEg96Z3hjeXkyMDE1MTEwNDUaCGhnc25qNWZo. (In Chinese).
7. Gemmell MA. Taeniidae: modification to the life span of the egg and the regulation of tapeworm populations. Exp Parasitol 1977;41(2): 314 – 28. http://dx.doi.org/10.1016/0014-4894(77)90104-7.
8. Matsudo K, Inaba T, Kamiya H. Detection of *Echinococcus multilocularis* eggs by centrifugal flotation technique: preliminary survey of soil left in the ferryboats commuting between Hokkaido Island, where *E. multilocularis* is endemic, and mainland Japan. Jpn J Infect Dis 2003;56(3):118 – 9.
9. Szostakowska B, Lass A, Kostyra K, Pietkiewicz H, Myjak P. First finding of *Echinococcus multilocularis* DNA in soil: preliminary survey in Varmia-Masuria Province, northeast Poland. Vet Parasitol 2014;203 (1 – 2):73 – 9. http://dx.doi.org/10.1016/j.vetpar.2014.02.028.
10. Lass A, Szostakowska B, Myjak P, Korzeniewski K. The first detection of *Echinococcus multilocularis* DNA in environmental fruit, vegetable, and mushroom samples using nested PCR. Parasitol Res 2015;114 (11):4023 – 9. http://dx.doi.org/10.1007/s00436-015-4630-9.

Vital Surveillances

Integrated Rabies Surveillance — Hunan Province, China, 2020

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Shanlu Zhao[1]; Ge Zeng[1]; Ziyan Liu[1]; Shixiong Hu[1,#]

ABSTRACT

Introduction: The objective of this paper was to assess the epidemiology of rabies in Hunan Province, analyze the associated factors, understand the status of prevention and treatment after rabies exposure, evaluate the effectiveness of prevention and treatment, and provide a scientific basis for formulating effective prevention and control measures.

Methods: The surveillance data of rabies in Hunan Province in 2020 were collected and analyzed by descriptive epidemiological method.

Results: In 2020, a total of 59 cases of rabies were reported in Hunan Province, with an incidence rate of 0.09/100,000. Overall, 42 cases (71.19%) were due to animal bites and 43 cases (72.88%) were of grade III. The proportion of hand and combined injury of hand was the highest (40.68%). A total of 603,261 cases of rabies exposure were reported from the rabies post-exposure prophylaxis (PEP) clinic in Hunan Province. Dogs were the main animal causing injuries, accounting for 74.21%. Only 83,418 (13.84%) of the animals had a clear immune history, and a total of 11 dog attacks were reported in Hunan Province. The average immunity rate of dogs in the whole province was 30.98%. In 2020, 554 dogs were sampled in the whole province; 20 of them were positive for a positivity rate of 3.61%.

Conclusions: Rabies in Hunan Province in 2020 had a relatively low prevalence. Failure to treat wounds, immunoglobulin injections, and vaccination after exposure were the main causes of rabies. Therefore, post-exposure management of rabies should be further strengthened to reduce the risk of rabies for high-risk populations.

Rabies is an acute human and animal infectious disease mainly caused by rabies virus infection of the central nervous system. Human rabies is usually transmitted by the bite of an animal carrying the rabies virus. There is no treatment method yet, and the case fatality rate is almost 100% (*1–2*). Since 1998, the incidence of rabies in China began to slowly increase, and after reaching the peak in 2007, the incidence generally decreased (*3*). Hunan Province had one of the highest incidences of rabies in China (*4*). In order to assess the epidemic situation and epidemic factors and provide a scientific basis for formulating effective prevention and control measures, the characteristics and trends of rabies in Hunan Province in 2020 were analyzed.

METHODS

The following aspects comprise the integrated rabies surveillance system: case surveillance, surveillance of prevention and treatment of rabies after exposure, surveillance of host animals, and laboratory testing methods.

Case surveillance: medical institutions at all levels and of various types diagnose rabies cases in accordance with the "Rabies Diagnostic Standards" (WS 281–2008). After receiving the rabies case report, each county and city's CDC will conduct an epidemiological investigation of the case, fill in the "Rabies Case Investigation Form," and collect specimens of the deceased for the provincial and municipal CDC for rabies virus testing.

Surveillance of prevention and treatment of rabies after exposure: all rabies post-exposure prophylaxis (PEP) clinics in Hunan are required to collect information about PEP services for all rabies exposure patients, including the PEP service seekers, exposure category, wound treatment, vaccination, and rabies immunoglobulin (RIG) use, by filling in the "Rabies PEP Clinic Registration Form," which is reported to the Provincial CDC every month.

Surveillance of host animals: 14 sentinel counties were set up, and each county was required to collect 20 wounded dog brain tissue specimens throughout the year. If stray dogs or unlicensed dogs were killed in an epidemic focus (within a five-kilometer radius of the case occurrence site) in the counties and urban areas where rabies cases had occurred, at least five canine brain specimens were collected. If one dog bit multiple people, then the brain specimens of that dog were collected as much as possible. All canine brain specimens were sent to the provincial CDC for rabies virus detection. The county-level CDC was required to collect, investigate, and understand the information of dogs and other host animals in the areas under its jurisdiction, including the number, density, and reported immunization numbers of dogs and cats, with the collaboration of relevant departments such as the local animal husbandry, veterinary, and public security sectors.

Laboratory test methods: Reverse transcription-polymerase chain reaction (RT-PCR) was used to detect rabies virus nucleic acid in case samples, and immunofluorescence and RT-PCR were used to detect canine brain samples. The direct immunofluorescence assay (DFA) was used to examine the dog brain.

RESULTS

A total of 59 rabies cases were reported in Hunan Province in 2020, an increase of 4 cases from 2019, and the reported incidence was 0.09/100,000 population, including 24 confirmed laboratory cases. In 2020, a total of 32 cases were sampled and tested in the province. The case detection rate was 54.24% (32/59), of which 21 cases were positive and the positive rate was 65.63% (21/32). In 2020, 25 counties (cities, districts) reported rabies cases. All 59 cases reported died in 2020.

Of the 59 cases, 51 (86.44%) did not treat wounds by themselves or attend medical institutions for wound treatment after exposure and did not receive vaccination or use RIG. Only eight went to medical institutions for wound treatment, three had their wounds squeezed and bled, five had their wounds cleaned and disinfected, and only four cases received RIG but not the complete rabies vaccine (Table 1).

In 2020, a total of 11 incidents of multi-victims

TABLE 1. Characteristics of exposure history and post-exposure prophylaxis, Hunan Province, 2020.

Contents	Number of cases	Constituent ratio (%)
Wound site		
Hand and combined injury of hand	24	40.68
Lower limb below knee	12	20.34
Arm	6	10.17
Head and face combined injury	5	8.47
Lower limbs above knee	6	10.17
Unknown	6	10.17
Exposure mode		
Bite	42	71.19
Scratch	7	11.86
Others	10	16.95
Exposure level		
Degree I	2	3.39
Degree II	14	23.73
Degree III	43	72.88
Wounding animals		
Dogs	56	94.92
Cats	2	3.39
Others	1	1.69
Category of wounding dog		
Self-raised	22	39.29
Neighbor raised	17	30.36
Stray dog	17	30.36

bitten by a single dog (i.e., one dog injuring three or more people) were detected. Overall, 8 of the 11 incidents occurred in rural areas and 3 in urban areas. Almost all months had such incidents reported except January, April, July, and December, and there were 2 incidents in March, August, and October. The incidents took place in 5 cities, including Yueyang (3 incidents), Yongzhou (3 incidents), Loudi (2 incidents), Changsha (2 incidents), and Changde (1 incident).

A total of 11 dogs were involved in the 11 incidents, of which 7 were stray dogs (63.64%) and 4 were domestic dogs; none of the domestic dogs had a history of animal rabies vaccination. Brain specimens of 10 dogs were collected for DFA detection, and the detection results were 100% positive.

A total of 67 persons were exposed in 11 incidents, with one incident involving as high as 10 persons, and the rest less than 10. Among all the exposed persons, 61 were classified as level III and 6 as level II. All victims were given standardized PEP according to the national guidelines and none developed rabies.

A total of 603,261 outpatients were reported in rabies PEP clinics in Hunan, accounting for 0.86% of the total population of Hunan (70.5 million). Of all reported outpatients, the male-female sex ratio was 1.04∶1; exposure grades I, II, and III accounted for 3.46%, 49.73%, and 46.81%, respectively. Injured animals were mainly dogs (447,316, 74.21%). Only 83,418 (13.84%) of attacking animals had a clear immune history.

From the surveillance data reported in Hunan, 44.96% of all outpatients treated the wounds in time after exposure; 87.45% received wound treatment in various preventive clinics; 96.84% were fully vaccinated after exposure; and 139,414 exposures received antiserum or immunoglobulin, accounting for 49.41% (139,414/282,173) of all graded exposures.

Rabies host animal surveillance data were reported in 14 sentinel cities in Hunan Province. According to the data reported, the density of dogs varied greatly in Hunan Province, with a range of 1.48–8.43/100 people and an average of 4.51/100 people. The immunization rates of the dogs also varied greatly among different cities, ranging from 11.82% to 68.24%, with an average of 30.98%.

In 2020, 554 dogs' brain tissue was collected in Hunan Province, and 20 dogs tested positive with a positivity rate of 3.61%. The positive detection of different kinds of dogs is shown in Table 2.

DISCUSSION

In 2020, there was a slight decrease in the number of reported cases in counties and districts, but there was a small rebound in the number of human cases (59 cases), compared to that of 2019 (55 cases). Rabies in Hunan Province continued to show a low epidemic level. This study also indicated that the risk of rabies was still high, and PEP was still not standardized, which was the main cause of death.

The canine surveillance of the disease control system in our province showed that the infection rate of dogs in our province increased significantly in the past 3 years (3.48% in 2017, 15.55% in 2018, and 10.02% in 2019). The infection rate decreased to 3.61% in 2020, which may be related to COVID-19 as animals moved less outside, reducing the risk of infection among animals (*5*).

The main factor of rabies risk was the country dogs that were kept in free range; the country dogs have a low immunity rate, free range, and come into contact with stray dogs and even wild animals (*6*–*8*).

In 2020, the majority of cases in Hunan Province were from farmers and students. The cases occurred in all months of the year, mainly in the population aged 55–65. Of the 59 cases, 51 (86.44%) did not receive any treatment for the wounds or go to a medical institution after exposure without vaccinations and passive immunizations. The number of cases in Shaoyang and Yongzhou accounted for 81.36% of the total number of cases, which may be due to the

TABLE 2. Results of dog rabies virus detection from different sources in Hunan Province in 2020.

Source of dogs	Number of dogs	Number of positive cases	Positive rate (%)
Generally hurt dogs*	265	2	0.75
Dogs in epidemic source areas†	258	0	0.00
Hurt multiple dogs§	31	18	58.06
Total	554	20	3.61

* A dog that only hurts one person.
† The dogs raised in areas within 5 kilometers of the location of the human rabies case.
§ Three or more people were injured by one dog.

underdeveloped economy and low level of urbanization. It is suggested that Hunan Province should strengthen its rabies prevention and control work in Shaoyang and Yongzhou. In addition, we will strengthen medical insurance reimbursement for middle-aged and elderly people after rabies exposure, and urge them to vaccinate after exposure. Simultaneously, publicity and health education should be increased to reduce the risk of disease (*9–11*).

Rabies prevention and control needs to establish and improve the rabies joint prevention and control mechanism with the participation of public security, urban management, agriculture and rural areas, health, and other departments. Actions include establishing and improving dog management methods, removing stray dogs, and carrying out the work of exterminating dogs in epidemic areas (*12–14*). At the same time, it is also necessary to strengthen the construction of standardized rabies prevention and treatment in outpatient clinics, carry out the planning and training of outpatient staff in key areas, and improve the success rate of prevention and treatment after rabies exposure to reduce the number of cases (*15*).

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REFERENCES

1. Wang XK, Song MH, Chen ZH. Progress in anti-viral treatment of rabies. Chin J Exp Clin Virol 2020;34(2):221 – 4. http://dx.doi.org/10.3760/cma.j.cn112866-20190506-0063. (In Chinese).
2. Liu X, Zhu WY. Research progress on rabies treatment methods and application of antiviral drugs. Chin J Zoonoses 2021;37(5):444-9. https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjIwMzIyEhJ6Z3JzZ2hienoyMDIxMDUwMTMaCGM3OXA5aTVl. (In Chinese).
3. Liu JJ, Duo L, Tao XY, Zhu WY. Epidemiological characteristics of human rabies in China, 2016-2018. Chin J Epidemiol 2021;42(1):131 – 6. http://dx.doi.org/10.3760/cma.j.cn112338-20200116-00037. (In Chinese).
4. Yang H, Deng ZH, Sun QL, Zhang HJ, Zhao SL, Zhang SY, et al. Analysis on the events of multi-victims bit by single dog in Hunan province from 2013 to 2017. J Trop Dis Parasitol 2018;16(2):86 – 9. http://dx.doi.org/10.3969/j.issn.1672-2302.2018.02.007. (In Chinese).
5. Lyu S, Gao F. Investigation of outpatients exposed to rabies on knowledge of rabies in Huangpu District, Shanghai. Shanghai J Prev Med 2021;33(8):708 – 13. http://dx.doi.org/10.19428/j.cnki.sjpm.2021.20099. (In Chinese).
6. Wu DH. Prevention and treatment measures of major zoonosis in Guangde. Chin J Anim Husb Vet Med 2020(6):64. http://dx.doi.org/10.3969/J.ISSN.1671-6027.2020.06.046. (In Chinese).
7. Wang B, Yan MH, Wei DP, Li S, Tang HM. Value analysis of health education in prevention and control of rabies. J Snake 2021;33(1):80 – 1. http://dx.doi.org/10.3969/j.issn.1001-5639.2021.01.023. (In Chinese).
8. Chen Y. Analysis on prevention and treatment of rabies exposed patients in dog trauma clinic of Ninth Hospital of Xi'an in 2019. Clin Res Pract 2021;6(23):23 – 6. http://dx.doi.org/10.19347/j.cnki.2096-1413.202123008. (In Chinese).
9. Mao DJ. Rabies epidemic and prevention and control. Graziery Vet Sci Electron Version, 2019(17):45-6. https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjIwMzIyEhdRS0MyMDE5MjAxOTEyMTcwMDA1MzY2MRoIb3RneGVscW0%3D. (In Chinese).
10. Tian BJ, Wu D, Yang F, Ning QE, Li YT, Chen D, et al. Comprehensive treatment and effect evaluation of a dog injury to multiple people. Clin Res Pract 2020;5(12):4 – 5,8. http://dx.doi.org/10.19347/j.cnki.2096-1413.202012002. (In Chinese).
11. Wen SY. Investigation and analysis of 11 cases of multiple people injured by one dog in Yudu County. Med Forum 2021;25(20):2932 – 3. http://dx.doi.org/10.19435/j.1672-1721.2021.20.066. (In Chinese).
12. Yin XR. Difficulties and solutions of grass-roots rabies prevention and control. Vet Orientat 2021(7):61 – 2. https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2021&filename=DWBJ202107047&uniplatform=NZKPT&v=DJFeXBF5FPWhSNrtx87kGQiPpIF52mMzNFKaCuLnyNsWeu-Sk7tHZgX4lplcuuWm. (In Chinese).
13. Cao LZ, He J, Liu B, Song FG, Liu F, Liu QH, et al. Problems and countermeasures of dog management in Hengshui City. Chin Livest Poult Breed 2021;17(3):80 – 1. http://dx.doi.org/10.3969/j.issn.1673-4556.2021.03.042. (In Chinese).
14. He J. Rabies prevention and control measures. Mod Anim Husb Sci Technol 2021(9):84 – 5. http://dx.doi.org/10.19369/j.cnki.2095-9737.2021.09.045. (In Chinese).
15. Zhang B, Liu QB, Li ZJ, Guo JL, Zhou GL. Thoughts on rabies prevention and control in Beijing. Contemp Anim Husb 2017(1):66 – 8. https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2017&filename=DDXM201703033&uniplatform=NZKPT&v=5OeRQSS6uia2nC68qOKs1PT2QGzoBkN5KC7DI6yiNXp4PiE8s5avABxgxsPd-4HU. (In Chinese).

Perspectives

Malaria Elimination in China and Sustainability Concerns in the Post-elimination Stage

Xinyu Feng[1]; Li Zhang[1]; Hong Tu[1]; Zhigui Xia[1,#]

ABSTRACT

The World Health Organization (WHO) certified China as officially malaria-free on June 30, 2021. Looking back at the public health history in China, malaria elimination has been a product of complex social engineering. Here, we summarized our experience and lessons, and found that malaria control and elimination in China is mainly attributed to governmental leadership, consistent efforts, technological innovations, and adaptive approaches. We also raised that vigilance should focus on imported cases through strengthening surveillance and response systems in order to prevent any re-establishment of transmission after elimination. China should continue to maintain its laboratory, clinical and field epidemiology capabilities. Continuous policy and financial support, multi-sectoral cooperation, and innovative strategies and approaches will remain essential. By integrating these, a malaria-free status can become sustainable.

INTRODUCTION

Malaria is a dangerous infection caused by parasites transmitted to humans through the bites of *Anopheles* mosquitoes. About half of the world's population is endangered by malaria, particularly those in under-developed countries. According to the latest World Malaria Report by the World Health Organization (WHO), there were an estimated 241 million malaria cases and a death toll of up to 627,000 globally in 2020 (*1*). While the gains in reducing global malaria cases and deaths to date have been impressive, the challenges remain substantial. The rate of progress that characterized the scale-up of interventions from 2000 to 2010 has not kept pace. In particular, the reductions in cases and deaths needed to achieve the 2030 targets for morbidity and mortality reduction from the WHO Global Technical Strategy for Malaria (2016–2030) have not been met over the last several years. Malaria case incidence and mortality rates continue to decline slower than needed. These facts highlight the need for continued efforts to reduce the toll of disease and approach the aggressive goal of being malaria-free globally.

Malaria has been eliminated in China since 2021. However, China should conscientiously implement the principles of "Consider prevention as a high-priority approach; Use scientific control strategies; Take adaptive measures; Comply with the classified guidance" and the working mechanism of "governmental leadership, multi-sectoral cooperation, and whole-society participation" to remain malaria-free. This study overviews malaria elimination in China and raises sustainability concerns about the post-elimination stage. These illustrations and encounters from China's success during malaria elimination will be significant references for nations focusing on elimination.

A BRIEF HISTORY OF MALARIA ELIMINATION IN CHINA: KEY STRATEGIES, METRICS, AND ACHIEVEMENTS

Malaria is an ancient disease with records that can be traced back to more than 3,500 years ago in oracle-bone inscriptions in China. The past centuries have witnessed several disasters by malaria-caused mortality and morbidity. In the early years after the founding of the People's Republic of China, approximately 80% of the population was under malaria threat, and the disease was prevalent in nearly 70% of counties (*2*–*5*). In 1954, 6.97 million malaria cases represented a national incidence rate of 12.29 per 1,000 estimated (Figure 1). There were still more than 24 million cases in 1970 (*6*). In China's malaria control campaign, concerted efforts for generations have led to an unprecedented descending incidence from 122.9/10,000 (6.97 million cases) in 1954 to 0.06/10,000 (7,855 cases) in 2010 (Figure 1). In

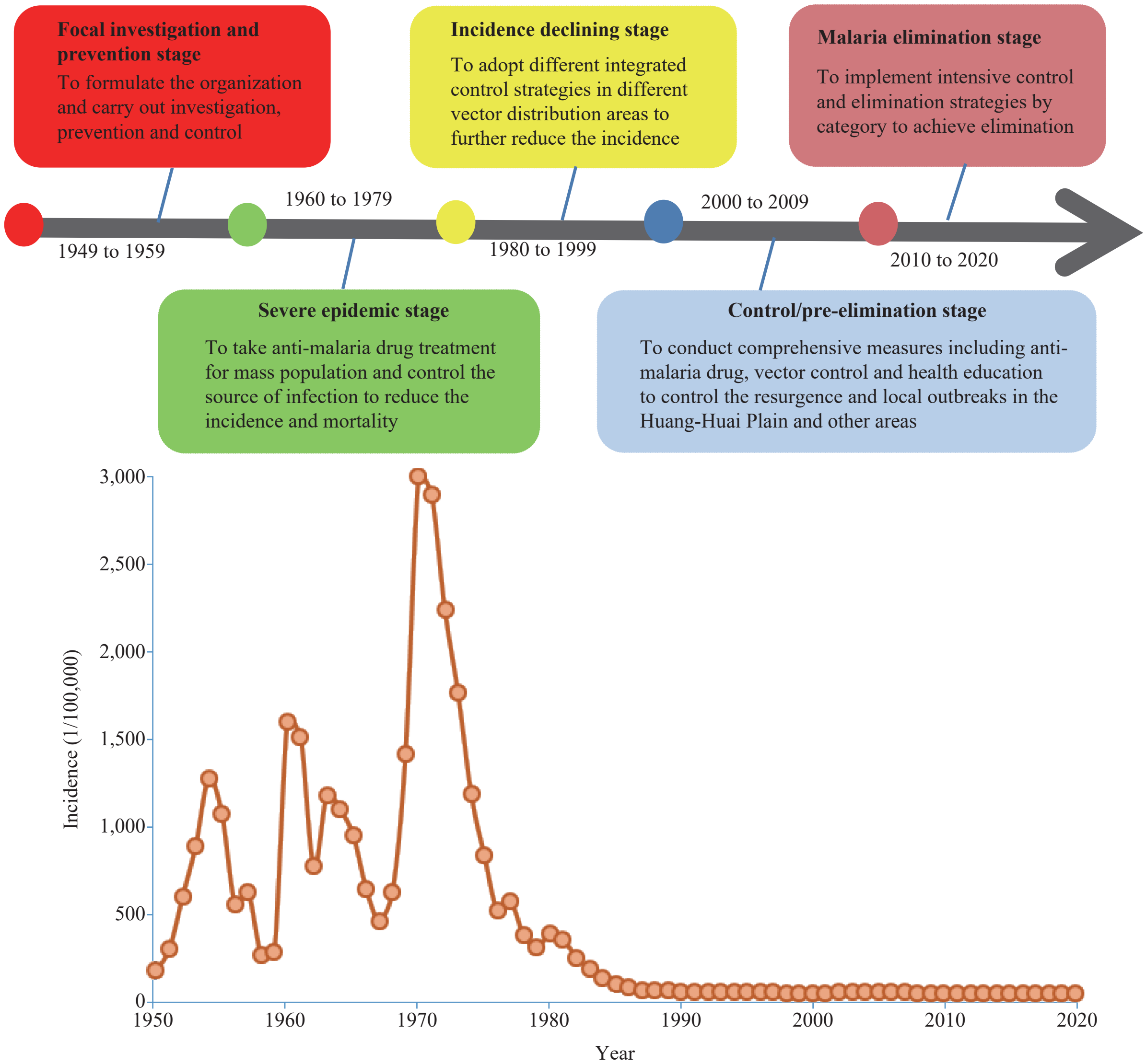

FIGURE 1. Malaria incidence in different periods and corresponding primary strategies in China.
Note: Focal investigation and prevention stage (1949–1959); Severe epidemic stage (1960–1979); Incidence declining stage (1980–1999); Control/pre-elimination stage (2000–2009); Malaria elimination stage (2010–2020).

response to the global malaria eradication initiative prompted by the Millennium Development Goals, China issued the National Action Plan for Malaria Elimination in China (2010–2020) in 2010: laying down the main objectives as eliminating malaria in most counties by 2015 and over the whole territory by 2020. In 2016, China was included by the WHO in the Elimination-2020 (E-2020) initiative as one of the 21 potential countries to reach malaria elimination by 2020. In 2017, for the first time, China reached the critical milestone of zero indigenous malaria cases (*7*). Zero indigenous transmission has been maintained for 4 consecutive years, achieving the goal proposed in the E-2020 initiative and the National Malaria Elimination Action Plan. Ultimately, on June 30, 2021, China was officially certified malaria-free by the WHO.

During the focal investigation and prevention stage (1949–1959), in light of high morbidity and mortality, lack of professional agencies, and lack of baseline data, China instituted professional agencies nationally and conducted baseline investigations and field trials for the national malaria control program. Notably, China defined malaria as a notifiable disease in 1956, which highlighted the hazards and importance of the disease for the first time.

The severe epidemic stage (1960–1979) was characterized by vivax malaria pandemics in central China. Therefore, China conducted mass drug administration (MDA) with prophylactic and radical medications and initiated intranational cooperation mechanisms where the epidemic was unstable and endemic.

Through the comprehensive strategies in remote areas with severe outbreaks during the incidence declining stage (1980–1999), combined with prevention and control measures adopted in an earlier stage, malaria incidence declined continuously.

During the control/pre-elimination stage (2000–2009), despite case decline, China still faced severe issues in combating malaria: serious underreporting and high transmission in the Yunnan and Hainan provinces of southern China, and resurgence and outbreaks in central China. In response, China strengthened blood tests, early diagnosis, and appropriate treatment to solve these problems. Free mass distribution of long-lasting insecticide-treated nets (LLINs), health education, and monitoring and evaluation were also conducted with the support from the Global Fund, which offered important stimuli towards malaria elimination. More importantly, China established a timely, web-based reporting system and conducted targeted MDA in central China, which substantially reduced incidence to a record low: indicating the feasibility of eliminating malaria (*5*,*7*–*8*).

When China entered the malaria elimination stage (2010–2020), many institutions at the provincial or county level still followed previously-used strategies. As a result, they overlooked the changes in concepts and methods necessary during the transition from the control to elimination stage. Consequently, the adaptation of alternative strategies at these governance levels was urgently needed. This involved setting priorities and operationalization based on local malaria epidemiology and robustness of the health system. These transitions required tailored responses, including an adaptive case- and focus-oriented comprehensive strategy and "1-3-7" approach, constructing and reinforcing elimination reporting systems, and implementing a diagnosis-reference laboratory network (*7*,*9*). Based on the successful experience of previous pilot trials on malaria control and elimination, Yunnan Province put forward and carried out a defensive 3-pronged strategy, as well as a "3+1" strategy (+1 was an extended buffer zone in Laiza City of Myanmar with a length of 20.5 km and a width of 2.5 km), in border areas to guarantee universal surveillance coverage and rapid response to any re-establishment of transmission (*9*–*10*).

In addition, regarding the management of imported malaria cases, an effective malaria detection and management system for migrant populations is essential: especially through multi-sectoral cooperation. Various capacity building and maintenance of malaria detection, diagnosis, treatment, and response are fundamental components of keeping vigilance and the key to achieving elimination. Through these initiatives, China has continuously scaled up its efforts to realize its malaria-free status. Integrated cooperation, efficient information sharing, and action coordination between sectors, regions, and provinces fueled the progress in the last mile towards elimination in China.

SUSTAINABILITY CONCERNS IN THE POST-ELIMINATION STAGE

Despite the fact that China has obtained enormous success in its national malaria elimination program since 2010, there is still a long way to go for consolidating the achievements gained. Given that imported cases (which act as a source of infection) are detected almost daily, and that structural malaria vectors still exist, China still faces a possible long-term risk of experiencing re-established, indigenous malaria transmission. Moreover, there are complex multivariate ecological factors along border areas neighboring 4 Southeast Asian countries that complicate the matter even further (*11*–*12*). In recent years, imported cases from Africa or Southeast Asia accounted for a substantial proportion of total reported cases: caused by increasing numbers of laborers and business people returning from malaria-endemic areas. Strong multi-sectoral collaboration is needed to improve the management of imported cases (Figure 2), especially between the customs, health, and education sectors. Moreover, international cooperation between countries with endemic malaria, such as the Yunnan-Myanmar and China-Africa cooperation, is highly recommended.

The inadequate capacity to diagnose malaria in communities where malaria cases seldom or never occur is also a big challenge in maintaining malaria-free status in China (Figure 2). Constant capacity building of medical workers on malaria detection, diagnosis, treatment and response is required to avoid delayed case detection. In addition, alternative approaches, such as rapid detection tests (RDTs), should be prepared as supplementary tools, especially at the township level in rural areas.

Resistance to antimalarial drugs is also alarming. Various studies reported *Plasmodium falciparum*

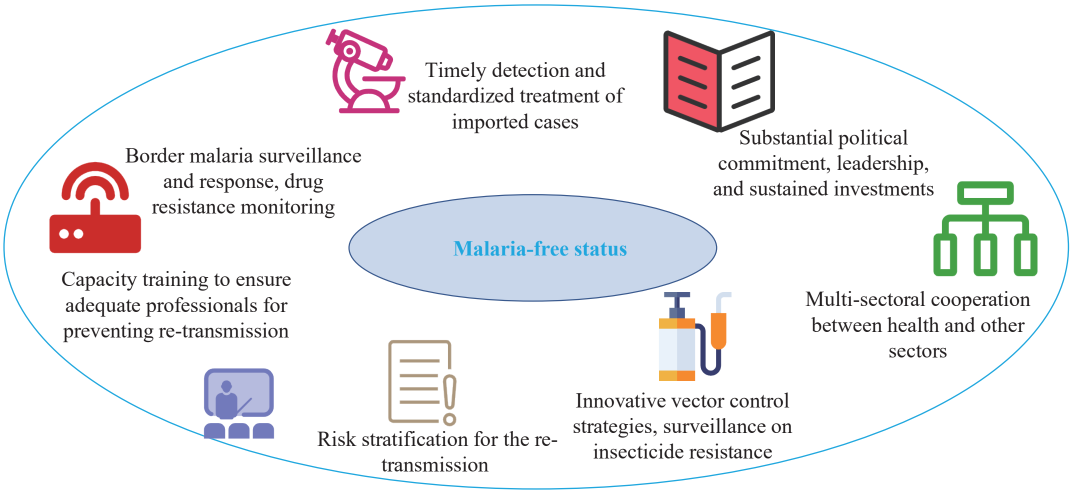

FIGURE 2. Key interventions needed to maintain malaria-free in the post-elimination stage.
Note: Countries that have achieved at least 3 consecutive years of zero indigenous cases are eligible to apply for a WHO certification of malaria-free status.

resistance to artemisinin, as well as *P. vivax* resistance to chloroquine, antifolate, and other therapies. To gather solid evidence on this issue, China has evaluated the prevalence of various drug-resistance genes in imported parasite isolates in past decades. Synonymous and nonsynonymous mutations in *pfmdr1, Pfdhfr, Pfdhps* and *Pfkelch13* were observed, indicating the presence and potential risk of multiple-drug resistance in imported malaria cases from both Africa and Southeast Asia isolates. The resistant parasite strains could contribute to the spread of drug resistance worldwide. Cases of imported malaria are increasing, and it is critical to conceive the approaches to surveillance, prevention and management of antimalarial drug resistance.

Also of importance, insecticide resistance has become a major obstacle to malaria control and elimination. The question of how to delay the spread of insecticide resistance is critical for developing and deploying effective vector control strategies and tools. Insecticide surveillance on primary malaria vectors in China indicated the spread of pyrethroid resistance among *An. sinensis* populations in a wide range of provinces including Yunnan and Hainan (*13–14*). Meanwhile, widespread and severe resistance to organophosphate insecticides in the southeastern region has also been reported. It is worth noting that some mosquito populations have evolved multi-resistance to applied insecticides such as pyrethroids, organophosphates, carbamates, and organochlorines.

To ensure the sustainability of a malaria-free status, it is necessary 1) to provide policy support, even after reaching the malaria-free milestone. Substantial political commitment and leadership, as well as sustained investments, are essential for deploying timely diagnosis, treatment, and effective prevention; 2) to maintain the continuity of sensitive and time-bound malaria surveillance-response systems so that all cases could be monitored promptly. Meanwhile, the corresponding response to foci could be delivered to prevent outbreaks or the reintroduction of malaria; 3) to improve reference laboratory and technical training, and to build and maintain the professional teams which can implement various measures; 4) to continue the multi-sectoral collaboration between the public health sector and other sectors such as commerce, tourism, and customs, and to strengthen closer international collaboration between malaria-endemic countries sharing a border with China. It will be more effective to perform joint and active surveillance and response by deploying prioritized activities through collaborations; 5) to invent active ingredients and integrate surveillance and monitoring of insecticides in addition to the core vector control approaches; 6) to monitor antimalarial drug resistance, especially through well-established antimalarial drug resistance markers and integrated drug efficacy surveillance (iDES), while conducting routine surveillance of imported malaria cases.

In addition, as SARS-CoV-2 spreads throughout the world, potential impacts on malaria incidence, mortality and service coverage have not been fully characterized. Thus, how to sustain China's malaria-free status once an outbreak or emergence of a novel infectious disease, like coronavirus disease-19 (COVID-19), is also an important issue. Interventions to mitigate these challenges should strengthen communications and information sharing between malaria diagnosis and COVID-19 detection to avoid exposing malaria cases to COVID-19 (*15*). The focus on COVID-19 reduces or overwhelms malaria messages from the health community, which interrupts the timely deployment of interventions. Home-based malaria management, such as RDT and artemisinin-based combination therapy prescription drugs, should be recommended in such conditions.

CONCLUSION

China's malaria elimination was hard-earned and came only after decades of sustained investment and effort. Although China has eliminated malaria, various challenges and barriers threatening its malaria-free status still exist. Robust surveillance and response, constant capacity building, demand-oriented scientific research, and multi-channel cooperation are further needed to sustain China's malaria-free status in the future.

Conflicts of interest: No conflicts of interest.

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REFERENCES

1. WHO. World malaria report 2020: 20 years of global progress & challenges. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2020. [2022-3-22].
2. Tang L. Progress in malaria control in China. Chin Med J (Engl) 2000;113(1):89-92. https://pubmed.ncbi.nlm.nih.gov/11775219/.
3. Feng XY, Xia ZG, Feng J, Zhang L, Yan H, Tang LH, et al. The contributions and achievements on malaria control and forthcoming elimination in China over the past 70 years by NIPD-CTDR. Adv Parasitol 2020;110:63 – 105. http://dx.doi.org/10.1016/bs.apar.2020.03.005.
4. Feng XY, Xia ZG, Vong S, Yang WZ, Zhou SS. Surveillance and response to drive the national malaria elimination program. Adv Parasitol 2014;86:81 – 108. http://dx.doi.org/10.1016/B978-0-12-800869-0.00004-4.
5. Zhou XN, Xia ZG, Wang RB, Qian YJ, Zhou SS, Utzinger J, et al. Feasibility and roadmap analysis for malaria elimination in China. Adv Parasitol 2014;86:21 – 46. http://dx.doi.org/10.1016/B978-0-12-800869-0.00002-0.
6. Yin JH, Yang MN, Zhou SS, Wang Y, Feng J, Xia ZG. Changing malaria transmission and implications in China towards National Malaria Elimination Programme between 2010 and 2012. PLoS One 2013;8(9):e74228. http://dx.doi.org/10.1371/journal.pone.0074228.
7. Feng J, Zhang L, Huang F, Yin JH, Tu H, Xia ZG, et al. Ready for malaria elimination: zero indigenous case reported in the People's Republic of China. Malar J 2018;17(1):315. http://dx.doi.org/10.1186/s12936-018-2444-9.
8. Feng XY, Levens J, Zhou XN. Protecting the gains of malaria elimination in China. Infect Dis Poverty 2020;9(1):43. http://dx.doi.org/10.1186/s40249-020-00661-y.
9. Xu JW, Lin ZR, Zhou YW, Lee R, Shen HM, Sun XD, et al. Intensive surveillance, rapid response and border collaboration for malaria elimination: China Yunnan's "3 + 1"strategy. Malar J 2021;20(1):396. http://dx.doi.org/10.1186/s12936-021-03931-8.
10. Lin ZR, Li SG, Sun XD, Guo XR, Zheng Z, Yang J, et al. Effectiveness of joint 3 + 1 malaria strategy along China-Myanmar cross border areas. BMC Infect Dis 2021;21(1):1246. http://dx.doi.org/10.1186/s12879-021-06920-z.
11. Zhang Q, Sun JL, Zhang ZK, Geng QB, Lai SJ, Hu WB, et al. Risk assessment of malaria in land border regions of China in the context of malaria elimination. Malar J 2016;15(1):546. http://dx.doi.org/10.1186/s12936-016-1590-1.
12. Zhou S, Li ZJ, Cotter C, Zheng CJ, Zhang Q, Li HZ, et al. Trends of imported malaria in China 2010-2014: analysis of surveillance data. Malar J 2016;15:39. http://dx.doi.org/10.1186/s12936-016-1093-0.
13. Yang HL, Baloch Z, Xu JW, Sun XD, Lin ZR, Zhou YW, et al. Malaria: elimination tale from Yunnan Province of China and new challenges for reintroduction. Infect Dis Poverty 2021;10(1):101. http://dx.doi.org/10.1186/s40249-021-00866-9.
14. Qin Q, Li YJ, Zhong DB, Zhou N, Chang XL, Li CY, et al. Insecticide resistance of *Anopheles sinensis* and *An. vagus* in Hainan Island, a malaria-endemic area of China. Parasit Vectors 2014;7:92. http://dx.doi.org/10.1186/1756-3305-7-92.
15. Teboh-Ewungkem MI, Ngwa GA. COVID-19 in malaria-endemic regions: potential consequences for malaria intervention coverage, morbidity, and mortality. Lancet Infect Dis 2021;21(1):5 – 6. http://dx.doi.org/10.1016/S1473-3099(20)30763-5.

Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, August 2022

Diseases	Cases	Deaths
Plague	0	0
Cholera	6	0
SARS-CoV	0	0
Acquired immune deficiency syndrome*	4,679	2,106
Hepatitis	141,324	74
Hepatitis A	1,116	1
Hepatitis B	115,375	26
Hepatitis C	21,891	45
Hepatitis D	30	0
Hepatitis E	2,255	2
Other hepatitis	657	0
Poliomyelitis	0	0
Human infection with H5N1 virus	0	0
Measles	112	0
Epidemic hemorrhagic fever	235	1
Rabies	20	11
Japanese encephalitis	57	0
Dengue	1	0
Anthrax	73	2
Dysentery	4,505	0
Tuberculosis	69,019	365
Typhoid fever and paratyphoid fever	730	0
Meningococcal meningitis	2	0
Pertussis	5,355	0
Diphtheria	0	0
Neonatal tetanus	2	1
Scarlet fever	940	0
Brucellosis	7,887	1
Gonorrhea	9,275	0
Syphilis	50,482	4
Leptospirosis	48	0
Schistosomiasis	4	0
Malaria	217	0
Human infection with H7N9 virus	0	0
COVID-19†	13,855	0
Influenza	183,345	3
Mumps	8,472	0

Continued

Diseases	Cases	Deaths
Rubella	128	0
Acute hemorrhagic conjunctivitis	2,267	0
Leprosy	32	0
Typhus	205	0
Kala azar	22	0
Echinococcosis	267	0
Filariasis	0	0
Infectious diarrhea§	100,107	0
Hand, foot and mouth disease	54,528	0
Total	658,201	2,568

* The number of deaths of acquired immune deficiency syndrome (AIDS) is the number of all-cause deaths reported in the month by cumulative reported AIDS patients.

† The data were from the website of the National Health Commission of the People's Republic of China.

§ Infectious diarrhea excludes cholera, dysentery, typhoid fever, and paratyphoid fever.

The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the mainland of China are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan, China are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

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