EPIDEMIOLOGICAL CHARACTERISTICS OF MUSHROOM POISONING IN YUNNAN PROVINCE, CHINA, 2004-2016

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Abstract. Mushroom consumption is common in Yunnan Province, China. We aimed to determine the epidemiology of mushroom poisoning (MP) in Yunnan in order to inform MP prevention measures. We retrospectively reviewed MP surveillance data for 2004-2016, recording demographic data of victims, type of mushroom ingested, and possible risk factors for fatal cases. A total of 1,538 MP cases, with 413 deaths were reported for Yunnan Province during the study period. More cases occurred during the summer each year. Seventy-six percent of cases occurred among adults aged 18-64 years. *Amanita farinosa* was the most common cause of MP and deaths. On multivariable logistic regression analysis, factors significantly associated with death were victim aged <7 years or >64 years, consuming self-picked mushrooms and onset of MP symptoms ≥ 6 hours after ingestion. MP is a public health problem in Yunnan Province, China. Preventive programs should target all age groups, especially young children and the elderly and should recommend against consuming self-picked mushrooms. The peak time MP prevention programs should be conducted is at the beginning of summer. Physicians should be informed that subjects with symptom onset ≥ 6 hours after ingestion are at greater risk of death.

Keywords: mushroom poisoning, epidemiological features, mycological identification, surveillance, Yunnan

INTRODUCTION

Mushroom poisoning (MP) refers to the harmful consequences that result from the intake of the toxic substances in mushrooms (Berger and Guss, 2005). Of the 5,000 known species of mushrooms, approximately 100 are known to be poisonous to humans (Graeme, 2014). Toxicities include gastrointestinal irritation, psychotropic effects, and acute renal or hepatic failure (Erden *et al*, 2013). MP has become a global public health problem, as mushroom hunting has gained popularity (Kintziger *et al*, 2011). It is estimated MP causes hundreds of deaths worldwide each year (Graeme, 2014).

Yunnan Province in southwestern China is known as the "Kingdom of Wild Mushrooms" (Visit Our China, 2016).

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More than 800 varieties of edible wild mushrooms are found here, accounting for two-thirds of all the mushroom species in China (Zhang and Xiao, 2013). Mushroom collection and consumption are common in Yunnan. However, toxic mushroom species grow in the same areas as nontoxic species and can be confused. There are no simple tests to identify poisonous mushrooms and no safe ways to render them nontoxic. Therefore, MP has long been a problem in Yunnan Province. However, there is little known about the epidemiology of MP in Yunnan. In this study, we analyze MP surveillance data from the Yunnan emergency response system in order to understand the epidemiology of MP and the risk factors for fatal MP. These results will inform MP prevention efforts.

MATERIALS AND METHODS

Data collection

In 2004, a web-based emergency response system for health threats was implemented in China. Any health threat affecting at least 30 people or causing a fatality should be reported, such as MP. Epidemiologists at all hospitals and health centers report the data, which is immediately sent to the national database, where officers at different levels of the China Centers for Disease Control and Prevention assess it and make appropriate actions. For this study, we accessed all cases of MP reported through this system from Yunnan Province, China during 2004-2016. Data collected included demographics and identification of the type of mushroom ingested. These data were then entered into the R program (version 3.2.1) for data analysis.

Statistics

The numbers of MP cases per month and by season were calculated. The annual incidence rate and case fatality rate were calculated for each county and mapped out using MapInfo, version 15. Percentages were calculated for the various demographic characteristics. Significant differences were calculated with the chi-square (χ^2) test. The types of mushrooms involved were recorded. Multinomial logistic regression analysis was used to determine if mortality was significantly associated with gender, age, how the mushroom were obtained, cooking method, and length of time from mushroom ingestion to onset of symptoms. Ethical approval for this study was obtained from the Ethics Committee of the Yunnan Provincial Center for Disease Control and Prevention.

RESULTS

Epidemic seasonal pattern

During the 2004-2016 study period, 254 MP events, comprised of 1,528 cases and 413 deaths, were reported from Yunnan Province. Seventy-nine percent of the cases occurred during spring and summer (May - August), which is the rainy season in Yunnan (Fig 1). However, there were 4 MP clusters that occurred in January (2005 and 2006), February (2016), and March (2006), respectively. Those 4 clusters were caused by eating fresh frozen mushrooms that had been collected during previous wild-mushroom seasons.

Geographic distribution

MP cases were reported in 75 out of the 129 counties in Yunnan Province during the study period. The average annual incidence rate of mushroom poisoning in Yunnan Province was 3.34 cases per 100,000 population (based on 2010 population data). The counties with higher incidence rates of MP were those in the southeastern, central and western parts of

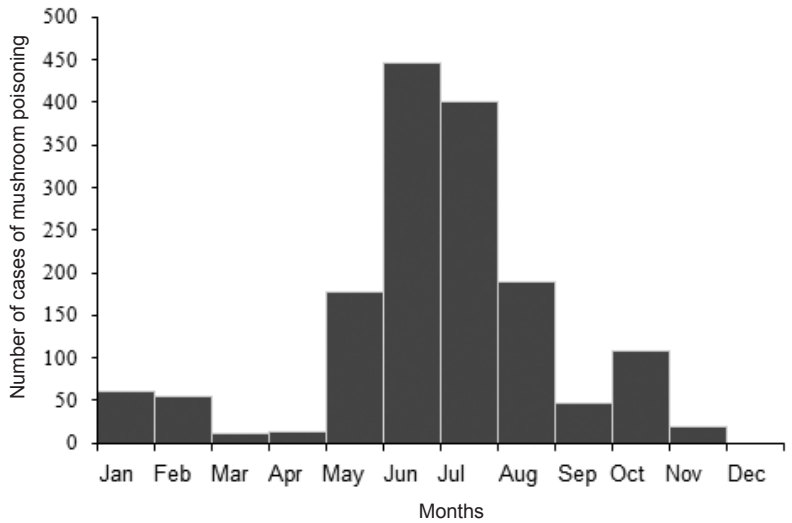

Fig 1–Monthly variation in mushroom poisoning cases in Yunnan Province, 2004-2016.

Yunnan Province (Fig 2 A). The average province case fatality rate was 27%, but higher fatality rates were reported from counties in southwestern Yunnan Province (Fig 2 B).

Characteristics of subjects

Victims were classified into 4 groups by age: preschool children (aged 0-6 years), students (aged 7-17 years), adults (aged 18-64 years), and the elderly (aged ≥65 years). Characteristics of the MP patients differed by age group (Table 1). Seventy-six percent of cases occurred among

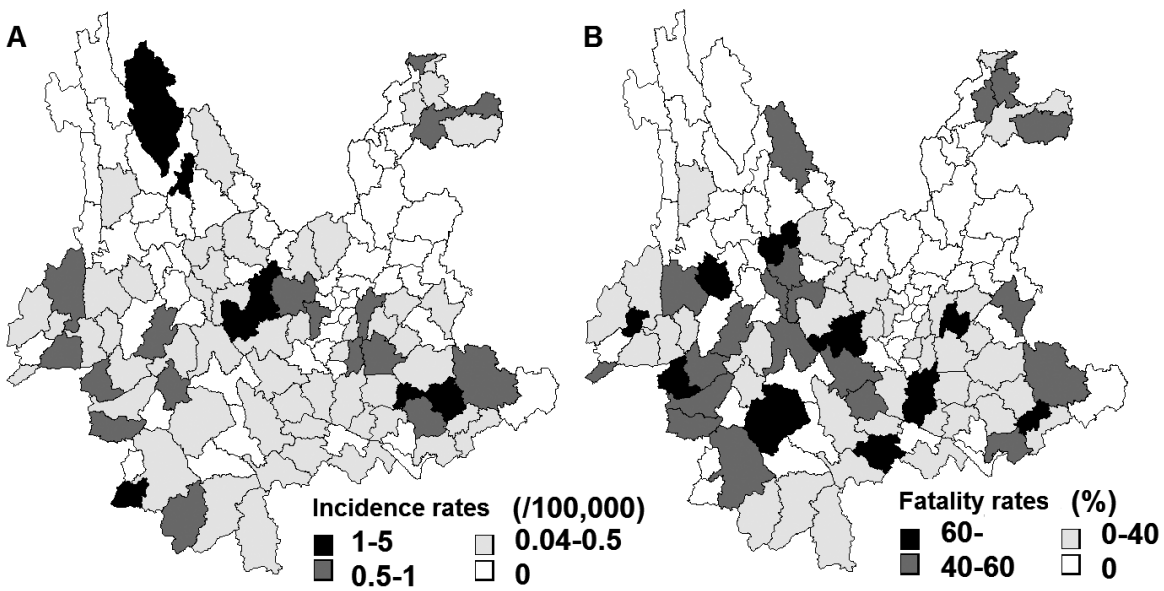

Fig 2–Mushroom poisoning in Yunnan Province, 2004-2016: average annual incidence rates by counties (A), average annual case fatality rates by counties (B).

Table 1
Characteristics of reported mushroom poisoning patients by age group in Yunnan Province, 2004-2016.

Characteristic	Age group in years				*p*-value[b]
	0-6 (*n*=93) *n* (%)	7-17 (*n*=193) *n* (%)	18-64 (*n*=1,164) *n* (%)	≥65 (*n*=7) *n* (%)	
Gender					<0.01
Male	40 (43.01)	103 (53.37)	721 (61.94)	40 (51.28)	
Female	53 (56.99)	90 (46.63)	443 (38.06)	38 (48.72)	
Source of mushrooms					<0.01
Self-picked	89 (95.70)	174 (90.16)	937 (80.50)	67 (85.9)	
Purchased	4 (4.30)	19 (9.84)	227 (19.50)	11 (14.1)	
Cooking method					0.75
Boiled	16 (17.20)	30 (15.54)	155 (13.32)	11 (14.1)	
Fried	75 (80.65)	160 (82.9)	995 (85.48)	67 (85.9)	
Roasted	2 (2.15)	3 (1.55)	14 (1.20)	0 (0)	
Latent period[a]					<0.01
< 6 hours	36 (38.71)	85 (44.04)	719 (61.77)	36 (46.15)	
≥ 6 hours	57 (61.29)	108 (55.96)	445 (38.23)	42 (53.85)	
Outcome					<0.01
Survived	50 (53.76)	133 (68.91)	889 (76.37)	43 (55.13)	
Died	43 (46.24)	60 (31.09)	275 (23.63)	35 (44.87)	

*Latent period from mushroom ingestion to onset of symptoms; [b]Chi-square test.

adults aged 18-64 years. Significantly more females than males aged 0-6 years had MP. Eighty-three percent of the cases ate self-picked mushroom from woodlands, and 85% of cooking method was frying the mushroom in oil. Early onset (<6 hours) of symptoms after ingestion occurred in 62% of adults. However, death occurred in 46% of preschool and 45% of elderly cases.

Mycological identification

The mushroom was identified in 393 cases (Table 2). *Amanita farinosa* was the most common mushroom species causing 53% cases and 78% deaths among the identified cases. The type of mushroom was not identified in 74% of cases.

Possible risk factors for death

All the independent variables from the 1,528 reported cases were included in the multinomial logistic regression model. The type of mushroom causing death was not included in the final analysis because the type of mushroom was only identified in 26% of patients. The factors significantly associated with death due to MP on multilogistic regression analysis were: age < 7 years and > 64 years, having eaten self-picked mushrooms, and having MP symptom onset ≥6 hours after ingestion (Table 3).

DISCUSSION

Few studies have evaluated the epide-

Table 2
Identification of cases of mushroom poisoning in Yunnan Province, 2004-2016.

Causative mushroom species	Proportion of cases with mycological identification No. who died/total no. (%)
Amanita farinosa	93/207 (44.93)
Boletus luridus	4/108 (3.70)
Russula subnigricans Hongo	14/35 (40.00)
Russula emetica	4/24 (16.67)
Trogia venenata	5/19 (26.32)
Unknown	293/1,135 (25.81)

Table 3
Factors associated with death among mushroom poisoning cases (*N*=1,528), Yunnan Province, 2004-2016.

Variables	Crude OR (95% CI)	Adjusted OR (95% CI)
Gender		
Male	0.8 (0.64-1.01)	0.81 (0.63-1.04)
Female	Reference	Reference
Age in years		
0-6	2.78 (1.81-4.27)	1.97 (1.25-3.11)
7-17	1.46 (1.04-2.04)	1.1 (0.77-1.56)
18-64	Reference	Reference
≥65	2.63 (1.65-4.19)	2.3 (1.39-3.79)
Source of mushroom		
Self-picked	5.42 (3.38-8.68)	2.76 (1.67-4.55)
Purchased	Reference	Reference
Cooking method		
Boiled	Reference	Reference
Fried	0.8 (0.59-1.1)	1.16 (0.83-1.63)
Roast	1.64 (0.63-4.28)	3.52 (1.3-9.49)
Latent period[a]		
< 6 hours	Reference	Reference
≥ 6 hours	4.33 (3.4-5.52)	3.53 (2.71-4.6)

[a]Latent period from mushroom ingestion to onset of symptoms.
OR, Odds ratio; CI, confidence interval.

miology of MP in China. We studied this subject in order to inform MP prevention efforts in Yunnan Province, China. Most of the MP cases in our study occurred during the raining season, which coincides with the wild mushroom season. A similar MP pattern (raining season) was reported from Switzerland (Schenk-Jaeger *et al*, 2012), Japan (Ishihara and Yamaura, 1992), America (Kintziger *et al*, 2011), Turkey (Yardan *et al*, 2010), Nepal (Joshi *et al*, 2007) and Iran (Pajoumand

et al, 2005). Intervention programs need to be implemented at the start of the wild-mushroom season each year.

Yunnan Province has a varied climate. The high MP incidence counties were those in southeastern, central and western Yunnan and the counties with the highest fatalities were in the southwest Yunnan. It is likely the climatic conditions in south-western Yunnan Province are conducive to growing poisoned mushroom species. The ecology of these areas needs to be further explored to determine what factors are associated with this presence of poisonous mushrooms in order to inform control and prevention measures.

In our study, 76% of MP victims were adults. In a study from Switzerland (Schenk-Jaeger *et al*, 2012), the identified reasons for MP varied by age group: children tended to be unintentionally poisoned by eating wild mushrooms in outdoor areas, while adults were more likely to collect and eat poisonous mushrooms intentionally, either as an attempt to commit suicide or homicide or in seeking a hallucinatory high (Eren *et al*, 2010). In our study all the cases were apparent accidental poisonings. High risk age groups need to be targeted by MP prevention programs.

Amanita farinosa was the most common poisonous mushroom identified in our study. *Amanita* is found worldwide (Koppel, 1993; Diaz, 2005b; Erguven *et al*, 2007; Levine *et al*, 2011). It is the cause of up to 90% of MP fatalities in some countries (Mullins and Horowitz, 2000; Enjalbert *et al*, 2002). *Trogia venenata* is also noteworthy since it was associated with clusters of death in Yunnan Province (Shi *et al*, 2012). People who live in these endemic growing areas should be taught how to identify and avoid these species.

Eating self-picked mushrooms was associated with mortality in our study. Poisonous and non-poisonous mushroom may be mistaken for eachother. There is no correlation between a particular morphological feature and a mushroom being poisonous (Chan *et al*, 2016). Wild mushrooms are usually picked in open rural fields and woodlands and then cooked and eaten. One study reported it is more dangerous to ingest raw mushrooms than cooked mushrooms (Eren *et al*, 2010). Many fungal toxins are not particularly sensitive to heat; α-amanitin, the poison produced by *Amanita phalloides* and others in that genus, is not denatured by heat (Smith and Davis, 2016).

In our study, preschool children, the elderly, and those who had late onset of symptoms were at greater risk for death, similar to the findings of other studies (Diaz, 2005a; Yardan *et al*, 2010; Cevik and Unluoglu, 2014; Chan *et al*, 2016). It is important for physicians to be aware that late onset symptoms are associated with death and which age groups are at highest risk of death.

Our study has several limitations: it only included patients reported to the surveillance system and most likely has underreported the extent of MP. Since only a few of the cases reported the type of mushroom, in most cases, the physician had to guess at the mushroom type. Therefore, the species involved with MP and the incidence of MP cause by each type can only be estimated.

In conclusion, MP is a public health problem in Yunnan Province, China where the collection and consumption of wild mushrooms is common. Prevention programs need to target at risk groups and educate physicians about those at greatest risk for MP and death due to MP. The season at greatest risk should also be taken into consideration in developing and implementing prevention programs.

ACKNOWLEDGEMENTS

The authors thank the staff of the Yunnan CDCs and hospitals who participated in the data collection and field investigation.

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