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中国疾病预防控制中心周报

Contents

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,

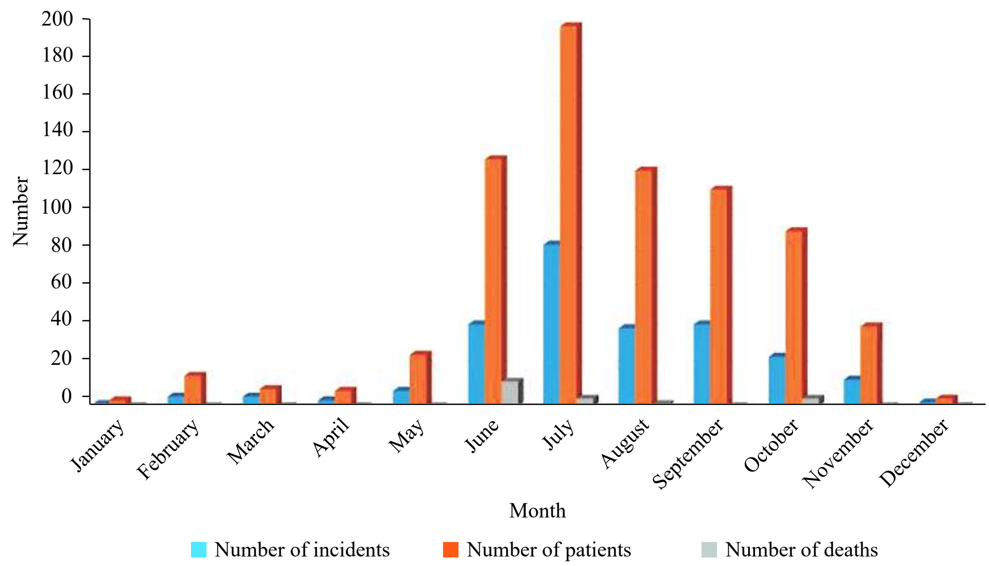

FIGURE 1. Monthly distribution of mushroom poisoning in China, 2019.

[*] 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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SUPPLEMENTARY TABLE S1. Spatial and temporal distribution of 13 lethal mushrooms causing poisoning incidents in China, 2019.

Mushroom species	Time of poisoning	Distribution（City, Province）	Remarks	References
Acute liver failure				
Amanita exitialis	March 3, 2019	Shenzhen, Guangdong	*Amanita exitialis*, the most common lethal mushroom in Guangdong, is called the "Guangzhou Destroying Angel". It grows in broad-leaved forest, and often appears in Guangdong from March to May. Remarkably, it was first found in tropical Yunnan areas (Dehong, Baoshan, Puer, etc.) in June to July every year and usually grows in subtropical Yunnan areas (Chuxiong, Dali, etc.) in July to early August, occasionally even late to early October (Kunming). This species also caused an incident in Qiannan, Guizhou Province in early June 2017.	(6,8–9) and this study
	March 7 , 2019	Shenzhen, Guangdong		
	June 11, 2019	Dehong, Yunnan		
	June 20, 2019	Dehong, Yunnan		
	June 29, 2019	Baoshan, Yunnan		
	June 30, 2019	Dehong, Yunnan		
	July 13, 2019	Baoshan, Yunnan		
	July 28, 2019	Chuxiong, Yunnan		
Amanita fuliginea	June 10, 2019	Xiangtan, Hunan	*Amanita fuliginea*, one of the most common lethal species in central China, is called "East Asian Brown Death Cap". It is recognized as the most dangerous species in Hunan Province in June. The species, widely distributed in Eastern, Central, Southern, and Southwestern China (Anhui, Fujian, Guangdong, Hunan, Jiangxi, Sichuan, Yunnan, and Zhejiang, etc.), grows in broad-leaved or mixed forests with Fagaceae and Pinaceae and appears from late spring, summer to autumn.	(6,8–9) and this study
	June 11, 2019	Chenzhou, Hunan		
	June 22, 2019	Changde, Hunan		
	July 18, 2019	Hangzhou, Zhejiang		
Amanita cf. *fuliginea*	June 26, 2019	Qiannan, Guizhou	Morphologically, *Amanita* cf. *fuliginea* is similar to *A. fuliginea*, but this species has distinctly larger basidiomata and different microstructures. Phylogenetic analyses also confirm it is different from *A. fuliginea*. Further studies are needed for its accurate identification and thus it is temporarily named as "*A.* cf. *fuliginea*" in this study.	This study
	June 28, 2019	Qiannan, Guizhou		
Amanita pallidorosea	June 26, 2019	Qiannan, Guizhou	*Amanita pallidorosea* is a common lethal mushroom distributed in northeastern, eastern, northwestern, central and southwestern China (Anhui, Gansu, Guizhou, Henan, Hubei, Jilin, Liaoning, Shaanxi, Shandong, and Yunnan). It is called "Pale-Rose Death Cap" because of its pale red pileus. This species grows in broad-leaved or mixed forests with Fagaceae and Pinaceae and appears from late June to mid-September.	(6,8–9) and this study
	July 10, 2019	Enshi, Hubei		
	July 16, 2019	Bijie, Guizhou		
	July 17, 2019	Zunyi, Guizhou		
Amanita rimosa	July 8, 2019	Qiannan, Guizhou	*Amanita rimosa*, a common lethal mushroom distributed in eastern, central, southern, and southwestern China (Guangdong, Guizhou, Hainan, Hubei, Hunan, Jiangxi, and Zhejiang), is called "Splitting Death Cap". It is considered as one of the most dangerous species in Guizhou, Hunan, Hubei, and Zhejiang from June to July, where poisoning incidents caused by this species happened frequently. This species grows in broad-leaved or mixed forests with Fagaceae and Pinaceae and appears from mid-May to mid-September.	(6,8–9) and this study
	July 24, 2019	Shaoxing, Zhejiang		
Amanita subjunquillea	August 21, 2019	Zibo, Shandong	*Amanita subjunquillea*, the most widely distributed lethal amanita in China including Anhui, Beijing, Gansu, Guizhou, Hebei, Henan, Hubei, Inner Mongolia, Jilin, Liaoning, Shaanxi, Shandong, Shanxi, and Yunnan, is called "East Asian Death Cap". It grows in broad-leaved forests dominated by Fagaceae and appears from July to mid-September.	(6,8–9) and this study

TABLE S1. (continued)

Mushroom species	Time of poisoning	Distribution(City, Province)	Remarks	References
Amanita subpallidorosea	October 16, 2019	Zunyi, Guizhou	*Amanita subpallidorosea* is only discovered from Guizhou, Hubei, Hunan, and Taiwan in China. It grows in broad-leaved forests dominated by Fagaceae and appears from September to early November. This species has become the first mushroom killer in Guizhou Province from late autumn to early winter.	(6,8–9) and this study
	October 21, 2019	Zunyi, Guizhou		
	October 22, 2019	Zunyi, Guizhou		
	October 27, 2019	Zunyi, Guizhou		
	October 27, 2019	Zunyi, Guizhou		
	October 27, 2019	Zunyi, Guizhou		
	November 1, 2019	Zunyi, Guizhou		
Galerina sulciceps	October 5, 2019	Chengdu, Sichuan	*Galerina sulciceps* is the most common poisonous species from the genus *Galerina* in China. It is distributed in Central, Northern, and Southwestern China (Beijing, Guizhou, Hubei, Jiangxi, Sichuan, and Yunnan). This species grows on rotten wood or even on sawdust and appears from late June to early December.	(6,11) and this study
	November 19, 2019	Zunyi, Guizhou		
	November 21, 2019	Enshi, Hubei		
	December 6, 2019	Zunyi, Guizhou		
Lepiota brunneoincarnata	April 30, 2019	Zhuzhou, Hunan	*Lepiota brunneoincarnata* is the most common poisonous species from the genus *Lepiota* in China. It is widely distributed in Northeastern, Northern, Northwestern, Eastern, and Central China (Beijing, Gansu, Hebei, Hunan, Jiangsu, Jilin, Liaoning, Ningxia, Shandong, Shanghai, Shanxi, Xinjiang, and Zhejiang, etc.). Previously, this species is discovered only from temperate areas including Northeastern, Northern, and Northwestern China. Recent years, it also caused several poisoning incidents in subtropical areas, including several provinces of Eastern and Central China. Further studies are needed for its geographic expansion. *L. brunneoincarnata* grows in pine forest and appears from late April to early September.	(6,12) and this study
	July 2, 2019	Shanghai		
	July 2, 2019	Zhejiang		
	July 16, 2019	Suzhou, Jiangsu		
	August 30, 2019	Shanxi		
Rhabdomyolysis				
Russula subnigricans	July 14, 2019	Yongzhou, Hunan	*Russula subnigricans* is the most common poisonous mushroom leading to rhabdomyolysis in China. It is widely distributed in Northern, Eastern, Central, Southern, and Southwestern China (Chongqing, Fujian, Gansu, Guangdong, Guizhou, Hainan, Hunan, Jiangxi, Shandong, Taiwan, Yunnan, and Zhejiang, etc.). This species grows in broad-leaved or mixed forests with Fagaceae and Pinaceae and appears from June to September.	(6,14) and this study
	July 16, 2019	Changsha, Hunan		
	July 17, 2019	Yongzhou, Hunan		
	July 22, 2019	Yongzhou, Hunan		
	August 6, 2019	Zhejiang		
	August 12, 2019	Miluo, Hunan		
	August 13, 2019	Huzhou, Zhejiang		
	August 16, 2019	Wenzhou, Zhejiang		
	August 18, 2019	Changsha, Hunan		
	August 19, 2019	Chongqing		
	August 21, 2019	Baoshan, Yunnan		
	August 22, 2019	Changde, Hunan		
	August 23, 2019	Chongqing		
	August 28, 2019	Nanping, Fujian		
	September 1, 2019	Hangzhou, Zhejiang		
	September 6, 2019	Huzhou, Zhejiang		

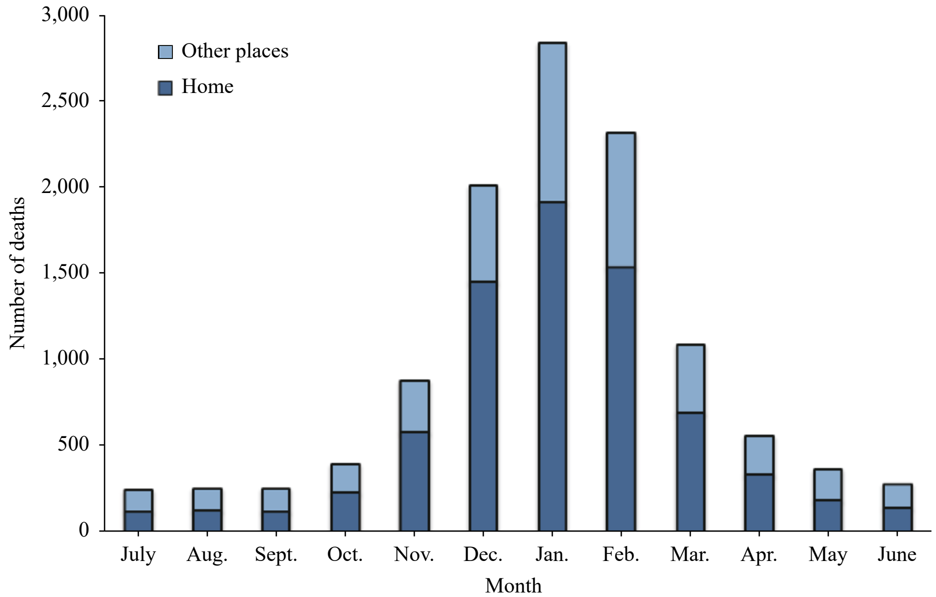
TABLE S1. (continued)

Mushroom species	Time of poisoning	Distribution（City, Province）	Remarks	References
Acute renal failure				
Amanita neoovoidea	June 19, 2019	Dehong, Yunnan	*Amanita neoovoidea*, a common poisonous mushroom distributed in Eastern, Central, Southern, and Southwestern China (Anhui, Fujian, Guangdong, Guangxi, Hunan, Jiangxi, Sichuan, and Yunnan), is called “East Asian Egg Amidella ”. It is regarded as edible in Japan and some areas in Anhui Province, China. But in recent years, several poisoning incidents happened after eating this species and thus, it cannot be removed from poisonous mushroom list. This species grows in pine, broad-leaved, or mixed forests and appears from June to October.	(*6*,*8*–*9*) and this study
Amanita oberwinklerana	June 24, 2019	Guiyang, Guizhou	*Amanita oberwinklerana*, the most common poisonous mushroom causing acute renal failure in China, is called “Oberwinkler's Destroying Angel ”. It is distributed in Northeastern, Central, Eastern, Southern, and Southwestern China (Anhui, Guangdong, Guizhou, Hainan, Hubei, Hunan, Jiangsu, Jilin, Taiwan, Yunnan, and Zhejiang). This species grows in broad-leaved or mixed forests with Fagaceae and Pinaceae and appears from July to September.	(*6*,*8*–*9*) and this study
	June 30, 2019	Guiyang, Guizhou		
	July 1, 2019	Changde, Hunan		
	July 2, 2019	Changde, Hunan		
	July 8, 2019	Yichang, Hubei		
	July 9, 2019	Changde, Hunan		
	July 11, 2019	Changde, Hunan		
	July 19, 2019	Huzhou, Zhejiang		
Amanita pseudoporphyria	June 28, 2019	Changsha, Hunan	*Amanita pseudoporphyria*, the most widely distributed mushroom causing acute renal failure in China, is called “Hongo's False Death Cap ”. It is distributed in Northern, Central, Eastern, Southern, and Southwestern China from tropical, subtropical to temperate areas (Beijing, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Henan, Hunan, Jiangsu, Jiangxi, Sichuan, and Yunnan). This species grows in scattered pine, broad-leaved, or mixed forests with Fagaceae and Pinaceae and appears from June to September.	(*6*,*8*–*9*) and this study

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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Outbreak Reports

Poisonings Caused by Wild Mushroom Containing Amanitin Toxins — Shaoxing City, Zhejiang Province, China, 2019

Xiaomin Xu[1]; Liang Sun[1]; Yizhe Zhang[2]; Jiayang Song[2]; Chao Xing[3]; Hongshun Zhang[2,#]

Summary

What is already known about this topic?

Among all food poisoning, poisonings caused by wild mushrooms containing amanitin toxins have the highest case fatality rate. Amanitin toxins can cause acute liver function damage, and symptoms of the poisoning can include vomiting and diarrhea in early stages and progressive liver damage 2–3 days later.

What is added by this report?

Before 2019, there were about 1–2 cases of wild mushroom containing amanitin toxins poisoning each year in Zhejiang Province. In 2019, 10 cases were identified through disease investigation and toxin detection and biological identification in Shaoxing City, Zhejiang Province. All patients had a history of wild mushroom consumption.

What are the implications for public health practice?

In the summer, some people collect the wild mushrooms for consumption. In China, about 20 species of mushrooms can cause death, and most people lack the ability to identify which mushrooms are edible. To combat this, effective science popularization and prevention and control work will be able to reduce the occurrence of related poisoning events.

BACKGROUND

From June 28 to July 15, 2019, 3 suspected poisoning events continuously occurred in Shaoxing City, Zhejiang Province, China. A total of 10 patients with different degrees of liver damage were found, and 1 patient died so the case fatality rate was 10%. The agencies for disease control and prevention formed a team to investigate this incident. Using a combination of epidemiological investigations, laboratory toxin analysis, and biological identification results of poisonous samples, the poisoning events were determined to be caused by the ingestion of a wild mushroom (*Amanita rimosa*) containing amanitin toxins. Through popular science publicity and education on wild mushroom poisonings and the prohibition of wild mushroom collection/consumption, similar poisoning events were reduced until the middle of August.

INVESTIGATION AND RESULTS

The Xinchang County CDC of Shaoxing City, Zhejiang Province, received an event report from a local hospital that 6 patients in a family went to a doctor with suspected food poisoning on June 29, 2019. The local CDC in Shaoxing immediately carried out an epidemiological investigation and found that the patients had the gastrointestinal irritation symptoms including nausea, vomiting, and diarrhea in the early stages. The patients then developed different degrees of liver function damage with symptoms including abnormal increase of glutamic pyruvic transaminase and glutamic oxaloacetic transaminase between 40–72 hours following consumption. One patient was found to be in severe condition upon rescuing and died. All other patients had improved conditions after medical treatments and were discharged from the hospital one week later. On July 11, the Shaoxing City CDC received a report from that local hospital of another 2 patients with similar symptoms. The national, provincial, and local CDC organized a joint survey team to carry out an epidemiological investigation.

From June 22 to July 25, 2019 in Shaoxing City, Zhejiang Province, case searching was carried out. The criteria included patients with symptoms of gastrointestinal irritation such as nausea, vomiting, and diarrhea appearing in early stages and then progressing to acute liver function damage within 12–72 hours with no obvious fever in the course of the disease.

The professionals of the local CDC carried out case searching in medical institutions within their jurisdiction by interviewing the patients that met the case definition, their families, and the medical staff involved in the treatment of the patients, collecting their medical records, and making household hygiene survey in the villages where the incidents occurred. The plasma/urine samples of the patients were collected and detected with α-amanitin by the Zhejiang Provincial CDC. Wild mushrooms were collected and detected as poisonous by the Zhejiang Provincial CDC and was identified with molecular biology by China CDC.

Until July 25, a total of 10 patients meeting the case definition were found including 6 patients in Xinchang County, 2 patients in Keqiao District, and 2 patients in Zhuji County.

All patients came from three families in Shaoxing City, which lived tens of kilometers apart. The members of the three families did not know each other, nor did they have any other common exposure factors. All patients became sick 10–22 hours after their family dinners. The consumption dates for three families were on June 27–28, July 10, and July 15. Family members who did not participate in the dinner did not become sick.

Field investigations revealed that the meals of the three families were relatively simple and mainly included fried vegetables, soups, and staple foods such as rice. All foods were cooked and eaten as soon as possible, and no individuals were in contact with raw or cold foods. The wild mushrooms were collected on mountains near their residence and were one of the main foods. From June 27 to 28, 7 people had dinner together in Xinchang County, 1 person ate noodles cooked with wild mushrooms, 6 persons (including the aforementioned individual) ate wild mushroom soup containing bamboo, and these 6 persons became sick; the remaining individual was a child who did not consume the wild mushroom and developed no disease. On July 10, 2 individuals in Keqiao District picked and ate a variety of cooked wild mushrooms for dinner. On the morning of July 11, both became sick. On July 15, 2 persons in Zhuji County ate wild mushroom soup collected by themselves for lunch and dinner, and both presented poisoning symptoms. Besides wild mushroom consumption, there were no other shared risk factor exposures between the patients. Therefore, wild mushroom consumption was identified as the exposure risk factor.

The morbidity timeline, place, and population distribution of poisoning patients are shown in Table 1.

Through interviewing the patients and their family members in three families, we found that all the wild mushrooms eaten by the patients were picked in the mountains near their residence and were white mushrooms with similar biological morphology. The investigation team immediately collected mushroom samples in the fields the patients identified. The mushrooms were confirmed by the patients and were sent to the laboratory for toxin detection and biological identification.

The clinical characteristics of all patients were as follows: 1) The latent period was between 10 hours and 22 hours; 2) the initial symptoms were gastrointestinal irritation including nausea, vomiting, abdominal pain, diarrhea, etc.; 3) 36–72 hours post-consumption of wild mushroom, liver function damage appeared and a death occurred as a result of acute liver failure; 4) about a week after of symptomatic support treatment, the liver function of the patients gradually recovered; and 5) there were no fever symptoms in the course of disease. The development of clinical symptom was consistent with the characteristics of acute toxic liver damage (*1*–*3*).

The clinical manifestations of poisoning patients are shown in Table 2.

The patients' plasma samples from their first day in the hospital were collected. The mushroom toxin α-amanitin in samples were detected by liquid chromatography with tandem mass spectrometry (LC-MS/MS). The toxins were found in 8 patients' plasma samples. The contents of α-amanitin in plasma were between 0.016–1.11 ng/mL. The toxins could not be

TABLE 1. The morbidity time, place, and population distribution of the poisoned patients

Meal events	Total number at meal	Number of consuming wild mushrooms	Poisoned patients	Poisoning sites	Time of consumption	Time of first case	Time of last case	Latent period (hours)
Xinchang 1	1*	1	1	Home	Jun 27, 7:00	Jun 27, 17:00	–	10
Xinchang 2	7	6	6	Home	Jun 28, 18:00	Jun 29, 5:00	Jun 29, 16:00	11−22
Keqiao 1	2	2	2	Home	Jul 10, 17:00	Jul 11, 8:00	Jul 11, 8:00	15
Zhuji 1	2	2	2	Home	Jul 15, 12:00	Jul 15, 22:00	–	10
Zhuji 2	2	2	2	Home	Jul 15, 18:00	Jul 15, 22:00	Jul 16, 4:00	10

* This patient consumed the poisonous mushroom twice and died.

TABLE 2. The clinical manifestations of the poisoned patients in the 3 areas.

Clinical characteristics	Xinchang	Zhuji	Keqiao	Total
Patients with gastrointestinal irritation				
Nausea and vomiting	5	2	2	9
Abdominal pain	6	2	2	10
Diarrhea	6	2	1	9
Patients with liver function damage				
Glutamic-pyruvic transaminase (GPT/ALT) and glutamic-oxaloacetic transaminase (GOT/AST)	6 (Up to 55 times higher)	2 (Up to 110 times higher)	2 (Up to 25 times higher)	10

detected in 2 patients' plasma samples 30 hours and 50 hours post-consumption of the mushrooms. The toxins were found in 2 patients' urine samples 62 hours and 51 hours post-consumption and the contents were 0.069 ng/mL and 1.24 ng/mL, respectively.

The wild mushroom samples were found to have α-Amanitin and β-amanitin, and the average contents in the dried samples were 8.63 mg/g and 2.57 mg/g, respectively.

Molecular identification was based on internal transcribed spacer (ITS) sequences. Based on morphological and molecular studies, the suspected mushroom was identified as *Amanita rimosa* (*4*–*5*) Figure 1. The contents of α-amanitin and β-amanitin in the sampled mushroom specimens were similar to those in previously reported *Amanita rimosa* (*6*).

PUBLIC HEALTH RESPONSE

After the cause of poisoning was determined, the CDCs in Shaoxing city immediately carried out the popular science publicity and education about wild mushroom poisonings and prohibited residents from picking and eating wild mushrooms. No similar poisoning incidents occurred until August 15, 2019.

FIGURE 1. Basidioma of *Amanita rimosa* (white bar= 1 cm). *Amanita rimosa* grows on the ground in broad-leaved forest dominated by the Fagaceae family of trees. Basidiocarp: small; pileus: 3–5 cm in diameter, white to whitish, middle white to slightly darker; stipe: white to whitish; volva: white; limbate annulus: subapical, white.

The local CDC also suggested regularly carrying out the popular science publicity and education of toxic mushroom poisonings before the rainy season (from the middle of June to the middle of July) in the future. They also decided to set up warning signs prohibiting the picking and eating of wild mushroom in mountain areas to prevent such incidents.

DISCUSSION

The rainy season in Zhejiang Province is from the middle of June to the middle of July every year and the average temperature is between 20 °C–30 °C, which are suitable temperatures and humidity for the growth of wild mushrooms (*7*). Some local mountain residents often consume wild mushrooms, but it is difficult to distinguish edible or toxic wild mushrooms for most residents. There is the possibility of poisoning in the collection and ingestion of toxic wild mushrooms.

The case fatality rate of wild mushroom poisonings with amanitin toxin is reportedly about 20% (*2*). The increase in transaminase levels of poisoning patients generally occurs 48–72 hours following consumption and the optimal treatment period is before 36 hours (*8*). Toxin detection should occur as early as possible to determine the cause of the disease and carry out effective interventions and treatment in time.

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Outbreak Reports

Waterborne Arsenic Poisoning Caused by Discarded Slags — Yongzhou City, Hunan Province, China, 2018

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Summary

What is already known about this topic?

Overexposure to arsenic is toxic and affects bodily systems. In severe cases, loss of motor function and death can occur.

What is added by this report?

At the end of 2018, a waterborne acute arsenic poisoning event occurred in Yongzhou City of Hunan Province because arsenic-containing slags contaminated the water supply, which resulted in 10 people being poisoned. Patients were poisoned through domestic use of contaminated well water excluding drinking.

What are the implications for public health practice?

Clinicians should be trained to correctly and promptly identify and diagnose acute arsenic poisoning. The arsenic slags and byproducts should be strictly managed by corresponding enterprises to avoid similar poisoning incidents. When dealing with such events, water intended for domestic use should be closely monitored and environmental pollution should be assessed and controlled.

BACKGROUND

At the end of 2018, the National Institute of Occupational Health and Poison Control (NIOHP) of China CDC received a suspected arsenic poisoning case from Hunan Province. An investigation, including epidemiological and field hygiene assessments, was launched by the NIOHP and the Hunan Prevention and Treatment Institute for Occupational Disease (HPTIOD). The results suggested that 10 villagers had experienced waterborne arsenic poisoning caused by discarded arsenic-containing slags. As a counter measure, the slags were disposed, the contaminated well was sealed, centralized clean water was supplied, and all patients received medical care. This case demonstrated that poisonings caused by polluted environments must be carefully monitored, the ability of clinicians to identify and diagnose acute arsenic poisoning needs improvement, and arsenic byproducts need strict management by corresponding enterprises.

INVESTIGATION AND RESULTS

The initial cases were found in three individuals from one family. Their initial symptoms were sore throat, diarrhea, bloating, rashes with itching, poor appetite, nausea, and vomiting. Their biological samples showed arsenic levels above local reference-levels including arsenic concentrations in the hair (normal <5.0 μg/g) and urine (normal <0.2 mg/L). Around August 23, 2018, a heap of slags had appeared on a hill near their village, and a continuous heavy rainfall occurred around October 13 when the slags were stacked, and a part of the slags seemed to have been washed into the public well and a karst cave underside. The underground water flowed through the cave and the water in the public well were likely contaminated after this rainfall. The three individuals reported using public well water to wash clothes, food, and cook meals. From reports from the local government and local CDC, the slags contained 3.66×10^3 mg/kg of arsenic, and the soil contained 1.86–2.08 mg/kg of arsenic. According to information above, their poisoning was likely related to the arsenic-containing slags, and the public well water may have been contaminated and poisoned these people.

To control the contamination and find potential cases, NIOHP and HPTIOD formed a joint investigation team (JIT) to investigate the cases and created a specific case definition. Suspected cases were defined as residents living in Xiongxin Village, Yongan County, Hunan Province since Octomber 2018 who had at least one of the following symptoms with unknown specific-causes: gastrointestinal problems including nausea, vomiting, and diarrhea; neurological symptoms including dizziness, weakness, and insomnia; and respiratory system problems including throat pain. Confirmed cases were defined as suspected cases that had hair arsenic levels >5.0 μg/g or urinary arsenic levels >0.2 mg/L. On November 15, 7 suspected cases were found, and they were confirmed the next day because of the high arsenic in their hair or urine.

The 10 confirmed patients' signs and symptoms all matched those of acute arsenic poisoning (details are presented in Table 1). These patients also all had sensory nerve conduction threshold decline or peripheral neurogenic damage of the limbs, either unilaterally or bilaterally. The ages of the patients were ranged from 8 years old to 48 years old, and the median age was 42 years old. There were 5 females and 5 males. The median date of symptom onset in the patients was October 21, 2018 (range: mid-October to December 11). The median date of diagnosis was November 16 (range: November 14 to 16). The median urine arsenic was 0.28 mg/L (range: 0.04 mg/L to 0.92 mg/L). The median hair arsenic was 20.2 μg/g (range: 3.5 μg/g to 35.6 μg/g). Their biological samples showed other heavy metals, although none of the metals were above toxic doses. None of the patients had direct contact with the slags; however, they all used the common public well water for domestic use excluding drinking.

TABLE 1. The signs and symptoms of the patients in arsenic poison accident of Hunan Province in 2018 (N=10).

Symptoms	Number	Percent (%)
Diarrhea	6	60
Vomit	6	60
Fatigue	6	60
Dizziness	3	30
Sore throat	2	20
Hyperpigmentation	2	20
Feet and wrist drop	2	20
Insomnia	2	20
Head ache	1	10
Tongue numbness	1	10
Pain allergic in feet	1	10

The epidemiological investigation and field hygiene investigation was conducted in December 2018 to verify the source and the route of poison. First, the results showed that the level of arsenic in the water of a patient's water container and the water exuded from the sealed public well was 192.4 times and 6.8 times of arsenic standard in drinking water, respectively. The water in the container was pumped from the public well and the public well had been sealed before the JIT arrived. A fish sample collected from a private pond near the public well tested high in arsenic levels as well. The detailed results are presented in Table 2. This information confirmed that the domestic water of patients and public well water were all polluted. Second, there was a ditch and an underground river between the area that the slags were stacked and the public well. The underground karst cave could be detected and the sound of water underground could be heard, but due to equipment limitations, no samples from the cave were collected. Third, the patients were all found to be living within a radius of 40 meters. The average distance between their houses and the public well was 67.5 meters (range: 50–100 meters), and the slags were no more than 200 meters from their houses. The height of the slags' location was higher than the surrounding markers with an average height difference of 3.4 meters (range: 2–5 meters). Therefore, we inferred that the slags had likely flowed into the public well and the cave due to heavy rain.

In summary, patients often used the public well water for domestic purposes, and the patients' collected water in their containers was found to be highly polluted. The public well water was likely contaminated by the slags, and the patients were likely poisoned when using the public well water for domestic purposes excluding drinking.

PUBLIC HEALTH RESPONSE

All patients were admitted and treated with

TABLE 2. The arsenic concentration in samples of the environment in the poison accident of Hunan Province in 2018.

Material	Arsenic concentration (mg/L)	Reference range (mg/L)
Domestic water	9.62	0.05
Water exuded from public well	0.34	0.05
Fish meat	0.11	–
Private well water	–	0.05
Water from the ditch	<0.05	0.05

supportive and symptomatic therapies. After an average hospital stay of 47 days, all patients recovered and were discharged. The local government disposed of the slags and sealed the contaminated well promptly and supplied centralized clean water to the local residents.

DISCUSSION

In China, poisoning episodes caused by arsenic slags are not rare. Incomplete statistics showed that 3,961 people were poisoned and 12 individuals had died from poisoning from arsenic slags between 1961 and 2005 (*1*–*2*). An estimated 70% of the world's proven arsenic reserves were in China, and most of the arsenic reserves are accompanied with many other metals. The smelting of these metals will produce arsenic containing slags and byproducts. Therefore, the management of arsenic slags and byproducts are important responsibilities for the corresponding enterprises.

From the investigation results, the interval between the median date of onset and diagnosis of arsenic poisoning patients was nearly 25 days. The non-specific symptoms and signs of acute arsenic poison and the insufficient ability of medical staff to recognize and diagnose the poisonings were major reasons. Therefore, training medical staff to correctly recognize and diagnose acute arsenic poison is a priority.

Arsenic poisoning induced by polluted drinking water was more common in the past, but this event showed that domestic use of arsenic-contaminated water also caused poisonings. When dealing with similar incidents, sampling and testing of domestic water should be taken into consideration. Furthermore, environment samples of water, soil, and animals were also found to be contaminated with arsenic. This may not immediately be reflected in adverse health events in the local populations, but it remains important to assess and treat environmental risk factors when dealing with similar events in the future.

This investigation was subject to some limitations. First, the investigation was conducted one month after the outbreak. In this case, the arsenic levels of the environmental samples may have reduced because of environmental self-purification and the removal of the slags. Second, most symptoms and signs of arsenic poisoning were non-specific. Some people may consider the initial symptoms as flu and gastroenteritis, which are less identifiable as poisonings. Therefore, only people who considered themselves as being ill were screened, which indicates that some cases might have been missed.

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Preplanned Studies

Characteristics in the Distribution of Chronic Benzene Poisoning Associated Industries — 6 PLADs, China, 2005–2019

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Summary

What is already known on this topic?

Starting in the early 1950s, the main industries in China associated with chronic benzene poisoning (CBP) included painting, pharmaceuticals, and shoemaking. However, because of rapid socioeconomic development, the distribution of industries associated with CBP likely changed.

What is added by this report?

From 2005 to 2019, CBP has become an increasingly important type of chronic occupational poisoning (COP) in China. CBP was mainly found to have occurred in manufacturing industries, especially private enterprises and small and medium-sized enterprises. The sub-industry with the highest proportion of CBP cases was general and special equipment manufacturing, followed by chemical raw materials and chemical manufacturing.

What are the implications for public health practice?

CBP was found to be the main component of COP in China, so the supervision and management in manufacturing, especially in the medium-sized and small enterprises, need to be strengthened. Occupational benzene exposure limits should also be adjusted accordingly.

Chronic exposure to benzene causes poisoning, acute myeloid leukemia (AML), and other hematopoietic malignancies. While benzene exposure has an overall 7-fold risk for development of leukemia, chronic benzene poisoning (CBP) is associated with a 71-fold risk for development of AML or myelodysplastic syndromes in humans (*1*–*2*). CBP patients experience a strong and prolonged hematotoxicity characterized by significantly reduced white blood cell counts. Malignant transformation in these CBP patients can take place in a short period of time (*3*). In this study, CBP data were obtained from the Occupational Disease and Occupational Health Monitoring Information System, a subsystem of the China Information System for Disease Control and Prevention. CBP patients from 6 provincial-level administrative divisions (PLADs)* were analyzed and characterized by age, enterprise scale†, ownership of the enterprise§, and industry¶ distribution. There was a total of 3,836 CBP patients across China during 2005–2019, of which 1,861 CBP in 6 PLADs were included in the analysis. This study suggests that a targeted occupational health survey is needed to determine the number of industries with CBP changes and strengthen the supervision and management of the industry with CBP.

CBP had been reported in China in the early 1950s with the main industries associated with CBP at the time being painting, pharmaceuticals, and distillation of coal and coal tar. In the 1970s, the prevalence of CBP was 1.1% (*4*). With the reduction of maximum allowable concentration (MAC) of benzene to 40 mg/m^3 in 1979 and the improvement of hygiene conditions of workplaces, the prevalence of CBP decreased to 0.5%. The annual mean number of CBP cases decreased from 892 cases during 1979–1982 to 594 cases during 1984–1993 and 223 cases during 1996–2003. Correspondingly, the main industries associated with CBP had shifted to light industry and machinery (*5*–*6*). The permissible concentration-time weighted average (PC-TWA) of benzene in workplace in China was reduced to 6 mg/m^3 in 2002. So far, whether the industrial distribution of CBP has changed with decreasing PC-TWA is unknown.

* Guangdong Province, Jiangsu Province, Shandong Province, Sichuan Province, Beijing Municipality, and Tianjin Municipality.

† Large, medium, small, and mini-sized enterprises.

§ State-owned, collective, pooling, private, foreign, stock, and Hong Kong, Macao, and Taiwan of mainland China.

¶ Chemical raw materials and chemical products manufacturing, general and special equipment manufacturing, non-mental mineral product industry, etc. More information about industry category is available at http://www.stats.gov.cn/tjsj/tjbz/hyflbz/201710/t20171012_1541679.html.

The 6 PLADs of Guangdong, Jiangsu, Shandong, Sichuan, Beijing, and Tianjin were selected because the number of CBP cases increased from 2005 to 2019 and accounted for more than half of the total number of new CBP patients in China after 2013. All CBP patients were diagnosed by local occupational disease diagnostic teams. To further refine the distribution of CBP in specific industries, the occupations of CBP patients in these PLADs were standardized using the *Industrial classification for national economic activities* (GB/T 4754–2017). Data were processed using Excel software (version Home and Student 2019, Microsoft Office).

From 2005 to 2019, the annual mean number of CBP cases increased to 256 and the proportion of CBP in chronic occupational poisoning (COP) increased and reached 46% in 2019 (Figure 1A). As shown in Table 1, the number of medium-sized enterprises with CBP cases increased rapidly in the 6 PLADs from 2005 to 2012 and subsequently remained at a high level from 2009 to 2019. The number of small businesses with CBP cases continued to rise, and both small and medium enterprises eventually comprised 71% of all enterprises with CBP cases from 2017 to 2019. When enterprises with CBP cases were categorized according to ownership type, the number of CBP cases reported by private enterprises was the highest and increased rapidly. It was followed by foreign enterprises and

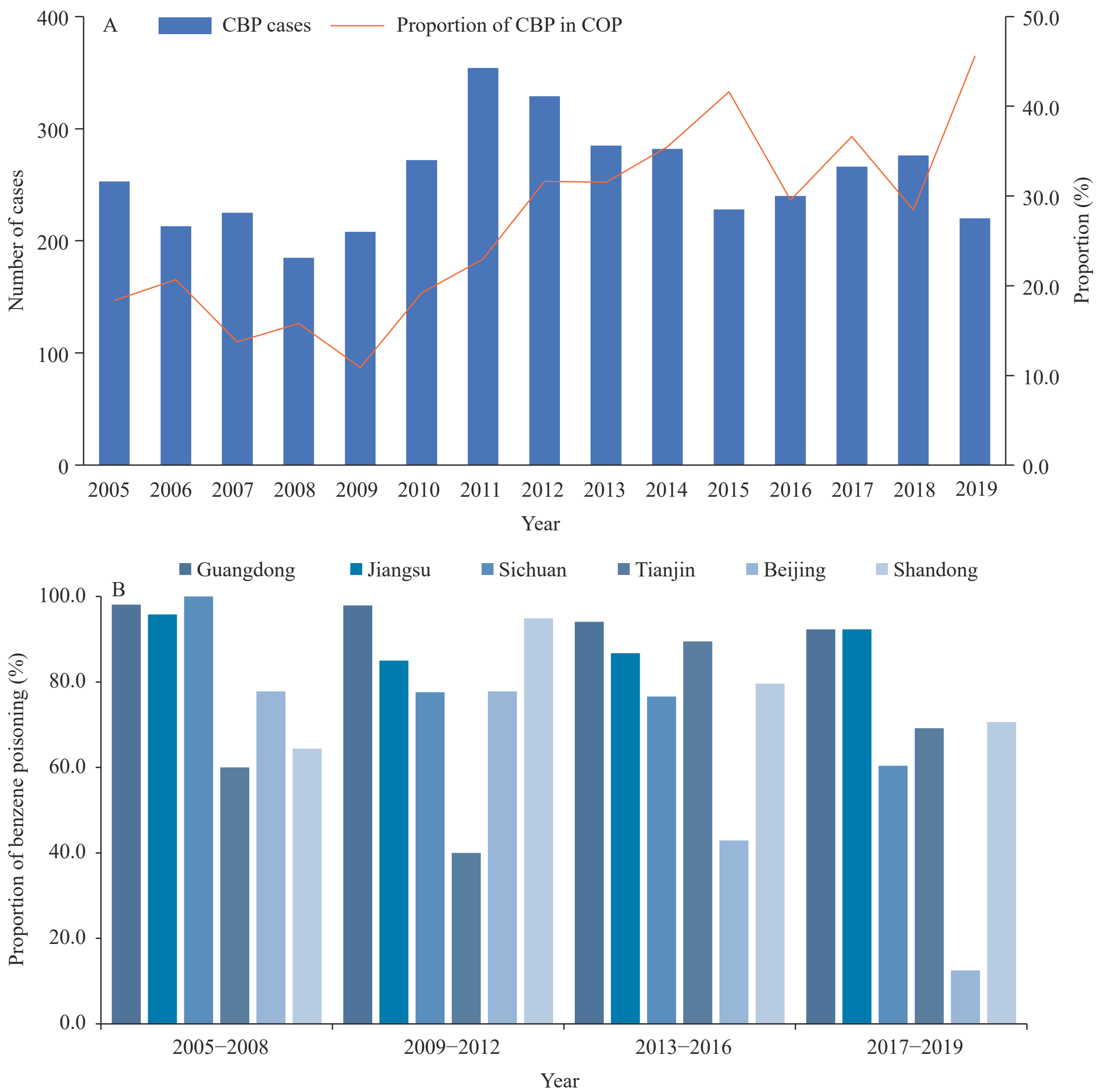

FIGURE 1. CBP in China, and manufacturing with CBP in 6 PLADs, 2005−2019. (A) New cases and proportion of reported CBP in China, 2005−2019; (B) The proportion of manufacturing with CBP in 6 PLADs in 4 periods of 4-years (2005−2008, 2009−2012, 2013−2016, 2017−2019).

TABLE 1. Distribution of enterprise scale and ownership type with chronic benzene poisoning (CBP) cases in 6 provincial-level administrative divisions (PLADs), 2005−2019.

Item	Number of CBP (%)			
	2005−2008	2009−2012	2013−2016	2017−2019
Total	252	464	595	550
Enterprise scale				
Large	59(23.4)	119(25.6)	157(26.4)	126(22.9)
Medium	73(29.0)	193(41.6)	190(31.9)	197(35.8)
Small	52(20.6)	111(23.9)	195(32.8)	195(35.5)
Mini-sized	0	0	6(1.0)	12(2.2)
Unrevealed	68(27.0)	41(8.8)	47(7.9)	20(3.6)
Ownership type				
State-owned	78(31.0)	74(16.0)	82(13.8)	38(6.9)
Collective	17(6.7)	20(4.3)	25(4.2)	4(0.7)
Pooling	9(3.6)	42(9.1)	46(7.7)	0
Private	72(28.6)	151(32.6)	237(39.8)	183(33.3)
Foreign	34(13.5)	77(16.6)	42(7.1)	140(25.5)
Hong Kong, Macao, and Taiwan of mainland China	16(6.3)	6(1.3)	6(1.0)	131(23.8)
Stock	0	20(4.3)	20(3.4)	22(4.0)
Unrevealed	26(10.3)	73(15.8)	137(23.0)	32(5.8)

Abreviation: CBP=chronic benzene poisoning.

Hong Kong, Macao, and Taiwan of mainland China enterprises, they showed a sharp increase from 2017 to 2019.

For industry distribution, manufacturing was the industry in the 6 PLADs with the highest number of CBP cases during 2005–2008, accounting for 60% up to 100% of all cases. In 2009, the number of CBP cases related to manufacturing decreased in all PLADs except Shandong, but manufacturing was still the primarily associated industry. During 2013–2019, the proportion of CBP cases in 5 PLADs, excluding Beijing, related to manufacturing exceeded 60%, ranging from 60.4% to 94.1% (Figure 1B).

During 2005–2019, CBP mainly occurred in general and special equipment manufacturing, followed by raw chemical materials and chemical product manufacturing. Compared with the previous periods from 2005 to 2016, the number of CBP cases in these 2 industries decreased from 2017 to 2019, but they remain the main industries associated with CBP.The distribution of associated industries and characteristics of CBP in PLADs often differed: 1) in Jiangsu, chemical raw materials and chemical products manufacturing was always found to be the main industry associated with CBP during 2009–2019 (2009–2012: 11 cases, 27.5% of the total; 2013–2016: 26 cases, 35.6% of the total; 2017–2019: 9 cases, 34.6% of the total), followed by general and special equipment manufacturing (2009–2012: 10 cases, 25.0% of the total; 2013–2016: 13 cases, 17.8% of the total; 2017–2019: 7 cases, 26.9% of the total); 2) in Sichuan, the main industries associated with CBP were general and special equipment manufacturing during 2013–2016 (22 cases, 34.4% of the total) and was outpaced by paper products manufacturing and electrical equipment manufacturing during 2017–2019 (both 9 cases, 17.0% of the total); 3) in Shandong, the main industry associated with CBP was general and special equipment manufacturing during 2005–2008 (30 cases, 30.0% of the total)—which increased during 2009–2012 (39 cases, 33.3% of the total) and decreased during 2013–2016 (11 cases, 11.8% of the total) and during 2017–2019 (5 cases, 14.7% of the total) — and several industries were associated with CBP as 34 cases occurred in 25 industries during 2017–2019; and 4) in Tianjin, several industries were also associated with CBP, but transportation equipment manufacturing gradually became the most associated with CBP (2013–2016: 5 cases, 26.3% of the total; 2017–2019: 7 cases, 26.9% of the total) (Table 2).

TABLE 2. Characteristics in distribution of the top three industries with the most chronic benzene poisoning (CBP) cases in Jiangsu, Sichuan, Shandong, and Tianjin, 2005−2019.

PLAD	Year	Industry	Number of CBP (%)
Jiangsu	2005−2008	Leather, fur, feather products and shoemaking manufacturing	9(36.0)
		Plastics and rubber products manufacturing	5(20.0)
		General and special equipment manufacturing	5(20.0)
	2009−2012	Chemical raw materials and chemical products manufacturing	11(27.5)
		General and special equipment manufacturing	10(25.0)
		Non-mental mineral product industry	3(7.5)
	2013−2016	Chemical raw materials and chemical products manufacturing	26(35.6)
		General and special equipment manufacturing	13(17.8)
		Metal product manufacturing	6(8.2)
	2017−2019	Chemical raw materials and chemical products manufacturing	9(34.6)
		General and special equipment manufacturing	7(26.9)
		Transportation equipment manufacturing	2(7.7)
Sichuan	2005−2008	Computer and electronic product manufacturing	6(60.0)
		General and special equipment manufacturing	3(30.0)
		Chemical raw materials and chemical products manufacturing	1(10.0)
	2009−2012	Transportation equipment manufacturing	13(27.5)
		Weapon and ammunition manufacturing	8(16.3)
		General and special equipment manufacturing	6(12.4)
	2013−2016	General and special equipment manufacturing	22(34.4)
		Transportation equipment manufacturing	9(14.1)
		Metal product manufacturing	5(7.8)
	2017−2019	Paper and paper products Manufacturing	9(17.0)
		Electrical equipment manufacturing	9(17.0)
		General and special equipment manufacturing	5(9.4)
Shandong	2005−2008	General and special equipment manufacturing	30(30.0)
		Transportation equipment manufacturing	11(11.0)
		Petroleum processing industry	9(9.0)
	2009−2012	General and special equipment manufacturing	39(33.3)
		Transportation equipment manufacturing	20(17.1)
		Chemical raw materials and chemical products manufacturing	10(8.5)
	2013−2016	Chemical raw materials and chemical products manufacturing	13(14.0)
		General and special equipment manufacturing	11(11.8)
		Transportation equipment manufacturing	6(6.5)
	2017−2019	General and special equipment manufacturing	5(14.7)
		Computer and electronic product manufacturing	5(14.7)
		Chemical raw materials and chemical products manufacturing	3(8.8)
Tianjin	2005−2008	Chemical raw materials and chemical products manufacturing	5(33.3)
		Petroleum processing industry	5(33.3)
		General and special equipment manufacturing	2(13.3)
	2009−2012	Petroleum processing industry	8(54.3)
		Computer and electronic product manufacturing	2(13.3)
		General and special equipment manufacturing	2(13.3)

TABLE 2. (Continued)

PLAD	Year	Industry	Number of CBP (%)
	2013−2016	Transportation equipment manufacturing	5(26.3)
		Metal product manufacturing	2(10.5)
		General and special equipment manufacturing	2(10.5)
	2017−2019	Transportation equipment manufacturing	7(26.9)
		General and special equipment manufacturing	3(11.5)
		Petroleum exploitation	3(11.5)

DICSUSSION

The number of new cases of CBP and the increased proportion of CBP in COP during 2005–2019 suggested that CBP may be the most important diseases in COP in China. The increasing number of cases may result from an increase in benzene-exposed workers; the increasing proportion of CBP in COP may result from a decrease in other occupational poisonings. The number of CBP cases needs to be further reduced due to the carcinogenicity of benzene.

In this study, we found that CBP mainly occurred in manufacturing industries, especially in private enterprises and small and medium-sized enterprises. The number of CBP cases in private and small enterprises have exceeded that of the large state-owned companies after 2013. This is probably due to the rapid development of small and medium-sized enterprises in recent years. Moreover, the production equipment and occupational health conditions in small and medium-sized enterprises are not as good as those of large state-owned enterprises. Therefore, it makes the occurrence of CBP increased and scattered. The supervision and management of small and medium-sized enterprises need to be strengthened.

In the past 15 year, the production and use of benzene was mainly in manufacturing, which accounts for one-third of all industries in China (GB/T 4754–2017). We further analyzed the manufacturing sub-industry and found that most industries with CBP were general and special equipment manufacturing, as well as chemical raw materials and chemical products manufacturing. Studies reported that the median benzene exposure level for general equipment manufacturing was 4.32 mg/m^3 (range: 0.03–244.51 mg/m^3) and was 3.52 mg/m^3 (range: 0.79–8.30 mg/m^3) for chemical raw materials and chemical products manufacturing during 1983–2014 (*7*). Though these exposure levels were lower than the 6 mg/m^3 required by the PC-TWA in China, there was no significant decrease in the average number of new cases from 2005 to 2019 compared to 1996–2003, suggesting that the occupational exposure limit of benzene at 6 mg/m^3 may need to be reconsidered. Furthermore, in high-income countries like the United States, benzene exposure levels are well below this occupational exposure limit (3.25 mg/m^3), so CBP cases were relatively rare (*8*). There was an average of only 10 CBP cases per year among 240,000 occupational benzene-exposed workers in the United States (*9*). By comparison, 186 of the 342,212 workers exposed to benzene in 5 PLADs in China in 2017 suffered from CBP.

During 1979–1981, CBP patients mainly occurred in spray paint workers (34.1%), painters (20.8%), and shoemakers (12%) (*4*). Less than 1% of shoemakers had CBP cases in the 6 PLADs by 2019. The number of CBP cases in computer and electronic product manufacturing began to increase, while the leather, fur, feather products, and shoe manufacturers were no longer the main industry for CBP (Table 2). Differing from China, the International Agency for Research on Cancer report states that synthetic rubber, paint, and ink manufacturing and painting are important sub-industries within manufacturing with serious CBP hazards. It can be seen that the distribution of industries associated with CBP in China is still quite different from that in other countries.

This study was subject to at least some limitations. First, this study included more than 50% of total CBP patients in China among 6 PLADs, but the descriptive statistics on the distribution of these cases may not be comprehensive, which could lead to an imprecise estimation of the distribution. Further investigation could include more patients and other PLADs. Second, the number of reported CBP cases was lower than the actual number of cases due to the lack of obvious clinical symptoms in CBP patients and the lack of full coverage of workers by physical examination, which may have led to an underestimation of the extent of CBP cases.

All enterprises and industries can benefit from a comprehensive approach to CBP prevention. A hierarchy of controls needs to be fully implemented. First, elimination and substitution: using non-toxic and low toxic substances instead of toxic or high toxic substances is the first choice to reduce exposure to toxic hazards. Second, engineering controls: strengthening ventilation and other engineering controls to bring the concentration of benzene in the workplace within the occupational exposure limit. Third, administrative controls: decreasing occupational benzene exposure limits to a safer concentration. Fourth, personal protective equipment (PPE): proper use of PPE to protect benzene workers. Other community-based strategies include strengthening economic supports, health education, and early finding, diagnosis, and treatment.

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Outbreak Reports

A Foodborne Bongkrekic Acid Poisoning Incident — Heilongjiang Province, 2020

Yuan Yuan[1,&]; Rui Gao[2,&]; Qiang Liang[3,&]; Li Song[4]; Jun Huang[3]; Nan Lang[1]; Jing Zhou[1,#]

Summary

What is already known on this topic?

Poisoning incidents caused by bongkrekic acid (BA), one of the metabolites of *Burkholderia gladioli* pathovar *cocovenenans* (*B. cocovenenans*), have been reported in Indonesia, Mozambique, and China. The reported case fatality rates averaged 60%, 32%, and 26.5%, respectively. In China, *B. cocovenenans* is often called *Pseudomonas cocovenenans* subsp. *farinofermentans*.

What is added by this report?

In October 2020, 9 persons in Jidong County, Heilongjiang Province died after consuming a homemade fermented corn flour product — sour soup — with a case fatality rate of 100%. BA was detected in both food samples and biological samples with a content of 330 mg/kg and 3 mg/L, respectively. The doses of BA consumed by the cases were approximately 22–33 times the lethal dose in human.

What are the implications for public health practice?

The consumption of fermented corn flour products, deteriorated fresh tremella, or black fungus and metamorphic starch products may cause BA poisoning. Health education should be strengthened so that homemade-starch-fermented food should be avoided and foods that have been kept for a long time should not be consumed. Meanwhile, training and emergency capacity building for primary healthcare workers should be strengthened to provide timely diagnosis and response.

On October 6, 2020, Jidong County CDC received a report that a family in Sihai Community, Xingnong Town had a suspected foodborne poisoning incident. By the investigation of the county, municipal, and provincial CDC, the incident was due to consumption of the local homemade specialty food, a sour soup, for breakfast on October 5. In the homemade processing and storage, this food was contaminated by *Burkholderia gladioli* pathovar *cocovenenans* (*B. cocovenenans*) which can produce bongkrekic acid (BA), resulting in deaths for all persons exposed due to poisoning. The case attack and fatality rates were both 100% in the persons who consumed the sour soup. Improper processing and storage of fermented corn flour products can cause BA poisoning.

INVESTIGATION AND FINDINGS

On October 4, a total of 12 persons involving 5 families gathered for lunch and dinner. At around 8∶00 am on October 5, the 12 persons had breakfast together and left separately. Among them, 9 persons consumed the sour soup , while 3 did not and all the 12 persons had consumed the other food items. The 9 persons then successively developed gastrointestinal symptoms such as nausea, vomiting, and abdominal pain. Finally, all 9 cases died after treatment.

On October 6, the investigation revealed that the 9 cases included 4 males and 5 females with an average age of 61 years (range: 45–72 years). Detailed clinical data were collected on the initial patient and her husband. Physical examination of the initial case showed tenderness in the upper abdomen. Laboratory abnormalities include progressive dysfunction of liver function, renal function, and coagulation function in her and her husband, and imaging indicated diffuse changes in the liver (Table 1). The attack rate was 100% in the persons who consumed sour soup and the attack rate was 0% in those who did not consume it, which suggested that the sour soup was the likely source of exposure. The median latency period was estimated as 3 hours (range: 2–8 hours) according to the time of consumption of sour soup and the onset time of the case. The median course of disease in 9 cases was 53 hours (range: 20–341 hours). The patients and cases were numbered 1–9 according to the latency period from short to long (Figure 1). Patient 9 had the longest latency period, and he returned home after receiving prescription medication from the outpatient department. He then died at home with the shortest course of illness, which was only 20 hours.

According to the investigation, the process of

TABLE 1. The clinical characteristics list of two typical cases in the foodborne bongkrekic acid poisoning incident in Jidong County, Heilongjiang Province, 2020.

Patient	Gender	Age (years)	Latency period (h)	Course of disease (h)	Clinical manifestation				Physical examination	Liver function		Coagulation function			Renal function		Imaging
					Nausea, vomiting	Diarrhea	Dizziness, fatigue	Oliguria	Tenderness in the upper abdomen	ALT (U/L)	AST (U/L)	PT (s)	APTT (s)	PLT (10^9/L)	UREA (mmol/L)	CREA (μmol/L)	Abdominal CT scan
Initial patient's husband	Male	49	4	61	+	+	+	+	+	22,640↑	43,900↑	>120↑	88.3↑	30↓	8.87↑	466↑	Liver diffuse lesions
Initial patient	Female	47	2	341	+	-	+	+	-	7,199↑	10,630↑	71.4↑	46.6↑	27↓	1.84↓	213↑	Liver diffuse lesions

Note: Marks: + : indicates symptoms that do occur; -: indicates symptoms that do not occur; ↑: means increasing; ↓: means decreasing.
Abbreviations and reference ranges: ALT: Alanine aminotransferase 0–40 U/L; AST: Aspartate aminotransferase 0–40 U/L; PLT: Platelets (100–300)*10^9/L; APTT: Activated partial thromboplastin time 23–35 s; PT: Prothrombin time 10.5–13 s; UREA: Urea nitrogen 2.3–7.2 mmol/L; CREA: Creatinine 44–110 mmol/L

making the homemade sour soup was as follows: one year ago, the corn was soaked in water for about a month to ferment. After mill grinding, the corn husks were filtered out in the water, and the delicate parts were kept to be dried in flour bags and formed into dough and then noodles with a specialized tool. It was consumed as soon as the noodle-based sour soup was ready and the rest of the dough was put in the refrigerator and frozen. This fall, because the refrigerator was used to store other foods, the dough was made into cornmeal powder and then stored in the refrigerator again to save space. After the corn dough was taken out, it was first exposed to air outside and covered with a simple porous plastic net. After drying for a day, it was transferred to dry in the house due to cloudy and rainy weather.

On October 5, the local public security department extracted all the types of residual food and detected them. No poisonous substances such as cyanide, organophosphorus, carbofuran, psychostimulant, or tetramine were found. On October 7, the municipal CDC tested all the types of food and a patient's gastrointestinal decompression fluid for salmonella, and the results were negative. The local hospital tested the food and found the aflatoxin was in excess. As this toxin is a common contaminant of corn, and it generally does not cause acute poisoning manifestations as the latency period is usually 2–3 weeks (*1*), which caused it to be excluded. On October 10, the provincial CDC detected BA in the remaining raw material for the sour soup, the corn flour, and the gastrointestinal decompression fluid. In accordance with national standard (*2*), the concentration of BA was 330 mg/kg and 3 mg/L, respectively. Combined with the epidemiological investigation result, the patient's clinical manifestations and laboratory test results, the investigation team confirmed this poisoning incident was caused by BA when bacteria contaminated the corn flour and was used to make the sour soup.

PUBLIC HEALTH RESPONSE

Local CDC and the National Early Warning Information Dissemination Center has issued a warning message about BA poisoning. China CDC tracks the handling of incidents, provides technical guidance on epidemiological investigation and sampling detection, and at the same time obtains information from surveillance systems and carries out risk assessments regularly.

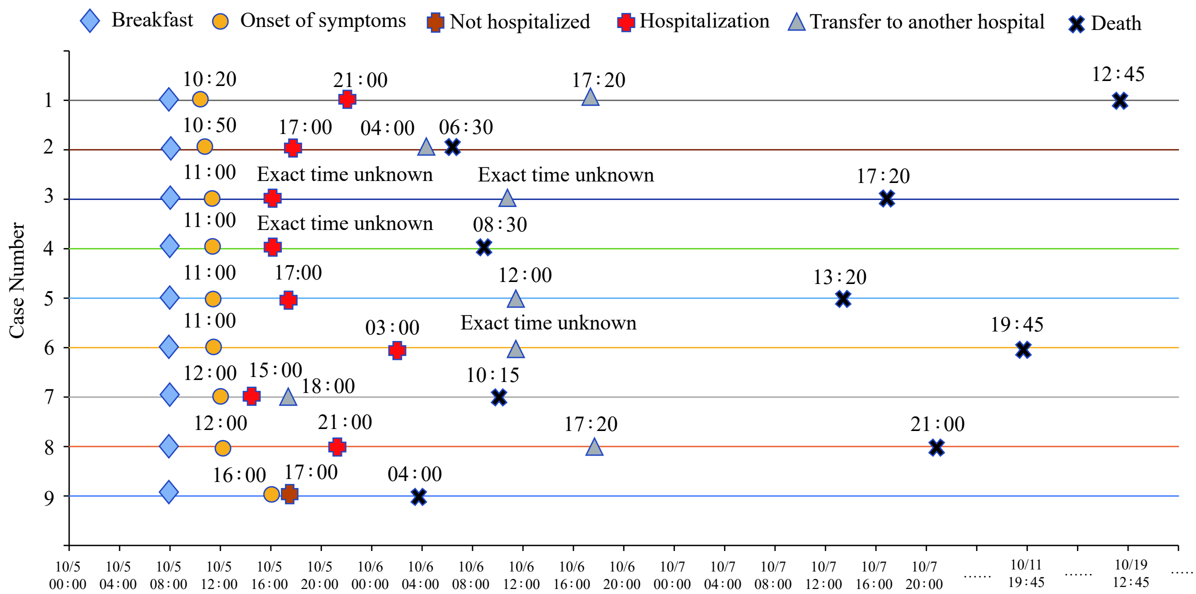

FIGURE 1. Sequence diagram of the course of disease of patients in the foodborne bongkrekic acid poisoning incident in Jidong County, Heilongjiang Province, 2020.

DISCUSSION

Based on the consumption of staple food of 100 g per person, the BA concentration of corn flour and the remaining raw food material collected on the scene, was 22–33 times higher than the lethal dose of 1–1.5 mg (*3*) and resulted in all 9 deaths. Laboratory studies have shown that coconut, corn, and other foods that are rich in oleic acid, are suitable for the growth of *B. cocovenenans* at a neutral pH of 22–30 ℃. When *B. cocovenenans* is cultured on coconut medium under ideal conditions, toxin production can reach 2–4 mg/g by the second day of culture (*4*). Although it is not clear how the corn flour used to make the sour soup was contaminated in this incident, we can learn from the production process that the poisoned sour soup was made in the same batch as last year. There was no abnormal consumption last year, and the contamination probably occurred after the food was taken out of the refrigerator. The corn dough was likely contaminated with bacteria when it was dried outside. The natural air drying speed was slow as the environment likely had poor ventilation, high relative humidity, and a suitable temperature for bacterial growth. These factors provide favorable conditions for the bacteria to multiply and produce the toxin. Despite the destruction of *B. cocovenenans* during cooking, the BA produced by them has a heat-stable character. Therefore, the storage, processing, and sanitary conditions of raw food materials were closely related to the occurrence of poisoning.

In Indonesia and Mozambique, the reported case fatality rate of BA poisoning were 60% and 32%, respectively (*4*–*6*). As of January 1, 2004, China CDC launched the Public Health Emergency Management Information System, which is a surveillance system for public health emergencies that may occur or have already occurred, which is reported online by medical and health institutions at all levels. The surveillance data showed that 15 BA poisoning incidents, 136 poisoned individuals, 36 resulting deaths, and a case fatality rate of 26.47% was reported during 2010–2019 in the mainland of China. These occurred in the provincial-level administrative divisions of Yunnan, Guizhou, Guangxi, Guangdong, Liaoning, and Shandong. Compared with 545 such incidents from 1953–1994, 3,352 persons were poisoned, among which 1,401 died (case fatality rate was 41.80%), and the scale showed a significant decline (*7*). According to the reported 15 incidents of foodborne poisoning caused by BA, there was 1 incident of sour soup poisoning at Liaoning Province in northeastern China, in which 4 persons were poisoned and all died. There were 2 incidents of poisoning caused by nonfermented rice noodle product at Guangdong Province in southern China, 8 people were poisoned and 5 died (case fatality rate was 62.5%). There were 5 incidents of poisoning caused by Diaojiangba (hanging syrup cake) in Yunnan Province, 47 people were poisoned and 15 people died (case fatality rate was 32%), suggesting that different types of starch products may lead to different case fatality rates.

There are few BA detection reports for past incidents, and they are mainly inferred based on exposure and clinical manifestations. The reason why the fatality rate of this incident was much higher than that of previous incidents was likely related to the exposure dose being much higher than the lethal dose.

The Health Emergency Information Platform for Poisoning Emergencies (an information system for emergency work for poisonings in provincial-level medical and health institutions) showed that up to July 2020 among the 81 institutions that were provincial CDCs, provincial treatment bases for poisoning, and designated medical institutions in China, only 7% had reserved and had access to the detection technology of BA in their daily work. It took 5 days and 6 days to get the qualitative and quantitative test results in this incident, respectively, which represents a shortcoming in the detection capacity of early and rapid diagnosis of BA.

At the same time, studies on the toxicokinetics of BA are lacking. There is no specific antidote (*8*) or standardized treatment guidelines for BA poisoning. The treatment of patients is mainly to terminate toxic contact, remove toxins that have not been absorbed in the body, and provide symptomatic support treatment. If the cases of this incident were treated in time at a hospital capable of treating severe poisoning, the case fatality rate may be reduced.

The investigation had several limitations. Because the patient who made the poisoned food fell ill and died, it was impossible to know all the details of how it was prepared. Most patients had a short course of illness with limited or unavailable clinical records. Not all patients had biological specimens collected for BA quantitative detection.

In high-risk areas, prevention of exposure to *B. cocovenenans* and BA and safer fermentation processes should be adopted. Meanwhile, training in BA poisoning and confirmative testing in primary health care facilities should be strengthened to improve emergency response capacity for timely diagnosis and response. In addition, scientific institutions should conduct studies on the distribution of *B. cocovenenans*, the laws of toxin production, and toxicokinetics of BA and develop commercial products for rapid detection of toxins in food.

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Preplanned Studies

Mushroom Poisoning Outbreaks — China, 2020

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Summary

What is already known about this topic?

Acute liver failure, rhabdomyolysis, acute renal failure, and hemolysis caused by poisonous mushrooms are the most important mushroom poisoning threats to the Chinese population. The most notorious lethal mushrooms are the species from genera *Amanita*, *Lepiota*, and *Galerina* that cause acute liver failure, and *Russula subnigricans* that leads to rhabdomyolysis.

What is added by this report?

In 2020, the total number of investigations reached 676, involving an estimated 102 species of poisonous mushrooms, 24 of which were newly recorded in China. *Gyromitra venenata* was newly discovered in incidents in Yunnan and Guizhou provinces and were the first reported poisonings due to gyromitrins in China since 2000. The rare poisoning Shiitake mushroom dermatitis was recorded in China. Hemolysis poisoning caused by *Paxillus involutus* was recorded for the second time since the beginning of the new century, resulting in one death in Inner Mongolia Autonomous Region.

What are the implications for public health practice?

Promoting knowledge about safe consumption of mushrooms is essential to reduce mushroom poisonings. It is not wise to collect and eat wild mushrooms. For southwestern provinces such as Yunnan, especially, caution must be exercised with unfamiliar mushroom species.

Preventing mushroom poisonings depends on cooperation between clinical doctors, CDC experts, and mycologists as well as the application of internet technology tools (*1*). Systematic epidemiological investigations, timely and accurate species identification, toxin detection, and appropriate diagnosis and treatment are key to properly controlling mushroom poisoning events.

In 2020, a total of 676 independent mushroom poisoning incidents from 24 provincial-level administrative divisions (PLADs) involving 1,719 patients and 25 deaths were investigated and the overall mortality was 1.45%. The number of cases ranged from 1 to 27,* and 14 outbreaks involved more than 10 patients. Of these cases, 93 patients from 24 incidents had eaten poisonous mushrooms purchased from market or given by friends; 51 patients from 12 incidents had been poisoned after eating dried mushrooms; 404 patients from 131 incidents with 7 deaths ate mixed mushrooms. Three rare clinical syndromes were recorded: Gamma-Aminobutyric Acid (GABA)-blocking mushroom poisoning caused by *Gyromitra venenata*, Hemolysis poisoning caused by *Paxillus involutus*, and Shiitake mushroom dermatitis caused by *Lentinula edodes*. Similar to 2019, mushroom poisonings occurred in every month but were centered from June to October (*1*). There were 2 peaks appearing in June and September involving 160 and 193 incidents, 428 and 412 patients, and 8 and 3 deaths, respectively (Figure 1).

In terms of geographical distribution, Southwest China [Yunnan, Guizhou, Sichuan, Chongqing, and Xizang (Tibet)] were the most severely affected region with 200 incidents, 604 patients, and 15 deaths. Central China (Hunan, Hubei, and Jiangxi) had more incidents (323 incidents), more patients (707 patients), but less deaths (4 deaths). East China (Anhui, Fujian, Jiangsu, and Zhejiang) had 82 incidents, 159 patients, and 0 deaths and were followed by the other regions: South China (Guangdong, Guangxi, and Hainan) had 33 incidents, 146 patients, and 3 deaths; North China (Beijing, Hebei, Henan, Shandong, and Shanxi) had 22 incidents, 69 patients, and 1 death; Northwest China (Ningxia and Gansu) had 13 incidents, 30 patients, and 1 death; and Northeast China (Inner Mongolia and Liaoning) had 3 incidents, 4 patients, and 1 death. In addition, 3 Burmese workers in Yunnan had gastroenteritis after eating *Chlorophyllum*

* The median number of cases per incident was two.

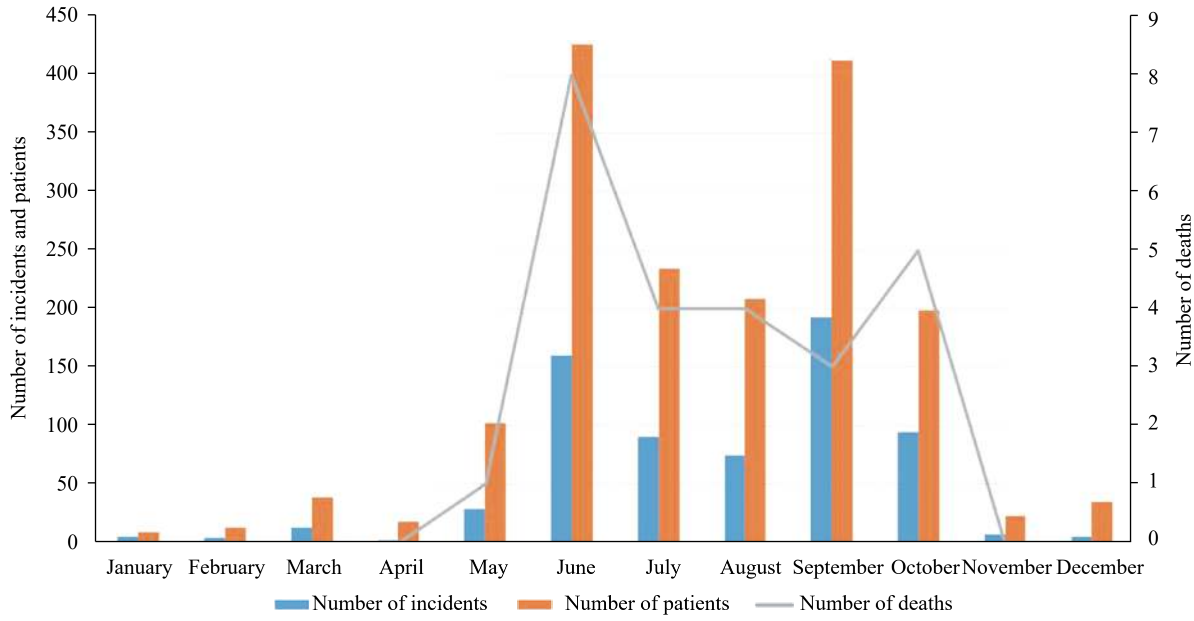

FIGURE 1. Monthly distribution of mushroom poisonings in China, 2020.

molybdites. Detailed information for each PLAD was displayed in Table 1.

Approximately 102 species of poisonous mushroom causing seven different clinical syndromes (acute liver failure, acute renal failure, rhabdomyolysis, hemolysis, gastroenteritis, psycho-neurological disorder, and Shiitake mushroom dermatitis) (*2*–*3*) were successfully identified. In 2020, 24 species were newly recorded as poisonous mushrooms and were added to the Chinese poisonous mushroom list. The most lethal 3 mushroom species were *Lepiota brunneoincarnata*, *Russula subnigricans*, and *Amanita subpallidorosea* killing 5, 4, and 4 people, respectively (Supplementary Table S1, available in http://weekly.chinacdc.cn/). *Chlorophyllum molybdites* caused the most poisonings (appearing in 154 incidents, 304 patients), were the most widely distributed mushroom (discovered in 15 PLADs) and had the longest active period (from late March to late October) in China, 2020 (Supplementary Table S1).

Similar to 2019, the same 9 species causing acute liver failure were identified in China, 2020 (*1*). *Lepiota brunneoincarnata* was found to be the most dangerous species in 2020, being responsible for 15 incidents, 29 patients, and 5 deaths as the lone cause or in combination with other species. *Lepiota brunneoincarnata* was discovered under coniferous trees, but in 2 incidents occurring in 2020, it was found in hardwood forest dominated by fagaceous trees in Guizhou and under *Ziziphus jujube* in Mengcun County, Hebei Province. The incident in Hebei Province on August 29 involved 6 patients. *Amanita exitialis* also appeared in Guangdong in late February, which was earlier than in 2019 but resulted in less deaths (*1*). There were also more incidents of patients consuming a combination of poisonous mushrooms, which can cause greater difficulties and risks for diagnosis and treatment due to species resulting in different symptoms (Supplementary Table S1).

Amanita gymnopus was a species discovered from poisoning investigations causing acute renal failure that was not found in 2019 (*1*). Due to delayed diagnosis and treatment, 3 people were killed by *A. pseudoporphyria* in early June in Guangxi. *Amanita oberwinklerana* was discovered in 18 incidents from 8 PLADs. *Amanita oberwinklerana*, a species occurring in southern China, also caused 6 incidents including 11 patients in North China for the first time from late July to late September. More deaths were caused by *Russula subnigricans*, which leads to rhabdomyolysis, when compared to 2019 (*1*, Supplementary Table S1).

On September 12–13, 2 incidents involving 2 patients and 1 death caused by *Paxillus involutus* resulting hemolysis occurred in Chifeng and Tongliao, Inner Mongolia Autonomous Region. Clinically, this type of poisoning stimulates an autoimmune reaction, with a short incubation period (usually 30 min–3 h), followed by gastrointestinal tract effects (GIT) including nausea, vomiting, abdominal pain, and/or diarrhea. Intravascular haemolysis, anaemia, with potential secondary renal failure, shock, disseminated

TABLE 1. Geographical distribution of mushroom poisoning incidents, cases, deaths, and case fatality in China, 2020.

PLADs	Number of incidents	Number of patients	Deaths	Case fatality (%)
Hunan	302	666	3	0.45
Yunnan	81	244	7	2.87
Guizhou	43	148	7	4.73
Zhejiang	43	78	0	0
Sichuan	40	123	1	0.81
Chongqing	35	88	0	0
Fujian	18	42	0	0
Guangxi	15	87	3	3.45
Anhui	12	30	0	0
Ningxia	12	29	1	3.45
Hubei	12	24	1	4.16
Guangdong	11	21	0	0
Jiangxi	9	17	0	0
Jiangsu	9	9	0	0
Beijing	8	23	0	0
Hainan	7	38	0	0
Hebei	7	33	0	0
Shandong	3	8	1	12.50
Henan	3	3	0	0
Inner Mongolia	2	2	1	50.00
Liaoning	1	2	0	0
Shanxi	1	2	0	0
Gansu	1	1	0	0
Xizang (Tibet)	1	1	0	0
Total	676	1,719	25	1.45

Abbreviation: PLADs=provincial-level administrative divisions.

intravascular coagulopathy, and acute respiratory failure developed on the following few days and even caused death (*3*).

A total of 56 species causing gastroenteritis were identified from mushroom poisoning incidents in China in 2020 (Supplementary Table S1). Among them, *Baorangia major*, *Chlorophyllum demangei*, *Entoloma caespitosum*, *Gymnopus densilamellatus*, *Lactarius atromarginatus*, *Lactifluus deceptivus*, *Lf. puberulus*, *Leucocoprinus cretaceous*, *Micropsalliota furfuracea*, *Neonothopanus nambi*, *Pholiota multicingulata*, *Pulveroboletus subrufus*, *Russula rufobasalis*, and *Tricholoma stans* were species newly discovered as poisonous mushrooms and subsequently added to the Chinese poisonous mushroom list (*1*–*2*, *4*–*6*). This was the first report of *Baorangia major* in China. The top 3 species were *Chlorophyllum molybdites*, *Russula japonica*, and *Entoloma omiense*, which was the same as 2019, but these 3 species caused more incidents and had wider geographical distribution (*1*).

About 28 species causing psycho-neurological disorders were identified from mushroom poisoning incidents in China in 2020, including *Clitocybe subditopoda*, *Gyromitra venenata*, *Inocybe* aff. *ericetorum*, *Mallocybe fulvipes*, *Inosperma* aff. *virosum*, *Inosperma* cf. *virosum*, *Pseudosperma* cf. *bulbosissimum*, and *Pseudosperma yunnanense*, which were species newly discovered as poisonous mushrooms and thus added to Chinese poisonous mushroom list (*1*–*2*, *7*–*9*). The top five species are *Amanita subglobose*, *A. rufoferruginea*, *Gymnopilus dilepis*, *A. melleiceps*, and *A. sychnopyramis* f. *subannulata* (Supplementary Table S1). Among them, *Gyromitra venenata* is a new species discovered from Yunnan and Guizhou resulting 4 patients poisoned as containing gyromitrins (*7*).

Inosperma aff. *virosum* and *Inosperma* cf. *virosum* were potentially two new independent species resulting in typical muscarinic syndrome post ingestion.

Lentinula edodes, commonly known as Shiitake mushroom, is one of the most famous edible mushrooms worldwide (*2*). Shiitake mushroom dermatitis was also reported, though its pathophysiology is unclear at present (*3*,*10*). Clinically, this type of mushroom poisoning presents 1–2 days post ingestion of raw or cooked mushrooms with sudden onset of whiplike (flagellate) linear wheals on limbs, trunk, and/or face/neck, and its toxin was assumed to be the thermolabile polysaccharide, lentinan (*3*,*10*). On January 5, an individual showed typical Shiitake mushroom dermatitis after eating *L. edodes* from Jiangxi. However, two other people who also consumed *L. edodes* were asymptomatic.

About 33 edible species were also identified from mushroom poisoning incidents in 2020 (Supplementary Table S1). These poisoning incidents may be attributed to consumption of mixed mushrooms with poisonous mushrooms, contaminated mushrooms, or some species potentially poisonous to certain people.

DISCUSSION

When comparing incidents in 2019 to 2020, more mushroom poisoning incidents occurred (276 in 2019 *vs.* 676 in 2020) involving more patients (769 *vs.* 1719) and deaths (22 *vs.* 25) (*1*). As in 2019, monthly distribution analysis showed that mushroom poisonings occurred every month and were centered from June to October; however, 1 peak appeared in July in 2019 (*1*), while 2 peaks (June and September) appeared in 2020. Geographical distribution analysis showed that mushroom poisoning incidents were reported in 24 PLADs in 2020—among which, 16 PLADs also reported cases in 2019 with the new PLADs being Anhui, Jiangxi, Beijing, Hebei, Inner Mongolia, Liaoning, Gansu, and Xizang (Tibet) (Supplementary Table S1). The PLADs with the highest number of mushroom poisonings were Hunan, Yunnan, Guizhou, Zhejiang, and Sichuan in 2020 (Supplementary Table S1), and Hunan, Yunnan, Zhejiang, Guizhou, and Chongqing in 2019 (*1*). Yunnan and Guizhou had the most deaths (*7*) in 2020, but in 2019, Yunnan had 14 deaths (*1*). Approximately 102 species of poisonous mushrooms were identified in incidents in 2020, among which 35 species were also identified in 2019, and the total number reached approximately 130 species.

In Spring 2020, 4 people were poisoned by "false morels" resulting in typical metabolic-based pathology secondary to blocking of GABA synthesis in multiple organs. Clinically, the incubation period is 5–12 hours or longer, followed by gastrointestinal system effects, ataxia, hypoglycaemia, haemolysis, methaemoglobinaemia, or even hepatic damage (*3*). Another study showed that this species was different from *Gyromitra esculenta* and represented a new species described as *G. venenata* (*7*).

Paxillus involutus was used as medicine for treating lumbago, skelalgia, and limb numbness in China and was considered edible in some areas of Northeast China, and recent studies also showed it was a good source of antioxidant (*2*). However, *Paxillus involutus* was reported as causing hemolysis after repeated exposure, and its toxins and poisoning mechanism are still unclear (*3*). The 2 incidents in 2020 involving 6 people but only 2 persons were poisoned with 1 death and the other developing renal failure. For safety, we strongly advise not to collect and eat this species although it seems safe to many people.

Gerhardtia sinensis was identified in 2 incidents involving 6 patients and treated as a highly suspected poisonous species in 2019 (*1*). In 2020, this species caused 4 incidents involving 13 patients and was confirmed as poisonous although its toxicology was still unclear (Supplementary Table S1). Another mushroom causing 5 people GIT on August 23 from Dehong, Yunnan, was identified as *Lactifluus pseudoluteopus*. As no toxicological knowledge is available, this mushroom is highly suspected as poisonous presently although several closely related species are edible (*4*).

Patients from many mushroom poisoning incidents consumed mixed wild mushrooms (Supplementary Table S1), and these poisonous mushrooms often caused different clinical syndromes, which put them at high risk. For example, patients consuming together *Amanita fuliginea* and *A. neoovoidea*, *A. fuliginea* and *A. pseudoporphyria*, or *A. fuliginea* and *A. oberwinklerana* could cause acute liver failure and acute renal failure at the same time (Supplementary Table S1). *Coprinus comatus* is a widely consumed mushroom, but as it is matures, coprine accumulates and may lead GIT, especially when combined with alcohol. Therefore, we strongly advise not combining consumption of mixed wild mushrooms and alcohol.

Over 1,000 edible mushrooms and approximately 500 poisonous species were reported in China (*1*–*2*,*4*).

Morphologically, many poisonous species are similar to edible ones, e.g. the lethal *Russula subnigricans* causing rhabdomyolysis is similar to the edible *R. nigricans*, making it hard to differentiate and repeatedly causing poisoning incidents. Educated individuals with the ability to recognize poisonous mushrooms and people aware of the risk of eating wild mushrooms are the basis for mushroom poisoning prevention and control. Therefore, science education is of great importance for reducing mushroom poisoning. In the last few years, many educational science materials for mushroom poisonings in China were produced with cooperation from governments, CDCs, doctors, and mycologists.

Accurate and timely species identification is of pivotal importance in mushroom poisoning incidents, and progress has been made as more incidents were properly identified, which could better guide the diagnosis and treatments for patients. The number of incidents with satisfactory mushroom identification grew from only 2 during 2010–2014 (*11*) to over 200 in 2019 (*1*) and over 600 in 2020. The growing number of poisonous mushroom identifications suggests that what we know only a portion of the variety of poisonous mushrooms. Many species need to be formally described and their edibility is not clear. More effort and closer cooperation are still needed urgently from local and national governments, CDC staff, doctors, and mycologists to properly control mushroom poisoning events.

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SUPPLEMENTARY TABLE S1. Mushroom species involved in poisoning incidents and their spatial and temporal distribution in China, 2020.

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Acute liver failure					
Amanita exitialis	11	36	2	5.56	Feb 24 to Mar 30, Guangdong; June 22 to July 22, Yunnan
Amanita fuliginea	9	23	0	0	June 1 to July 18, Hunan and Guizhou
Amanita fuliginea and *A. neoovoidea*[ARF]	1	2	0	0	June 28, Zhejiang
Amanita fuliginea and *A. pseudoporphyria*[ARF]	2	3	0	0	June 2 to 9, Hunan
Amanita fuliginea and *A. subjunquillea*[ALF]	1	4	3	75.00	July 18, Guizhou
Amanita fuliginea and *A. oberwinklerana*[ARF]	1	2	0	0	June 23, Hunan
Amanita fuliginea and *A. fritillaria*[G/P]	3	9	0	0	June 5 to 15, Hunan
Amanita* cf. *fuliginea	2	9	0	0	June 18 to June 19, Guizhou and Chongqing
Amanita pallidorosea	4	7	0	0	June 16 to July 8, Guizhou
Amanita pallidiorosea and *A. sinocitrina*[P]	1	1	0	0	June 30, Guizhou
Amanita pallidorosea and *A. fritillaria*[G/P]	1	2	0	0	June 30, Chongqing
Amanita rimosa	4	10	0	0	June 6 to 27, Hunan, Hubei, and Chongqing
Amanita rimosa and *Lepiota brunneoincarnata*[ALF]	1	4	0	0	June 12, Hunan
Amanita subjunquillea	6	28	0	0	June 18 to 28, Guizhou; Aug 20 to Sept 2, Hebei and Beijing
Amanita subpallidorosea	4	8	4	50.00	Sept 16 to Oct 15, Yunnan and Guizhou
Amanita subpallidiorosea, A. citrina[P] and ***Lactifluus puberulus***[G]	1	3	0	0	Oct 20, Guizhou
Amanita sp., *Psathyrella candolleana*[G/P], *Russula* sp.[U] and *Agaricus* sp.[U]	1	2	1	50.00	July 13, Sichuan
Galerina sulciceps	6	12	2	16.67	Oct 8 to 16, Yunnan, Sichuan, and Guizhou
Lepiota brunneoincarnata	14	28	5	17.86	May 13 to July 3, Hubei, Hunan, and Jiangsu; Aug 19 to 30, Ningxia, Gansu, Shandong, Hebei and Liaoning
Lepiota brunneoincarnata and *Gymnopus dryophilus*[G]	1	1	0	0	Sept 14, Guizhou
Rhabdomyolysis					
Russula subnigricans	10	26	4	15.38	June 26 to Oct 4, Yunnan, Zhejiang, and Hunan
Russula subnigricans and *R. japonica*[G]	1	4	0	0	July 5, Yunnan
Russula subnigricans and *Entoloma prismaticum*[U]	1	2	0	0	Aug 8, Sichuan
Acute renal failure					
Amanita gymnopus	3	4	0	0	June 14 to July 7, Hunan and Yunnan; Oct 10, Zhejiang
Amanita neoovoidea	4	4	0	0	Sept 24 to Oct 19, Hunan and Sichuan
Amanita oberwinklerana	14	36	0	0	June 6 to July 5, Guizhou, Chongqing, Hunan, and Jiangsu; July 26 to Sept 25, Henan, Shanxi, Beijing, Hebei and Hunan
Amanita oberwinklerana and *A.* cf. *ibotengutake*[P]	1	1	0	0	Sept 5, Beijing
Amanita oberwinklerana and *A. pseudoporphyria*[ARF]	2	3	0	0	June 3 to Sept 30, Hunan
Amanita pseudoporphyria	14	49	3	6.12	June 6 to Oct 14, Hunan, Guangxi, and Yunnan
Amanita aff. *pseudoporphyria*	3	10	0	0	June 6 to Oct 5, Hunan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Amanita pseudoporphyria and *Suillus placidus*[G] (dried mushrooms)	1	3	0	0	Dec 16, Hunan
Hemolysis					
Paxillus involutus	2	2	1	50.00	Sept 12 to 13, Inner Mongolia
Gastroenteritis					
Baorangia major	1	4	0	0	May 25, Fujian
Baorangia major and *B. pseudocalopus*[G]	1	7	0	0	July 19, Yunnan
Baorangia sp.	1	5	0	0	July 23, Yunnan
Boletellus cf. *emodensis*	1	1	0	0	Aug 12, Yunnan
Chlorophyllum demangei and *Scleroderma aurantiacum*[G]	1	2	0	0	July 31, Sichuan
Chlorophyllum globosum	3	14	0	0	June 3 to Aug 20, Sichuan
Chlorophyllum hortense and *Clitocybe* sp.[P]	1	1	0	0	Oct 26, Sichuan
Chlorophyllum molybdites	152	302	0	0	Mar 28 to Oct 20, Hunan, Guangxi, Zhejiang, Anhui, Sichuan, Hubei, Yunnan, Chongqing, Jiangxi, Hainan, Henan, Guangdong, Fujian, Guizhou, and Jiangsu
Chlorophyllum molybdites and *Ch. hortense*[G]	1	1	0	0	Sept 13, Hunan
Chlorophyllum molybdites and *Entoloma omiense*[G]	1	1	0	0	Sept 28, Hunan
Chlorophyllum spp.	3	9	0	0	July 31 to Dec 14, Sichuan, Hunan, and Guangdong
Cortinarius sinensis.[E] and *C. fulminoides*[U] (bought from market)	1	4	0	0	Sept 8, Ningxia
Entoloma caespitosum	1	1	0	0	Sept 20, Hunan
Entoloma omiense	28	49	0	0	June 28 to Oct 9, Hunan, Zhejiang, Hainan, and Fujian
Entoloma omiense, Entoloma sp[U] and *Psathyrella candolleana*[G/P]	1	1	0	0	July 8, Hunan
Entoloma omiense and *Micropsalliota* sp[U]	1	3	0	0	Sept 10, Fujian
Entoloma omiense and *Suillus placidus*[G]	1	4	0	0	Sept 17, Guizhou
Entoloma cf. *rhodopolium*	1	5	0	0	Aug 4, Yunnan
Entoloma cf. *sinuatum*	2	4	0	0	Sept 14 to 21, Guizhou
Entoloma spp.	17	51	0	0	June 5 to Oct 18, Guangxi, Guizhou, Hunan, and Yunnan
Gerhardtia sinensis	4	13	0	0	Oct 7 to 11, Hunan
Gymnopus densilamellatus	3	19	0	0	Feb 12 to May 31, Hunan and Guizhou
Hygrophorus cf. *whitei*[U], *Lycoperdon caudatum*[U] and *Megacollybia marginata*[U]	1	5	0	0	Oct 9, Sichuan
Hypholoma fasciculare	3	9	0	0	July 8 to Dec 4, Sichuan and Yunnan
Lactarius subhirtipes	3	9	0	0	May 31 to July 26, Hunan, Guizhou, and Anhui
Lactifluus deceptivus, *Lf. pilosus*[G], *Lf.* aff. *piperatus*[G] and ***Lf. puberulus***[G] (dried mushrooms)	1	2	0	0	Feb 9, Hunan
Lactifluus pseudoluteopus[U]	1	5	0	0	Aug 23, Yunnan
Leucocoprinus cretaceous and *Lc. cepistipes*[G]	1	2	0	0	Sept 13, Hunan
Marasmius maximus[E] and *Mycena* sp.[U]	1	1	0	0	July 18, Hubei
Melanoleuca griseobrunnea[U]	1	2	0	0	May 12, Zhejiang
Micropsalliota furfuracea	1	2	0	0	Sept 14, Hunan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Micropsalliota sp.[U], *Hortiboletus rubellus*[E] and *Russula pectinatoides*[E]	1	2	0	0	Sept 24, Hunan
Neoboletus venenatus (patients of two incidents ate dried mushrooms, bought from market)	4	9	0	0	Aug 13 to Sept 24, Xizang, Guangdong, Hunan, and Sichuan
Neoboletus venenatus and *Scleroderma bovista*[G] (dried mushrooms, bought from market)	1	2	0	0	June 18, Hunan
Neonothopanus* aff. *nambi	2	4	0	0	May 13 to July 13, Yunnan
Omphalotus guepiniformis	2	10	0	0	May 28, Guangxi; Oct 4, Hunan
Omphalotus olearius	2	16	0	0	Sept 9 to Nov 16, Yunnan
Pholiota multicingulata	2	9	0	0	Sept 22 to Oct 5, Hunan
Pulveroboletus subrufus, *Russula punctipes*[G], *Chiua virens*[G] and *Suillus pinetorum*[G]	1	2	0	0	Dec 6, Guizhou
Rubroboletus sinicus and *Neoboletus* cf. *multipunctatus*[U]	1	4	0	0	July 28, Guizhou
Rubroboletus sinicus and *Retiboletus fuscus*[E]	1	3	0	0	June 18, Yunnan
Rubroboletus sp.[U]	1	2	0	0	July 25, Hunan
Russula viridicinnamomea[E], *Agaricus* sp.[U], *Termitomyces microcarpus*[E] and *Lactarius vividus*[E]	1	5	0	0	Aug 2, Sichuan
Russula rufobasalis	1	1	0	0	June 10, Hunan
Russula rufobasalis, ***Lactarius atromarginatus***[G], *Amanita fritillaria*[G/P] and *Russula citrina*[U]	1	2	0	0	June 11, Hunan
Russula rufobasalis, *Amanita fritillaria*[G/P], *Russula compacta*[E], *R. nigricans*[E], *R. subatropurpurea*[E], *R.* cf. *fragrantissima*[U], and *Cortinarius purpurascens*[U]	1	2	0	0	June 11, Hunan
Russula grata, R. cf. *subfoetens*[G], *Lactifluus* aff. *glaucescens*[G], *R. fragrantissima*[U], *R. pseudoamoenicolor*[U], *R. sarnarii*[U], *R. cyanoxantha*[E], *R. variata*[E], *R. vesca*[E], *R. virescens*[E] and *Entoloma* cf. *undatum*[U] (dried mushrooms, bought from market)	1	3	0	0	Feb 5, Hunan
Russula japonica	58	151	0	0	May 31 to Oct 15, Hunan, Zhejiang, Chongqing, Anhui, Yunnan, Guizhou, Fujian, and Hubei
Russula japonica, Entoloma omiense[G] and *Agaricus* sp.[U]	1	3	0	0	Oct 5, Hunan
Russula japonica, R. cerolens[E], *Leotia lubrica*[U] and *Phylloporus dimorphus*[E]	1	2	0	0	July 11, Guizhou
Russula japonica and *R. foetens*[G]	1	1	0	0	June 15, Hunan
Russula japonica and *R. sanguinea*[G]	1	3	0	0	June 10, Hunan
Russula japonica and *R. puncitpes*[G]	1	3	0	0	Oct 3, Hunan
Scleroderma areolatum	1	12	0	0	Aug 12, Beijing
Scleroderma cepa	4	11	0	0	July 7 to Sept 27, Yunnan, Sichuan, Hunan, and Chongqing
Scleroderma citrinum	1	1	0	0	Oct 13, Hunan
Suillus granulatus (dried mushrooms, bought from market)	1	2	0	0	Mar 23, Ningxia
Suillus granulatus, Amanita sinocitrina[P], *A. griseofolia*[G/P], *Russula* spp.[U], *Lycoperdon* sp.[U] and *Gymnopus* sp.[U]	1	1	0	0	Sept 24, Hunan
Suillus pinetorum	1	8	0	0	July 21, Yunnan
Thicholoma highlandense	1	2	0	0	Nov 13, Yunnan
Tricholoma sinopardinum, T. sinoportentosum[E], *Lactarius deterrimus*[E] and *Agaricus* sp.[U]	1	3	0	0	July 21, Sichuan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Tricholoma stans	1	6	0	0	Nov 14, Yunnan
Tylopilus neofelleus	1	1	0	0	Aug 9 to Sept 27, Yunnan and Chongqing
Psycho-neurological disorder					
Amanita griseopantherina and *Russula foetens*[G]	1	12	0	0	July 21, Sichuan
Amanita melleiceps	5	20	0	0	May 30 to Sept 15, Hunan and Guangxi
Amanita orientigemmata	1	1	0	0	Sept 23, Hunan
Amanita orsonii, A. pseudovaginata[U] and *Entoloma* cf. *subcorvinum*[U]	1	2	0	0	June 28, Guizhou
Amanita rufoferruginea	6	18	0	0	June 6 to Aug 6, Hunan, Chongqing, and Sichuan
Amanita cf. *subfrostiana*	1	2	0	0	July 21, Yunnan
Amanita subglobosa	17	49	0	0	June 19 to Sept 24, Guizhou, Anhui, Chongqing, Sichuan, Yunnan, and Hunan
Amanita sychnopyramis f. *subannulata*	4	42	0	0	Apr 26 to June 10, Hainan, Guangxi, and Hunan
Butyriboletus roseoflavus (bought from market, maybe from Yunnan)	1	9	0	0	Nov 5, Hainan
Clitocybe dealbata	1	2	0	0	July 15, Yunnan
Clitocybe subditopoda	1	3	0	0	Oct 5, Guizhou
Gymnopilus dilepis	6	13	0	0	June 21 to Sept 23, Sichuan, Yunnan, and Guizhou
Gymnopilus spp.	5	8	0	0	May 9 to Oct 3, Jiangxi, Hubei, Hunan, and Yunnan
Gyromitra venenata	2	4	0	0	Mar 13 to 21, Guizhou, Yunnan
Inocybe* aff. *ericetorum and *Russula insignis*[G]	1	1	0	0	May 26, Hunan
Inocybe serotina	1	2	0	0	Sept 19, Ningxia
Inocybe serotina and ***Mallocybe fulvipes***[P]	1	1	0	0	Sept 2, Ningxia
Inocybe serotina and *Pseudosperma umbrinellum*[P] = *Inocybe umbrinella*	1	4	0	0	Aug 28, Ningxia
Inocybe splendentoides	1	1	0	0	Oct 7, Beijing
Inosperma* aff. *virosum	2	16	0	0	Sept 9 to 16, Yunnan
Inosperma* cf. *virosum	1	5	0	0	May 9, Hainan
Lanmaoa asiatica	1	4	0	0	July 19, Yunnan
Lanmaoa asiatica, Rubroboletus latisporus[G], *Suillus granulatus*[G], *Caloboletus xiangtoushanensis*[U] and *Imperator* sp.[U] (dried mushrooms, from Chongqing)	1	3	0	0	Aug 27, Guangdong
Lanmaoa asiatica, Rubroboletus latisporus[G], *Tylopilus neofelleus*[G], *Neoboletus* sp.[U] and *Sutorius* aff. *eximius*[G] (dried mushrooms, from Chongqing)	1	3	0	0	Oct 13, Zhejiang
Panaeolus fimicola	1	2	0	0	June 30, Shandong
Pseudosperma* cf. *bulbosissimum	1	4	0	0	Oct 5, Ningxia
Pseudosperma umbrinellum, ***Mallocybe siciliana***[P] = *Inocybe siciliana, Hebeloma dunense*[U] and *Psathyrella candolleana*[G/P]	1	4	0	0	Sept 4, Hebei
Pseudosperma yunnanense	1	1	0	0	July 10, Yunnan
Psilocybe cubensis	1	2	0	0	Nov 27, Hunan
Shiitake mushroom dermatitis					
Lentinula edodes[E]	1	1	0	0	Jan 5, Jiangxi

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Unclassified					
Agaricus blazei[E]	1	2	0	0	Aug 25, Yunnan
Amanita cf. *constricta* and *Entoloma* cf. *piceinum*[U]	1	5	0	0	Aug 7, Sichuan
Amanita griseofolia	1	4	0	0	June 27, Guizhou
Butyriboletus yicibus[E] (from Yunnan)	1	4	0	0	July 26, Hunan
Coprinopsis nivea[E]	1	3	0	0	June 29, Hunan
Coprinus comatus[E]	2	3	0	0	Early August to Oct 25, Beijing and Ningxia
Cortinarius sinensis.[E] (bought from market)	1	2	0	0	Sept 24, Ningxia
Lactarius cinnamomeus[E]	1	2	0	0	Mar 14, Hunan
Lactifluus tenuicystidiatus[E]	1	2	0	0	Aug 25, Yunnan
Panus gigianteus[E]	1	4	0	0	Sept 20, Hunan
Panus tigrinus[E]	1	1	0	0	May 16, Yunnan
Pleurotus ostreatus[E]	1	1	0	0	Oct 31, Ningxia
Retiboletus fuscus[E] (dried mushrooms, from Yunnan)	1	2	0	0	Mar 6, Fujian
Russula cf. *viridicinnamomea*[E]	1	4	0	0	July 29, Fujian
Scleroderma yunnanense[E]	3	7	0	0	June 25 to Sept 15, Hunan, Yunnan, and Fujian
Stropharia rugosoannulata[E]	1	1	0	0	Jan 31, Guizhou
Xerocomus parvulus[E]	1	4	0	0	Sept 28, Hunan

Abbreviations: ALF=Acute liver failure, ARF=Acute renal failure, G= Gastroenteritis, P= Psycho to neurological disorder, U=Unclassified, E=edible.
Note: Species newly recorded as poisonous mushrooms in China are in bold.

Outbreak Reports

A Poisoning Outbreak Caused by *Millettia Pachycarpa* — Chongqing Municipality, December 2020

Qian He[1]; Xun Tang[2]; Shisong Wang[3]; Maolin Zhang[3]; Hongshun Zhang[4,#]

Summary

What is already known about this topic?

Millettia pachycarpa belongs to the Fabaceae family and is widely distributed in the southern China. It is toxic for the rotenone contained in its roots and seeds, and ingesting its seeds could result in poisoning.

What is added by this report?

In December, 2020, a poisoning from plant seeds occurred in Chongqing Municipality. The etiological association was confirmed based on epidemiological investigation, clinical manifestation, plant species identification, and rotenone analysis. The patient rapidly developed central nervous and respiratory depression with metabolic acidosis. The plant was identified as *Millettia pachycarpa*, and toxin analysis indicated that the rotenone content contained in the seeds was high enough to cause intoxication.

What are the implications for public health practice?

Millettia pachycarpa poisoning is rare but could be fatal. Efforts should be made to educate and communicate with the public, doctors, and public health practitioners that the toxic effects the seeds could be life-threating when swallowed, both accidentally or intentionally.

On December 18, 2020, the National Poison Control Center received notification that a poisoning accident occurred due to ingestion of plant seeds, and the patients were admitted to Fengdu County People's Hospital of Chongqing Municipality. The plant seemed to stem from the *Millettia* genus based on the pictures provided by one patient's wife. To further clarify the causality of the intoxication outbreak and provide control measures, an investigation into the outbreak was conducted in collaboration with Chongqing Poison Control Center. The plants with fruits were collected at the site where the poisoning occurred, and the doctors and patients were interviewed to obtain the clinical course and treatments. Then, the species of plants was identified, and the rotenone contents of the seeds and gastric lavage samples were analyzed.

INVESTIGATION AND FINDINGS

Around 11:30 on December 18, 2020, 2 workers picked fruits thinking they were edible on the hillside besides their workplace in a village in Fengdu County, Chongqing Municipality. Subsequently, they grilled the fruits and shared several fruits with another worker, and all the three workers ate the seeds after peeling the pericarp. They developed discomfort a few minutes after ingesting the seeds. Two of the workers spit out most of the seeds due to poor taste and experienced slightly transient nausea and dizziness but recovered relatively quickly. In contrast, the other 32-year-old male worker who swallowed a whole seed unsuccessfully tried to induce vomiting for himself. He underwent limb weakness and dizziness and rapidly lost consciousness and progressed to coma about ten minutes later. He was then sent to Fengdu County People's Hospital immediately. The patient was unconsciousness on the way to the hospital and admitted to hospital in about fifty minutes.

The patient experienced central nervous system depression and respiratory failure when arriving at the hospital. He presented deep coma, mydriasis, and had no light reflection. His breath was slow, averaging 6 breaths per minute, and the blood oxygen saturation was 67%. Physical examination showed breathing sounds were rough and that wet rales (crackling sounds) were present in both lower lungs. The patient was intubated and treated with ventilator-assisted ventilation to stabilize the vital signs immediately, during which scarlet foam was ejected from the trachea, and gastric lavage was performed to decrease toxin absorption. Chest computed tomography (CT) showed patchy shadows and pleural effusion in both lower lungs. Blood gas analysis indicated metabolic acidosis with pH: 7.09; lactic acid: 11.76 mmol/L. The patient was admitted to the intensive care unit after emergency treatment, underwent hemoperfusion therapy once, and was administrated intravenous sodium bicarbonate to maintain electrolyte balance. The patient took off the ventilator 28 hours after admission and resumed spontaneous breathing, and his consciousness recovered. He was treated and observed in the hospital until his chest CT completely recovered and was discharged.

The plant specimens were collected at the scene of the poisoning incident and testified as the ingested plants by the patient. It was identified as the *Millettia pachycarpa* (Figure 1) using morphological and DNA barcoding method, which belongs to Fabaceae family. The specimen was deposited in the Poisonous Plants Herbarium affiliated with the National Poison Control Center (No. 2020121801).

The primary toxin rotenone in *Millettia pachycarpa* seeds and biological samples were analyzed used liquid chromatography coupled to mass spectrometry method. The rotenone content in *Millettia pachycarpa* seeds (n=2) were 1,389.46 mg/kg and 928.88 mg/kg, and the rotenone content in gastric fluid sample was 3.16 μg/mL. In addition, there were others rotenoid compounds found in the seeds with untargeted screening.

DISCUSSION

China CDC collaborated with the local poison control center to conduct an investigation to clarify how this poisoning occurred. This outbreak was exactly attributed to the ingestion of *Millettia pachycarpa* seeds, and the etiological association was confirmed based on the evidence in epidemiological correlation, clinical manifestations, plant species identification and rotenone toxin analysis. This work demonstrated that *Millettia pachycarpa* has potential for poisoning and that the public should be warned about the severe toxic effects and potential fatal effects.

Although ingestion of *Millettia pachycarpa* seeds is relatively rare, it may be fatal without appropriate and timely treatment. This incident involved 3 persons, 2 of whom experienced slightly transient dizziness and recovered fast, while the other suffered severe central nervous and respiratory depression, due to the difference in intake amount. The neurological symptoms of the 32-year-old male patient progressed rapidly from dizziness to coma with respiratory depression in about 10 minutes after the ingestion. The scarlet foam ejected from the trachea and the chest CT indicated aspiration pneumonia developed, which was accounted for the central nervous depression and vomiting caused by gastrointestinal irritation. The patient was intubated and ventilated immediately after admission to the emergency department, then, the gastric lavage was carried out to break off more toxin absorption. In addition, the patient underwent hemoperfusion therapy and administered sodium

FIGURE 1. The leaves, fruits, and seeds of *Millettia pachycarpa*.

bicarbonate to maintain acid-base balance.

The toxicity of *Millettia pachycarpa* seeds is attributed to its rotenone and rotenoids. Rotenone mainly exerts toxicity to the nervous, respiratory, and gastrointestinal systems when ingested orally. There is no specific antidote available for rotenone poisoning, and treatment mainly relies on symptomatic and supportive measures (*1*), including intubation, mechanically-assisted ventilation, maintenance of acid-base balance, and stabilizing the vital signs. Gastrointestinal decontamination, such as emetic and gastric lavage, should be used to prevent more toxin absorption even when the patient is unconsciousness. There is insufficient evidence that hemoperfusion therapy is effective for eliminating rotenone, but it is one of the choices for the treatment of rotenone poisoning. The recognition and treatment of the inhalation of pneumonia should be a priority when such patients are encountered.

Millettia pachycarpa is a rotenone-containing plant and is widely distributed in the south of China. Reports of *Millettia pachycarpa* poisoning were uncommon in China, but 2 incidents occurred in Guizhou and Hunan provinces in 2020. Another rotenone-containing plant, *Pachyrhizus erosus*, has an edible root and is cultivated extensively in southeastern China, but its rotenone-containing seeds can cause occasional poisonings by accidental ingestion. Additionally, there were several reports of poisonings caused by rotenone-containing plants in other countries and regions. In China (Taiwan) (*2*–*3*) and Thailand (*4*), *Pachyrhizus erosus* seeds, also called “yam beans,” were reported to result in life-threating poisonings and deaths. In French Guiana (*5*), a woman ingesting another rotenone-containing plant belonging to *Lonchocarpus* genus committed suicide, and the exact species was unable to be determined.

In the region where *Millettia pachycarpa* and other rotenone-containing plants were distributed, ingestion and misuse of the plants should be prevented. Therefore, the public should be educated to distinguish the plants and recognize its toxic effects. Clinicians should be aware and trained to recognize clinical toxicological characteristics and treatment of rotenone-containing plants intoxication. In addition, the pathophysiological, toxicokinetic, and treatment strategy of rotenone-containing plants poisoning should be further reviewed and studied.

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Vital Surveillances

Mushroom Poisoning Outbreaks — China, 2010–2020

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ABSTRACT

Introduction: Mushroom poisoning was the leading cause of foodborne disease outbreaks and outbreak-associated deaths in China. Mushroom poisoning outbreak surveillance can provide insight into the epidemiological characteristics of mushroom poisonings and guide policymaking and health education to reduce illnesses and deaths.

Methods: Foodborne Disease Outbreak Surveillance System was upgraded in 2011 to collect foodborne disease outbreaks in China. Mushroom poisoning outbreaks during 2010–2020 were selected to analyze geographical distribution, seasonal distribution, and setting of food preparation.

Results: A total of 10,036 outbreaks, which resulted in 38,676 illnesses and 788 deaths, were reported in this period. Mushroom poisonings occurred all over the country, but with highest incidence in the southwest and central China. Overall, 84.6% outbreaks were associated with food prepared in households, followed by 8.7% in street stalls, and 2.5% in canteens. Mushroom poisoning outbreaks clearly exhibited seasonality, and the peak season was summer through autumn. Outbreaks occurring between May and October accounted for 94.1% of total outbreaks, 92.4% illnesses, and 97.2% deaths.

Conclusions: Mushroom poisoning is a food safety issue of higher concern in China. Targeted health education is essential to reduce mushroom poisoning, especially in southwest China. Citizens are advised to not collect or eat wild mushrooms.

INTRODUCTION

Wild mushroom consumption is widespread throughout the world, due to the nutritional value and medicinal properties (*1*–*2*). However, mushroom poisoning is a cause of major mortality and morbidity throughout the world (*3*–*4*). Toxic mushrooms are distributed across the globe with over 5,000 species. Among them, 100 species are responsible for most of the cases of mushroom poisoning (*5*). A total of 1,020 edible, 692 medicinal, and 480 poisonous species have been identified in China (*6*). Mushrooms are more abundant in warm and rainy summer and autumn, and mushroom pickers, especially if inexperienced, may not fully perceive the risks associated with ingesting potentially toxic mushroom species. Most mushroom poisonings reported were accidental oral ingestion of poisonous mushrooms misidentified for edible species. Morphological characteristics and appearance of many edible species were like those of poisonous mushrooms. Poisonous mushrooms cause the most deaths in remote districts in southwest regions in China (*7*). Mushroom poisonings often occur in other countries (*8*–*9*), but outbreaks were rarely reported (*10*).

Different levels of CDCs in China investigate and report foodborne disease outbreaks according to the requirements of the Food Safety Law. The China National Center for Food Safety Risk Assessment (CFSA) maintains and manages the Foodborne Disease Outbreaks Surveillance System for data collection and analysis. This study aimed to summarize and analyze the epidemiological characteristics of mushroom poisoning outbreaks from 2010 to 2020 in China.

METHODS

A foodborne disease outbreak is defined as an incident in which two or more cases involve a similar illness resulting from the consumption of a common food (*11*). A standard form was used to report the foodborne disease outbreaks investigated by CDCs at provincial, municipal, and county levels. All approved mushroom poisoning outbreak reports from 2010 through 2020 were collected through Foodborne Disease Outbreaks Surveillance System. Data collected in each outbreak report included the reporting CDC, the date of occurrence, the number of illnesses, hospitalizations, deaths, the etiologic agents, implicated food vehicle, setting of food preparation, and contributing factors.

All reported outbreaks were audited and checked, then stored and managed using Microsoft Excel (version 2016, Microsoft, USA). All variable values were reported as counts or proportions (%).

RESULTS

During 2010–2020, a total of 10,036 mushroom poisoning outbreaks were reported to Foodborne Disease Outbreaks Surveillance System, resulting in 38,676 illnesses, 21,967 hospitalizations, and 788 deaths. The annual number of reported outbreaks increased each year, from 37 reported in 2010 to 2,705 in 2020 (Figure 1). The average number of illnesses per outbreak was 3.9, and average hospitalization and fatality rates were 56.8% and 2.0%, respectively.

Except for Xizang (Tibet) Autonomous Region, the other 30 provincial-level administrative divisions (PLADs) in China reported outbreaks (Figure 2). Southwest China was the region with highest number of outbreaks (6,062), illnesses (24,444), and deaths (454); 1,900 outbreaks occurred in central China, leading to 6,559 illnesses and 137 deaths; 1,132 outbreaks occurred in east China, leading to 4,094 illnesses and 112 deaths; 423 outbreaks occurred in south China, leading to 1,663 illnesses and 30 deaths; and followed by northwest China (213 outbreaks, 749 illnesses, and 20 deaths), north China (153 outbreaks, 621 illnesses, and 25 deaths), and northeast China (153 outbreaks, 546 illnesses, and 10 deaths). The total number of outbreaks reported by each PLAD varied from as low as 1 in Tianjin and Shanghai to as high as 4,010 in Yunnan. The overall national reporting rate during 2010–2020 was 0.3 outbreaks/million population. The top 5 PLADs, including Yunnan, Hunan, Guizhou, Sichuan, and Jiangxi, comprised 79.7% (8,002/10,036) of total outbreaks, 80.3% (31,058/38,676) of total illnesses, and 74.6% (588/788) of total deaths. Yunnan reported the most outbreaks, illnesses, and deaths, accounting for 40.0%, 43.6%, and 41.0%, respectively.

The locations of food preparation were divided into 2 main categories: household and catering service places (Table 1). Among the 10,036 reported outbreaks, 84.7% were associated with food prepared in private homes (leading to 77.8% illnesses and 92.8% deaths), followed by 8.8% related with food prepared in street stalls (leading to 8.6% illnesses and 2.0% deaths), and 2.5% in canteens (leading to 4.6% illnesses and 1.9% deaths). The major cause of private-home outbreaks was self-harvest of wild mushrooms, which led to 98.1% of all private home outbreaks, 98.2% of illnesses, and 99.6% of deaths. Purchase of wild mushroom was the most common cause of catering service outbreaks, accounting for 63.5% of all catering service outbreaks, 49.0% illnesses, and 28.3% deaths.

From 2010 to 2020, mushroom poisoning outbreaks annually clearly exhibited seasonality (Figure 3). A large proportion of outbreaks occurred between May and October, accounting for 94.1% of total outbreaks, 92.4% of total illnesses, and 97.2% of total deaths. In Yunnan, there was a clear peak of

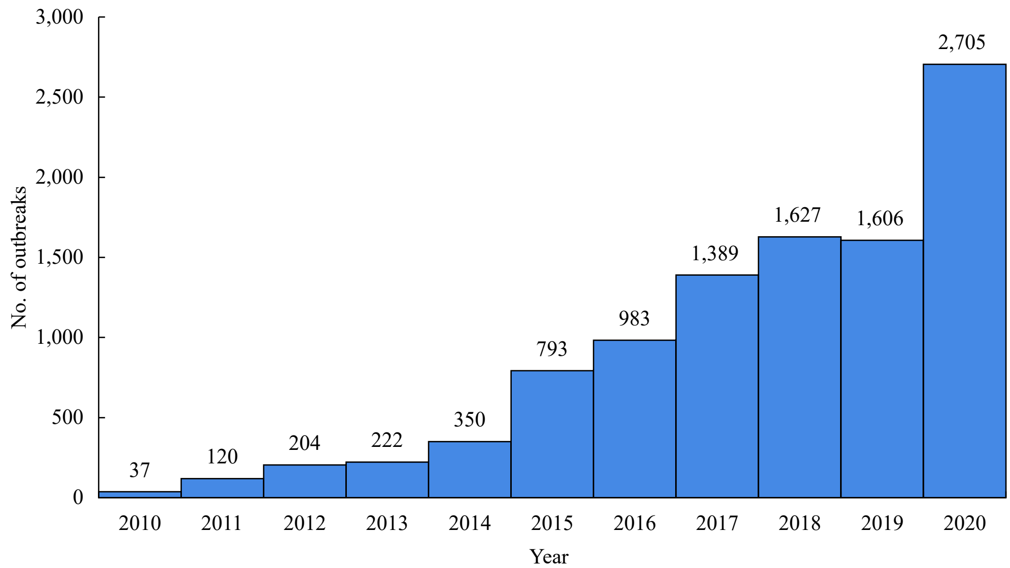

FIGURE 1. Number of reported mushroom poisoning outbreaks by year, Foodborne Disease Outbreak Surveillance System, China, 2010–2020.

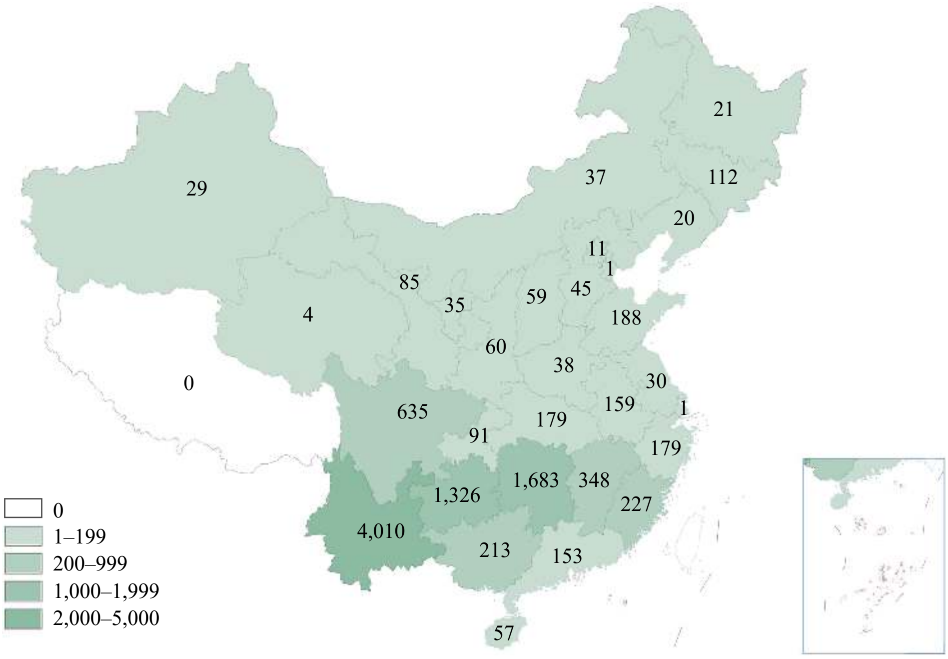

FIGURE 2. Number of reported mushroom poisoning outbreaks by PLADs in China, 2010–2020.
Abbreviation: PLADs=provincial-level administrative divisions.

TABLE 1. Number and percentage of mushroom poisoning outbreaks, illnesses, hospitalizations, and deaths by settings in China, 2010–2020.

Setting	Outbreaks		Illnesses		Hospitalizations		Deaths	
	Number	%	Number	%	Number	%	Number	%
Household	8,495	84.6	30,098	77.8	17,456	79.5	731	92.8
Catering Service Places	1,463	14.6	8,083	20.9	4,196	19.1	46	5.8
Street stall	878	8.7	3,317	8.6	1,677	7.6	16	2.0
Staff canteen	249	2.5	1,783	4.6	899	4.1	15	1.9
Restaurant	175	1.7	1,107	2.9	550	2.5	0	0.0
Rural banquet	58	0.6	1,240	3.2	789	3.6	9	1.1
Cafe	50	0.5	276	0.7	131	0.6	3	0.4
Fast food store	32	0.3	144	0.4	83	0.4	3	0.4
School canteen	7	0.1	71	0.2	30	0.1	0	0.0
Home delivery of meal	5	0.0	109	0.3	12	0.1	0	0.0
Other	9	0.1	36	0.1	25	0.1	0	0.0
Campus	6	0.1	27	0.1	14	0.1	0	0.0
Other location	72	0.7	468	1.2	301	1.4	11	1.4
Total	10,036	100.0	38,676	100.0	21,967	100.0	788	100.0

outbreaks in July, while 2 peaks appearing in June and September were observed in Hunan and Guizhou.

For all the reported outbreaks, 96.8% involved fewer than 10 cases per outbreak, leading to 95.7% of the total deaths. In addition, 12 outbreaks had more than 30 cases, met the limits of the public health emergency incidents of China, and led to 943 illnesses and no reported deaths.

DISSCUSSION

Mushroom poisoning was the leading cause of foodborne disease outbreaks and outbreak-associated deaths in China. Surveillance data showed that mushroom poisonings accounted for 31.8% of the total outbreaks and 47.4% of the total associated deaths from 2003–2017 (*12*). The annual number of

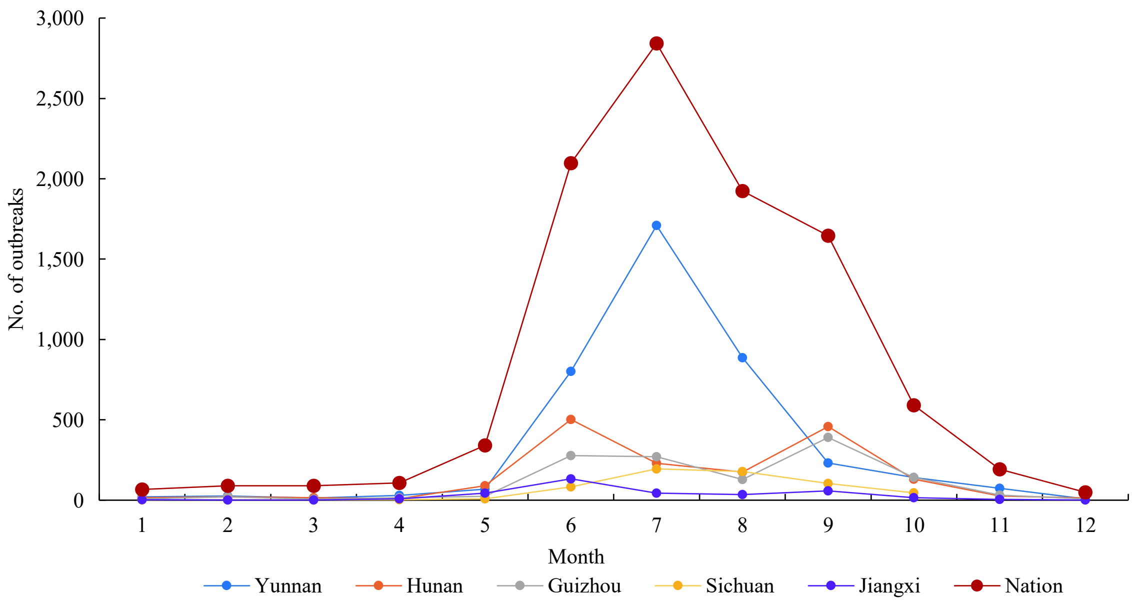

FIGURE 3. Monthly distribution of reported mushroom poisoning outbreaks in China, 2010–2020.

mushroom poisoning outbreaks reported in China gradually increased between 2010 and 2020. The increase is expected to be associated with the implementation of compulsory surveillance in 2011, increasingly strict requirements for outbreak reporting, and enhancement of reporting awareness. Therefore, the increase owed a great deal to the improvement of surveillance sensitivity. Even though 2,075 mushroom outbreaks were reported in 2020, underreporting is still likely.

Mushroom poisonings were reported throughout the country, but the incidence was highest in the southwest and central, likely due to the warm and damp climate conditions. Most outbreaks occurred in private home settings, especially in rural areas, mainly because of the self-harvesting of wild mushroom. Non-expert wild mushroom picking and consumption increases the risk of poisoning due to the difficulties of identifying poisonous mushrooms and distinguishing them from non-poisonous mushrooms. Although citizens are advised not to collect and eat wild mushrooms, mushroom poisoning continues to occur every year.

Mushroom poisoning occurred every month, with peaks in summer and autumn. The seasonality suggests that, albeit always important, health education is especially crucial in this period. Since mushroom picking is more frequent in rural environments, health education targeted for specific groups in rural areas is also essential to reduce mushroom poisonings.

Only 3,872 outbreaks (38.6%) were reported with mushroom names, involving 15,475 illnesses (40.0%) and 275 deaths (34.9%); 65.1% deaths were reported in 6,164 outbreaks involving unidentified mushrooms. Absence of relevant mushroom samples and ingestion of multiple mushrooms increased the difficulty of identifying causative species. Over 180 mushroom names were reported, but most of the outbreaks were reported with trivial, non-scientific names. Accurate and prompt species identification is crucial in the diagnosis and treatment process. More effort and cooperation is needed from administrative agencies, epidemiologists, doctors, and mycologists to increase the identification rate (*13*).

It is not possible to evaluate if the increase in reporting of mushroom poisoning outbreaks in investigations is only due to changes in surveillance practices or reflecting a true increase in incidence. Evaluating trends will be possible when surveillance and reporting practices are well-established and stable throughout the country. Currently, some degree of underreporting still exists, which is also a challenge for all foodborne illnesses globally (*14*). In addition to challenges in surveillance, underreporting is also related to failures in any other step between the occurrence of an illness and the reporting of the outbreak, i.e., patients seeking medical care, the cause of the illness being investigated, and the illness being registered (*15*).

Despite important improvements in surveillance of mushroom poisoning outbreaks, some of the results in the analysis were still subject to some limitations. Some of the epidemiological information is still not complete and accurate, such as mushroom species identification. Efforts should be made to improve investigative procedures, reporting practices, and data collection. Because of different surveillance systems and reporting standards, the results might be different from the other published results earlier or later (*13*).

Identifying and prioritizing interventions to reduce diseases, including mushroom poisoning, requires data on the public health impact of these diseases. The results of this study showed that targeted interventions to reduce mushroom poising in China are crucial. Policy efforts should be focused on citizen campaigns to raise awareness of the risks, and are particularly important in summer and autumn months, rural areas, and specific regions of China.

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Preplanned Studies

Mushroom Poisoning Outbreaks — China, 2021

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Summary

What is already known about this topic?

Mushroom poisoning is one of the most serious food safety issues in China. Most poisoning incidents resulted from eating mushrooms causing gastroenteritis and psycho-neurological disorder from which patients usually could fully recover. Most deaths resulted from species causing acute liver failure and rhabdomyolysis, and the remaining deaths were attributed to acute renal failure and hemolysis.

What is added by this report?

In 2021, the total number of investigations was 327 from 25 provincial-level administrative divisions, involving 923 patients and 20 deaths, and the overall mortality was 2.17%. Overall, 74 poisonous mushrooms causing 6 different clinical syndromes were successfully identified, 15 of which were newly recorded in China as poisonous mushrooms.

What are the implications for public health practice?

Considering the potential huge risks for collecting and eating wild mushrooms, we strongly advise not collecting and eating unfamiliar wild mushrooms. Promoting knowledge about poisonous mushrooms is essential and urgent to reduce mushroom poisonings. Precise species identification timely after mushroom poisoning is important for appropriate diagnosis and treatment. Many deaths were ascribed to delayed hospitalization.

In recent years, an efficient mushroom poisoning control and prevention working system involving governments, clinical doctors, CDC experts, and mycologists has been established in China (*1*–*2*). Based on the technical support network, mushroom poisoning information was systematically collected by WeChat, telephone calls, and E-mails. Mushroom samples were collected by CDC staff or hospital professionals. Species identification depending on morphological observations and DNA data was carried out by mycologists from China CDC, universities, and research institutes nationwide. Related clinical symptoms data were summarized from the hospital records (*1*–*2*). In 2021, 327 independent mushroom poisoning incidents from 25 provincial-level administrative divisions (PLADs) involving 923 patients and 20 deaths were investigated. About 74 poisonous mushrooms resulting in 6 different clinical syndromes were successfully identified. Among the 74 species, 15 species were newly recorded in China. *Hygrocybe rimosa*, *Inosperma muscarium*, and *Pseudosperma arenarium* nom. prov. were three new species discovered in China. *Mallocybe fulvoumbonata*, *Psilocybe ovoideocystidiata*, and *P. papuana* were 3 records new to China, and the 9 remaining previously edibility unclear species were confirmed to be poisonous from poisoning incidents.

In 2021, a total of 327 mushroom poisoning incidents involving 923 patients and 20 deaths were investigated and the overall mortality was 2.17%. The number of cases ranged from 1 to 20, the average number of cases per incident was 2, and 6 incidents involved more than 10 patients. Of these cases, 68 patients from 14 incidents ate poisonous mushrooms purchased from a market or given by friends; 46 patients from 10 incidents were poisoned after eating dried mushrooms and 113 patients from 28 incidents ate mixed mushrooms.

Monthly distribution analysis showed that mushroom poisonings occurred every month, centered from May to November involving 294 incidents, 796 patients, and 18 deaths, and reached its peak in August (Figure 1). The first death appeared in early March from Guangdong. The top 3 months for deaths caused by poisonous mushrooms were September, July, and November with 7, 5, and 4 deaths, respectively.

In terms of geographical distribution, mushroom poisoning incidents were reported in 25 PLADs. Overall, 10 PLADs had over 10 incidents, and Hunan, Yunnan, Sichuan, Fujian, and Guizhou were the top 5 PLADs; 12 PLADs had over 20 patients and Yunnan, Hunan and Sichuan were the top 3 PLADs. Yunnan, Guizhou, and Guangdong had 4 deaths, Sichuan and

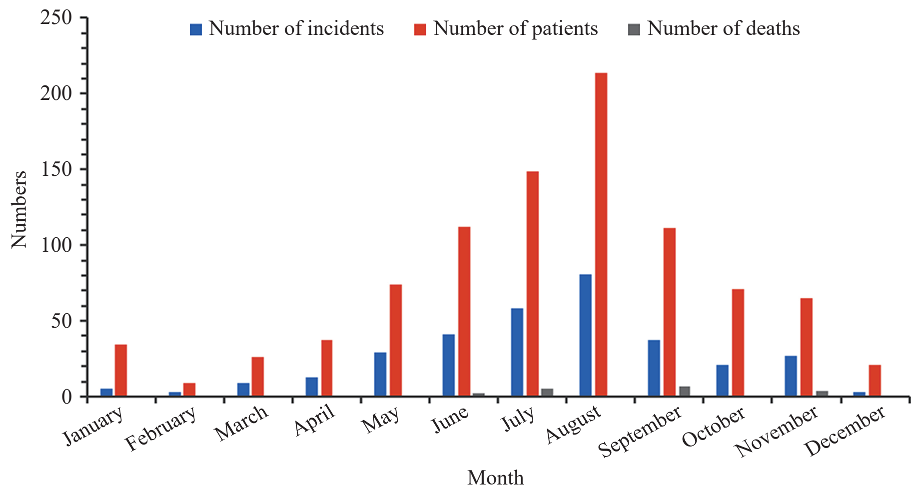

FIGURE 1. Monthly distribution of mushroom poisonings in China, 2021

Shanxi had 2 deaths, followed by Hunan, Guangxi, Beijing, and Xizang (Tibet) with 1 death each, and the remaining 16 PLADs had no deaths. Southwest China [Yunnan, Sichuan, Guizhou, Chongqing, and Xizang (Tibet)] was the most severely affected region with 138 incidents, 426 patients, and 11 deaths. Detailed information for each PLAD was shown in Table 1.

In 2021, 74 species of poisonous mushrooms caused 6 different clinical syndromes; acute liver failure, acute renal failure, rhabdomyolysis, hemolysis, gastroenteritis, and psycho-neurological disorder were successfully identified (Supplementary Table S1, available in http://weekly.chinacdc.cn/). A total of 15 species were newly recorded as poisonous mushrooms and were added to the Chinese poisonous mushroom list. *Hygrocybe rimosa*, which causes gastroenteritis, *Inosperma muscarium* and *Pseudosperma arenarium* nom. prov., which stimulated parasympathetic nervous system, were three new species discovered in China. *Mallocybe fulvoumbonata*, *Psilocybe ovoideocystidiata,* and *P. papuana* resulted in psycho-neurological disorders were three records new to China. *Agaricus atrodiscus*, *Boletellus indistinctus*, *Lactarius purpureus*, *L. rubrocorrugatus*, *Lactifluus pseudoluteopus*, *Melanoleuca humilis*, *Ramaria gracilis,* and *Scleroderma* aff. *albidum* cause gastroenteritis, and *Inocybe* aff. *glabrodisca* stimulates the parasympathetic nervous system; these species were confirmed to be poisonous from poisoning incidents.

The top three lethal mushroom species were *Russula subnigricans*, *Galerina sulciceps,* and *Lepiota brunneoincarnata*, which caused 6, 5, and 3 deaths, respectively. *Chlorophyllum molybdites*, the most widely distributed mushroom (discovered in 13 PLADs),

TABLE 1. Geographical distribution of mushroom poisoning incidents in China, 2021.

Location	Number of incidents	Number of patients	Deaths	Case fatality rate (%)
Hunan	64	159	1	0.63
Yunnan	59	200	4	2.00
Sichuan	34	98	2	2.04
Fujian	32	82	0	0
Guizhou	26	69	4	5.80
Zhejiang	21	50	0	0
Chongqing	17	53	0	0
Guangdong	16	33	4	12.12
Ningxia	13	26	0	0
Guangxi	12	42	1	2.38
Jiangsu	4	24	0	0
Hainan	4	11	0	0
Jiangxi	4	4	0	0
Shandong	3	20	0	0
Hubei	3	7	0	0
Beijing	2	14	1	7.14
Anhui	2	7	0	0
Shaanxi	2	4	0	0
Hebei	2	3	0	0
Xizang	2	2	1	50.00
Inner Mongolia	1	5	0	0
Xinjiang	1	4	0	0
Shanxi	1	3	2	66.67
Tianjin	1	2	0	0
Jilin	1	1	0	0
Total	327	923	20	2.17

caused the most poisonings incidents (appearing in 66 incidents affecting 123 patients) and had distinct long active period (from middle April to late December).

In 2021, 8 species (6 *Amanita* spp., 1 *Galerina* sp., and 1 *Lepiota* sp.) causing acute liver failure were identified in China (Supplementary Table S1, available in http://weekly.chinacdc.cn/). *Galerina sulciceps* killed 5 persons in 14 incidents involving 39 patients turned out to be the most dangerous species causing acute liver failure. *Lepiota brunneoincarnata* was responsible for 3 deaths in 15 incidents involving 45 patients, and this is the first report for its distribution in Yunnan Province (*1–3*). *Amanita fuligineoides* was originally described from Hunan and known from Yunnan as well (*4–5*). In late June, 2021, 5 people from Fujian were poisoned by this lethal species, which is indicative of a wider distribution of *A. fuligineoides*.

Three species causing acute renal failure were identified from mushroom poisoning incidents (Supplementary Table S1, available in http://weekly.chinacdc.cn/). *Amanita oberwinklerana* caused the most incidents. It grew in March in Guangdong, then appeared from July to August in Central and Southwest China. *Amanita kotohiraensis* was responsible for poisoning 2 patients on August 19.

Exposure to *Russula subnigricans* led to rhabdomyolysis causing 6 deaths; this species was found in 9 PLADs and appeared from May 10 to September 9. A total of 2 incidents involving 2 patients and 1 death caused by *Paxillus involutus* resulting in hemolysis occurred in Lasa, Xizang (Tibet).

A total of 39 species causing gastroenteritis were identified from mushroom poisoning incidents in China in 2021 (Supplementary Table S1, available in http://weekly.chinacdc.cn/). Among them, *Agaricus atrodiscus*, *Boletellus indistinctus*, *Hygrocybe rimosa*, *Lactarius purpureus*, *L. rubrocorrugatus*, *Lactifluus pseudoluteopus*, *Melanoleuca humilis*, *Ramaria gracilis*, and *Scleroderma* aff. *albidum* were species newly discovered as poisonous mushrooms and subsequently added to the Chinese poisonous mushroom list (*1–3*). *Hygrocybe rimosa* was a new species discovered in 2021 (*6*). Notably, *A. atrodiscus* poisoning was reported for the first time from Yunnan since it was originally described from Thailand in 2015 (*7*) and discovered in Hainan Province, China, in 2020 (*8*). The top three species in this category were *C. molybdites*, *R. japonica* and *Entoloma omiense*.

About 22 species causing psycho-neurological disorders were identified from mushroom poisoning incidents in China in 2021 (Supplementary Table S1, available in http://weekly.chinacdc.cn/). Among them, 6 species (*Inocybe* aff. *glabrodisca*, *Inosperma muscarium*, *Pseudosperma arenarium* nom. prov., *Mallocybe fulvoumbonata*, *Psilocybe ovoideocystidiata,* and *P. papuana*) were newly discovered as poisonous mushrooms (*1–3*). *Inosperma muscarium* and *Pseudosperma arenarium* were two new species. The former species was described in 2021 (*9*) and the latter was identified as *P.* cf. *bulbosissimum* in 2020 (*2*). Further study showed that *P.* cf. *bulbosissimum* was a new species. *Mallocybe fulvoumbonata*, *P. ovoideocystidiata,* and *P. papuana* were Chinese new records. The top five species were *Amanita subglobosa*, *Gymnopilus dilepis*, *A. pseudosychnopyramis*, *Inosperma muscarium*, and *Pseudosperma arenarium*.

Nine boletes (*Baorangia major*, *B. pseudocalopus*, *Boletellus indistinctus*, *Heimioporus gaojiaocong*, *H. japonicus*, *Neoboletus venenatus*, *Rubroboletus sinicus*, *Suillus pinetorum*, and *Tylopilus neofelleus*) causing gastroenteritis and one (*Lanmaoa asiatica*) causing psycho-neurological disorder were identified from poisoning incidents.

Interestingly, 2 incidents caused by polypores occurred in 2021. On February 28, 2021, one person from Guangxi had slight gastrointestinal symptoms after consumption of *Cryptoporus volvatus*, a recorded medicinal polypore (*3*). On the same date, one person from Guangdong also suffered from gastroenteritis after drinking boiled water using dried "medicinal mushrooms." This mixture was confirmed as medicinal or edible mushrooms, *Trametes hirsuta*, *Irpex lacteus*, and *Schizophyllum commune* (*3*). Their toxicity and safe usage need to be further studied.

About 6 edible mushrooms were also identified from mushroom poisoning incidents in 2021, which could be attributed to the consumption of mixed mushrooms with poisonous mushrooms, contaminated mushrooms, or some species potentially poisonous to certain people.

DISCUSSION

In 2021, mushroom poisoning incidents and patients were more than 2019 but less than 2020 as deaths slightly decreased (20 *vs*. 22 and 25) (*1–2*). Shaanxi, Xinjiang, Tianjin, and Jilin were four PLADs with newly recorded incidents (*1–2*). Approximately 74 poisonous mushrooms were successfully identified, among which 46 species were already recorded in 2019 and 2020 (*1–2*), raising the total species number from incidents reached over 150 in China by the end of

2021. The most dangerous mushroom was *Russula subnigricans*, killing 6 people in 2021, differing from *Amanita exitialis* that killed 13 people in 2019 and *Lepiota brunneoincarnata* that killed 5 people in 2020 (*1–2*).

Monthly distribution analysis showed that mushroom poisonings in 2021 centered from May to November, longer than 2019 and 2020, peaking in August, which was later than the July peak in 2019, and different from 2020 that had 2 peaks in June and September (*1–2*).

The top two PLADs with the most incidents were Hunan and Yunnan in 2021, identical to 2019 and 2020, and Southwest China remained the most severely affected area (*1–2*). Yunnan had the most deaths in the last three years, but declined markedly (*1–2*). Mushroom poisoning incidents decreased sharply in Zhejiang from 50 in 2019 to 43 in 2020 and to 21 in 2021 (*1–2*).

Mushroom poisoning resulting in acute liver failure caused by *Amanita* spp. dropped sharply from 32 incidents, 80 patients, and 19 deaths in 2019 (*1*), to 53 incidents, 153 patients and 10 deaths in 2020 (*2*), and to 17 incidents, 52 patients and 5 deaths in 2021. This great progress mainly contributed to the continuous science popularization and health education on *Amanita* spp. *Galerina sulciceps* poisoning increased from 4 incidents, 9 patients, and 1 death in 2019 (*1*), to 6 incidents, 12 patients, and 2 deaths in 2020 (*2*), and to 14 incidents, 39 patients, and 5 deaths in 2021. Except appearing in autumn and winter, *G. sulciceps* also resulted in 1 death in April in Hunan. Attention must also be paid to *Lepiota brunneoincarnata* that caused 3 incidents in 2019 and 15 incidents in 2020 and 2021. Continuous and extensive science popularization about these lethal species was necessary and urgent in future.

Similar to 2019 and 2020, *Amanita oberwinklerana* caused the most incidents, but resulted in relatively less incidents and patients than the last two years (*1–2*). *Amanita kotohiraensis* was discovered from one mushroom poisoning incident and expanded its distribution to Fujian (*5*).

Compared to 2019 and 2020, *Russula subnigricans* leading to rhabdomyolysis caused more deaths (6 *vs.* 1 and 4), was discovered in more PLADs (9 *vs.* 5 and 4), and appeared earlier (*1–2*). *Paxillus involutus* resulting in hemolysis appeared earlier in Xizang (Tibet) than in Inner Mongolia, 2020 (*2*). On account of the huge risk of eating this mushroom, we strongly advise not collecting and eating this species although it was previously accepted as edible and medicinal fungus in China and seems safe to many people (*2*).

Overall, 39 species causing gastroenteritis were successfully identified in 2021, which was more than 2019 (30 species) and less than 2020 (56 species), and the top three species were *Chlorophyllum molybdites*, *Russula japonica*, and *Entoloma omiense*, the same as 2019 and 2020 (*1–2*).

Lactifluus pseudoluteopus was a species originally described from tropical Yunnan and was considered edible (*10*). In 2020, 5 people experienced gastroenteritis after eating *Lf. pseudoluteopus*, and we suspected the species might be poisonous (*2*). Subsequently, on June 4, 2021, another person also developed gastroenteritis after eating *Lf. pseudoluteopus* and we now could confirm that this species is toxic (*10*).

Many species from *Agaricus* section *Xanthodermatei* were considered poisonous as they resulted in gastroenteritis, and 7 species were discovered in China by 2019 (*3*). In 2021, *Agaricus atrodiscus* and *A. xanthodermus* were identified from mushroom poisoning incidents. This was the first poisoning incident report caused by *A. atrodiscus* worldwide and supplemented poisoning information of *A. xanthodermus* (*3*,*7*).

Omphalotus guepiniformis caused poisoning incidents in East, Central, South, and Southwest China in the recent years, whereas *O. olearius* poisoning only occurred in Yunnan Province (*1–2*). On July 11 and October 3, 2021, 22 persons were poisoned by a white, wood-rotting fungus which was similar to *Pleurotus* spp. Further studies showed that it might be an undescribed species of *Omphalotus* species, and we temporarily recorded it as *Omphalotus* sp. in the present investigation.

Coprinellus micaceus, *Coprinopsis atramentaria*, and *Coprinus comatus* were three common and widely distributed mushrooms resulted in several poisoning incidents in 2021. They could produce coprine, especially when mature, and thus resulted in disulfiram-like mushroom poisoning when consumed with alcohol (*11*). In China, *Cp. atramentaria* and *C. comatus* were also considered edible, and *C. comatus* has been widely cultured commercially. *Coprinellus micaceus* was also considered as medicinal fungus (*3*). For the sake of safety, we strongly advise not eating these three species collected from the field or drinking alcohol when consuming cultured *C. comatus*.

Baorangia major was firstly discovered in Fujian and Yunnan and resulted in 2 poisoning incidents either individually or in conjunction with *B. pseudocalopus* consumption in 2020 (*2*), and caused another incident in Fujian, 2021. Previously, *Neoboletus venenatus* was often discovered from incidents in which dried boletes were consumed (*1–2*). On September 19, 2021, 7 people from Yunnan were poisoned after eating fresh basidiomata. On August 19, 2021, 1 person from Fujian suffered from gastroenteritis after eating a red bolete. Our study indicated that it might be a new species and temporarily recorded as *Rubroboletus* sp.

About 22 species causing psycho-neurological disorders were identified in 2021, which was more than 2019 (18 species) but less than 2020 (28 species), and *Amanita subglobosa* occupied the first for the last three years (*1–2*). Except the 6 newly added poisonous species, the previously convincible poisonous species *A. ibotengutake*, *A. melleialba*, *A. pseudopantherina*, *A. pseudosychnopyramis*, and *Panaeolus bisporus* appeared in poisoning incidents in 2021 (*1*–*5*).

Amanita is the most famous genus worldwide since it includes many notorious poisonous mushrooms which could cause acute liver failure, acute renal failure, and psycho-neurological disorder (*1–3*, *5*, *11*). In China, many species are China-specific, 9 lethal species leading to acute liver failure and 10 species leading to psycho-neurological disorder were originally described from China (*4–5*), and their toxicity of many species had been confirmed from poisoning incidents (*1–2*). Although dozens of species of this genus are edible, on account of the high phenotypic similarity between edible and lethal species, we strongly advise not eating *Amanita* spp. unless the identity is fully determined.

Lanmaoa asiatica, commonly known as "red bolete with onion smell," is a delicious bolete that needs properly cooking, which was originally described from China (*12*). When causing poisoning, this species could cause hallucinations. Different from species containing psilocybin, its toxicity is still unclear and needs further studies.

The incidents reported in this study only represent a portion of actual mushroom poisonings. In some poisoning incidents, some specimens cannot be given a satisfactory species name. More taxonomic work is needed and more new species will be hopefully discovered (*1–3*, *5–10*, *12*). The low level of awareness of mushroom poisoning, in contrast to the high species diversity in China is a huge challenge for mushroom poisoning control and prevention. The practice demonstrates that more efforts and closer cooperation are still urgently needed from governments, CDC staff, doctors, and mycologists to properly control mushroom poisoning events in the future.

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SUPPLEMENTARY TABLE S1. Mushroom species involved in poisoning incidents and their spatial and temporal distribution in China, 2021.

Clinical syndromes or mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Acute liver failure					
Amanita exitialis	3	8	1	12.50	March 3, Guangdong; June 24 to 26, Yunnan
Amanita exitialis and *A. fuligineoides*	1	4	0	0	July 2, Yunnan
Amanita fuliginea and *A. oberwinklerana* ARF	1	5	0	0	July 5, Hunan
Amanita fuligineoides	2	9	1	11.11	June 25 and July 2, Fujian, and Yunnan
Amanita pallidorosea	1	2	0	0	June 19, Hunan
Amanita rimosa	1	3	0	0	June 2, Hunan
Amanita subjunquillea	1	2	0	0	September 17, Sichuan
Amanita spp.	7	19	3	15.79	June 22 to July 26, Yunnan, Hunan, Chongqing, and Zhejiang
Galerina sulciceps	14	39	5	12.82	April 16, Hunan; November 3 to 30, Sichuan, Chongqing, Hubei, Guizhou, and Hunan
Galerina sp.	1	18	0	0	December 28, Sichuan
Lepiota brunneoincarnata	15	45	3	6.67	July 4 to September 28, Yunnan, Hebei, Shanxi, Xinjiang, Shandong, Inner Mongolia, Ningxia, Shaanxi, Jilin, Beijing, and Tianjin
Rhabdomyolysis					
Russula subnigricans	16	50	6	12.00	May 10 to September 9, Yunnan, Zhejiang, Hunan, Jiangsu, Fujian, Jiangxi, Guizhou, Guangdong, and Guangxi
Acute renal failure					
Amanita kotohiraensis	1	2	0	0	August 19, Fujian
Amanita oberwinklerana	6	9	0	0	mid-March, Guangdong; July 20 to August 29, Hubei, Sichuan, and Guizhou
Amanita aff. *pseudoporphyria*	2	2	0	0	August 22 and 23, Hunan
Hemolysis					
Paxillus involutus	2	2	1	50.00	July 31 and August 7, Xizang
Gastroenteritis					
Agaricus atrodiscus	1	6	0	0	July 28, Yunnan
Agaricus xanthodermus	1	1	0	0	April 29, Hunan
Agaricus sp.	1	2	0	0	August 20, Hunan
Baorangia major	1	5	0	0	May 28, Fujian
Baorangia pseudocalopus	2	8	0	0	June 23, Yunnan; September 17, Hunan
Boletellus indistinctus	1	6	0	0	August 3, Yunnan
Chlorophyllum aff. *globosum*	2	8	0	0	August 30 and September 5, Sichuan
Chlorophyllum hortense	2	3	0	0	August 12 to September 29, Hunan, and Guangxi
Chlorophyllum molybdites	65	120	0	0	April 15 to December 27, Zhejiang, Guizhou, Hunan, Hainan, Fujian, Guangdong, Guangxi, Yunnan, Sichuan, Chongqing, Jiangsu, Hubei and Jiangxi
Chlorophyllum molybdites and *Cordyceps gunnii* M	1	3	0	0	August 21, Guizhou
Coprinellus micaceus	1	1	0	0	September 29, Beijing
Coprinellus micaceus and *Panaeolus bisporus* P	1	3	0	0	September 20, Ningxia
Coprinopsis atramentaria	1	1	0	0	April 19, Shandong
Coprinus comatus	1	1	0	0	October 19, Sichuan

Continued

Clinical syndromes or mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Cryptoporus volvatus M	1	1	0	0	February 28, Guangxi
Entoloma caespitosum	1	4	0	0	May 24, Fujian
Entoloma omiense	7	22	0	0	June 6 to August 30, Fujian, Guangdong, Yunnan, Zhejiang, and Guizhou
Entoloma aff. *strictius*	1	3	0	0	April 12, Hunan
Entoloma aff. *sinuatum*	1	9	0	0	August 8, Yunnan
Gymnopus densilamellatus, *G. dryophilus* G and *Ripartites tricholoma* U	1	2	0	0	August 6, Hebei
Gymnopus indoctus U, *Leucoagaricus sinicus* U, *Panaeolus papilionaceus* P, *Ileodictyon gracile* U and *Agaricus* sp. U	1	4	0	0	October 14, Guangdong
Heimioporus gaojiaocong	3	5	0	0	January 12, Yunnan (dried boletes bought from market); June 3 to July 20, Yunnan
Heimioporus japonicus	2	9	0	0	August 26 and September 7, Fujian
Hygrocybe rimosa	1	2	0	0	July 1, Guizhou
Lactarius purpureus	1	1	0	0	August 29, Hunan
Lactarius rubrocorrugatus	2	7	0	0	July 11 and 27, Sichuan
Lactifluus pseudoluteopus	1	1	0	0	June 4, Yunnan
Melanoleuca humilis	1	2	0	0	September 15, Ningxia
Neoboletus brunneissimus E,M, *Butyriboletus yicibus* E, *Catathelasma subalpinum* E and *Cortinarius similis* U	1	3	0	0	August 16, Sichuan (dried boletes from Yunnan)
Neoboletus venenatus	3	12	0	0	March 10 and July 2, Hunan and Sichuan (dried boletes, bought from market); September 19, Yunnan
Omphalotus guepiniformis	1	3	0	0	May 1, Guizhou
Omphalotus olearius	2	4	0	0	July 28 and October 18, Yunnan
Omphalotus sp.	4	44	0	0	July 11 and October 18, Yunnan
Pholiota multicingulata	1	4	0	0	September 13, Chongqing
Ramaria gracilis	1	1	0	0	August 28, Yunnan
Rubroboletus sinicus and *Retiboletus fuscus* E	1	20	0	0	January 11, Jiangsu (dried boletes bought from market)
Rubroboletus sp.	1	1	0	0	August 19, Fujian
Russula foetens	1	1	0	0	August 26, Fujian
Russula japonica	24	70	0	0	May 25 to August 26, Guangxi, Hunan, Sichuan, Guizhou, Yunnan, Chongqing, Fujian, and Zhejiang
Russula japonica and *R. punctipes* G	1	2	0	0	May 31, Hunan
Russula leucocarpa U and *Russula* sp.	1	4	0	0	September 4, Fujian
Russula punctipes	1	6	0	0	August 23, Hunan
Scleroderma* aff. *albidum	2	9	0	0	March 7 and July 9, Guangxi and Sichuan
Scleroderma cepa	4	7	0	0	July 5 to August 25, Yunnan; October 27 to November 15, Hunan
Suillus pinetorum, *Amanita javanica* E, *Boletus bainiugan* E and *Phlebopus portentosus* E	1	8	0	0	April 15, Yunnan
Thicholoma highlandense	1	1	0	0	November 20, Guizhou
Trametes hirsuta M, *Irpex lacteus* M and *Schizophyllum commune* E,M	1	1	0	0	February 28, Guangdong (dried mushrooms from Sichuan)
Tricholoma stans	1	2	0	0	November 3, Yunnan
Tricholoma aff. *stans*	2	5	0	0	November 2 and December 1, Guizhou and Yunnan

Continued

Clinical syndromes or mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Psycho-neurological disorder					
Amanita ibotengutake	1	17	0	0	September 5, Shandong
Amanita melleialba	1	1	0	0	August 10, Yunnan
Amanita orientigemmata	1	2	0	0	August 10, Yunnan
Amanita pseudopantherina	1	1	0	0	August 9, Yunnan
Amanita pseudosychnopyramis	2	11	0	0	April 6 and 15, Fujian and Zhejiang
Amanita orsonii and *Amanita* sp. U	1	3	0	0	June 29, Chongqing
Amanita rufoferruginea	1	6	0	0	July 6, Sichuan
Amanita subglobosa	4	13	0	0	June 29 to August 19, Sichuan and Hunan
Amanita sychnopyramis f. *subannulata*	1	5	0	0	May 28, Guangxi
Clitocybe subditopoda	1	3	0	0	October 26, Guizhou
Clitocybe sp.	1	2	0	0	October 18, Hainan
Gymnopilus dilepis	3	5	0	0	May 1 to July 2, Sichuan and Guizhou
Inocybe* aff. *glabrodisca	1	4	0	0	November 26, Guizhou
Inosperma muscarium	2	7	0	0	May 30 and June 5, Guangxi and Fujian
Lanmaoa asiatica	1	1	0	0	July 2, Yunnan
Lanmaoa asiatica, *Heimioporus japonicus* G and *Tylopilus neofelleus* G	1	4	0	0	January 27, Chongqing (dried boletes bought from market)
Panaeolus bisporus	1	2	0	0	August 14, Guizhou
***Pseudosperma arenarium* nom. prov.**	2	3	0	0	September 22 and 30, Ningxia and Shaanxi
Pseudosperma umbrinellum and ***Mallocybe fulvoumbonata*** P	1	2	0	0	September 21, Ningxia
Psilocybe ovoideocystidiata	1	2	0	0	March 26, Guizhou
Psilocybe papuana	1	2	0	0	April 30, Hunan
Unclassified					
Cortinarius cupreorufus U	1	3	0	0	September 3, Ningxia
Laccaria vinaceoavellanea E	1	2	0	0	August 1, Yunnan
Leucoagaricus barssii E	1	2	0	0	September 6, Ningxia
Porphyrellus nigropurpureus U	1	4	0	0	August 1, Fujian
Russula densifolia E	1	2	0	0	August 13, Yunnan
Scleroderma yunnanense E	1	4	0	0	July 2, Yunnan
Stropharia rugosoannulata E	2	2	0	0	April 29 and May 16, Hunan and Chongqing
Tricholoma myomyces E	1	2	0	0	March 16, Hunan

Note: Species newly recorded as poisonous mushrooms in China are in italic bold.
Abbreviations used for mushroom poisoning incidents with more than two species: ARF=Acute renal failure, G=Gastroenteritis, P=Psycho to neurological disorder, M=Medicinal, U=Unclassified, E=Edible.

Outbreak Reports

A Poisoning Outbreak Caused by *Anisodus tanguticus* — Maqin County, Qinghai Province, China, July 2021

Xuebin Guo[1,&]; Qian He[2,&]; Bangguo Qi[3]; Chenye Sun[2]; DongJin Lyu[1,#]; Hongshun Zhang[2,#]

Summary

What is already known about this topic?

Anisodus tanguticus belongs to the Solanaceae family. The plant is toxic due to the tropane alkaloids it contains and can cause poisoning when it is ingested or used inappropriately.

What is added by this report?

A poisoning outbreak involved 10 patients, and one death was caused by *Anisodus tanguticus*. The etiological association of plant exposure and poisoning was confirmed with evidence from an epidemiological investigation, clinical manifestations, plant identification and a toxin analysis.

What are the implications for public health practice?

The risk of poisoning caused by mistakenly collecting and ingesting tropane alkaloid-containing plants should be highlighted, and public health practitioners should be on alert.

At 4:40 am on July 17, 2021, the Qinghai CDC received a telephone report from Guoluo Prefecture CDC of 10 patients with similar complaints and spatiotemporal aggregation who were admitted to Guoluo Prefecture People's Hospital in 2 sessions from 23:00 on July 16 to 1:00 on July 17. They assumed this outbreak was due to food poisoning and initiated an investigation. The Qinghai CDC evaluated and verified the outbreak promptly and sent a team with 2 epidemiologists and 1 laboratory expert to the incident site to cooperate with the local government and the CDC to respond to the incident. According to the clinical syndrome and the information provided by the local CDC, this outbreak was probably caused by tropane alkaloid-containing plants, and the researchers contacted the China CDC for further confirmation. Then, field epidemiological and hygiene investigations were conducted, and plant samples were collected in collaboration with provincial, prefecture, and county CDC staff. The plant samples were identified as *Anisodus tanguticus* by morphological identification and molecular analysis.

INVESTIGATION AND RESULTS

The outbreak occurred in a remote village located on the Tibetan Plateau at an average altitude of 3,500 m. It is approximately 60 km away from the Maqin county seat, and travel was inconvenient. A total of 69 households with more than 300 people are in the village. All the patients (9 males, 1 female, ages: 27–57 years old) were migrant workers from a construction company in Henan Province who engaged in road maintenance in the second bid and lived in 3 tents around the construction site on a temporary base.

On July 16, approximately 30 min after dinner at 20:00, the first case appeared and was characterized by stagger, fatigue, dizziness, and nausea; subsequently, another 9 workers exhibited similar symptoms and signs, and only 1 worker had no symptoms. Then, all the patients were sent to Guoluo People's Hospital from 23:00 on July 16 to approximately 1:00 on July 17. Four patients had severe neurotoxic symptoms with unconsciousness and dilated pupils, and the other 6 patients had dizziness, fatigue, nausea, blurred vision, irritability, and tachycardia. The clinical presentation resembled atropine poisoning, which probably indicated that the poisoning outbreak was caused by atropine-containing plants. The first patient vomited twice by stimulating his pharynx with his fingers when feeling discomfort. All patients in Guoluo People's Hospital underwent gastric lavage, monitoring with electrocardiography, and fluid infusion therapy. A 49-year-old male patient suddenly developed dysphoria and choking cough and then suffered cardiac arrest with loss of consciousness and facial cyanosis when pumping his stomach. Endotracheal intubation and mechanical ventilation were performed, while external cardiac compression and intravenous administration of adrenaline were performed to restore the beating of the heart. Unfortunately, the patient died after 45 minutes of rescue. During intubation, a large quantity of gastric contents filled his mouth, which might have resulted in suffocation and further aggravated the condition. Because 1 patient died, the other 9 patients were transferred to Qinghai People's Hospital and Qinghai Red Cross Hospital in Xining City for further treatment. A patient treated at Qinghai Red Cross Hospital underwent hemoperfusion. When arriving at Xining, the vital signs of the patients were stable; after symptomatic and supportive treatment, the patients were discharged from the hospital from July 22 to 25.

The latency period of the first case was 30 min, and the longest latency period was approximately 40 min. The average latency was 35 min. The temporal, spatial, and population distributions and correlations of the patients revealed that this outbreak may have been a food-borne outbreak. The field and food hygiene investigation showed that 10 male migrant workers lived in 2 tents, while another tent was the kitchen and the living room of the female migrant worker as chef; their living and sanitary conditions were poor. Their drinking water was obtained from the river beside their residence, and all vegetables and ingredients were purchased in Maqin County every 2 days. Their living conditions and food supply had not changed compared to previous ones, and their residence was isolated from outsiders. The only difference in the dinner was excess consumption of cold wild vegetables; all the patients had ingested the cold dish, while the worker who did not develop the disease did not eat the cold dish. This outbreak was a single exposure, and no new cases occurred after the consumption of wild vegetables was stopped. The result of the field epidemiological investigation indicated that the cold wild vegetables may be the cause of this outbreak.

The wild vegetables were picked by 3 migrant workers belonging to the Sichuan Province, from neighboring areas to the construction site. Approximately 1 kg was blanched by the chef, and then a cold dish was prepared. Guoluo CDC took pictures and videos of the wild vegetables immediately to allow the plant to be recognized and identified. Then, the pictures and videos were sent to the China National Center for Food Safety Risk Assessment, Institute of Occupational Health and Poisoning Control (National Poison Control Center), and the College of Pharmacy at Qinghai Nationalities University for further expert support. All the experts had a preliminary consensus opinion that the plant belongs to the *Anisodus* genus. The plant specimens were collected in the field and then identified as *Anisodus tanguticus* (Figure 1) by morphological and molecular identification. A voucher specimen was deposited in the Poisonous Plants Herbarium affiliated with the National Poison Control Center (No: 2021071701).

The remainder of the dinner, plants, and vomitus were collected to screen and confirm the toxicants. The results of the tests for organophosphorus pesticides, carbamate pesticides, tetramine, fluoroacetamide, and nitrite were negative. According to the epidemiological investigation result, the distinct toxins of the wild plants were analyzed using high-performance liquid chromatography coupled to tandem mass spectrometry. The main tropane alkaloids, atropine, anisodamine, scopolamine, and anisodine, in the cold dish were present at concentrations of 107.4, 0.58, 12.6, and 39.8 mg/kg, respectively, and at 107.0, 1.498, 15.4, and 95.8 mg/kg, respectively, in the wild vegetable plant. The contents of atropine, anisodamine, and anisodine in a vomitus sample were 0.492, 0.07, and 0.802 μg/kg, respectively, and scopolamine was undetected (Table 1). Cardiac blood and stomach content samples of the death patient were collected and tested by the police agency, and atropine, anisodamine, scopolamine and anisodine were detected in the biological samples. All four toxins were positive in all the aforementioned samples.

DISCUSSION

This poisoning outbreak was responded to and investigated by the national, provincial and local CDCs with multidisciplinary experts in clinical

FIGURE 1. The *Anisodus tanguticus* plant that caused a poisoning outbreak in Maqin County, Qinghai Province. (A) Collection of the plant sample; (B) The *Anisodus tanguticus* plant; (C) The *Anisodus tanguticus* flower; (D) The *Anisodus tanguticus* seeds.

TABLE 1. The contents of tropane alkaloids in the remainder of the cold dish, plants and vomitus sample from one patient in the poisoning outbreak caused by *Anisodus tanguticus.*

Sample	Atropine	Anisodamine	Scopolamine	Anisodine
Remainder of the cold dish (mg/kg)	107.4	0.580	12.6	39.8
Wild vegetable plant(mg/kg)	107.0	1.498	15.4	95.8
Vomitus* (μg/kg)	0.492	0.070	Undetected	0.802

* Only vomitus sample from one patient was obtained and analyzed.

toxicology, analytical toxicology, epidemiology and plant taxonomy. Clearly, the incident was a food-borne poisoning outbreak caused by eating the wild plant *Anisodus tanguticus* as a vegetable. According to the solid results from the epidemiological investigation, hygienic investigation, clinical diagnosis and treatment, laboratory tests, and wild plant morphological identification analysis, tropane alkaloids in the plant were confirmed as the etiological toxins. This outbreak indicated that eating *Anisodus tanguticus* by mistake as a wild vegetable might cause severe public health problems, and the public should be alerted and educated to avoid poisoning incidents.

The clinical manifestations of patients with poisoning were explained by the anticholinergic activity of tropane alkaloids. Unlike one etiological chemical associated with anticholinergic drug overdose or poisoning, more tropane alkaloids are usually present in plants, and differences exist in the effects exerted by the different toxins, all of which should be included in the poisoning hypothesis formation and validation. In this outbreak, 4 tropane alkaloids were tested to explain the poisoning. *Anisodus tanguticus* belongs to the *Anisodus* genus of the Solanaceae family and is mainly distributed in Qinghai, Gansu, Sichuan (northwest and southwest), Tibet (east), Yunnan (northwest) of China and Nepal (*1*). *Anisodus tanguticus* is the most important species used in Tibetan medicine (*2*), and the whole plant, especially the roots, contains a variety of tropane alkaloids, such as hyoscyamine, scopolamine, cuscohygrine, anisodamine and anisodine. These alkaloids allow the plants to be used as medicinal plants and important sources of anticholinergic drugs, and these alkaloids are also the main cause of their toxicity.

In China, tropane alkaloid-containing plant poisoning is due to people mistakenly picking plants as vegetables and using them as drugs for therapy. Poisoning caused by another tropane-containing plant, *Datura stramonium,* is more common. Tropane alkaloid-containing plant poisoning has been reported in other countries and regions. In Germany (*3*), the United Kingdom (*4*), and Morocco (*5*), poisoning caused by berries of *Atropa belladonna* has been reported. In Uganda in 2009, a batch of super cereals was contaminated with *Datura* seeds, resulting in a series of food poisoning outbreaks; 278 cases and 5 deaths occurred, and atropine and scopolamine were detected as the main toxins (*6*). In Turkey (*7*), Iran (*8*), and Israel (*9*), tropane alkaloid poisoning was caused by *Datura stramonium.*

As we noted, this report is the first to document tropane alkaloid poisoning caused by eating the stems and leaves of *Anisodus tanguticus*, and the poisoned population was migrant workers. With the rapid development in China, many people working in different locations may be exposed to a different environment; thus, the possibility of harvesting and ingesting wild poisonous plants has significantly increased. The public should be alerted and educated to increase their awareness of self-protection and avoid eating unfamiliar or unknown wild plants to cope with this challenge.

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Preplanned Studies

Mushroom Poisoning Outbreaks — China, 2022

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Summary

What is already known about this topic?

Mushroom poisoning is one of the most serious food safety issues in China. By the end of 2021, over 520 poisonous mushrooms had been discovered in China. The Southwest region of China was the most severely affected. Mushroom poisonings mainly concentrated in the summer and autumn months.

What is added by this report?

In 2022, China CDC conducted an investigation of 482 incidents of mushroom poisoning across 21 provincial-level administrative divisions (PLADs). This resulted in 1,332 patients and 28 deaths, with a total case fatality rate of 2.1%. A total of 98 mushrooms were identified, causing 7 different clinical types of diseases. Three provisional new species (*Collybia humida* nom. prov., *Spodocybe venenata* nom. prov., and *Omphalotus yunnanensis* nom. prov.) were newly recorded as poisonous mushrooms in China, in addition to 10 other species.

What are the implications for public health practice?

In view of the extensive impact and harm of poisonous mushrooms on public health, it is necessary to promote prevention and improve the ability of professionals to identify, diagnose, and treat mushroom poisoning.

Mushroom poisoning has become a serious food safety issue in China. With the support of the government, over the past decade, China has gradually established a mushroom poisoning prevention and treatment system involving experts in disease prevention and control, clinical diagnosis and treatment, fungal classification, and basic medicine (*1*–*3*). In recent years, a mushroom-poisoning information collecting, diagnosis, and treatment support network has been established, utilizing WeChat, telephone, email, and other methods. After poisoning incidents occur, mushroom samples are collected by CDC staff or hospital professionals and sent to mycological researchers at universities and institutions for identification, based on morphological characters and DNA sequence data (*1*–*3*).

In 2022, China CDC investigated 482 mushroom poisoning incidents involving 1,332 patients and 28 deaths, with a total case fatality rate of 2.1%. The number of cases per incident ranged from 1 to 28, with an average of 2. A total of 13 incidents involved more than 10 patients. Of these cases, 73 patients from 23 incidents ate poisonous mushrooms purchased from markets or given by friends; 9 patients from 6 incidents were poisoned after eating raw *Chlorophyllum molybdites*, *Boletus bainiugan*, and *Macrocybe gigantea*, although the last two species were considered to be edible after proper cooking (Supplementary Table S1, available in https://weekly.chinacdc.cn/); 44 patients from 7 incidents were poisoned after eating dried mushrooms; and 213 patients and 3 deaths from 55 incidents ate mixed mushrooms.

The temporal distribution shows that mushroom poisonings occurred in all months, with the highest number of incidents occurring between May and November (460 incidents, 1,234 patients, and 22 deaths). The first death occurred in mid-February in Fujian. The top 3 months for deaths were June (13 deaths), July (3 deaths), and September (3 deaths) (Figure 1).

In terms of geographical distribution, mushroom poisoning incidents were reported in 21 provincial-level administrative divisions (PLADs). Overall, 10 PLADs had more than 10 incidents, and Yunnan, Hunan, Sichuan, Guangxi, Chongqing, and Zhejiang were the top 6 (Table 1); 11 PLADs had more than 20 patients, and Yunnan, Hunan, Sichuan, and Guangxi had over 100 patients each (Table 1). Yunnan, Hunan, and Guangdong were the top 3 PLADs in terms of deaths, with 9, 7, and 5 deaths, respectively (Table 1). Southwest China (Yunnan, Sichuan, Chongqing, and Guizhou) was the most severely affected region, with 234 incidents, 703 patients, and 13 deaths. This was followed by Central China (Hunan, Hubei, and Henan) with 109 incidents, 277 patients, and 8 deaths; East China (Zhejiang, Fujian, Jiangsu, Jiangxi, Anhui,

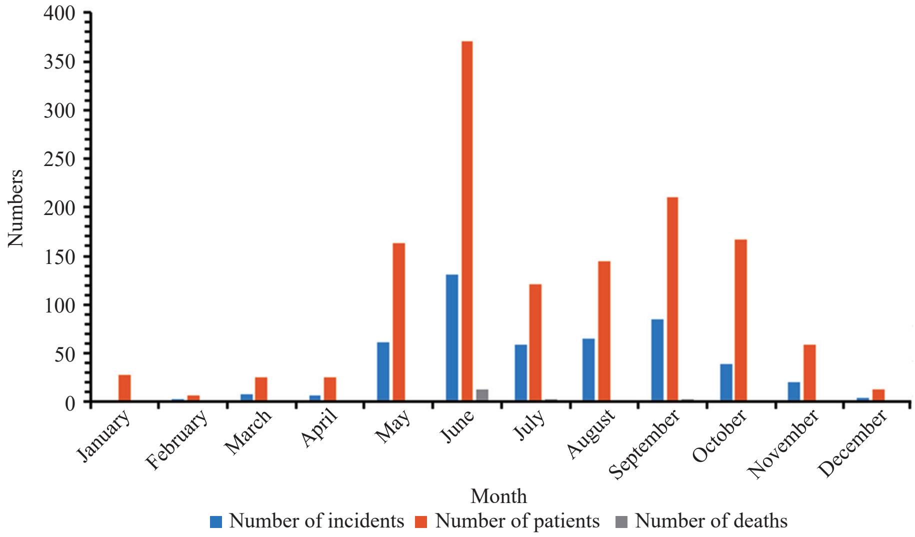

FIGURE 1. Monthly distribution of mushroom poisonings in China, 2022.

TABLE 1. Geographical distribution of mushroom poisoning incidents in China, 2022.

PLAD	Number of incidents	Number of patients	Deaths	Mortality (%)
Yunnan	131	404	9	2.23
Hunan	89	229	7	3.06
Sichuan	57	130	2	1.54
Guangxi	29	106	0	0
Chongqing	27	82	1	1.22
Zhejiang	27	72	0	0
Guangdong	20	46	5	10.87
Guizhou	19	87	1	1.15
Ningxia	19	29	0	0
Hubei	17	42	0	0
Shandong	9	19	1	5.26
Fujian	8	15	1	6.67
Jiangsu	7	20	0	0
Jiangxi	6	7	0	0
Anhui	5	16	0	0
Hebei	4	10	0	0
Henan	3	6	1	16.67
Shanghai	2	2	0	0
Liaoning	1	5	0	0
Shanxi	1	3	0	0
Heilongjiang	1	2	0	0
Total	482	1,332	28	2.10

Note: Species newly recorded as poisonous mushrooms in China are in italic bold.
Abbreviation: ALF=Acute liver failure; ARF=Acute renal failure; G=Gastroenteritis; P=Psycho to neurological disorder; M=Medicinal; U=Unclassified; E=edible.

and Shanghai) with 55 incidents, 132 patients, and 1 death; South China (Guangxi and Guangdong) with 49 incidents, 152 patients, and 5 deaths; Northwest China (Ningxia) with 19 incidents, 29 patients, and 0 deaths; North China (Shandong, Hebei, and Shanxi) with 14 incidents, 32 patients, and 1 death; and Northeast China (Liaoning and Heilongjiang) with 2 incidents, 7 patients, and 0 deaths. Detailed information for each PLAD is presented in Table 1.

In 2022, 98 species of poisonous mushrooms were successfully identified from mushroom poisoning events, resulting in seven different clinical syndromes. Among these 98 species, 13 were newly recorded as poisonous species in China. *Collybia humida* nom. prov., *Spodocybe venenata* nom. prov., and *Omphalotus yunnanensis* nom. prov. represented 3 undescribed species. The first two species contained muscarine and stimulated the parasympathetic nervous system, while the last species caused gastroenteritis. *Coprinopsis aesontiensis* and *Leucoagaricus purpureolilacinus* species complex were two new records in China causing gastroenteritis. The eight remaining species, previously of unclear edibility, were confirmed to be poisonous based on poisoning incidents. These species were *Tricholoma olivaceum*, a species originally discovered in China and causing gastroenteritis (*4*); *Candolleomyces yanshanensis*, *Anthracoporus holophaeus*, *Anthracoporus nigropurpureus*, *Inocybe* cf. *assimillata*, *Inocybe* aff. *decemgibbosa*, *Inocybe* aff. *pseudoreducta,* and *Inosperma* cf. *gregarium,* which caused psycho-neurological disorders (*5*–*6*).

The top three lethal mushroom species were *Amanita exitialis*, *A. rimosa,* and *Russula subnigricans*, which caused 7, 7, and 6 deaths, respectively (Figure 2, Supplementary Table S1). *Chlorophyllum molybdites*, the most widely distributed mushroom (discovered in 16 PLADs), caused the most poisonings incidents (appearing in 114 incidents and affecting 257 patients) and had a distinct long active period (from early April to early December).

In 2022, nine species causing acute liver failure were identified in China (Figure 2, Supplementary Table S1). *Amanita exitialis* was the most dangerous species, causing 7 deaths in 14 incidents involving 41 patients. *Amanita rimosa* and *Galerina sulciceps* caused seven and three deaths, respectively. *Amanita subfuliginea*, a lethal species originally described from Guangdong in 2016 (*7*), was also identified. On May 29, two people from Chongqing were poisoned by a gray amanita mushroom, marking the first reported poisoning incident since the mushroom was described and the first record of this gray poisonous amanita in Southwest China (*7*).

Three species of mushroom were identified as causing acute renal failure in mushroom poisoning incidents (Figure 2, Supplementary Table S1). *Amanita pseudoporphyria* was the most common, appearing in 12 incidents either alone or in combination with other species. *Amanita neoovoidea* had the longest active period, occurring from mid-June to early November.

Russula subnigricans was linked to 15 incidents of rhabdomyolysis, involving 44 patients and resulting in 6 deaths, either alone or in combination with other mushroom species. This species was found in Yunnan, Hunan, and Zhejiang from June to September. The first *Paxillus orientalis* poisoning incident from China, resulting in hemolysis, occurred in Sichuan in early June (Figure 2, Supplementary Table S1).

A total of 51 species causing gastroenteritis were identified from mushroom poisoning incidents in China in 2022 (Supplementary Table S1). Among them, four species were identified as poisonous mushrooms and subsequently added to the Chinese poisonous mushroom list (*1*–*3*,*8*). *Omphalotus yunnanensis* nom. prov. was discovered from a poisoning incident in Yunnan. The top three species in this category were *Chlorophyllum molybdites*, *Russula japonica,* and *Scleroderma cepa* (Figure 2).

In 2022, 32 species of mushrooms causing psycho-neurological disorders were identified in China (Supplementary Table S1). Nine of these species were newly discovered as poisonous (*1*–*3*,*8*), including *Collybia humida* nom. prov. and *Spodocybe venenata* nom. prov., which need to be formally described. The top five species were *Lanmaoa asiatica*, *Gymnopilus dilepis*, *Anthracoporus nigropurpureus*, *Amanita rufoferruginea*, and *Amanita sychnopyramis* f. *subannulata* (Figure 2).

On September 30, five Burmese workers in Dehong, Yunnan were poisoned by *Inosperma hainanense*, a newly discovered species containing muscarine that was identified in Hainan in 2021 (*9*).

DISCUSSION

In 2022, mushroom poisoning incidents and patients were more than those in 2019 and 2021 but fewer than in 2020, while deaths slightly increased (28 compared to 22, 20, and 25) (*1*–*3*). Heilongjiang was newly recorded with poisoning incidents (*1*–*3*). A total of 98 poisonous species were successfully identified from poisoning incidents in 2022, among which 62 species had already been recorded from 2019 to 2021 (*1*–*3*), raising the total number of species from incidents to over 190 in China by the end of 2022.

FIGURE 2. Poisonous mushrooms identified from mushroom poisoning incidents in China in 2022.
Note: 1: *Amanita exitialis*; 2: *A. fuliginea*; 3: *A. fuligineoides*; 4: *A. rimosa*; 5: *A. subfuliginea* (provided by Yalin Zhou); 6: *A. subjunquillea*; 7: *A. pallidorosea*; 8: *Galerina sulciceps*; 9: *Lepiota brunneoincarnata*; 10: *Russula subnigricans*; 11: *A. neoovoidea*; 12: *A. oberwinklerana*; 13: *A. pseudoporphyria*; 14: *Paxillus orientalis*; 15: *Cordierites frondosus*; 16: *Chlorophyllum molybdites*; 17: *Russula japonica*; 18: *Scleroderma cepa* (provided by Tianhong Li); 19: *Coprinopsis aesontiensis* (provided by Wensong Chen); 20: *Leucoagaricus purpureolilacinus* species complex (provided by Xia Rong); 21: *Omphalotus yunnanensis* nom. prov.; 22: *Tricholoma olivaceum*; 23: *Lanmaoa asiatica* (provided by Guanliang Wen); 24: *Gymnopilus dilepis* (provided by Ya'an CDC); 25: *Anthracoporus nigropurpureus*; 26: *Amanita rufoferruginea*; 27: *A. sychnopyramis* f. *subannulata* (provided by Zuohong Chen); 28: *Anthracoporus holophaeus* (provided by Yanchun Li); 29: *Collybia humida* nom. prov.; 30: *Spodocybe venenata* nom. prov.

The most dangerous mushrooms were *Amanita exitialis* and *A. rimosa*, each causing seven deaths in 2022, different from 2019 to 2021 (*1*–*3*).

Temporal distribution analysis showed that mushroom poisonings in 2022 were concentrated from May to November, similar to 2021 but longer than 2019 and 2020 (*1*–*3*). The peak occurred in June and the incidents decreased in July and August, likely due to the rare drought in southern China. With the arrival of rain in September, mushroom poisoning reached its second peak in September and then gradually decreased in the following three months (Figure 1).

From 2019 to 2021, Hunan was the province with the most incidents among PLADs. However, in 2022, Yunnan had the highest number of incidents, and Southwest China remained the most severely affected area (*1*–*3*). Yunnan also had the most deaths over the last four years (*1*–*3*).

On June 5, one person in Sichuan was poisoned by *Paxillus orientalis*, resulting in hemolysis. This was the first reported case of poisoning from this species in China (*10*). In 2020 and 2021, species of the same genus, *Paxillus involutus*, were reported to have caused poisoning in Xizang (Tibet) and Inner Mongolia (*2*–*3*). We strongly advise against collecting and eating species of *Paxillus*, despite their previous acceptance as edible and/or medicinal fungi in China and the perception of safety among many people (*8*,*10*).

In 2022, 51 species of gastroenteritis-causing organisms were identified, more than in 2019 (30 species) and 2021 (39 species), but slightly fewer than in 2020 (56 species). The top two species were *Chlorophyllum molybdites* and *Russula japonica*, which remained the same from 2019 to 2021, but the third species in 2022 was *Scleroderma cepa*, instead of *Entoloma omiense* in the previous three years (*1*–*3*).

In 2022, 32 species causing psycho-neurological disorders were identified, more than the 18, 28, and 22 species reported in the previous three years (*1*–*3*). Surprisingly, *Lanmaoa asiatica* ranked first, unlike the previous three years when *Amanita subglobosa* was the most common (*1*–*3*). *Lanmaoa asiatica* is a delicious bolete that must be cooked properly (*8*). The increased poisoning incidents of this species may be partially attributed to the rise of online shopping, which lacks face-to-face communication about proper cooking.

Anthracoporus nigropurpureus (*Porphyrellus nigropurpureus*), a black bolete, caused nine poisoning incidents in Sichuan, Yunnan, and Zhejiang, resulting in dizziness, blurred vision, amyosthenia, headache, muscle cramps, hand or foot tremors, and red eyes, among other symptoms. However, its toxicity remains unclear, and further studies are urgently needed. Another species from the same genus, *Anthracoporus holophaeus*, was also identified from two incidents with similar clinical manifestations. At present, we strongly advise against collecting and eating black boletes of the genus *Anthracoporus*.

Cordierites frondosus is a species morphologically similar to edible *Auricularia* spp., but the former species can cause typical photosensitive dermatitis, which poisoned three people from Chongqing on April 21, 2022. Compared to 2019, we found that this species appeared in different months in different areas; for example, two incidents occurred in Yunnan in early June and in Guizhou in early December (*1*). Further research is needed to uncover its spatial and temporal distribution characteristics and rules for better poisoning control.

Sixteen edible mushrooms were identified from mushroom poisoning incidents in 2022 (Supplementary Table S1). These incidents were likely due to the consumption of mixed mushrooms with poisonous mushrooms, contaminated mushrooms, or some species that may be poisonous to certain individuals.

This study only represents a portion of actual mushroom poisonings. In some cases, no mushroom specimens were obtained, making it impossible to confirm the exact poisonous mushroom species. To reduce the risk of poisoning, we recommend that people set aside some fruiting bodies before eating or take a photo of the fresh mushrooms before cooking. Knowledge popularization of poisonous mushrooms is also important to decrease the number of poisoning incidents. To this end, we recommend creating more scientific, plain, and varied popularization materials and publicizing them to people at risk before and throughout the poisoning season. In the past decades, our knowledge of poisonous mushrooms has increased drastically, and more patient poisoning incidents have become more standardized.

The previous practice of controlling and preventing mushroom poisoning demonstrates that more effort and closer cooperation are urgently needed from governments, CDC staff, doctors, and mycologists in the future.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Mushroom species involved in poisoning incidents and their spatial and temporal distribution in China, 2022.

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Acute liver failure					
Amanita exitialis	14	41	7	17.07	February 13 to April 1, Fujian and Guangdong; May 6 to 30, Sichuan and Guizhou; June 7 to July 2, Yunnan
Amanita cf. *exitialis*	1	1	0	0.00	May 29, Guangxi
Amanita fuliginea	8	19	0	0.00	May 23 to June 19, Hunan
Amanita fuliginea, *A. fritillaria*[P] and *Russula* spp.[U]	1	1	0	0.00	June 13, Hunan
Amanita fuligineoides	1	4	0	0.00	June 8, Yunnan
Amanita fuligineoides, *A. pseudoporphyria*[ARF] and *A. kitamagotake*[E]	1	2	0	0.00	June 15, Zhejiang
Amanita cf. *pallidorosea*	2	5	1	20.00	July 28, Henan; September 1, Shandong
Amanita rimosa	4	27	7	25.93	June 11 to 25, Hunan, Zhejiang
Amanita subfuliginea	1	2	0	0.00	May 29, Chongqing
Amanita subjunquillea	3	9	0	0.00	June 11 and 24, Guizhou; September 1, Shandong
Amanita subjunquillea, *A. fritillaria*[P], *Lactarius oomsisiensis*[G] and *Agaricus flocculosipes*[E]	1	2	0	0.00	July 27, Shandong
Amanita subjunquillea, *Amanita pallidorosea*[ALF], *Amanita oberwinklerana*[ARF], *Hypholoma fasciculare*[G], *Agaricus abruptibulbus*[G], *Agaricus sinoplacomyces*[G], *Amanita fritillaria*[P], *Agaricus flocculosipes*[E], *Lepista nuda*[E], *Agaricus beijingensis*[U] and *Lanmaoa* sp.[U]	1	5	0	0.00	September 23, Liaoning (bought from market)
Amanita sp., *Suillus luteus*[G], *Lactarius hatsudake*[E] and *Russula sanguinea*[E]	1	2	1	50.00	September 1, Shandong
Amanita sp.	1	5	1	20.00	May 19, Chongqing
Galerina sulciceps	9	33	3	9.09	June 19, Guizhou; September 22 to November 26, Sichuan, Yunnan, Guizhou
Galerina sp.	1	1	0	0.00	June 19, Yunnan
Lepiota brunneoincarnata	11	17	0	0.00	June 27, Ningxia; July 5, Yunnan; July 15 to August 28, Ningxia
Rhabdomyolysis					
Russula subnigricans	11	32	6	18.75	June 22 to September 23, Yunnan, Hunan
Russula subnigricans and *R. adusta*[E]	2	3	0	0.00	August 18 and September 5, Yunnan
Russula subnigricans, *R.* cf. *nigricans*[E] and *R. densifolia*[E]	1	7	0	0.00	July 23, Zhejiang
Russula subnigricans, *Lactifluus sinensis*[E], *Russula pseudocompacta*[E], *Russula viridirubrolimbata*[E], *Xerocomus parvulus*[E] and *Russula* sp.[U]	1	2	0	0.00	July 10, Hunan (bought from market)
Acute renal failure					
Amanita neoovoidea	4	6	0	0.00	June 16, Yunnan; September 19 to October 1, Zhejiang; November 4, Chongqing (bought from market)
Amanita oberwinklerana	5	11	0	0.00	June 23 to July 1, Guizhou and Yunnan; August 1, Jiangsu; August 31, Hebei
Amanita cf. *oberwinklerana*	1	3	0	0.00	August 13, Hebei
Amanita pseudoporphyria	9	20	0	0.00	May 25 to July 6, Guangxi, Jiangxi, Hubei, Hunan, Yunnan
Amanita pseudoporphyria and *Russula japonica*[G]	2	6	0	0.00	June 13 and 14, Zhejiang, Hunan
Amanita pseudoporphyria and *A. fritillaria*[P]	1	4	0	0.00	June 14, Hunan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Hemolysis					
Paxillus orientalis	1	1	0	0.00	June 5, Sichuan
Gastroenteritis					
Agaricus bresadolanus and *Lycoperdon pratense*[E]	1	2	0	0.00	August 25, Shandong
Albatrellus dispansus	1	1	0	0.00	August 1, Yunnan
Baorangia major	2	9	0	0.00	May 26 and 29, Yunnan (one incident bought from market)
Chlorophyllum globosum	1	4	0	0.00	May 31, Yunnan
Chlorophyllum aff. *globosum*	3	10	0	0.00	September 12 to 27, Sichuan
Chlorophyllum hortense	1	1	0	0.00	July 25, Hubei
Chlorophyllum molybdites	114	257	0	0.00	April 2 to December 6, Guangdong, Hubei, Jiangxi, Guangxi, Hunan, Fujian, Sichuan, Chongqing, Yunnan, Shandong, Anhui, Jiangsu, Sichuan, Zhejiang, Shanghai, Fujian (5 patients in 4 incidents from Guangdong, Shanghai and Jiangsu were eaten raw)
Chlorophyllum cf. *molybdites*	1	1	0	0.00	September 2, Henan
Coprinopsis aesontiensis	1	6	0	0.00	April 21, Yunnan
Entoloma cf. *sinuatum*	1	2	0	0.00	August 13, Yunnan
Entoloma sp., *Xerocomus parvulus*[E], *Russula* cf. *pseudobubalina*[U]	1	2	0	0.00	September 9, Zhejiang
Entoloma omiense	5	15	0	0.00	June 6, Yunnan; July 12 and August 13, Guangxi, Guangdong; September 14 and 21, Zhejiang, Guizhou
Entoloma omiense, *Suillus pinetorum*[G], *Suillus luteus*[G], *Amanita sinocitrina*[P], *Lycoperdon perlatum*[E,M] and *Lactarius vividus*[E]	1	5	0	0.00	September 24, Sichuan
Gymnopus densilamellatus	1	3	0	0.00	May 30, Yunnan (bought from market)
Gymnopus dryophilus	1	1	0	0.00	June 15, Yunnan
Heimioporus gaojiaocong	1	5	0	0.00	August 24, Guizhou
Lactarius hirtipes	1	2	0	0.00	October 10, Sichuan
Lactarius laccarioides	1	1	0	0.00	August 7, Yunnan
Lactarius rubrocorrugatus	1	1	0	0.00	June 13, Yunnan
Lactarius subhirtipes or *L. subatlanticus*[G]	1	1	0	0.00	June 13, Chongqing
Lactifluus pseudoluteopus	1	3	0	0.00	June 14, Yunnan (bought from market)
Lactifluus piperatus	1	5	0	0.00	June 23, Yunnan
Leucoagaricus leucothites	2	6	0	0.00	September 21, Ningxia; November 27, Anhui
***Leucoagaricus purpureolilacinus* species complex**	1	1	0	0.00	September 21, Sichuan
Neoboletus venenatus	1	8	0	0.00	August 2, Sichuan
Neoboletus venenatus and *Butyriboletus yicibus*[E]	1	2	0	0.00	Late June, Hunan (dried boletes, bought from market)
Omphalotus guepiniformis	3	18	0	0.00	March 25 and 26, Guangxi; December 13, Fujian
Omphalotus guepiniformis and *Macrolepiota procera*[E,M,G]	1	8	0	0.00	October 5, Yunnan
Omphalotus olearius	1	3	0	0.00	September 24, Yunnan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
***Omphalotus yunnanensis* nom. prov.**	1	1	0	0.00	September 24, Yunnan
Rubroboletus latisporus	2	10	0	0.00	July 22, Yunnan; October 2, Guizhou
Russula japonica	42	136	0	0.00	May 16 to October 27, Yunnan, Hunan, Chongqing, Sichuan, Zhejiang, Guizhou, Anhui
Russula japonica, *R. crustosa*[E,M] and *Amanita fritillaria*[P]	1	1	0	0.00	June 8, Hunan
Russula japonica, *Lactifluus volemus*[E] and *Hygrocybe* sp.[U]	1	5	0	0.00	June 8, Chongqing
Russula japonica and *R. aeruginea*[E]	1	2	0	0.00	June 10, Hunan
Russula japonica and *R. compacta*[E]	1	4	0	0.00	June 9, Hunan
Russula japonica and *R. punctipes*[G]	1	2	0	0.00	June 1, Hunan
Russula japonica and *R. punctipes*[G], *R. virescens*[E] and *Lactifluus leoninus*[E]	1	3	0	0.00	August 10, Sichuan
Russula japonica, *Suillus granulatus*[E,G] and *Tylopilus pseudoballoui*[E]	1	1	0	0.00	July 16, Yunnan
Russula japonica and *Gomphus* sp.[U]	1	1	0	0.00	July 11, Yunnan
Russula japonica and *Russula* sp.[U]	1	2	0	0.00	August 7, Sichuan
Russula rufobasalis	1	3	0	0.00	May 29, Hunan
Scleroderma aff. *albidum*	1	2	0	0.00	September 7, Yunnan
Scleroderma cf. *areolatum* and *Scleroderma yunnanense*[E]	1	9	2	22.22	June 12, Yunnan
Scleroderma cepa	9	41	0	0.00	June 20 to August 7, Yunnan; September 9 and 18, Yunnan, Hunan; October 25, Zhejiang
Scleroderma cepa and *S. bovista*[E,M]	1	2	0	0.00	June 17, Yunnan
Scleroderma venenatum	1	2	0	0.00	September 1, Hebei
Suillus granulatus and *Lactarius hatsudake*[E]	1	1	0	0.00	June 13, Chongqing
Suillus phylopictus, *Amanita vaginata* complex[U], *Lactarius cinnamomeus*[E], *Russula compacta*[E], *Cortinarius hinnuleoarmillatus*[U], *Veloporphyrellus pseudovelatus*[U], *Entoloma undatum*[U], *Lactarius brachycystidiatus*[U] and *Russula* spp.[U]	1	2	0	0.00	July 8, Yunnan
Tricholoma equestre and *Tricholoma* sp.[U]	1	1	0	0.00	October 10, Yunnan
Thicholoma highlandense and *Tricholoma* sp.[G]	1	6	0	0.00	October 6, Yunnan
Tricholoma highlandense, *Gomphus floccosus*[G], *Boletus* sp.[U], *Russula* spp.[U] and *Ramaria* sp.[U]	1	4	0	0.00	June 14, Yunnan
Tricholoma olivaceum	1	2	0	0.00	August 18, Yunnan
Tricholoma stans, *Hygrophorus yunnanensis*[E] and *Hygrophorus* sp.[U]	1	6	0	0.00	October 17, Guizhou (eaten in a restaurant)
Tylopilus felleus, *Suillus granulatus*[G,E], *Amanita fritillaria*[P], *Amanita* cf. *hemibapha*[E], *Amanita princeps*[E], *Russula cerolens*[U], *Russula* sp.[U], *Lactifluus* sp.[U] and *Cortinarius* sp.[U]	1	2	0	0.00	July 8, Shandong
Psycho-neurological disorder					
Amanita concentrica	1	2	0	0.00	June 15, Yunnan
Amanita melleiceps and *Gymnopus* sp.[U]	1	2	0	0.00	June 10, Fujian
Amanita pseudosychnopyramis	1	1	0	0.00	March 26, Zhejiang
Amanita rufoferruginea	4	11	0	0.00	June 10 to 14, Hunan, Chongqing, Guangxi; August 4, Sichuan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Amanita rufoferruginea, *Russula compacta*[E] and *Termitomyces* sp.[E]	1	4	0	0.00	June 9, Zhejiang
Amanita rufoferruginea, *A. subglobosa*[P]	1	3	0	0.00	June 17, Hunan
Amanita subglobosa	2	4	0	0.00	June 1 to July 29, Chongqing
Amanita sychnopyramis f. *subannulata*	5	15	0	0.00	May 18 to June 12, Guangxi, Hunan
Anthracoporus holophaeus	1	1	0	0.00	June 10, Yunnan
Anthracoporus holophaeus, *Lactarius subhirtipes*[G]	1	3	0	0.00	June 5, Sichuan
Anthracoporus nigropurpureus	9	17	0	0.00	June 10 to July 13, Sichuan, Yunnan, Zhejiang
Candolleomyces yanshanensis	1	3	0	0.00	June 16, Shandong
Clitocybe nebularis	1	1	0	0.00	August 25, Yunnan
***Collybia humida* nom. prov.**, ***Spodocybe venenata* nom. prov.**[P], *Hypholoma fasciculare*[G], *Pholiota multicingulata*[G], *Gymnopus dryophilus*[G], *Lactarius citrinus*[G], *Mycena pura*[P], *Lepiota magnispora*[U], *Cystodermella lactea*[U], *Laccaria* sp.[U], *Cystoderma amianthinum*[E] and *Armillaria mellea*[E]	1	20	0	0.00	October 19, Yunnan
Collybia sp.	1	7	0	0.00	October 1, Guizhou
Gymnopilus dilepis	10	34	0	0.00	May 2 to June 9, Sichuan, Hunan, Chongqing; July 23, Fujian; October 28, Sichuan
Inocybe* aff. *decemgibbosa	1	2	0	0.00	May 21, Hunan
Inocybe* cf. *assimillata	1	1	0	0.00	November 27, Hunan
Inosperma* cf. *gregarium	1	1	0	0.00	September 22, Yunnan
Inosperma hainanense	2	7	0	0.00	August 9, Guangxi; September 30, Yunnan (5 Burmese)
Inosperma muscarium	1	4	0	0.00	May 20, Guangxi
Laetiporus versisporus	1	1	0	0.00	June 28, Yunnan
Lanmaoa asiatica	12	14	0	0.00	July 6 to October 20, Guangdong, Chongqing, Yunnan, Hunan (9 patients from 7 incidents ate boletes bought from Yunnan market)
Panaeolus cyanescens	1	1	0	0.00	September 12, Shandong
Panaeolus subbalteatus	1	1	0	0.00	July 1, Ningxia
Pseudosperma citrinostipes and ***Inocybe* aff. *pseudoreducta***[P]	1	4	0	0.00	July 3, Yunnan
Pseudosperma umbrinellum	3	4	0	0.00	August 31 to September 15, Ningxia
Pseudosperma sp.	1	2	0	0.00	May 17, Hunan
Psilocybe cubensis	4	9	0	0.00	March 29, Hunan; August 1 and 4, Hunan, Guangxi; November 2; Guangxi
Psilocybe keralensis	1	1	0	0.00	May 4, Fujian
Psilocybe ovoideocystidiata	1	5	0	0.00	May 1, Hubei
Psilocybe samuiensis	2	2	0	0.00	November 28 and December 3, Zhejiang, Hunan
Photosensitive dermatitis					
Cordierites frondosus	1	3	0	0.00	April 21, Chongqing
Unclassified					
Amanita pseudoprinceps[E]	1	2	0	0.00	August 12, Yunnan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Armillaria gallica^{E}	1	3	0	0.00	May 6, Hunan (dried mushrooms, given by a friend from Northeast China)
Armillaria mellea^{E}	1	3	0	0.00	November 10, Guizhou
Boletus bainiugan^{E} and *B. reticuloceps*^{E}	1	28	0	0.00	January 13, Yunnan (dried boletes, bought from market)
Boletus bainiugan^{E}	1	2	0	0.00	August 8, Guangdong (bought from Yunnan market, eaten raw)
Boletus bainiugan^{E}, *Lanmaoa asiatica*^{E,P}, *Tricholomopsis rutilans*^{G}, *Caloboletus xiangtoushanensis*^{U}, *Imperator* sp.^{U} and *Xerocomus* sp.^{U}	1	2	0	0.00	July 16, Ningxia (dried boletes, given by a friend from Sichuan)
Butyriboletus yicibus^{E}	1	2	0	0.00	July 29, Guangdong (bought from Yunnan market)
Cortinarius sinensis^{E}	1	2	0	0.00	September 14, Ningxia
Lanmaoa asiatica^{E,P}, *Rubroboletus flammeus*^{U}, *Rubroboletus* sp.^{U}, *Clitocella orientalis*^{U}, *Imperator* sp.^{U}, *Caloboletus* sp.^{U}, *Inocybe* sp.^{U}, *Russula laurocerasi*^{U} and *Russula mariae*^{E}	1	2	0	0.00	August 5, Guizhou (dried boletes)
Lepista nuda^{E,M}	1	4	0	0.00	September 12, Hebei
Lycoperdon perlatum^{E,M}	1	1	0	0.00	May 27, Yunnan
Macrocybe gigantea^{E,M}	1	2	0	0.00	May 25, Yunnan (was eaten raw)
Pholiota spumosa^{E,M}	1	3	0	0.00	September 27, Sichuan
Russula crustosa^{E} and *Laccaria yunnanensis*^{E}	1	6	0	0.00	September 4, Sichuan
Russula leucocarpa^{E}	1	3	0	0.00	August 6, Sichuan
Russula leucocarpa^{E}, *Russula densifolia*^{E} and *Russula* sp.^{U}	1	2	0	0.00	June 22, Sichuan
Russula leucocarpa^{E} and *Amanita* sp.^{U}	1	2	0	0.00	June 22, Sichuan
Termitomyces fuliginosus^{E}	1	1	0	0.00	June 19, Sichuan
Tricholoma terreum^{E}	2	2	0	0.00	March 1 and 5, Hunan

Note: Species newly recorded as poisonous mushrooms in China are in italic bold.

Abbreviation: ALF=Acute liver failure; ARF=Acute renal failure; G=Gastroenteritis; P=Psycho to neurological disorder; M=Medicinal; U=Unclassified; E=Edible.