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Cover Photo: 12 lethal mushrooms causing poisoning incidents in China, 2019（Photographs from Haijiao Li).

Preplanned Studies

Mushroom Poisoning Outbreaks — China, 2019

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Summary

What is already known about this topic?

Mushroom poisoning is becoming one of the most serious food safety issues in China, which is responsible for nearly a half of all oral poisoning deaths.

What is added by this report?

In China, many mushrooms were previously "recorded" as poisonous. In this study, about 70 species obtained from mushroom poisoning incidents including several new records were confirmed accurately by morphological and molecular evidence in 2019, and spatial and temporal distribution characters of 13 lethal mushrooms were summarized systematically.

What are the implications for public health practice?

Precise and timely species identification is of pivotal importance in mushroom incidents. More efforts and cooperation are continued to be needed urgently for the governments, CDC staff, doctors and mycologists in future.

Macrofungi, commonly known as mushrooms, are important sources of foods and medicines especially in China (*1*). But with the utilization of wild edible and medicinal mushrooms, many poisoning incidents occur every year. At least 100 estimated people die every year worldwide, which is likely underestimated given the approximate 50–100 deaths separately reported each year in both Europe and China (*2*–*5*). Mushroom poisoning is a major cause of death by oral poisoning in China and is characterized by typical space-time clustering (in South areas of China, from summer to autumn), high mortality (about 20%), and high risk to farmers (*3*,*6*). After mushroom poisoning events, mushroom poisoning information is systematically collected by a technical support network including professional staff of CDC, doctors and mycologists, and an epidemiological investigation is immediately conducted. In 2019, 276 independent mushroom poisoning incidents from 17 provinces involving 769 patients and 22 deaths were investigated and the overall mortality was 2.86%.

Currently, 480 varieties of poisonous mushrooms have been recorded in China (*1*) that result in seven different kinds of clinical syndromes including acute liver failure, acute renal failure, rhabdomyolysis, gastroenteritis, psycho-neurological disorder, hemolysis, and photosensitive dermatitis (*2*,*6*). Among these clinical syndromes, poisonous mushrooms resulting in acute liver failure and rhabdomyolysis are responsible for almost all deaths.

Information from epidemiological investigations was systematically recorded and analyzed, and the information focused primarily on location, poisoning time, incubation, complaints, number of patients and deaths, mushroom species, method of acquisition (including self-harvested, market purchase), and syndromic classification. The patients' number of a few incidents resulting gastroenteritis or psycho-neurological disorder were not accurately obtained, they were treated as one patient for each incident. Following poisoning events, mushroom specimens were obtained by local CDC, China CDC, or hospital professionals from the venue where the mushrooms were consumed or from the field and confirmed by the patients. Almost all specimens were processed and deposited in the National Institute of Occupational Health and Poison Control (NIOHPC) of China CDC. Some were also deposited in Cryptogamic Herbarium of Kunming Institute of Botany, Chinese Academy of Sciences (HKAS), Herbarium of College of Life Sciences, Hunan Normal University (MHHNU), and other local CDCs. All mushroom specimens were identified by morphological and molecular analyses, DNA gene fragment internal transcribed spacer (ITS) was selected for species recognition. Related clinical symptoms data were summarized from the hospital records.

In 2019, a total of 276 independent mushroom poisoning incidents from 17 provinces involving 769 patients and 22 deaths were investigated and the overall mortality was 2.86%. Among them, the mushroom species could accurately be identified in 264 incidents (95.65%). There were 26 patients from 9 incidents with 1 death who had eaten poisonous mushrooms purchased from market. Ten patients from five incidents had been poisoned after eating dried *Russula* spp. or boletes. Patients from 33 incidents had consumed mixed wild mushrooms. Mushroom poisoning happened every month all year round and centered from June to October with its peak in July, which involved 85 incidents including 200 patients and 4 deaths (Figure 1).

In terms of geographical distribution, the provincial-level administrative division with the most incidents was Hunan, which involved 77 incidents and 221 patients, followed by Yunnan, Zhejiang, Guizhou, and Chongqing. The number of incidents and patients in the top 5 provinces accounted for more than 80% of the total (82.61% and 80.49%) and 95.45% (21/22) of the total death toll. The number of cases ranged from 1 to 23,* and 6 outbreaks involved more than 10 patients. Yunnan had 14 patients die after eating poisonous mushrooms, followed by Guizhou (5 deaths), Zhejiang (2 deaths), and Sichuan (1 death).

In addition, There were 12 patients from Burma who had been involved in 3 incidents with 6 deaths. There was one patient who had eaten *Chlorophyllum molybdites*, which causes gastroenteritis, four patients who had consumed *Psilocybe thaiaerugineomaculans*, which leads to hallucinations, and the other seven patients had eaten the lethal mushroom *Amanita exitialis*.

About 70 species of poisonous mushroom causing 6 different kinds of clinical syndromes were successfully identified by morphological and molecular studies (Table 1). Seven species (*Entoloma strictius*, *Gymnopilus lepidotus*, *Inocybe serotina*, *I. squarrosolutea*, *Lactarius atrobrunneus*, *Lactifluus vellereus*, and *Psilocybe thaiaerugineomaculans*) were newly recorded as poisonous mushrooms in 2019 and were added to the Chinese poisonous mushroom list. This is the first report of *I. serotina* and *P. thaiaerugineomaculans* in China. *Gerhardtia sinensis* and *Tolypocladium dujiaolongae* were treated as highly suspected poisonous species and further investigations will be continued to certify their edibility or toxicity.

Nine species (*A. exitialis*, *A. fuliginea*, *A. cf. fuliginea*, *A. pallidorosea*, *A. rimosa*, *A. subjunquillea*, *A. subpallidorosea*, *Galerina sulciceps*, and *Lepiota brunneoincarnata*) causing acute liver failure resulted in 41 incidents involving 100 patients and 20 deaths and thus, *A. exitialis* had been recognized as the most dangerous mushroom in 2019 (Table 1). *Russula subnigricans* which leads to rhabdomyolysis resulted in 15 incidents involving 54 patients and 1 death (Table 1). Three species (*A. neoovoidea*, *A. oberwinklerana*, and *A. pseudoporphyria*) from the genus *Amanita* causing acute renal failure were identified, leading to 11 incidents involving 23 patients and no deaths (Table 1). As almost all deaths for mushroom poisoning were attributed to acute liver failure,

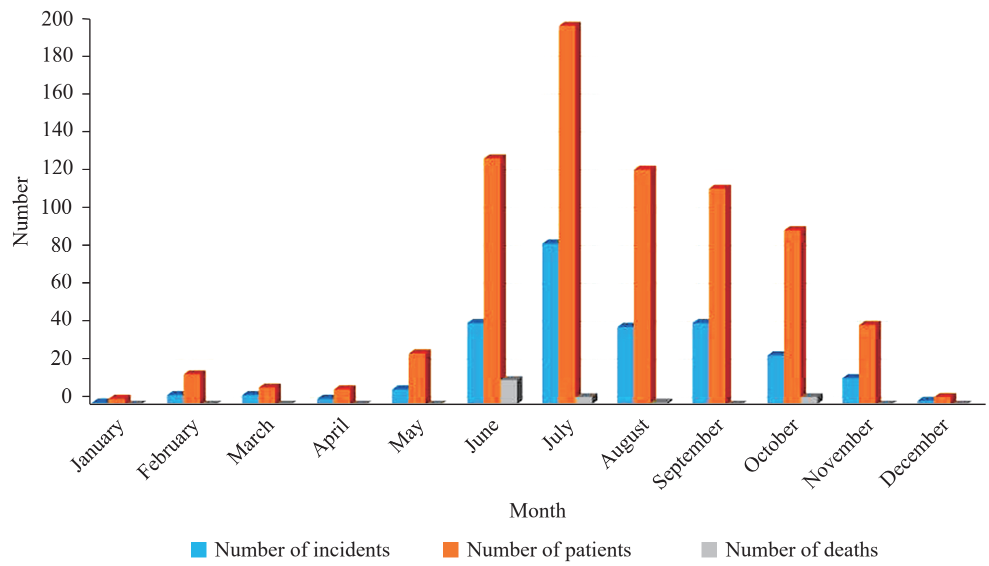

FIGURE 1. Monthly distribution of mushroom poisoning in China, 2019.

* The median number of cases was two.

TABLE 1. Toxic mushroom species causing poisoning incidents in China, 2019.

Mushroom species	Number of incidents	Number of patients	Deaths	Mortality (%)
Acute liver failure				
Amanita exitialis	8	25	13	52.00
Amanita fuliginea	4	9	0	0
Amanita cf. fuliginea	2	5	1	20.00
Amanita fuliginea or *Amanita rimosa*	4	14	1	7.14
Amanita pallidorosea	4	9	1	11.11
Amanita rimosa	2	4	0	0
Amanita subjunquillea	1	3	0	0
Amanita subpallidorosea	7	11	3	27.27
Galerina sulciceps	4	9	1	11.11
Lepiota brunneoincarnata	5	11	0	0
Rhabdomyolysis				
Russula subnigricans	15	54	1	1.85
Acute renal failure				
Amanita neoovoidea	1	2	0	0
Amanita oberwinklerana	9	18	0	0
Amanita pseudoporphyria	1	3	0	0
Gastroenteritis				
Agaricus cf. *arvensis**	1	1	0	0
*Agaricus subrufescens**	1	4	0	0
Other *Agaricus* spp.	4	10	0	0
Baorangia pseudocalopus	2	2	0	0
Chlorophyllum globosum	2	8	0	0
Chlorophyllum hortense	1	1	0	0
Chlorophyllum molybdites	54	126	0	0
Chlorophyllum molybdites and *Chlorophyllum hortense*	1	7	0	0
Entoloma omiense	8	31	0	0
Entoloma quadratum	1	2	0	0
Entoloma strictius	1	2	0	0
Entoloma sp.	1	3	0	0
Gerhardtia sinensis	2	6	0	0
Lactarius atrobrunneus	1	1	0	0
Lactarius torminosus and *Megacollybia clitocyboidea*	1	4	0	0
Lactifluus vellereus	1	7	0	0
Omphalotus guepiniformis	3	19	0	0
Porphyrellus cf. *holophaeus*	1	2	0	0
Russula cf. *emetica*	1	3	0	0
Russula foetens	3	8	0	0
Russula grata	1	2	0	0
Russula illota and *Entoloma* cf. *abortivum*	1	2	0	0
Russula japonica	26	68	0	0
Russula cf. *japonica*	10	43	0	0
Russula japonica and *Amanita sepiacea*	1	3	0	0

TABLE 1. (continued)

Mushroom species	Number of incidents	Number of patients	Deaths	Mortality (%)
Russula japonica and *Entoloma omiense*	1	1	0	0
Russula japonica and *Russula foetens*	3	7	0	0
Russula sp.	1	4	0	0
Scleroderma cepa	4	8	0	0
Scleroderma sp.	1	1	0	0
Suillus pictus	1	5	0	0
Sutorius flavidus	1	1	0	0
Sutorius sp.	1	3	0	0
*Tricholoma terreum**	3	6	0	0
Tylopilus neofelleus	1	1	0	0
Psycho-neurological disorder				
Amanita concentrica	4	6	0	0
Amanita melleiceps	1	5	0	0
Amanita rufoferruginea	2	4	1	25.00
Amanita subglobosa	3	10	0	0
Amanita cf. *subglobosa*	1	2	0	0
Amanita cf. *virgineoides*	1	1	0	0
Boletus cf. *bicolor*	1	9	0	0
Butyriboletus roseoflavus	1	7	0	0
Clitocybe sp.	4	14	0	0
Gymnopilus dilepis	2	3	0	0
Gymnopilus lepidotus	1	1	0	0
Gymnopilus sp.	2	2	0	0
Inocybe rimosa	2	4	0	0
Inocybe serotina	1	2	0	0
Inocybe squarrosolutea	1	1	0	0
Panaeolus fimicola and *Conocybe* sp.	1	2	0	0
Psilocybe cubensis	1	5	0	0
Psilocybe cubensis and *Panaeolus papilionaceus*	1	6	0	0
Psilocybe samuiensis	2	7	0	0
Psilocybe thaiaerugineomaculans	1	4	0	0
Photosensitive dermatitis				
Cordierites frondosus	2	3	0	0
Unclassified				
Amanita citrinoannulata	1	4	0	0
Amanita clarisquamosa	1	3	0	0
Amanita fritillaria	2	8	0	0
Amanita hamadae	1	1	0	0
*Lepista sordida**	1	1	0	0
*Macrocybe gigantea**	1	1	0	0
*Scleroderma yunnanense**	1	1	0	0
*Tolypocladium dujiaolongae**	3	9	0	0
Other mushrooms	12	46	0	0

* Species recorded as edible mushrooms.

rhabdomyolysis, and acute renal failure, and these species have drawn the most attention and been regarded as the most dangerous mushrooms.†

As displayed in Table 1, about 30 species causing gastroenteritis were identified. *Chlorophyllum molybdites* is the most common poisonous mushroom followed by *Russula japonica*, *Russula* cf. *japonica*, and *Entoloma omiense*. This study also confirmed that several recorded poisonous mushrooms were involved in poisoning incidents including *Entoloma quadratum*, *E. strictius*, *Lactarius atrobrunneus*, *L. torminosus*, *Lactifluus vellereus*, *Megacollybia clitocyboidea*, and *Suillus pictus*.

The 18 species from 8 genera causing psycho-neurological disorder were also identified (Table 1). *Amanita concentrica*, *Gymnopilus lepidotus*, *Inocybe serotina*, *I. squarrosolutea* and *P. thaiaerugineomaculans* were confirmed involving in poisoning incidents in China. *Inocybe serotina* and *P. thaiaerugineomaculans* were the first time recorded in China (*7*). *Cordierites frondosus* appeared from Yunnan and Guizhou provinces resulted in 2 incidents with photosensitive dermatitis.

The 8 species resulting in 11 incidents had been still not clear about their clinical classification (Table 1). *Amanita clarisquamosa* and *A. fritillaria* were previously recorded as poisonous mushrooms although their clinical classification remains poorly understood (*1*). Moreover, toxicity of *Amanita citrinoannulata* and *A. hamadae* had been not recorded (*1*,*8*–*9*). *Lepista sordida* and *Macrocybe gigantea* were deemed as edible mushrooms, but two people ate these two mushrooms and then exhibited gastrointestinal symptoms, which indicated that some edible mushrooms are toxic to some humans in certain circumstances (*1*). *Tolypocladium dujiaolongae*, a new species seen in China, was used as medicine (*10*), and nine patients from three independent incidents after eating this species showed gastrointestinal and psycho-neurological disorder symptoms. In one incident from Yunnan, left-over mushroom samples were identified as *Scleroderma yunnanense*, which is edible and often consumed in large quantities by local residents. This may possibly be due to a mixture of *Scleroderma* mushrooms being sold in the market and real poisonous mushroom samples not being obtained.

Discussion

Mushroom poisoning is becoming one of the most serious food safety issues in China. Mushroom poisonings are reported every month and concentrated from summer to autumn peaking in July. Southwestern and Central China are the most seriously affected areas, followed by Eastern and Southern China with noticeably lower levels in Northern, Northeastern and Northwestern China. Notably, Zhejiang in Eastern China has been viewed as the region with the fastest growing threat. About 70 species, including 7 newly recorded species causing 6 different clinical syndromes, were successfully confirmed. This study accumulated first-hand information of mushroom poisoning, which is considerably valuable for mushroom poisoning control, diagnosis, and treatments for patients and for popular science education for thousands of people who are potentially threatened by poisonous mushrooms.

Most mushroom poisoning incidents have favorable outcomes, only presenting with gastrointestinal or psycho-neurological disorder complaints and needing symptomatic treatments. Almost all deaths were caused by lethal mushrooms companied by acute liver failure and rhabdomyolysis (*6*). Lethal mushroom species causing acute liver failure were mainly concentrated in the genera of *Amanita*, *Galerina*, and *Lepiota* (*1*,*6*). The 12 species from *Amanita* section *Phaloideae* were discovered in China (*1*,*8*–*9*), and 6 recorded species and 1 species currently identified as *A.* cf. *fuliginea* were involved in mushroom poisoning in 2019 (Table 1, Supplementary Table S1). The 14 poisonous *Galerina* species were recorded in China (*1*,*11*), and the most common species was *G. sulciceps* which caused 4 incidents in 2019 (Table 1, Supplementary Table S1). Eight poisonous *Lepiota* species were recorded in China (*1*,*12*–*13*), and the most common species was *L. brunneoincarnata* (Table 1, Supplementary Table S1). *Russla subnigricans* and *Tricholoma equestre* could cause rhabdomyolysis, and the former species is the most common resulting in at least 50 deaths in the last 2 decades in China (*6*,*14*).

Accurate and timely species identification is of pivotal importance in mushroom incidents. Unfortunately, previous studies suggested that the rate of correct species identification in mushroom incidents was considerably low, between 5% and 27%, or even lower (*15*). Of the 212 reported incidents from 2010 to 2014 in China, the mushrooms were scientifically identified only in 2 incidents (*3*). In recent years, a large number of mycologists have begun participating

† Supplementary Table S1 (available in http://weekly.chinacdc.cn) summarized their spatial and temporal distribution.

in mushroom poisoning in China, which has greatly benefitted mushroom poisoning control. Beginning in 1996, a 24 hour/365 day on-call mycological service became available in northern Italy, which has helped with the identification of poisonous mushroom in 89.6% of incidents (*15*). A similar poisoning-counselling service (010-83132345) became available in China in 1999 and plays a crucial role in mushroom poisoning control.

In Europe, mushroom poisoning risk dramatically increased and was ascribed to recent mass immigrations to Europe (*2*). Likewise, thousands of foreigners come to China every year and the three mushroom poisoning incidents involving Burmese people in 2019 drew attention to the need for targeted science and health education for foreigners in addition to local residents.

The incidents investigated in this report only represent a portion of the variety of mushroom poisonings happening every year. More effort and continued cooperation are needed urgently from local and national governments, CDC staff, doctors, and mycologists to properly control mushroom poisoning events.

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Outbreak Reports

A Cluster of Rhabdomyolysis Syndrome Resulting from Carp Consumption in Gongcheng Yao Autonomous County, Guangxi, 2016

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Summary

What is already known about this topic?

A common food that has been associated globally with rhabdomyolysis syndrome is freshwater fish including freshwater cod, barracuda, buffalo fish, and pomfret. However, cases caused by freshwater fish have been relatively rare in China.

What is added by this report?

In this investigation, a cluster of five cases of rhabdomyolysis syndrome were found that were linked to consumption of carp testes and eggs, one of the first carp-related rhabdomyolysis syndrome cases reported in China.

What are the implications for public health practice?

To avoid similar incidents, food safety education for local residents needs to be prioritized and implemented. In addition, case monitoring of rhabdomyolysis syndrome should be strengthened through more thorough collection of epidemiological data and monitoring of pathogenic foods.

Background

Rhabdomyolysis syndrome is a condition where skeletal muscle breaks down rapidly and results in symptoms including muscle pain, weakness, vomiting, and excessive creatine kinase (CK) levels in the blood. Five villagers in Ping'an village, Gongcheng Yao Autonomous County, Guangxi Zhuang Autonomous Region, experienced an onset of symptoms indicative of rhabdomyolysis syndrome including vomiting, backache, lumbago, and CK levels exceeding five times the normal range after dinner on November 7, 2016. This dinner is suspected to be the common exposure event for this cluster. In order to verify the incident and find the cause of the disease, a team of health professionals arrived at the scene for investigation on November 10.

Investigation and Results

The case definitions for this investigation were established as the following (*1*): suspected cases were those who had onset of systemic or local muscle pain, fatigue, brown urine, and other symptoms related to rhabdomyolysis syndrome with unknown specific-causes; clinically-confirmed cases were those with levels of CK at least five times higher than that of the normal range upper limit. The investigation team conducted case searches door-to-door in Ping'an village.

Five clinically confirmed cases were found, with an incidence of 5.1% (5/98). The main symptoms were onset of muscle soreness 5/5), vomiting (4/5, 1–3 times), brown urine (4/5), and fatigue (3/5). Clinical examination showed that CK increased more than 5 times (5/5, value is 1,389–4,073 U/L), leukocyte count increased (5/5), and myoglobin increased (4/5).

The first case occurred at 19:30 on November 7, and the last case occurred at 01:00 on November 8. The event lasted for 5.5 hours. The epidemiological curve's distribution suggested a point source exposure. There was no history of joint exposure except for dinner on the evening of November 7 for the 5 cases, which was then confirmed as the exposure event. The median incubation period from consumption to onset of symptoms was 5 hours (range: 0.5–6 hours).

On November 7, 2016, a total of 6 persons from two families consumed the hotpot containing carp, vegetables, and dumplings together. Patient A caught the carp in his own pond and prepared the carp while retaining the testes, eggs, and swim bladder, which are often consumed. Patient A then fried the parts of the carp with oil and then boiled them in a pot of water for ten minutes. Afterwards, the vegetables and dumplings were added to the pot to be boiled for five minutes. One person only consumed the vegetables and dumplings and did not fall ill, while the five others who consumed parts of the carp fell ill. In addition to these two families, patient A also shared the remaining parts of the carp with two neighbor families consisting of nine addition people, but the neighbors prepared the carp separately and consumed only the fish's flesh. These additional nine people exhibited no related symptoms or disease.

Using a retrospective cohort study design, eating carp testes (RR=10.99, 95% CI*: 1.70–71.28) and carp eggs (RR=6.00, 95% CI: 1.69–21.26) were found to be risk factors for the disease (Table 1). To study the relationship between CK value and food intake, the investigation team took photos of various carp meat samples weighing 10 g, 30 g, and 50 g to help patients recall their level of consumption before the onset of symptoms. The results showed that CK levels were positively correlated with total recalled intake of carp testes and eggs (Pearson correlation coefficient r=0.98, p=0.04) (Figure 1).

Further investigation of the external environment, i.e. the pond where the carp was raised, showed that the water levels were extremely low and had accumulated high levels of algae. In addition, a large quantity of abandoned bait, fishing materials, pesticides, fertilizer, and other packaging bags were found in the vicinity. Samples from the pond and from the hotpot leftovers were collected, but due to a lack of hypothesis on pathogenic factors and direction for the investigation, a determination could not be made. However, the above samples were stored by Gongcheng County CDC for possible future testing.

Discussion

This cluster of rhabdomyolysis syndrome likely results from the consumption of carp. Consumption of the carp testes and eggs was associated with higher risk of disease, and because those who did not consume these parts of the carp did not exhibit disease symptoms, testes and egg consumption are likely risk

TABLE 1. Risk analysis between consuming different parts of carp and rhabdomyolysis syndrome in Ping'an village, Gongcheng Yao Autonomous County, Guangxi, 2016. (N=15).

Part of carp	Consumers		Non-consumers		Attack rate (%)		RR (95% CI)	Fisher's exact test
	Case	Total	Case	Total	Consumers	Non-consumers		
Flesh	5	12	0	3	41.7	0	Undefined	p=0.510
Swim bladders	2	4	3	11	50	27.3	1.83(0.46−7.25)	p=0.560
Testes	4	4	1	11	100	9.1	10.99(1.70−71.28)	p=0.004
Eggs	3	3	2	12	100	16.7	6.00(1.69−21.26)	p=0.020

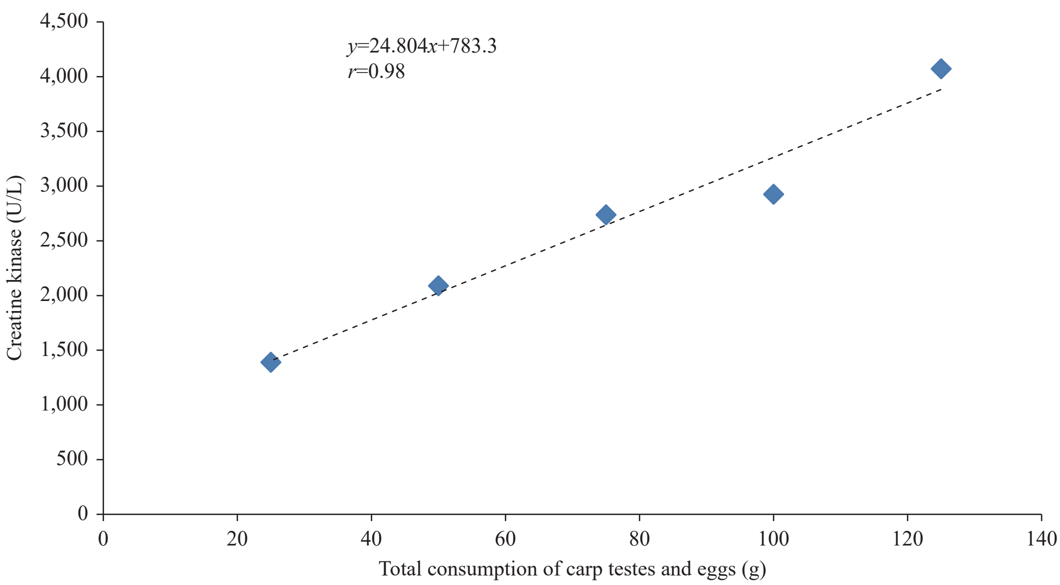

FIGURE 1. Analysis of the correlation between creatine kinase value of rhabdomyolysis syndrome patients and total recalled consumption of carp testes and eggs in Ping'an village, Gongcheng Yao Autonomous County, Guangxi, 2016.

* CI=Confidence Interval.

factors. Following the line of our investigation, the consumption of vegetables and dumplings in this event could also be excluded from consideration as risk factors.

Common foods causing rhabdomyolys is syndrome are often freshwater fish such as cod and barracuda in Baltic regions (*2*), buffalo fish in the United States (*3*), and the freshwater pomfret and "olho de boi" fish in Brazil (*4–5*). In China, the common food-related cause of rhabdomyolysis syndromeis crawfish (*6–9*), and cases caused by freshwater fish are relatively rare. A case of rhabdomyolysis syndrome caused by consuming freshwater pomfret had been reported in Guangdong province (*10*), but cases related to consumption of carp have not been previously reported. At present, the etiology and pathogenes is of food-borne rhabdomyolysis syndrome are not clear.

To prevent the recurrence of similar events, the following suggestions should be considered. First, food safety publicity and education of local residents should be prioritized and strengthened in order to advise against the consumption of carp testes and eggs. Second, case monitoring of food-borne rhabdomyolysis syndrome should be strengthened through the collection of more epidemiological data concerning pathogenic foods. Finally, common factors among all kinds of pathogenic foods need to be explored and determined in order to provide new ideas and methods for the study of pathogenic factors and pathogenesis of food-borne rhabdomyolysis syndrome.

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Perspectives

The Practice of the Public Health Cooperation in the Republic of Sierra Leone: Contributions and Experiences

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Since the outbreak of Ebola virus disease (EVD) in three countries in West Africa, China CDC has conducted two phases of technical cooperation projects based on the Sierra Leone-China Friendship Biological Safety Laboratory (SLE-CHN BSL-3 Lab) in the Republic of Sierra Leone (*1–2*). Phase I was conducted from July 2015 to June 2017, while Phase II started in July 2017 and will continue to June 2020. In total, 85 Chinese public health specialists have been dispatched to Freetown, the capital city of Sierra Leone, with 80 serving for 6 months and 5 serving for a year. Most Chinese staff came from China CDC and the remaining roughly 15% came from different provincial-level CDCs. This report summarizes major developments to Sierra Leone's public health field and comments on experiences obtained from the joint effort.

Contributions

The collaboration between China CDC and the Sierra Leone Ministry of Health and Sanitation (Sierra Leone MoHS) has yielded several major developments to help confront infectious disease threats.

First, the local laboratory capacity for determining pathogens was greatly increased. Before the outbreak of EVD, only a few pathogens could be determined via laboratory tests in Sierra Leone, such as malaria, Lassa fever, HIV, tuberculosis (TB), and hepatitis B virus (HBV). Some other diseases, such as Marburg virus disease and Monkeypox, needed to be diagnosed in labs in other countries, usually receiving feedback months later. Since a SLE-CHN BSL-3 Lab was established, the methodologies to determine Ebola virus, malaria, and more than 24 various viruses and 10 bacteria were established. Those remarkably increased the laboratory diagnostic capacity for infectious diseases in Sierra Leone.

Second, following the EVD outbreak, SLE-CHN BSL-3 Lab was conferred as the national reference laboratory for viral hemorrhagic fevers, which has helped ensure health security. More than 200 specimens from patients suspected as Ebola or other fatal hemorrhagic fever were submitted by the Sierra Leone MoHS for diagnosis or distinguishing diagnosis since the beginning of Phase II. Among them, 106 samples were tested between July 2018 and June 2019. All specimens were tested immediately in SLE-CHN BSL-3 laboratory and the results were returned within 12 hours. No Ebola virus was detected, whereas two cases of Monkeypox were identified by the real-time PCR (RT-PCR) assays. Those two cases of Monkeypox were the fourth and fifth cases to appear since the initial case of Monkeypox in Sierra Leone (*3*). Moreover, the positive results of RT-PCR for Monkeypox were confirmed using Nanopore DNA sequencing assays. This irreplaceable laboratory capacity significantly enhanced the emergency response capability of Sierra Leone for public health events. The capacity of the SLE-CHN BSL-3 Lab was also highly recognized and praised by local colleagues and Sierra Leone MoHS.

Third, several active pathogenic surveillance networks were established, including surveillance for patients with fever, surveillance for patients with bacterial diarrhea, environmental surveillance for mosquitos, and environmental surveillance for water. The surveillance networks covered Freetown, Bo, and Kenema with 10 sentinel hospitals (Figure 1). Collected samples and information sheets were transferred to the laboratory once a week. The main detecting pathogens in the surveillance networks for patients with fever were Ebola, Lassa fever, Marburg, Rift Valley Fever, Chikungunya, Dengue, Zika and Yellow fever viruses, while the bacterial pathogens in the surveillance for diarrhea were *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Salmonella*, *Shigella*, and diarrheagenic Escherichia coli (DEC).

More than 9,000 serum samples were collected and roughly 17,000 tests of RT-PCR were performed during Phase II so far. Outside of five positive samples of Lassa fever virus collected from Kenema, no other fatal viruses were detected from those serum samples. Between January and June of 2019, 3,791 serum

FIGURE 1. Distribution of 10 sentinel hospitals for syndromic surveillance of patients with fever or bacterial diarrhea.

samples were tested with malaria rapid detecting technique. The positive rate of malaria in outpatients with fever was 16.2% (614/3,791), in which the positive rate in Freetown was 16.1% (416/2,586), in Bo was 19.8% (137/692), and in Kenema was 11.9% (61/513). A total of 65 stool samples were collected from the patients with diarrhea and bacteria cultures were performed. A total of 2 strains of *Vibrio parahaemolyticus*, 10 strains of diarrheagenic Escherichia coli (4 strains of enterotoxin of DEC, 2 strains of enteroinvasive *E. coli*, 4 strains of enteroaggregative *E. coli*) were isolated. No *Vibrio cholerae*, *Salmonella, Shigella* were isolated from the stool samples. One strain of *Salmonella* was isolated from the blood sample of a fever patient.

Fourth, public health personnel capacity was improved. Since the implementation of Phase I in July 2015, multiple training courses had been conducted in Sierra Leone, which covered a broad range of preventive and clinical medicines, such as leading capacity, control and prevention for infectious diseases, clinical management for infectious diseases, emergency response for public health events, malaria control, molecular diagnosis, pathogen determination, and identification and diagnosis techniques for many special infectious diseases. At the National Training Center for Biosafety, several training courses of biosafety and biosecurity, laboratory management and quality control also had been conducted. A total of 356 Sierra Leone professionals attended the various training courses.

In total, 12 young Sierra Leone professionals have worked in SLE-CHN BSL-3 Lab, and 3 of them have received scholarships for master or doctoral programs. Most of them joined the SLE-CHN BSL-3 Lab without any experience for laboratory. Through attending various training courses, particularly in-person training and daily laboratory work, several young staff have already mastered operating skills for BSL-2 laboratories, with some mastering even BSL-3 laboratory skills, as well as principles for laboratory biosafety and management.

Finally, the collaboration between China and Sierra Leone yielded a platform for international communication and cooperation. Several international collaborating studies were conducted, such as an evaluation of the rapid diagnostic test for Ebola virus and for Ebola RNA persistence in semen from survivors (*4*). In addition, comprehensive discussions and communications are carried out with various international organizations such as the World Health Organization (WHO) Sierra Leone Office, World

Bank, United Nations International Children's Emergency Fund (UNICEF), The Joint United Nations Programme on HIV and AIDS (UNAIDS), US CDC, United States Agency for International Development (USAID), European Research Council, Department for International Development (DFID) UK, and German Agency for International Cooperation.

Two separate international workshops were held in Freetown at the end of 2018, which were sponsored by China CDC and the Bill & Melinda Gates Foundation. One workshop focused on the birth dose for HBV vaccination, and the other focused on malaria control and prevention. Dozens of specialists from China CDC, WHO, WHO-AFRO, Global Alliance for Vaccines and Immunization (GAVI), US CDC and other African countries participated in the meetings. Strategies and techniques for control of HBV and malaria as well as possible future opportunities for collaboration were deeply discussed.

Experiences

Infectious diseases, particularly emerging infectious diseases, should be the highest priority as they directly affect global health security. In the past 15 years after the severe acute respiratory syndromes (SARS) outbreak, numerous emerging and re-emerging infectious diseases have caused regional or global concerns, such as Ebola, Middle East respiratory syndrome (MERS), pandemic influenza, and Zika. Review of the emergence of new infectious diseases in China in the past years also illustrates that the majority are imported cases, e.g., poliovirus (wild-type) in 2011 (*5*), MERS in 2015 (*6*), Zika in 2016 (*7*), and yellow fever in 2016 (*8*). Control and prevention of cross-border transmission, especially long-distance transmission of infectious diseases, became one of the most important topics for global health security.

Besides Ebola, many other fatal infectious diseases including Marburg fever, Lassa fever, Yellow fever, Monkeypox, and Cholera, continually threaten regional and global health security (*9–10*). Timely identification, recognition and determination of the pathogens, and proper and efficient implementation of local response measures are critical for any outbreak of infectious disease that has potential to spread regionally and globally. Therefore, increasing the capacity of rapid response to emerging infectious diseases in each country in the African continent is crucial for global health security.

In addition to emerging infectious diseases, other traditional infectious diseases such as malaria, HIV/AIDS, and respiratory TB are still major public health problems and have high disease burdens in many African countries. According to WHO, over 61% of global HIV-related mortality is found in Africa in 2018 (*11*), while that of malaria is approximately 93% (*12*). Lack of nutrition, environmental pollution, and safe water supply are also recurring issues. Although these challenges are improving due to concerted effort from the international community, the problems are still far from being solved. Improving the efficiency and effectiveness of future China-Africa cooperation is also a major challenge for Chinese public health staff.

Cooperative projects in public health also require an in-dept understanding of local circumstances and requirements. Proper communication and adjustments can ensure the smooth implementation of surveillance projects, though further improvements in sensitivity and quality still need to be made for many of these systems. Furthermore, involving local staff provides several advantages as many Chinese public health staff benefitted from collaborating with local colleagues to overcome language barriers, to communicate knowledge of local culture and circumstances, and offer invaluable suggestions and comments.

China is still a relatively young partner as involvement in the field of global health was prioritized relatively recently (*13*). Many aspects of global health collaboration remain to be learned and to be adjusted to, and active communication with international partners will benefit mutual understanding and cooperation. China CDC will continually focus on public health cooperation with African countries to strengthen their public health system and the capabilities of African public health personnel with the aim of supporting African countries to achieve the African Union 2063 Agenda and the Sustainable Development Goals of the United Nations.

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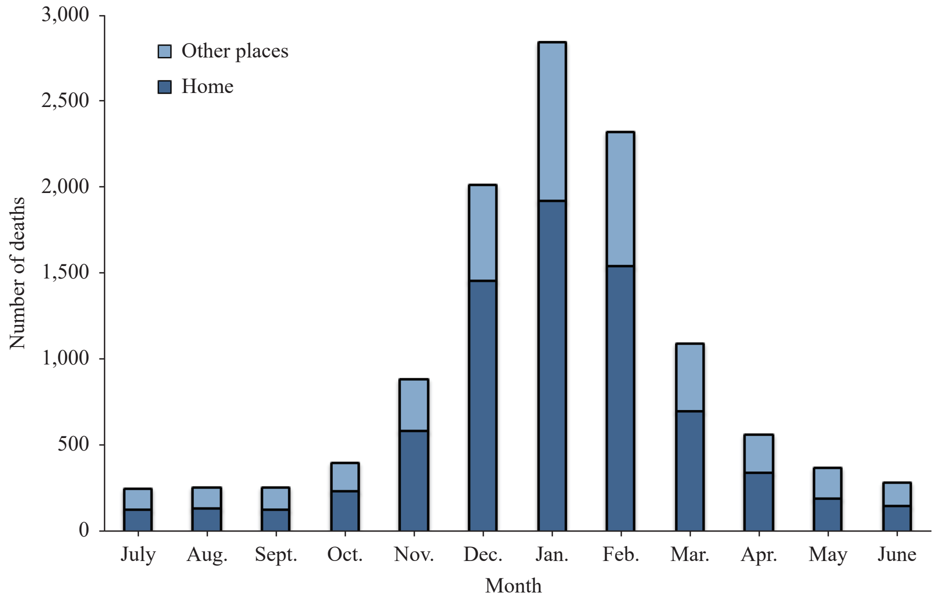
Key Statistics

National Center for Chronic and Noncommunicable Disease Control and Prevention

Number of Deaths due to Carbon Monoxide Poisoning* by Month and by Place of Death† — China, 2018



*Deaths from carbon monoxide poisoning are identified using the International Classification of Diseases, Tenth Revision (ICD-10) underlying cause of death codes T58 and X47.

†Based on the ICD-10 underlying cause of death codes, dying at home is defined using the code X47.0 and dying in other places is defined using codes T58 and X47 excluding X47.0.

In 2018, there were 11,523 deaths caused by carbon monoxide poisoning reported in China, with the highest number of deaths in January (2,845), February (2,321), and December (2,010). The proportions of carbon monoxide poisoning deaths occurring at home were far higher than that of other places in the winter with the highest proportions occurring in December (72.59%), January (67.42%), and February (66.48%). The proportion of deaths occurring at home remained stable in the summer months such as June (51.41%), July (50.00%), and August (52.78%). This suggests carbon monoxide poisoning in winter months needs further attention and awareness.

Source: China Cause of Death Reporting System (CDRS), 2018.

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