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Preplanned Studies

Mushroom Poisoning Outbreaks — China, 2024

Haijiao Li[1]; Yizhe Zhang[2]; Hongshun Zhang[1]; Jing Zhou[1]; Zhongfeng Li[2]; Yu Yin[2]; Qian He[2]; Shaofeng Jiang[2]; Yutao Zhang[2]; Yuan Yuan[1]; Nan Lang[2]; Bowen Cheng[2]; Jiaju Zhong[2]; Mingxuan Yuan[2]; Zhiyuan Liu[2]; Chengye Sun[1,#]

Summary

What is already known about this topic?

Mushroom poisoning is a serious food safety problem in China. Since 2019, China CDC has conducted a series of investigations into mushroom poisoning outbreaks. These investigations have revealed the spatial and temporal distribution patterns of mushroom poisoning and the diversity of poisonous mushroom species in China.

What is added by this report?

In 2024, China CDC investigated 599 mushroom poisoning incidents across 28 provincial-level administrative divisions (PLADs). These incidents affected 1,486 patients and resulted in 13 deaths, with a case fatality rate of 0.87%. Investigators identified 110 poisonous mushroom species causing 7 distinct clinical disease types, including 8 species newly documented as poisonous mushrooms in China.

What are the implications for public health practice?

Timely species identification, toxin detection, and clinical type confirmation are crucial for effective mushroom poisoning control and proper patient treatment.

ABSTRACT

Introduction: Mushroom poisoning represents a significant food safety concern in China. Over the past decade, China has established an effective mushroom poisoning control and prevention system involving government agencies, clinicians, CDC experts, and mycologists.

Methods: Under the system of mushroom poisoning control and prevention, information of mushroom poisoning incidents were systematically collected, with identifing species, detecting toxins, and analyzing the spatial and temporal distribution characteristics and species diversity.

Results: In 2024, the China CDC investigated 599 mushroom poisoning incidents across 28 provincial-level administrative divisions (PLADs), involving 1,486 patients and resulting in 13 deaths, with a case fatality rate of 0.87%. The number of cases per incident ranged from 1 to 14 (median=2), with 11 incidents involving more than 10 patients. Among these cases, 50 patients (including 2 fatalities) from 17 incidents consumed poisonous mushrooms purchased from markets, 37 patients from 14 incidents were poisoned after consuming dried mushrooms, and 15 patients from 10 incidents consumed uncooked wild mushrooms. Temporal analysis revealed that mushroom poisoning incidents occurred throughout the year, with the highest frequency between June and October, peaking in June. Geographically, incidents were reported in 28 PLADs, with 13 PLADs reporting more than 10 incidents. Sichuan, Yunnan, Hunan, Guizhou, and Chongqing were the five most affected regions. Deaths were reported in Guizhou (5 deaths), Sichuan (2 deaths), Chongqing (2 deaths), Heilongjiang (2 deaths), Hunan (1 death), and Jiangsu (1 death). A total of 110 poisonous mushroom species causing 7 distinct clinical syndromes were identified, including 8 newly documented poisonous species, bringing the total number of mushroom species involved in poisoning incidents in China to approximately 246 by the end of 2024. The five most lethal mushrooms were *Amanita exitialis*, *A. molliuscula*, *A. subpallidorosea*, *Lepiota brunneoincarnata*, and *Russula subnigricans*, each causing 2 deaths. *Chlorophyllum molybdites* was responsible for the highest number of poisoning incidents (147 incidents affecting 269 patients). *Paxillus obscurosporus*, which causes hemolysis, was identified in a poisoning incident for the first time.

Conclusions: The persistent severity of mushroom poisoning in China underscores the need for continued public education efforts, strengthened market supervision, and enhanced collaboration across departments and disciplines to reduce the incidence of mushroom poisoning.

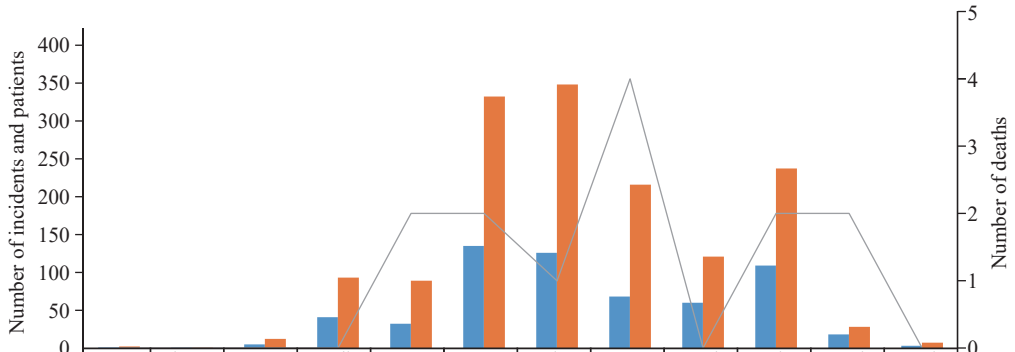
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Mushroom poisoning represents a significant food safety challenge in China. Over the past decade, China has established an effective mushroom poisoning control and prevention system that integrates government agencies, clinical physicians, China CDC experts, and mycologists (*1*–*5*). Within this system, CDC personnel and hospital staff promptly collect mushroom specimens, photographs, and biological samples such as blood and urine immediately following poisoning incidents. Mushroom specimens and photographs are forwarded to mycologists for species identification, while mushroom and biological samples are sent to CDC experts and hospital professionals for toxin detection. Based on species identification, toxin analysis, and clinical manifestations, patients receive accurate diagnoses and timely treatment (*1*–*5*). In 2024, the China CDC investigated 599 mushroom poisoning incidents across 28 provincial-level administrative divisions (PLADs), involving 1,486 patients and resulting in 13 deaths, yielding a case fatality rate of 0.87%. Investigators successfully identified 110 poisonous mushroom species, including 8 newly documented species, associated with 7 distinct clinical manifestations. This brings the total number of mushroom species linked to poisoning incidents in China to 246 by the end of 2024.

In 2024, the number of cases per mushroom poisoning incident ranged from 1 to 14, with a median of 2 cases per incident. Among these incidents, 11 involved more than 10 patients. Notably, 50 patients (including 2 fatalities) from 17 incidents consumed poisonous mushrooms purchased from markets, while 37 patients from 14 incidents were poisoned after consuming dried mushrooms. Additionally, 15 patients from 10 incidents became ill after consuming uncooked wild mushrooms (Supplementary Table S1, available at https://weekly.chinacdc.cn/).

Temporal distribution analysis revealed that mushroom poisoning incidents occurred throughout the year, with the highest frequency observed between June and October (498 incidents, 1,254 patients, and 9 deaths), peaking in June (135 incidents, 332 patients, and 2 deaths). The first death occurred on May 2 in Chongqing. The highest mortality was recorded in August (4 deaths), followed by May, June, October, and November (2 deaths each) (Figure 1).

Regarding geographical distribution, mushroom poisoning incidents were reported in 28 PLADs, with 13 PLADs recording more than 10 incidents. Sichuan, Yunnan, Hunan, Guizhou, and Chongqing PLADs were the 5 most affected regions (Table 1). Deaths were reported in 6 PLADs: Guizhou (5 deaths), Sichuan (2 deaths), Chongqing (2 deaths), Heilongjiang (2 deaths), Hunan (1 death), and Jiangsu (1 death) (Table 1). Southwestern China (Sichuan, Yunnan, Guizhou, and Chongqing) was the most severely affected region, with 321 incidents, 882 patients, and 9 deaths, followed by Central China (Hunan, Hubei, Henan, and Jiangxi) with 126 incidents, 235 patients, and 1 death. East China (Zhejiang, Anhui, Jiangsu, Fujian, and Shanghai) reported 59 incidents, 130 patients, and 1 death; Northwestern China (Ningxia, Qinghai, Xinjiang, and Shanxi) had 31 incidents, 68 patients, and no deaths; Southern China (Guangxi, Guangdong, and Hainan) recorded 30 incidents, 77 patients, and no deaths; Northern China (Hebei, Shandong, Shanxi, Beijing, and Inner Mongolia) had 22 incidents, 62 patients, and no deaths; and Northeastern China (Heilongjiang, Liaoning, and Jilin) reported 10 incidents, 32 patients,



	January	February	March	April	May	June	July	August	September	October	November	December
Number of incidents	1	1	5	41	32	135	126	68	60	109	18	3
Number of patients	2	1	12	93	89	332	348	216	121	237	28	7
Number of deaths	0	0	0	0	2	2	1	4	0	2	2	0

FIGURE 1. Monthly distribution of mushroom poisonings in China, 2024.

TABLE 1. Geographical Distribution of Mushroom Poisoning Incidents in China, 2024.

PLADs	Number of incidents	Number of patients	Deaths	Mortality (%)
Sichuan	116	307	2	0.65
Yunnan	99	281	0	0
Hunan	99	174	1	0.57
Guizhou	54	173	5	2.89
Chongqing	52	121	2	1.65
Ningxia	26	48	0	0
Zhejiang	23	52	0	0
Hubei	23	49	0	0
Guangxi	16	56	0	0
Anhui	12	34	0	0
Jiangsu	12	24	1	4.17
Guangdong	12	13	0	0
Fujian	11	18	0	0
Hebei	8	27	0	0
Heilongjiang	8	20	2	10.00
Shandong	7	19	0	0
Shanxi	3	6	0	0
Qinghai	2	15	0	0
Hainan	2	8	0	0
Henan	2	7	0	0
Beijing	2	5	0	0
Inner Mongolia	2	5	0	0
Jiangxi	2	5	0	0
Xinjiang	2	3	0	0
Liaoning	1	8	0	0
Jilin	1	4	0	0
Shanxi	1	2	0	0
Shanghai	1	2	0	0
Total	599	1486	13	0.87

Abbreviation: PLADs=provincial-level administrative divisions.

and 2 deaths. Detailed information for each PLAD is presented in Table 1.

In 2024, a total of 110 species of poisonous mushrooms were identified in mushroom poisoning cases, resulting in 7 distinct clinical syndromes. Among these, 8 species (*Lactarius trivialis*, *Lactifluus bertillonii*, *Ligymnopus moseri*, *Marasmius maximus*, *Russula insignis*, *Tricholoma olivaceum*, *T. ustaloides*, and *Tylopilus vinosobrunneus*) causing gastroenteritis were newly documented as poisonous mushrooms in China (*1*–*7*) (Figure 2K–O, Supplementary Table S1).

The five most lethal mushrooms were *Amanita exitialis*, *A. molliuscula*, *A. subpallidorosea*, *Lepiota brunneoincarnata*, and *Russula subnigricans* (Figure 2A–E), each responsible for 2 deaths (Supplementary Table S1). *Chlorophyllum molybdites* (Figure 2I) caused the highest number of poisoning incidents (147 incidents affecting 269 patients), either alone or in combination with other species. This species also exhibited the widest geographical distribution (found in 16 PLADs) and the longest active period (from late March to late November).

In 2024, 8 species of *Amanita*, 1 species of *Galerina*, and 1 species of *Lepiota* were identified as causes of acute liver failure in China (Supplementary Table S1). Among these, *Amanita exitialis*, *A. molliuscula*, *A. subpallidorosea*, and *Lepiota brunneoincarnata* (Figure 2A–D) were the most dangerous species, each causing 2 deaths. The three mushroom species responsible for the highest number of incidents were *Galerina sulciceps* (15 incidents with 26 affected patients), *Lepiota brunneoincarnata* (14 incidents with 32 affected patients and 2 deaths), and *Amanita molliuscula* (7 incidents with 19 affected patients and 2 deaths).

Two species, *Amanita oberwinklerana* and *A. pseudoporphyria*, were identified as causes of acute kidney injury in 2024 (Supplementary Table S1). *A. oberwinklerana* was the most prevalent species, present in 10 incidents involving 30 patients, either alone or in combination with other species. *A. pseudoporphyria* (Figure 2F) resulted in 1 fatality across 6 incidents affecting a total of 19 patients.

Russula subnigricans (Figure 2D) caused 15 cases of rhabdomyolysis, affecting a total of 37 patients and resulting in 2 fatalities, either independently or in conjunction with other mushrooms. *Paxillus obscurosporus* (Figure 2G) along with 4 other species caused hemolysis in one incident affecting 5 patients in late July in Chongqing. Additionally, *Cordierites frondosus* (Figure 2H) caused photosensitive dermatitis when consumed with edible *Auricularia* sp., resulting in 1 incident with 3 patients in Yunnan during mid-June (Supplementary Table S1).

A total of 70 mushroom species causing gastroenteritis were identified in China in 2024 (Supplementary Table S1). Among these, 8 were newly identified as poisonous mushrooms and have been added to the Chinese poisonous mushroom list (*1*–*7*). The three most commonly encountered species in this category were *Chlorophyllum molybdites* (Figure 2I, appeared in 147 incidents affecting 269 patients), *Russula* aff. *japonica* (appeared in 40 incidents affecting

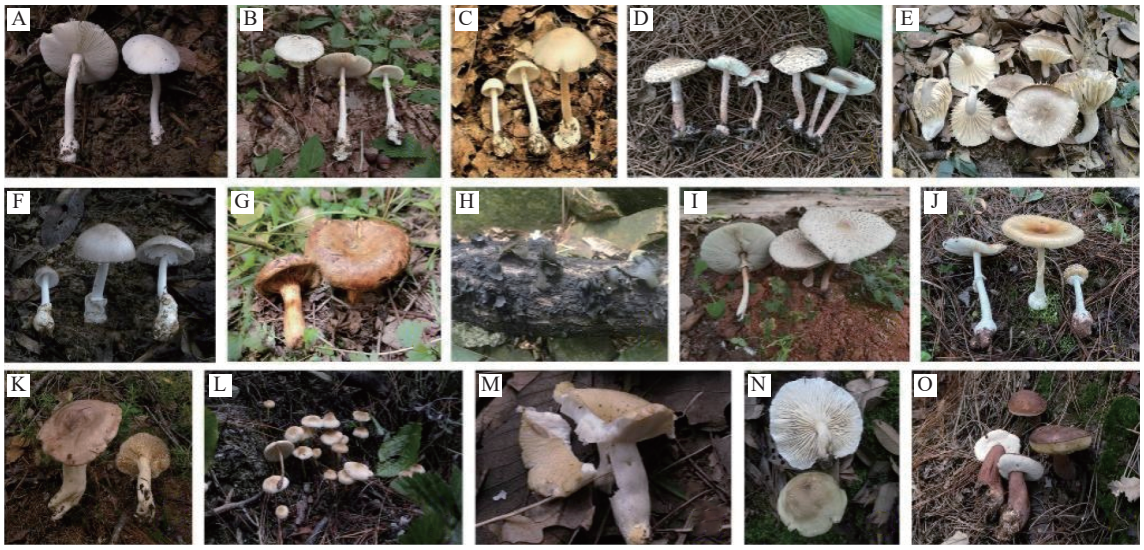


FIGURE 2. Fifteen important poisonous mushrooms were discovered from mushroom poisoning incidents in China, in 2024, which caused deaths, resulting in the highest number of different types of poisoning or newly added to the Chinese poisonous mushroom list. (A) *Amanita exitialis*, (B) *A. molliuscula*, (C) *A. subpallidorosea*, (D) *Lepiota brunneoincarnata*, (E) *Russula subnigricans*, (F) *A. pseudoporphyria*, (G) *Paxillus obscurosporus,* (H) *Cordierites frondosus*, (I) *Chlorophyllum molybdites*, (J) *Amanita subglobosa*, (K) *Lactarius trivialis*, (L) *Marasmius maximus*, (M) *Russula insignis*, (N) *Tricholoma olivaceum*, (O) *Tylopilus vinosobrunneus*.

92 patients), and *Entoloma omiense* (appeared in 31 incidents affecting 105 patients).

In 2024, 25 mushroom species associated with psycho-neurological disorders were identified in China (Supplementary Table S1). The three most frequently encountered species were *Amanita subglobosa* (Figure 2J, 14 incidents affecting 35 patients), *Anthracoporus nigropurpureus* (11 incidents affecting 24 patients), and *Gymnopilus dilepis* (8 incidents affecting 13 patients).

DISCUSSION

In 2024, the number of mushroom poisoning incidents and patients ranked second highest in the past six years, though with the fewest deaths (*1–5*). Among the 2024 poisoning incidents, 110 poisonous mushroom species were successfully identified, with 84 previously documented (*1–5*), bringing the total number of mushrooms involved in poisoning incidents in China to approximately 246 by the end of 2024. Unlike previous years (*1–5*), the most dangerous mushrooms causing fatalities in 2024 were more diverse, with 4 species each causing 2 deaths. Acute liver failure and rhabdomyolysis were the most lethal clinical presentations, with the remaining deaths attributed to acute renal failure and hemolysis. Most poisoning incidents resulted from mushrooms causing gastroenteritis and psycho-neurological disorders, from which patients typically fully recovered.

Our studies (*1–5*) found that patients from many incidents consumed mixed mushrooms, sometimes including poisonous species causing different clinical syndromes. This highlights the importance of comprehensive investigations by CDC staff, physicians, and mycologists to collect all suspicious mushroom samples to avoid missing potentially dangerous species.

The temporal distribution analysis revealed that mushroom poisonings in 2024 primarily occurred from June to October, a shorter period compared to 2019–2023 (*1–5*). Similar to 2022 and 2023, the peak of mushroom poisonings in 2024 was observed in June (*1–5*). Unlike previous years (*1–5*), Sichuan had the highest number of incidents among all PLADs in 2024.

In 2024, among species causing acute liver failure, *Amanita exitialis* was first discovered in Chongqing, resulting in 1 incident involving 4 patients and 2 deaths (*1–6*,*8–9*). *Amanita molliuscula*, first described in China in 2016 (*8–9*), was identified in mushroom poisoning incidents (7 incidents, 19 affected patients, and 2 deaths) for the first time, expanding its known distribution from its type locality in Shanxi to include Hubei, Henan, Jilin, and Heilongjiang.

In 2024, only *Amanita oberwinklerana* and *A. pseudoporphyria* were identified as causes of acute

kidney injury, similar to findings in 2023 but fewer than observed during 2019–2022 (*1*–*5*). *Russula subnigricans* caused 15 incidents of rhabdomyolysis, equal to the number reported in 2019 and 2022, less than in 2021 (16 incidents), and more than in 2020 (12 incidents) and 2023 (14 incidents) (*1*–*5*). Notably, *Paxillus obscurosporus* was documented as a cause of hemolysis in poisoning incidents for the first time (*2*–*4*).

In 2024, we identified 70 species causing gastroenteritis, including 8 newly recorded poisonous mushrooms, exceeding the number identified in each of the previous five years (*1*–*5*). Additionally, 25 mushroom species associated with psycho-neurological disorders were documented, fewer than in 2020 (28 species), 2022 (32 species), and 2023 (33 species), but more than in 2019 (18 species) and 2021 (22 species) (*1*–*5*).

This study represents only incidents that were investigated through our collaborative system comprising CDC staff, doctors, and mycologists. It is important to note that numerous poisoning incidents lacked mushroom specimens or even photographic documentation, making it impossible to confirm the exact species of poisonous mushrooms involved and thereby hindering targeted treatment for affected patients.

To reduce the incidence of mushroom poisoning, we advocate for closer collaboration among CDC staff, physicians, and mycologists. This includes developing diverse and accessible educational materials about poisonous mushrooms and conducting extensive public education campaigns to raise awareness about mushroom safety.

Conflicts of interest: No conflicts of interest.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Mushroom species implicated in cases of poisoning and their spatial and temporal distribution in China, 2024.

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Acute liver failure					
Amanita exitialis	6	23	2	8.70	May 2, Chongqing; May 29 to July 18, Yunnan
Amanita fuliginea	3	6	0	0.00	June 11 to 26, Hunan, Anhui
Amanita fuliginea, *A. fritillaria*[P]	1	2	0	0.00	June 26, Anhui
Amanita fuligineoides	1	1	0	0.00	June 16, Yunnan
Amanita molliuscula	7	19	2	10.53	August 22 to 31, Heilongjiang (2 incidents, 4 patients, 2 deaths ate mushrooms bought from the market)
Amantia rimosa	1	1	0	0.00	June 13, Hunan
Amantia rimosa and *Amanita* sp.[U]	1	1	0	0.00	June 30, Zhejiang
Amantia rimosa, *Russula* sp.[U] and *Agaricus* sp.[U]	1	1	0	0.00	June 29, Zhejiang
Amanita subfuliginea	1	3	0	0.00	May 19, Chongqing
Amanita subjunquillea	4	12	0	0.00	April 29, Hebei (dried mushrooms, collected in August to September, 2023); July 9 to August 19, Chongqing, Yunnan, Hebei
Amanita subjunquillea and *Lactarius cremicolor*[U]	1	4	0	0.00	August 16, Hebei
Amanita subpallidorosea	3	7	2	28.57	March 19, Chongqing (dried mushrooms, collected in 2023); October 18 and November 10, Yunnan, Guizhou
Amanita subpallidorosea and *A. parvipantherina*[P]	1	3	0	0.00	October 27, Sichuan
Amanita subpallidorosea, *A. citrina*[P], *Stropharia aeruginosa*[G], *Agaricus parasubrutilescens*[U], and *Lepiota* sp.[U]	1	2	0	0.00	November 7, Yunnan
Amanita sp.	1	4	1	25.00	June 19, Sichuan
Galerina sulciceps	13	23	0	0.00	May 2 to 9, Chongqing and Sichuan; October 16 to December 8, Sichuan, Yunnan, Hubei, Chongqing
Galerina sulciceps and *Pholiota microspora*[U]	1	1	0	0.00	November 4, Sichuan
Galerina sulciceps and *Gymnopilus* sp.[U]	1	2	0	0.00	November 17, Sichuan
Lepiota brunneoincarnata	12	29	2	3.90	June 9 to 26, Xinjiang, Guizhou; July 9, Shandong; August 13 to October 19, Ningxia, Beijing, Chongqing (poisoned in Ningxia), Inner Mongolia, Jiangsu
Lepiota brunneoincarnata, *Pseudosperma arenarium*[P], *Inocybe nobilis*[U] and *I. pallida*[U]	1	1	0	0.00	August 15, Ningxia
Lepiota brunneoincarnata, *Leucoagaricus barssii*[U], and *Agrocybe dura*[E]	1	2	0	0.00	August 17, Ningxia
Rhabdomyolysis					
Russula subnigricans	13	33	2	6.06	July 6 to October 20, Yunnan, Guizhou, Zhejiang, Sichuan, Fujian, Anhui, Guangxi
Russula subnigricans and *Amanita pallidorosea*[ALF]	1	1	0	0.00	July 1, Guizhou
Russula subnigricans, *Inosperma muscarium*[P], *Russula* sp.[U], and *Ramaria* sp.[U]	1	3	0	0.00	June 17, Yunnan
Acute kidney injury					
Amanita oberwinklerana	5	14	0	0.00	May 9 to October 15, Hunan, Yunnan, Shandong, Sichuan
Amanita oberwinklerana and *A. subglobosa*[P]	1	2	0	0.00	July 30, Shanxi

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Amanita oberwinklerana, *A. subglobosa*[P], *Gymnopus similis*[G], *Xerula sinopudens*[E], *Lactarius mirus*[U], *Agaricus luteopallidus*[U], *Russula* sp.[U], *Entoloma* sp.[U]	1	7	0	0.00	July 2, Guizhou
Amanita oberwinklerana and *Russula flavescens*[G]	1	2	0	0.00	August 26, Shanxi
Amanita oberwinklerana and *Russula* cf. *olivacea*[E]	1	2	0	0.00	July 26, Sichuan
Amanita oberwinklerana, *A.* cf. *princeps*[E], *Agaricus* sp.[U], and *Russula* sp.[U]	1	3	0	0.00	July 19, Sichuan
Amanita pseudoporphyria	3	10	1	10.00	May 2 to August 16, Guangdong, Guizhou, Hunan
Amanita pseudoporphyria and *Russula flavescens*[G]	1	5	0	0.00	August 19, Guangxi
Amanita pseudoporphyria and *Tylopilus* sp.[U]	1	3	0	0.00	July 23, Shandong
Amanita pseudoporphyria, *A. sinocitrina*[P], *A. sinesis*[E], *A. ochracea*[E], *Lactarius vividus*[E], *Cantharellus* sp.[E], *Amanita* spp.[U], *Marasmius* sp.[U] and *Russula* sp.[U]	1	1	0	0.00	June 25, Zhejiang
Gastroenteritis					
Agaricus tibetensis	1	5	0	0.00	July 15, Sichuan
Baorangia major	1	3	0	0.00	August 20, Hunan (dried boletes)
Baorangia aff. *pseudocalopus*, *Lactifluus glaucescens*[G], *Russula rufobasalis*[G], *Suillus pinetorum*[G], *Tylopilus neofelleus*[G], *Anthracoporus nigropurpureus*[P], *A. sinensis*[E], *Russula rosea*[E], *R. huotanjun*[E], *Entoloma* aff. *cyanoniger*[U], and *Lactarius gloeocarpus*[U]	1	2	0	0.00	May 14, Hunan (dried mushrooms)
Boletellus indistinctus	2	8	0	0.00	June 25 and 26, Sichuan and Yunnan
Chiua virens and *Sutorius eximius*[G]	1	1	0	0.00	July 14, Yunnan
Chlorophyllum demangei and *Entoloma* sp.[U]	1	7	0	0.00	July 19, Sichuan
Chlorophyllum globosum	1	3	0	0.00	June 20, Sichuan
Chlorophyllum cf. *globosum*	13	36	0	0.00	May 18 to October 26, Sichuan, Chongqing
Chlorophyllum cf. *globosum*, *Agaricus xanthodermus*[G], *Gymnopilus dilepis*[P], and *Marasmius* sp.[U]	1	2	0	0.00	July 11, Sichuan
Chlorophyllum hortense	6	12	0	0.00	June 9 to November 12, Yunnan, Sichuan, Hunan
Chlorophyllum molybdites	145	267	0	0.00	March 24 to November 30, Guangxi, Hunan, Chongqing, Guangdong, Guizhou, Hainan, Fujian, Zhejiang, Sichuan, Anhui, Hubei, Yunan, Shandong, Henan, Jiangsu, Shanghai (1 patient from Zhejiang ate raw mushrooms; 2 patients in 1 incident from Chongqing ate mushrooms bought from the market)
Chlorophyllum molybdites and *Chlorophyllum hortense*[G]	1	1	0	0.00	May 29, Guangdong
Chlorophyllum molybdites and *Marasmius maximus*[G]	1	1	0	0.00	May 9, Guangdong (1 child ate raw mushrooms)
Coprinellus micaceus	1	1	0	0.00	October 15, Hebei (1 child ate raw mushrooms)
Coprinopsis atramentaria	1	1	0	0.00	May 5, Ningxia
Coprinus comatus	1	3	0	0.00	October 29, Hubei
Entoloma caespitosum	2	7	0	0.00	June 13 and 29, Sichuan
Entoloma cf. *subsinuatum*, *Russula insignis*[G], *Ganoderma lucidum*[M], *Descolea quercina*[U], *Hebeloma asperosporum*[U], *Tricholoma* sp.[U] and *Russula* sp.[U]	1	2	0	0.00	October 24, Sichuan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Entoloma omiense	20	67	0	0.00	May 21 to September 17, Hainan, Hunan, Yunnan, Zhejiang, Sichuan, Jiangsu
Entoloma omiense, *Agaricus flocculosipes*[E] and *Agaricus* sp.[U]	1	3	0	0.00	July 16, Sichuan
Entoloma omiense, *Agaricus flocculosipes*[E] and *Amanita* sp.[U]	1	1	0	0.00	July 16, Sichuan
Entoloma omiense and *Amanita* sp.[U]	1	4	0	0.00	June 20, Hunan
Entoloma omiense, *Gymnopilus* sp.[P], *Amanita sepiacea*[P], *Tylopilus balloui*[E], *Collybiopsis subnuda*[E], *Amauroderma rugosum*[M], *Collybiopsis clavicystidiata*[U], and *Amanita* sp.[U]	1	3	0	0.00	June 28, Guizhou
Entoloma omiense, *Lactarius akahatsu*[E], *Termitomyces* sp.[E], *Amanita hamadae*[U], and *A. ceciliae*[U]	1	3	0	0.00	June 9, Hunan
Entoloma omiense, *Lactarius vividus*[E], *Agaricus luteopallidus*[U], *Stropharia* sp.[U], and *Russula* sp.[U]	1	2	0	0.00	July 15, Sichuan
Entoloma omiense and *Marasmius maximus*[G]	1	4	0	0.00	July 17, Sichuan
Entoloma omiense and *Marasmius* sp.[U]	1	1	0	0.00	June 2, Hunan
Entoloma omiense and *Oudemansiella* sp.[E]	1	10	0	0.00	June 28, Sichuan
Entoloma omiense, *Scleroderma yunnanense*[E] and *Entoloma* sp.[U]	1	4	0	0.00	June 25, Guizhou
Entoloma omiense and *Tylopilus* sp.[U]	1	3	0	0.00	July 16, Sichuan
Entoloma sp., *Collybiopsis clavicystidiata*[U] and *Marasmius* sp.[U]	1	2	0	0.00	July 18, Sichuan
Entoloma spp.	2	6	0	0.00	July 18 and October 30, Sichuan, Hunan
Flammula alnicola	1	2	0	0.00	July 5, Guizhou
Gymnopus densilamellatus	4	26	0	0.00	May 14 to June 25, Guizhou, Yunnan; July 19, Jilin; September 10, Yunnan
Gymnopus densilamellatus and *Infundibulicybe ellipsospora*[U]	1	2	0	0.00	June 19, Guizhou
Gymnopus spp.	2	2	0	0.00	June 26 to July 10, Yunnan
Heimioporus japonicus	1	1	0	0.00	June 30, Yunnan
Hypholoma fasciculare	2	3	0	0.00	July 3 to 4, Yunnan, Guizhou
Lactarius laccarioides	1	3	0	0.00	August 1, Yunnan
Lactarius subhirtipes	3	6	0	0.00	June 11 and July 22, Guizhou, Sichuan
Lactarius subzonarius, *Suillus granulatus*[G], *Russula* cf. *olivacea*[E], *Lactarius* sp.[U], and *Russula* sp.[U]	1	2	0	0.00	July 28, Shandong
Lactarius trivialis, *Tricholoma sinoportentosum*[G], *Neoboletus venenatus*[G], *Turbinellus szechwanensis*[G], *Hygrophorus pseudopurpurascens*[E], *Ramaria schildii*[U], and *Tricholoma* sp.[U]	1	5	0	0.00	September 5, Sichuan
Lactarius spp.	2	4	0	0.00	July 16 and 21, Shandong, Sichuan
Lactifluus bertillonii	1	1	0	0.00	August 26, Heilongjiang
Lactifluus pseudoluteopus, *Russula punctipes*[G] and *Lactarius sordidus*[U]	1	2	0	0.00	June 23, Yunnan
Leucocoprinus cepistipes	1	1	0	0.00	May 6, Guangdong (eaten by raw)
Leucocoprinus sp.	1	2	0	0.00	July 21, Henan
Ligymnopus moseri	1	3	0	0.00	October 17, Sichuan
Marasmius maximus	1	2	0	0.00	September 12, Guangxi (2 students ate raw mushrooms)
Marasmius sp.	1	1	0	0.00	May 30, Hunan

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Neoboletus venenatus	5	19	0	0.00	March 18, Shanxi (dried boletes, bought from Yunnan market); May 17, Guiyang (dried boletes); August 1 and 20, Sichuan (dried boletes)
Neoboletus venenatus, *Baorangia pseudocalopus*[G], *Neoboletus* sp.[U], and *Butyriboletus sanicibus*[E]	1	2	0	0.00	April 18, Hubei (dried boletes, bought from Yunnan market)
Neoboletus venenatus and *Boletus shiyong*[E]	1	2	0	0.00	July 24, Jiangsu (dried boletes)
Neoboletus venenatus and *Lepista nuda*[E]	1	6	0	0.00	October 18, Chongqing
Omphalotus guepiniformis	1	10	0	0.00	October 25, Guizhou
Pholiota multicingulata and *Hygrophorus flavoalbus*[U]	1	1	0	0.00	October 1, Yunnan
Rubroboletus flavus	1	2	0	0.00	August 14, Guizhou
Russula brevispora	1	3	0	0.00	May 22, Guangxi
Russula emetica, *Ganoderma leucocontextum*[M] and *R. cyanoxantha*[E]	1	3	0	0.00	July 30, Sichuan
Russula flavescens	1	2	0	0.00	October 26, Yunan
Russula foetens and *R.* cf. *lavandula*[U]	1	7	0	0.00	October 3, Guizhou
Russula aff. *japonica*	40	92	0	0.00	May 30 to October 2, Hunan, Chongqing, Yunnan, Guizhou, Zhejiang, Jiangsu
Russula laurocerasi	1	6	0	0.00	June 14, Guizhou
Russula pseudojaponica	6	28	0	0.00	June 24 to September, Hunan, Guizhou
Russula pseudojaponica, *R. insignis*[G], *Scleroderma venenatum*[G], *R. densifolia*[E], and *R. cerolens*[U]	1	2	0	0.00	June 30, Sichuan
Russula pseudojaponica and *R. niveopicta*[U]	1	3	0	0.00	July 2, Yunnan
Russula punctipes, *R. crustosa*[E], *Boletus bainiugan*[E], *Agaricus iranicus*[U], *Amanita pseudofritillaria*[U], *Tylopilus atroviolaceobrunneus*[U], *Russula* sp.[U], *Amanita* sp.[U], and *Strobilomyces* sp.[U]	1	2	0	0.00	July 22, Sichuan (bought from the market)
Scleroderma bovista	1	2	0	0.00	September 9, Hebei
Scleroderma cepa	4	18	0	0.00	July 5 to 14, Yunnan; October 15, Chongqing; October 22, Hebei
Scleroderma cepa, *Omphalotus olearius*[G], and *Lactarius cinnamomeus*[E]	1	2	0	0.00	October 8, Yunnan
Scleroderma cepa and *Termitomyces* sp.[E]	1	2	0	0.00	July 3, Yunnan
Scleroderma spp.	3	10	0	0.00	May 16 to October 25, Sichuan, Guizhou, Hunan
Suillellus flaviporus	1	3	0	0.00	October 2, Yunnan
Suillus huapi, *Entoloma* cf. *sinuatum*[G], *Lactarius akahatsu*[E], *Russula olivacea*[E], *Amanita chepangiana*[E], *Lactarius mirus*[U], *Helvella* sp.[U], *Agaricus purpureosquameus*[U], and *Russula shawarensis*[U]	1	2	0	0.00	July 15, Yunnan
Suillus huapi, *S. pinetorum*[G], *Tricholoma ustaloides*[G], *Amanita orientigemmata*[P], *Rugiboletus extremiorientalis*[E], *Thaxterogaster purpurascens*[E], *Armillaria cepistipes*[E], *Lactarius hatsudake*[E], *Russula cyanoxantha*[E], *R.virescens*[E], *Descolea quercina*[U], *Cortinarius subbalaustinus*[U], *Lactarius aurantiozonatus*[U], *L. spadiceus*[U], *Hygrophorus orientalis*[U], *Entoloma* sp.[U], and *Cortinarius* spp.[U]	1	2	0	0.00	October 28, Sichuan (dried mushrooms, bought from the market)

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Suillus huapi, *S. pinetorum*[G], *Boletus bainiugan*[E], *Butyriboletus roseoflavus*[E], *Lyophyllum decastes*[E], *Naematelia aurantialba*[E], *Oudemansiella raphanipes*[E], *Phlebopus portentosus*[E], *Rubroboletus esculentus*[E], *Sparassis latifolia*[E], *Stropharia rugosoannulata*[E], and *Cantharellus* sp.[E]	1	3	0	0.00	October 10, Beijing (ate in restaurant)
Tricholoma highlandense	1	1	0	0.00	October 29, Sichuan
Tricholoma olivaceum	1	1	0	0.00	September 9, Yunnan
Tricholoma cf. *pardinum*	2	4	0	0.00	May 21 and June 21, Guizhou
Tricholoma sinopardinum	1	9	0	0.00	July 18, Qinghai
Tricholoma stans, *Suillus pinetorum*[G], *Pulveroboletus macrosporus*[G], *Russula rosea*[E], and *Lactifluus* cf. *vellereus*[U]	1	9	0	0.00	October 26, Yunnan
Tricholoma spp.	9	25	0	0.00	June 20, Yunnan; October 5 to 26, Yunnan, Qinghai
Tylopilus neofelleus	1	2	0	0.00	August 23, Guizhou
Tylopilus vinosobrunneus	1	1	0	0.00	July 15, Sichuan
Tylopilus sp.	1	1	0	0.00	May 15, Hunan
Psycho-neurological disorder					
Amanita concentrica and *A. virgineoides*[G,P]	1	1	0	0.00	August 5, Yunnan
Amanita sepiacea, *Russula crustosa*[E], *R. delica*[E], *Termitomyces* sp.[E], *A. lignitincta*[U], *A. pseudofritillaria*[U], *Lactifluus sinensis*[U]	1	1	0	0.00	June 6, Hunan
Amanita sepiacea, *Boletus bainiugan*[E], *Russula zhuzuijun*[E], *Tricholoma qiaomianjun*[E], and *Agaricus thiersii*[U]	1	1	0	0.00	October 5, Yunnan
Amanita melleiceps	1	5	0	0.00	April 2, Hunan
Amanita orientigemmata	2	4	0	0.00	April 30, Chongqing; August 12, Guizhou
Amanita parvipantherina	1	3	0	0.00	June 22, Yunnan
Amanita siamensis	4	18	0	0.00	July 12 to 25, Chongqing, Hubei, Sichuan
Amanita siamensis, *Lactarius trivialis*[G], and *L. vividus*[E]	1	2	0	0.00	July 27, Sichuan
Amanita siamensis, *Russula* sp.[U], and *Lactarius* sp.[U]	1	3	0	0.00	July 25, Sichuan
Amanita sinocitrina	1	4	0	0.00	April 20, Jiangxi
Amanita sinocitrina, *Suillus granulatus*[G], and *Lactarius vividus*[E]	1	2	0	0.00	July 16, Sichuan
Amanita subglobosa	11	29	0	0.00	April 23 to 30, Hunan; June19 to October 18, Sichuan, Chongqing, Hubei, Guizhou, Inner Mongolia
Amanita subglobosa, *Inocybe bulbinella*[U], and *Collybiopsis clavicystidiata*[U]	1	2	0	0.00	April 27, Hunan
Amanita subglobosa, *Lactarius hatsudake*[E], and *Ticholoma* sp.[U]	1	1	0	0.00	April 27, Hunan
Amanita subglobosa and *Lactarius subhirtipes*[G]	1	3	0	0.00	July 17, Sichuan
Amanita sychnopyramis f. *subannulata*	6	20	0	0.00	April 15 to May 4, Guangxi and Hunan; May 30 to June 17, Sichuan, Zhejiang
Amanita sychnopyramis f. *subannulata*, *A. fritillaria*[P], and *Russula* sp.[U]	1	5	0	0.00	May 7, Guangxi
Amanita sp. (maybe *A. concentrica*)	1	2	0	0.00	June 20, Yunnan
Anthracoporus nigropurpureus	9	18	0	0.00	June 17 to July 28, Sichuan, Yunnan
Anthracoporus nigropurpureus, *Agaricus atrodiscus*[G] and *Lactarius chrysorrheus*[G]	1	3	0	0.00	June 22, Guizhou

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Anthracoporus nigropurpureus, *Tylopilus vinosobrunneus*[G], *Retiboletus sinensis*[E], and *Strobilomyces calidus*[U]	1	3	0	0.00	June 26, Sichuan
Candolleomyces candolleanus	1	1	0	0.00	May 31, Guizhou
Clitocybe sp.	1	2	0	0.00	October 30, Sichuan
Collybiopsis peronata	1	1	0	0.00	February 28, Hubei
Gymnopilus dilepis	7	12	0	0.00	April 22 to May 8, Sichuan, Guizhou, Hubei, Hunan; September 15 to October 16, Sichuan
Gymnopilus dilepis and *Termitomyces microcarpus*[E]	1	1	0	0.00	July 13, Sichuan
Gyromitra venenata	1	2	0	0.00	March 22 to 23, Yunnan
Inocybe amelandica	1	2	0	0.00	September 11, Ningxia
Inosperma hainanense	1	11	0	0.00	August 4, Yunnan
Lanmaoa asiatica	2	2	0	0.00	July 11 and October 12, Guangdong (bought from Yunnan)
Panaeolus cyanescens	3	10	0	0.00	April 28, Guizhou; July 27 and 30, Hebei
Panaeolus cyanescens and *Agaricus bisporus*[E]	1	2	0	0.00	May 4, Guizhou
Panaeolus subbalteatus	1	2	0	0.00	July 21, Shandong
Pseudosperma arenarium	1	1	0	0.00	September 7, Ningxia
Pseudosperma umbrinellum	6	9	0	0.00	September 5 to 26, Ningxia
Pseudosperma umbrinellum and *P. arenarium*[P]	1	4	0	0.00	August 18, Ningxia
Psilocybe cubensis	3	5	0	0.00	April 19, Guangxi; July 3, Yunnan; August 5, Guizhou
Hemolysis					
Paxillus obscurosporus, *Suillus luteus*[G], *Russula aeruginea*[E], *Leccinum* sp.[E], and *Russula dryadicola*[U]	1	5	0	0.00	July 26, Chongqing
Photosensitive dermatitis					
Cordierites frondosus and *Auricularia* sp.[E]	1	3	0	0.00	Middle June, Yunnan
Unclassified					
Agaricus bitorquis[E]	1	2	0	0.00	August 15, Ningxia
Agaricus pseudopratensis[U]	2	4	0	0.00	September 7 and 12, Ningxia
Agrocybe dura[E]	1	1	0	0.00	April 15, Hubei
Albatrellus ellisii[E]	1	1	0	0.00	July 19, Guizhou (bought from Yunnan)
Alloclavaria orientalis[E]	1	1	0	0.00	April 28, Sichuan
Amanita cf. *princeps*[E], *Amanita caojizong*[E], *Russula* cf. *sanguinaria*[E], *Russula rosea*[E], *Boletus bainiugan*[E], *Scleroderma yunnanense*[E], *Morchella sextelata*[E], *Phallus echinovolvatus*[E], *Lyophyllum decastes*[E], *Cordyceps militaris*[E,M], *Macrocybe gigantean*[E], and *Amanita* sp.[U]	1	2	0	0.00	January 24, Shanxi (dried mushrooms, bought from market, 2023)
Amanita caijizong[E], *Amanita* sp.[U]	1	1	0	0.00	August 2, Sichuan
Armillaria mellea[E]	1	1	0	0.00	November 4, Sichuan (dried mushrooms, given by friends from Heilongjiang)
Clitocybe sp.[U]	1	2	0	0.00	October 11, Sichuan
Clitopilus piperatus[U], *Agrocybe flexuosipesv*, and *Lepista* sp.[U]	1	2	1	50.00	October 21, Sichuan
Collybiopsis orientisubnuda[U]	1	4	0	0.00	October 13, Guizhou
Cordyceps chanhua[E,M]	1	6	0	0.00	June 25, Zhejiang

Continued

Mushroom species	Number of incidents	Number of patients	Deaths	Case fatality (%)	Spatial and temporal distribution
Cortinarius sp.[U]	1	2	0	0.00	October 24, Yunnan
Cyclocybe chaxingu[E]	1	2	0	0.00	May 19, Sichuan (bought from Yunnan)
Entoloma sp.[U], *Lactarius betulinus*[U], and *Russula decipiens*[U]	1	8	0	0.00	November 12, Liaoning
Favolus sp.[U]	1	3	0	0.00	April 16, Sichuan (eaten raw)
Inocybe latibulosa[U]	1	4	0	0.00	June 7, Guizhou
Lactifluus pseudohygrophoroides[U], *Hydnum berkeleyanum*[E], and *Lactarius volemus*[E]	1	8	0	0.00	August 27, Yunnan
Lepista cremeoinvoluta[U]	1	2	0	0.00	October 17, Yunnan
Lepista sordida[E]	1	1	0	0.00	June 19, Zhejiang (eaten raw)
Leucoagaricus barssii[U], *La. croceobasis*[U], *Coprinopsis* sp.[U], and *Inocybe amelandica*[P]	1	2	0	0.00	September 8, Ningxia
Leucoagaricus rubrobrunneus[U], *Leucoagaricus* sp.[U], and *Lactarius vividus*[E]	1	2	0	0.00	July 22, Sichuan
Leucoagaricus sp.[U]	1	2	0	0.00	July 14, Sichuan
Morchella sextelata[E]	1	1	0	0.00	June 19, Zhejiang (1 patient ate a half dried raw mushroom)
Russula brunneocystidiata[E]	1	1	0	0.00	August 22, Guangxi
Russula cf. *densifolia*[E]	1	1	0	0.00	June 30, Fujian
Russula crustosa[E], *Amanita* sp.[E], *Calvatia holothurioides*[U], *Russula acrifolia*[U], and *Descolea* sp.[U]	1	4	0	0.00	July 24, Sichuan
Russula decipiens[U] and *Russula* spp.[U]	1	1	0	0.00	August 3, Sichuan (bought from market)
Russula delica[E]	1	7	0	0.00	August 23, Guangxi
Russula indocatillus[U], *Strobilomyces latirimosus*[U] and *Russula* sp.[U]	1	2	0	0.00	June 28, Yunnan
Russula sp.[U] and *Coprinellus radians*[M]	1	2	0	0.00	September 3, Guizhou
Russula succinea[U] and *Lactarius hygrophoroides*[E]	1	8	0	0.00	June 25, Guizhou
Scleroderma yunnanense[E]	1	1	0	0.00	October 1, Guizhou
Scleroderma yunnanense[E], *Lactarius aurantiacus*[E], *Russula* spp.[U], *Lactarius* sp.[U], and *Suillus* sp.[U]	1	1	0	0.00	September 12, Yunnan
Sutorius sp.[U] and *Tylopilus pseudoballoui*[E]	1	1	0	0.00	June 1, Yunnan
Thelephora ganbajun[E]	1	10	0	0.00	August 25, Yunnan
Trametes sanguinea[M]	1	1	0	0.00	November 19, Jiangsu
Tricholoma matsutake[E], *Sarcodon imbricatus*[E], and *Floccularia luteovirens*[E]	1	10	0	0.00	August 12, Sichuan (bought from market, ate in a restaurant)
Tricholoma terreum[E]	3	14	0	0.00	July 15 to October 22, Yunnan
Macrolepiota dolichaula[E]	1	2	0	0.00	June 24, Yunnan (1 student ate raw mushroom)

Abbreviations used for mushroom poisoning incidents involving more than two species: ALF=Acute liver failure; ARF=Acute renal failure; G=Gastroenteritis; P=Psycho to neurological disorder; M=Medicinal; U=Toxicity unknown; E=edible.

Preplanned Studies

National Survey on the Prevalence and Geospatial Variation of Body Fat Percentage Among Preschoolers — 31 PLADs, China, 2020

Chenglong Wang[1]; Mei Wang[1]; Qiang Feng[1]; Chaoqun Fan[1]; Huiqi Song[2]; Mingzhe Li[1]; Chenhui Xiao[1]; Jingjing Wang[1,#]

Summary

What is already known on this topic?

Body fat percentage (BF%) is a fundamental indicator of body composition that provides critical insights into fat distribution patterns. However, comprehensive national data on BF% and its geographical distribution patterns among the Chinese preschoolers aged 3 to 6 years remain limited.

What is added by this report?

This study presents novel national data analyzing the prevalence and geographical patterns of BF% among Chinese preschool children, along with key determinants. The findings reveal a mean BF% of 20.7% among the Chinese preschoolers, with distinct geographical clustering patterns. The analysis identifies significant hotspots and cold spots aligned with major geographical boundaries, while demonstrating that sex, parental characteristics, education level, and environmental factors significantly influence preschool children's BF%.

What are the implications for public health practice?

These findings provide critical baseline data on preschool children's BF% levels and reveal substantial geographical disparities. The observed regional variations suggest the need for targeted public health interventions and region-specific strategies for childhood obesity prevention, emphasizing the importance of implementing evidence-based health education and intervention programs tailored to local contexts.

ABSTRACT

Introduction: Body fat percentage (BF%) refers to the proportion of adipose tissue relative to total body weight. Compared to body mass index (BMI), BF% demonstrates superior sensitivity in predicting cardiometabolic risk and insulin sensitivity in children. Elevated BF% is associated with multiple adverse health outcomes, including reduced bone mineral density, lower extremity injuries, and systemic inflammation. Despite its clinical significance, comprehensive national data on BF% and its geographical distribution patterns among the Chinese preschoolers aged 3 to 6 years remain limited. This study aims to examine BF% prevalence among preschoolers and identify associated factors, while analyzing geospatial variations across the 31 provincial-level administrative divisions (PLADs) to elucidate regional disparities.

Methods: Data were derived from the 5th Chinese National Physical Fitness Surveillance (CNPFS) conducted in 2020, encompassing 40,222 preschoolers. Geospatial analyses, including hotspot and cold spot identification, were performed using ArcGIS 10.8 software and ArcToolbox with the Hot Spot Analysis (Getis-Ord Gi*) tool.

Results: The study revealed a mean BF% of 20.7% among Chinese preschool children, with females exhibiting significantly higher values (22.1±5.0)% compared to males (19.2±5.4)%. The geographical distribution demonstrated distinct clustering patterns, with hotspots predominantly concentrated in Northeast China and cold spots clustered in southern PLADs. Notably, the distribution of hotspots and cold spots showed symmetrical patterns along China's natural geographical boundaries — the Qinling-Huaihe Line and Bo-Tai Line. Key determinants of preschool children's BF% included sex, parental weight status, education level, and residential environment characteristics.

Conclusions: These findings underscore the necessity for targeted interventions to address regional inequalities and promote healthy development among preschoolers.

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Body fat percentage (BF%) represents the proportion of adipose tissue relative to the total body weight. Compared to body mass index (BMI), BF% demonstrates superior sensitivity in predicting cardiometabolic risk (*1*) and insulin sensitivity (*2*) in children. Elevated BF% is associated with multiple adverse health outcomes, including decreased bone mineral density (*3*), increased risk of lower extremity injuries (*4*), and heightened systemic inflammation (*5*).

The preschool period represents a critical window for physical growth and development. Children who accumulate excessive body fat during this stage face an increased likelihood of maintaining obesity through adolescence and into adulthood (*6*). Since 2000, the Chinese National Physical Fitness Surveillance (CNPFS) has conducted quinquennial assessments using skinfold-thickness measurements to estimate body composition. However, significant concerns persist regarding the consistency, precision, and accuracy of skinfold-thickness measurements. Notably, the absence of a universally accepted predictive formula has precluded the estimation and reporting of national BF% data for the Chinese preschoolers. The implementation of bioelectrical impedance analysis (BIA) in place of skinfold-thickness measurements in the 5th CNPFS in 2020 established a foundation for objective evaluation of body fat mass. This study aims to examine BF% prevalence among preschoolers and identify associated factors, thereby advancing our understanding of childhood obesity in China. Additionally, we analyze geospatial variation across the 31 provincial-level administrative divisions (PLADs) to elucidate regional disparities in childhood obesity.

This study analyzed data from the 5th CNPFS conducted between August and November 2020. As previously documented (*7*), the CNPFS employs a cross-sectional design every five years using a complex, stratified, multistage probability cluster sampling method. The study population comprised urban and rural preschoolers aged 3 to 6 years in China, representing 31 PLADs. Within each PLAD, three cities were selected based on socioeconomic status, with one urban and one rural district sampled per city, ensuring equal representation across age-sex groups (Supplementary Figure S1, available at https://weekly.chinacdc.cn/). The final analysis included 40,222 preschoolers with valid informed consent forms. The study protocol received approval from the institution's ethics committee (No. CISSLA-20240219).

BF% measurements were conducted using a BIA device (GMCS-TZL3, Jianmin, Beijing, China) with impedance set at 100 μA. All measurements were performed under standardized conditions following fasting and urination. Participants wore light clothing without metal objects and stood barefoot on the analyzer, ensuring contact between their hands and feet with the 8 electrodes (2 on the palms, 2 on the thumbs, 2 on the toes, and 2 on the heels) (*8*). The tetrapolar bioelectrical impedance method provided BF% measurements to 0.1% precision. Additional data on potential influencing factors were collected through proxy-reported questionnaires.

Statistical analyses were performed using SPSS (version 27.0, IBM SPSS, Armonk, NY, USA). Between-group differences in BF% were assessed using *t*-tests and analysis of variance (ANOVA). Multinomial linear regression identified factors influencing preschoolers' BF%, with statistical significance set at a two-sided P value < 0.05. Geospatial patterns of BF%, including hotspot and cold spot clusters, were analyzed using ArcGIS 10.8 software and ArcToolbox with the Hot Spot Analysis (Getis-Ord Gi*) tool. The Getis-Ord Gi* statistic generated Z-scores for BF% characteristics across the 31 PLADs, quantifying the degree to which regional BF% characteristics clustered with similar high or low values. High positive Z-scores indicated high-value clusters (hotspots), while low negative Z-scores indicated low-value clusters (cold spots).

This study included 40,222 preschoolers aged 3 to 6 years, comprising 20,150 males (50.1%) and 20,072 females (49.9%). The urban-rural distribution was nearly equal, with 19,813 (50.3%) urban and 19,511 (49.7%) rural preschoolers. The mean (standard deviation) values for height, weight, BMI, and BF% were 110.4 (8.4) cm, 19.3 (3.9) kg, 15.7 (1.8) kg/m^2, and 20.7 (5.4)%, respectively. While height, weight, and BMI showed age-related increases, BF% exhibited a general declining trend. Females demonstrated significantly higher BF% compared to males (t=−56.238, P<0.01), and urban residents showed notably higher values than their rural counterparts (t=7.889, P<0.01) (Table 1).

Table 2 illustrates the stratification of BF% by sex, age, and residence. Females consistently demonstrated higher BF% than males across all residence-age groups. Similarly, urban preschoolers exhibited higher BF% compared to their rural counterparts across all sex-age subgroups. However, the age-related progression of BF% from 3 to 6 years showed no consistent pattern within residence-sex subgroups, with notable fluctuations observed between ages 4 and 5.

TABLE 1. Preschoolers' anthropometric measurements in China in 2020.

Variables	Sample size *n* (%)	Height Mean[(SD), cm]	Weight Mean [(SD), kg]	BMI Mean [(SD), kg/m^2]	BF% Mean (SD)
Total	40,222 (100.0)	110.4 (8.4)	19.3 (3.9)	15.7 (1.8)	20.7 (5.4)
Sex					
Male	20,150 (50.1)	111.0 (8.4)	19.7 (4.0)	15.9 (1.8)	19.2 (5.4)
Female	20,072 (49.9)	109.9 (8.4)	18.8 (3.7)	15.5 (1.7)	22.1 (5.0)
t		13.22	22.86	22.93	−56.24
P		<0.01	<0.01	<0.01	<0.01
Age(years)					
3.0	10,200 (25.4)	101.4 (4.8) *†§	16.1 (2.1) *†§	15.6 (1.5) *†§	21.1 (4.9) *†
4.0	10,392 (25.8)	107.5 (4.9) *†¶	18.1 (2.5) *†¶	15.6 (1.6) †¶	20.4 (5.1) *†
5.0	10,438 (26.0)	114.7 (5.2) *§¶	20.8 (3.4) *§¶	15.8 (1.9) *§¶	20.9 (5.6) *§
6.0	9,192 (22.9)	119.0 (5.6) †§¶	22.5 (3.9) †§¶	15.8 (2.0) †¶	20.2 (6.0) †§¶
F		22387.77	8586.05	39.66	59.17
P		<0.01	<0.01	<0.01	<0.01
Residence					
Urban	20,274 (50.4)	110.1 (8.5)	19.1 (3.9)	15.7 (1.8)	20.4 (5.4)
Rural	19,948 (49.6)	110.8 (8.4)	19.4 (3.9)	15.7 (1.8)	20.9 (5.3)
t		8.59	7.98	1.73	7.89
P		<0.01	<0.01	0.084	<0.01
Region					
Northeast	3,796 (9.4)	111.8 (8.5) *†§**††§§	20.3 (4.2) *†§**††§§	16.1 (1.9) *†§**††§§	22.6 (5.6) *†§**††§§
North	6,552 (16.3)	111.0 (8.5) ¶**††§§	19.5 (4.1) ¶**††	15.8 (1.9) *†¶**††§§	21.3 (5.6) ¶**††
Northwest	6,340 (15.6)	110.7 (8.1) ¶**††§§	19.4 (3.7) ¶**††	15.7 (1.8) §¶**††	20.9 (5.2) ¶**††
East	9,114 (22.7)	111.0 (8.3) ¶**††§§	19.5 (3.9) ¶**††	15.8 (1.7) §¶**††	20.9 (5.2) ¶**††
Central	3,995 (9.9)	110.2 (8.8) *†§¶**††	19.3 (4.0) ¶**††	15.8 (1.8) §¶**††§§	20.7 (5.2) ¶**††
Southwest	6,313 (15.7)	109.3 (8.5) *†§¶**§§	18.6 (3.6) *†§¶**§§	15.5 (1.6) *†§¶**§§	19.8 (4.9) *†§¶**§§
South	4,112 (10.2)	108.7 (8.2) *†§¶††§§	18.2 (3.5) *†§¶††§§	15.3 (1.7) *†§¶††§§	18.3 (5.3) *†§¶††§§
F		78.84	138.68	89.87	279.18
P		<0.01	<0.01	<0.01	<0.01

Abbreviation: BMI=body mass index; BF%=body fat percentage; SD=standard deviation.
* compared with age at 6 years in age groups or East in region groups, *P*<0.05.
† compared with age at 5 years in age groups or Northwest in region groups, *P*<0.05.
§ compared with age at 4 years in age groups or North in region groups, *P*<0.05.
¶ compared with age at 3 years in age groups or Northeast in region groups, *P*<0.05.
** compared with South in region groups, *P*<0.05.
†† compared with Southwest in region groups, *P*<0.05.
§§ compared with Central in region groups, *P*<0.05.

Figure 1 illustrates the spatial distribution of BF% among preschoolers across PLADs in China. A distinct north-south gradient emerged, with higher values in northern regions and lower values in southern regions. The highest BF% prevalence was observed in Heilongjiang Province (23.3%), Liaoning Province (23.0%), and Xinjiang Uygur Autonomous Region (22.5%). Conversely, the lowest prevalence was found in Hainan Province (18.4%), Guangdong Province (18.4%), and Guangxi Zhuang Autonomous Region (17.9%). Using the Getis-Ord Gi* statistic, significant spatial clustering patterns were identified (Figure 2). Hotspots are predominantly concentrated in Northeast China, while cold spots are clustered in the southern PLADs. Notably, the distribution of these clusters exhibited symmetrical patterns along both the Qinling-

Huaihe Line and Bo-Tai Line, which represent China's natural geographical and developmental boundaries.

Multiple factors were significantly associated with higher BF% in the multinomial logistic regression analysis. Female sex showed the strongest positive association (β=2.92), followed by urban residence (β=0.43). Parental education levels demonstrated a dose-response relationship, with higher education corresponding to increased BF% (paternal: senior high school/junior college, β=0.56; college and above, β=0.79; maternal: senior high school/junior college, β=0.60; college and above, β=0.89). Parental body weight status also showed strong associations, with parental obesity having the largest effect (paternal: thin, β=−1.10; overweight, β=1.20; obese, β=2.39; maternal: thin, β=−0.98; overweight, β=1.13; obese, β=1.56). Protective factors included daily moderate-to-vigorous physical activity (MVPA) of 180 minutes or more (β=−0.28) and access to neighborhood playgrounds (β=−0.30) or recreational facilities (β=−0.22) (Table 3).

TABLE 2. Body fat percentage among preschoolers by sex, age, and residential area.

Age (years)	3	4	5	6
Urban-Female	23.2 (4.5) *†§	22.1 (4.7) *†	22.4 (4.9) *†§	21.7 (5.4) *†§
Rural-Female	22.8 (4.6) *†¶	22.0 (4.6) *†	21.9 (5.3) *†¶	20.8 (5.5) *†¶
Urban-Male	19.3 (4.6) §¶	18.9 (5.1) *§¶	19.8 (5.6) §¶	19.7 (6.1) *§¶
Rural-Male	19.1 (4.5) §¶	18.6 (4.8) †§¶	19.5 (5.9) §¶	18.8 (6.2) †§¶
F	590.60	403.11	186.45	108.62
P	<0.01	<0.01	<0.01	<0.01

* compared with Rural-Male in sex-age groups, P<0.05.
† compared with Urban-Male in sex-age groups, P<0.05.
§ compared with Rural-Female in sex-age groups, P<0.05.
¶ compared with Urban-Female in sex-age groups, P<0.05.

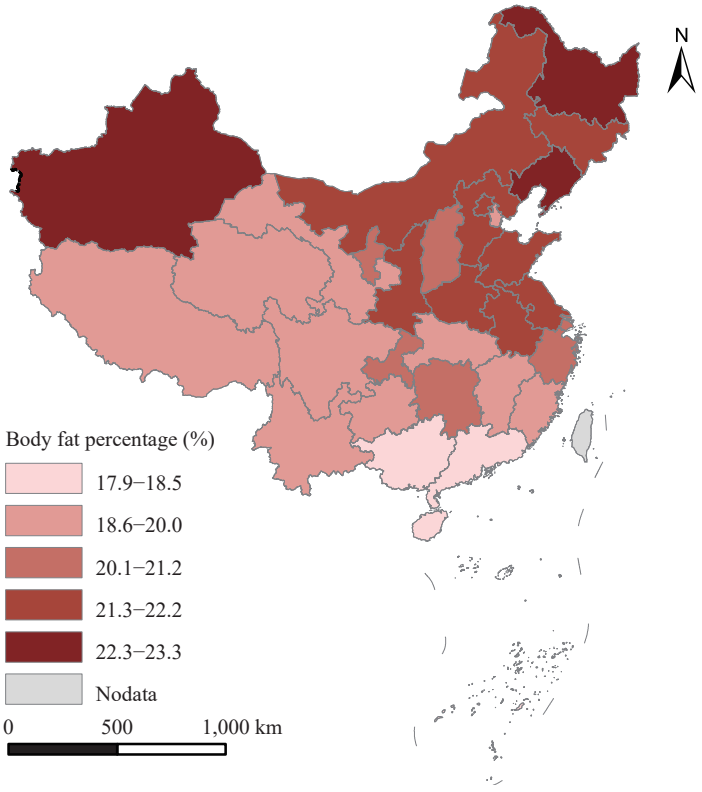


FIGURE 1. Body fat percentage of preschoolers aged 3–6 years across 31 provincial-level administrative divisions in China. Map approval number: GS 京 (2025) 0574 号.

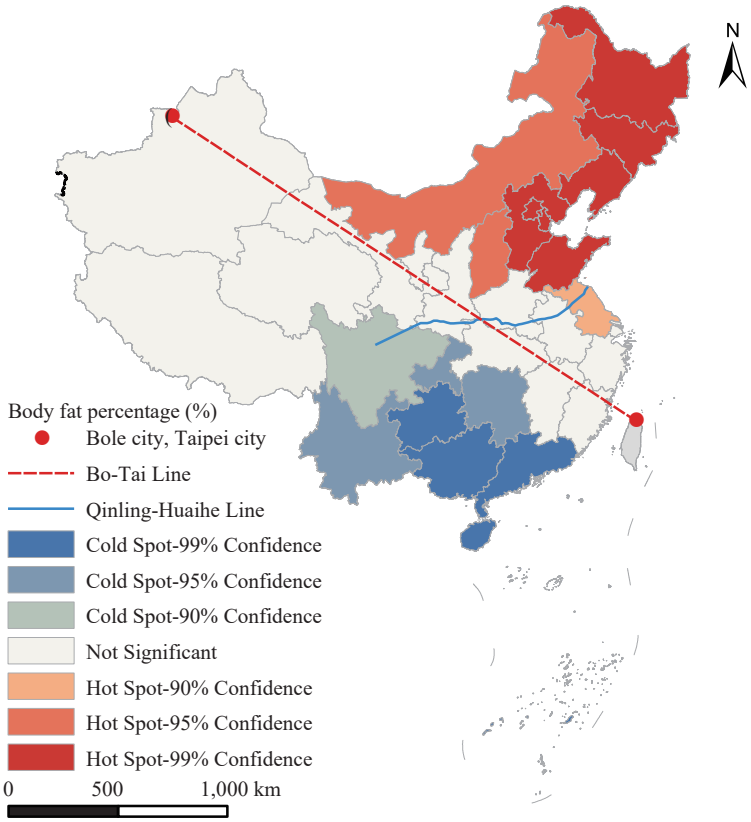


FIGURE 2. Clusters of BF% hotspots among preschoolers aged 3–6 years, combined with geographical boundaries of the Qinling-Huaihe Line and Bo-Tai Line.
Map approval number: GS 京 (2025) 0574 号.

DISCUSSION

This national study examined the prevalence and geospatial patterns of BF% among the Chinese preschoolers and explored its determinants using a representative sample. Our findings revealed significant sex-based differences, with females exhibiting higher BF% (21.1%) compared to males (19.2%), and residential variations, with urban preschoolers showing elevated BF% (20.9%) relative to their rural counterparts (20.4%). The analysis demonstrated distinct north-south geographical clustering patterns, characterized by higher BF% concentrations in northern regions and lower values in southern areas. Key determinants of preschoolers' BF% included sex, parental characteristics, residential environment, and physical activity behaviors.

The observed mean BF% of 20.7% among the Chinese preschoolers aged 3 to 6 years aligns with previous research from Poland, which reported a BF% of 20.4% in children aged 5 to 6 years (*9*). The higher BF% found in urban areas likely reflects socioeconomic disparities and distinct dietary patterns across residential settings. The consistent sex-based difference, with males showing lower BF%, may be attributed to higher levels of physical activity participation among boys. While adiposity rebound (AR) typically occurs between 6 and 8 years of age, marking the second rise in body mass index (*10*), our cohort of 3- to 6-year-olds did not exhibit this phenomenon. However, the observed BF% variations across different residence-sex subgroups suggest this period represents a critical window of adiposity sensitivity.

A key methodological innovation of this study was the application of the Getis-Ord Gi* statistic, which revealed significant north-south geospatial clustering patterns aligned with the Qinling-Huaihe Line and Bo-Tai Line (*11*). The Bo-Tai Line, connecting Bole in Xinjiang Uygur Autonomous Region to Taipei in Taiwan, China, serves as a developmental boundary aimed at promoting balanced growth between the northern and southern regions. These geographical boundaries are supported by genetic evidence (*12*), with Han population genetics showing differentiation along the Qinling-Huaihe Line. Environmental factors likely contribute to these north-south differences, as

TABLE 3. Multinomial linear regression analysis of the factors influencing BF% among preschoolers aged 3–6 years in China, 2020.

Variables	*n* (%)	*β* (95% *CI*)	*P*
Sex			
Male	20,150 (50.1)	Ref.	
Female	20,072 (49.9)	2.92 (2.82, 3.02)	<0.01
Residence			
Rural	19,948 (49.6)	Ref.	
Urban	20,274 (50.4)	0.43 (0.32, 0.53)	<0.01
Parental education			
Paternal education level			
Junior high school and below	9,087 (22.6)	Ref.	
Senior high school/junior college	16,596 (41.3)	0.56 (0.43, 0.70)	<0.01
College and above	13,285 (33.0)	0.79 (0.65, 0.94)	<0.01
Missing	1,254 (3.1)		
Maternal education level			
Junior high school and below	8,969 (22.3)	Ref.	
Senior high school/junior college	16,670 (41.4)	0.60 (0.47, 0.74)	<0.01
College and above	13,486 (33.5)	0.89 (0.75, 1.03)	<0.01
Missing	1,097 (2.7)		
Parental body weight status (BMI, kg/m^2)			
Normal (18.5–23.9)	16,394 (40.8)	Ref.	
Thin (<18.5)	665 (1.7)	−1.10 (−1.51, −0.69)	<0.01
Overweight (24.0–27.9)	15,611 (38.8)	1.20 (1.08, 1.32)	<0.01
Obese (≥28.0)	4,381 (10.9)	2.39 (2.21, 2.56)	<0.01
Missing	3,171 (7.9)		
Maternal body weight status (BMI, kg/m^2)			
Normal (18.5–23.9)	26,515 (65.9)	Ref.	
Thin (<18.5)	3,378 (8.4)	−0.98 (−1.17, −0.79)	<0.01
Overweight (24.0–27.9)	6,113 (15.2)	1.13 (0.98, 1.28)	<0.01
Obese (≥28.0)	1,282 (3.2)	1.56 (1.26, 1.86)	<0.01
Missing	2,934 (7.3)		
Neighborhood environment			
Playground of residence			
Yes	30,296 (75.3)	Ref.	
No	9,044 (22.5)	−0.28 (−0.41, −0.15)	<0.01
Missing	822 (2.2)		
Facility of residence			
Yes	21,825 (54.3)	Ref.	
No	17,481 (43.5)	−0.30 (−0.41, −0.20)	<0.01
Missing	916 (2.3)		
Movement Behavior			
MVPA			
<180 min/d	13,198 (32.8)	Ref.	
≥180 min/d	18,865 (46.9)	−0.22 (−0.34, −0.10)	<0.01
Missing	8,159 (20.3)		

Abbreviation: BF%=body fat percentage; *CI*=confidence interval; Ref.=reference; BMI=body mass index; MVPA=moderate-to-vigorous physical activity.

colder northern temperatures necessitate greater fat accumulation for thermal regulation. The observed geospatial variations in preschooler BF% may also reflect differences in urban livability (*13*), precipitation patterns, ambient particulate matter pollution, and regional dietary habits. These disparities underscore the importance of analyzing early childhood body composition using nationwide data to identify and address regional inequalities.

The determinants of preschoolers' BF% levels appear to emerge from complex social and environmental interactions. Consistent with existing literature, elevated childhood BF% shows strong associations with parental overweight (*14*). This relationship likely reflects both genetic predisposition and the direct influence of family dynamics on children's physical activity patterns, dietary behaviors, and weight management practices (*15*). Additionally, residential environmental characteristics emerge as crucial determinants of preschooler BF%, including green space availability and accessibility (*16*), fine particulate matter exposure (*17*), and school neighborhood characteristics (*18*).

Several limitations warrant consideration in interpreting our findings. First, the cross-sectional nature of the study design precludes establishing causal relationships between the identified factors and BF%. Second, key determinants of BF% in the Chinese preschoolers, including dietary patterns and sleep behaviors, were not comprehensively assessed in this analysis. Lastly, although this study utilized the latest nationally representative data (5th CNPFS, 2020), BF% may have changed over time. Future research should explore spatiotemporal trends in preschool children's BF% to capture potential variations.

Our study provides the first comprehensive assessment of BF% prevalence among the Chinese preschoolers aged 3–6 years, establishing a foundation for developing standardized BF% criteria for defining overweight and obesity in this population. The identification of significant BF% disparities across residential areas and the 31 PLADs addresses a critical gap in the current literature. These findings underscore the urgent need for targeted policy interventions aimed at reducing regional health inequalities and promoting optimal development during this crucial developmental period.

Conflicts of interest: The authors declare no conflicts of interest.

Ethical statement: Received ethical approval from the Ethics Committee of the China Institute of Sport Science (approval number: CISSLA-20240219).

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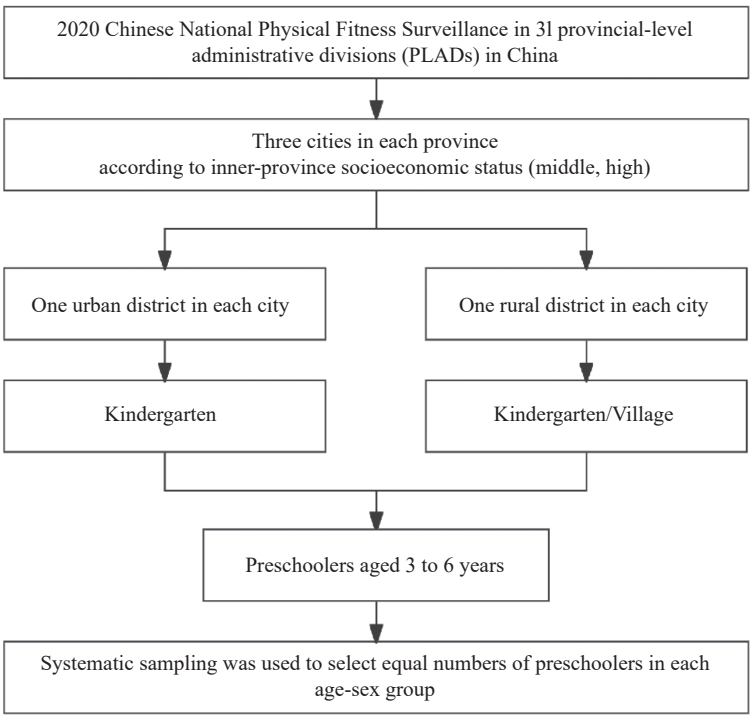
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SUPPLEMENTARY MATERIAL



SUPPLEMENTARY FIGURE S1. Flow chart of sampling design in the 2020 Chinese National Physical Fitness Surveillance.

Preplanned Studies

A Multi-Regional Epidemiological Evaluation on Post-vaccination Serological Testing in Prevention of Vertical Transmission of Hepatitis B Virus — 10 Counties, 5 Provinces, China, 2019–2024

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Summary

What is already known about this topic?

Post-vaccination serologic testing (PVST) of infants born to hepatitis B virus (HBV) infected mothers is important for evaluating effectiveness of strategies for preventing mother-to-child transmission (MTCT) of HBV.

What is added by this report?

PVST was conducted in 43.7% of 7,425 infants born to HBV-infected mothers and showed that 0.8% of infants had breakthrough infections, indicating a very low level of prevention failure; anti-HBs positivity was 97.0% showing vaccine-induced protection; and 2.2% of HBV-exposed infants needed revaccination. Prevention failure was 12.7-fold higher among infants born to HBeAg-positive mothers.

What are the implications for public health practice?

MTCT prevention strategy is highly effective. PVST evaluates MTCT prevention strategy and identifies infants needing revaccination; its use should be increased. Findings support WHO's HBV elimination strategy.

ABSTRACT

Introduction: Infants born to HBsAg-positive mothers are exposed to hepatitis B virus (HBV) during childbirth and require timely hepatitis B vaccination (HepB) and hepatitis B immunoglobulin (HBIG) to prevent vertical transmission. Post-vaccination serological testing (PVST) determines whether HBV-exposed infants are protected, infected, or need revaccination. This study evaluated PVST implementation among HBV-exposed infants and the effectiveness of the recommended strategy to prevent mother-to-child transmission (MTCT) of HBV.

Methods: This observational study of infants born to HBsAg-positive mothers evaluated implementation of the MTCT prevention strategy and PVST follow-up across five provinces in China. Chi-square tests assessed timely HepB1 and HBIG administration and HepB series completion. PVST was used to evaluate MTCT prevention effectiveness. Bivariate analyses explored factors influencing infection and protection rates among HBV-exposed infants.

Results: Among 7,425 infants born to HBsAg-positive mothers, 94.8% received timely HepB1 and HBIG, and 99.5% completed the full HepB vaccination series. PVST was conducted in 3,243 (43.7%) infants; the median interval between HepB3 and PVST was 66 days (interquartile range: 47–114). 26 (0.8%) infants tested HBsAg-positive; 3,147 (97.0%) developed protective antibody levels; and 72 (2.2%) were neither infected nor protected, requiring revaccination. Maternal HBeAg positivity was a significant risk factor for MTCT prevention failure [adjusted odds ratio (a*OR*)=12.7, 95% confidence interval (*CI*): 4.7, 34.1].

Conclusions: The MTCT prevention strategy was highly effective. PVST for infants born to HBsAg-positive mothers enables evaluation of MTCT prevention strategies and improvement of strategy their effectiveness. PVST utilization should be expanded to test all HBV-exposed infants to ensure their protection and to further enhance the MTCT prevention.

Timely administration of a birth dose of hepatitis B vaccine (HepB) is critically important for preventing hepatitis B virus (HBV) infection by preventing vertical transmission of HBV during childbirth (*1*). According to the World Health Organization (WHO), the prevalence of chronic HBV infection among

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children under five years of age declined from approximately 5% in the pre-vaccine era (1980s to early 2000s) to below 1% in 2019 (*2*). In China, the HepB immunization schedule provides the first dose (HepB1) within 24 hours of birth, followed by second (HepB2) and third (HepB3) doses at 1 and 6 months of age. The National Viral Hepatitis Prevention and Control Plan (2017–2020) set targets to maintain timely HepB1 coverage >90% and full-series coverage (HepB3) >95%. A 2020 nationally-representative survey found that among 1–4-year-old children, 91.54% received HepB1 ≤24 hours after birth and 99.21% completed HepB3. Among 1–14-year-old children, corresponding rates were 89.05% and 98.46%, indicating high ultimate coverage but persistent gaps in timely HepB1 administration (*3*). Universal HepB vaccination significantly reduced hepatitis B infection among children and adolescents. The 2020 national HBV seroepidemiological survey shoewd dramatic declines in hepatitis B surface antigen (HBsAg) prevalence, from 9.67% (in 1992) to 0.30% in children aged 1–4 years, and from 10.74% to 0.94% in 5–14-year-old (*4*).

The WHO's 2030 goal to eliminate viral hepatitis as a major public health threat has an objective to achieve an HBsAg seroprevalence of ≤0.1% among children under five years old. Preventing mother-to-child transmission (MTCT) of HBV during childbirth is essential to achieve this objective. Co-administration of hepatitis B immunoglobulin (HBIG) with HepB1 enhances MTCT prevention efficacy (*5*). China's Guidelines for the Prevention and Treatment of Chronic Hepatitis B and the National Immunization Program Schedule for Children (2021 Edition) emphasize administering HepB1 and HBIG within 12 hours of birth to newborns of HBsAg-positive mothers (*6*). Post-vaccination serological testing (PVST) is used to determine the effectiveness of MTCT prevention in infants. PVST assesses HBsAg and anti-HBs antibody levels at 9–12 months of age or 1–2 months after vaccine series completion.

We evaluated timeliness of HepB vaccination and effectiveness of MTCT prevention strategies in children born during 2019–2024 in pilot counties/districts with established PVST surveillance. We determined factors associated with MTCT prevention failure and assessed impact of the current strategy, with an aim to provide evidence-based recommendations for optimizing MTCT prevention.

The study was conducted in selected counties across five provinces in China: Zhejiang (Jinyun and Suichang counties), Fujian (Shishi City and Huian County), Henan (Yuanyang and Sui counties, and Huaiyang District), Sichuan (Dujiangyan City and Lu County), and Gansu (Ganzhou District and Tongwei County). Study subjects included infants born to HBsAg-positive mothers during 2019–2024 and their mothers. Data collection encompassed demographics, prenatal HBV screening results, use of antiviral therapy during pregnancy, maternal HBIG use, delivery details, administration of HepB1, HBIG, and HepB3, PVST results, and HepB revaccination if indicated by PVST. Data were obtained from maternal and child health (MCH) institutions (information on mothers, pregnancies, deliveries, and HepB1 and HBIG administration), vaccination clinics (HepB2 and HepB3 data), and MCH laboratories (PVST results).

Infant-level outcomes were defined as: 1) PVST utilization: testing blood for HBsAg and HBsAb; 2) MTCT prevention success: HBsAg-negative and HBsAb-positive; 3) HBV infection: HBsAg-positive; 4) HBV susceptibility: HBsAg-negative and HBsAb-negative; 5) timely co-administration of HepB1+HBIG: HepB1 administered ≤24 hours and HBIG1 ≤12 hours after birth; and 6) timely completion of HepB3.

Statistical analysis was performed using Microsoft Excel 2019 (Microsoft Corp., Redmond, WA, USA) and SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Descriptive statistics were used to summarize baseline characteristics. Outcomes are reported as proportions with 95% confidence intervals (*CI*). Chi-square tests (α =0.05, two-tailed) were used for univariate analysis, while multivariate analysis was conducted using unconditional logistic regression (α =0.05, two-tailed).

Table 1 shows characteristics of the subjects: 7,425 HBsAg-positive mothers and their liveborn, HBV-exposed infants. The mean maternal age was 31.19±4.39 years. Among these infants, 7,041 (94.8%) received timely HepB1 and HBIG co-administration, and 7,386 (99.5%) completed the HepB3 series. Among the infant subjects, 3,243 (43.7%) underwent post-vaccination serologic testing. The median interval between HepB3 administration and PVST was 66 days (interquartile range: 47–114). Of the infants with PVST, 26 (0.8%) were HBsAg-positive,indicating breakthrough infection. HBsAg positivity decreased by year from 1.7% in 2019 to 0.3% in 2023. Additionally, 3,147 (97.0%) infants were anti-HBs-positive, indicating vaccine-induced protection, while 72 (2.2%) infants tested negative for both HBsAg and

TABLE 1. Timely co-administration (HepB1 + HBIG1) and full-course vaccination in infants born to HBsAg+ mothers, 2019–2024.

Variable	No. observed (*N*=7,425, %)	Timely co-administration (HepB1 + HBIG1)		Full-course vaccination with HepB	
		No. observed (*N*=7,041)	Rate (%)	No. observed (*N*=7,386)	Rate (%)
Province					
Zhejiang	496 (6.7)	472	95.2	489	98.6
Fujian	4,087 (55.0)	3,930	96.2	4,072	99.6
Henan	1,141 (15.4)	1,006	88.1	1,139	99.8
Sichuan	993 (13.4)	973	98.0	989	99.6
Gansu	708 (9.5)	660	93.2	697	98.5
Maternal age (years)					
15–24	436 (5.9)	411	94.3	433	99.3
25–29	2,238 (30.1)	2,107	94.1	2,221	99.2
30–34	3,119 (42.0)	2,970	95.2	3,104	99.5
35–50	1,632 (22.0)	1,553	95.2	1,628	99.8
Ethnicity					
Han	7,099 (95.6)	6,725	94.7	7,060	99.5
Other	326 (4.4)	316	96.9	326	100.0
Maternal education					
Junior high school and below	5,299 (71.4)	5012	94.6	5,271	99.5
High school and above	2,125 (28.6)	2,028	95.4	2,114	99.5
Maternal occupation					
Farmer	1,475 (19.9)	1,374	93.2	1,470	99.7
Other	5,950 (80.1)	5,667	95.2	5,916	99.4
HBV infected time (y)					
≤5	3,412 (46.0)	3,219	94.3	3,393	99.4
>5	4,013 (54.0)	3,822	95.2	3,993	99.5
Maternal receipt of HBV DNA tested					
Yes	842 (11.4)	820	97.4	835	99.2
No	6,568 (88.6)	6,209	94.5	6,537	99.5
Maternal receipt of antiviral therapy during pregnancy					
Yes	386 (5.2)	373	96.6	383	99.2
No	7,038 (94.8)	6,667	94.7	7,002	99.5
Maternal HBeAg status during pregnancy					
Negative	5,582 (75.2)	5,295	94.9	5,558	99.6
Positive	1,675 (22.6)	1,594	95.2	1,663	99.3
Unknown	166 (2.2)	150	90.4	163	98.2
Infant sex					
Male	3,958 (53.3)	3,758	94.9	3,936	99.4
Female	3,463 (46.7)	3,281	94.7	3,446	99.5
Birth weight (kg)					
≥2.50	7,198 (97.0)	6,839	95.0	7,164	99.5
<2.50	225 (3.0)	201	89.3	220	97.8

Continued

Variable	No. observed (*N*=7,425, %)	Timely co-administration (HepB1 + HBIG1)		Full-course vaccination with HepB	
		No. observed (*N*=7,041)	Rate (%)	No. observed (*N*=7,386)	Rate (%)
Pregnancy duration (weeks)					
≥37	7,022 (94.6)	6,687	95.2	6,987	99.5
<37	401 (5.4)	353	88.0	397	99.0
Maternal parity					
1	2,105 (28.4)	1,986	94.4	2,096	99.6
2	3,936 (53.0)	3,753	95.4	3,916	99.5
≥3	1,381 (18.6)	1,301	94.2	1,371	99.3
Mode of delivery					
Vaginal delivery	3,942 (53.1)	3,717	94.3	3,917	99.4
Caesarean section	3,482 (46.9)	3,323	95.4	3,468	99.6

Abbreviation: HBV=hepatis B virus; DNA=deoxyribonucleic acid; HBeAg=hepatis B e-antigen; HepB1 + HBIG1=first dose of hepatitis B vaccine plus hepatitis B immunoglobulin; HepB=hepatitis B vaccine.

anti-HBs and required revaccination. No significant difference in maternal HBeAg status was observed between infants with PVST (22.2% HBeAg+) and those without PVST(23.0% HBeAg+) (*P*=0.56) (Supplementary Table S1, available at https://weekly.chinacdc.cn/).

Table 2 shows univariate analyses of HBsAg-positivity (MTCT prevention failure) and HBsAb positivity in infants by demographic, maternal, and delivery characteristics. There were significant differences in HBsAg positivity by maternal age and HBeAg status. There were significant differences in HBsAb positivity by maternal occupation, maternal HBV DNA testing, and receipt of HBIG during pregnancy (*P*<0.05). In multivariate logistic regression, maternal HBeAg-positivity was significantly associated with infant HBsAg-positivity (a*OR*=12.7, 95% *CI*: 4.7, 34.1).

DISCUSSION

This real-world study evaluated the effectiveness of the current HepB vaccine- and HBIG-based strategy for preventing mother-to-child transmission of HBV during childbirth. Based on post-vaccination serologic testing of HBV-exposed infants, we found an exceptionally low prevention strategy failure rate of 0.8%. Vaccination induced protective antibody levels in 97.0% of HBV-exposed infants, while the remaining 2.2% were neither infected nor protected, requiring revaccination to ensure protection. The PVST utilization rate was 43.7% among these HBV-exposed infants, and the 66-day median interval between the last dose of HepB vaccine and PVST was appropriate for accurate test results. Our findings strongly support the HepB vaccine- and HBIG-based strategy for prevention of vertical transmission and demonstrate the importance of increasing PVST utilization among HBV-exposed infants in China.

The 43.7% PVST rate we observed is lower than previously reported PVST follow-up rates in China. A retrospective study in Jilin, Henan, Sichuan, and Gansu provinces found a PVST rate of 66% (*7*). Zhejiang Province (2016–2020) and Bao'an District in Shenzhen City, Guangdong Province (2017–2019) reported PVST rates of 67% (*8*) and 54% (*9*), respectively. The suboptimal PVST compliance rate and wide provincial variation we identified highlight a critical gap in monitoring MTCT prevention strategies and underscore the need for improved adherence to PVST protocols.

The MTCT prevention failure rate of 0.8% that we found is slightly lower than the 1.1% rate in the USA (*10*) and the 3.7% rate reported in a four-province study (*11*), but slightly higher than the 0.77% rate observed in Zhejiang Province (*8*), suggesting regional variation in implementation of HBV MTCT prevention measures. HBeAg positivity was a significant risk factor for breakthrough infection, consistent with other studies (*7*,*11*), reinforcing the importance of prenatal HBV serological screening to identify high-risk pregnancies (*12*).

Encouragingly, 97.0% of HBV-exposed infants developed protective hepatitis B surface antibody (anti-HBs), providing likely lifelong protection from HBV infection. This finding was similar to the 97% anti-

TABLE 2. Maternal characteristics, HBsAg and HBsAb positivity in infants, and associated risk factors based on PVST results..

Variable	No. with PVST (*N*=3,243)	HBsAg status		HBsAb status	
		No. positive (*N*=26)	Rate (%)	No. positive (*N*=3,147)	Rate (%)
Maternal age (years)*					
15–24	215	2	0.9	210	97.7
25–29	963	14	1.4	928	96.4
30–34	1,340	6	0.5	1,299	96.9
35–50	725	4	0.6	710	97.9
Maternal ethnicity					
Han	3,115	25	0.8	3,024	97.1
Other	128	1	0.8	123	96.1
Maternal education					
Junior high school and below	2,187	13	0.6	2,117	96.8
High school and above	1,056	13	1.2	1,030	97.5
Maternal occupation†					
Farmers	881	9	1.0	840	95.3
Other	2,362	17	0.7	2,307	97.7
HBV infected time (years)					
≤5	1,410	9	0.6	1,373	97.4
>5	1,833	17	0.9	1,774	96.8
Maternal HBV DNA tested†					
Yes	469	4	0.9	462	98.5
No	2,761	22	0.8	2,672	96.8
Maternal receipt of antiviral therapy during pregnancy					
Yes	202	2	1.0	197	97.5
No	3,040	24	0.8	2,949	97.0
Maternal HBeAg status during pregnancy*					
Negative	2,420	5	0.2	2,370	97.9
Positive	745	19	2.6	704	94.5
Unknown	77	2	2.6	72	93.5
Received HBIG during pregnancy†					
Yes	41	1	2.4	40	97.6
No	2,950	24	0.8	2,860	97.0
Unknown	248	1	0.4	243	98.0
Infant sex					
Male	1,687	15	0.9	1,639	97.2
Female	1,554	11	0.7	1,506	96.9
Birth weight (kg)					
≥2.50	3,121	26	0.8	3,025	96.9
<2.50	120	0	0.0	120	100
Pregnancy duration (weeks)					
≥37	3,058	26	0.9	2,965	97.0
<37	183	0	0.0	180	98.4

Continued

Variable	No. with PVST (*N*=3,243)	HBsAg status		HBsAb status	
		No. positive (*N*=26)	Rate (%)	No. positive (*N*=3,147)	Rate (%)
Maternal parity					
1	1,042	10	1.0	1,011	97.0
2	1,646	13	0.8	1,599	97.1
≥3	552	3	0.5	534	96.7
Mode of delivery					
Vaginal delivery	1,639	14	0.9	1,598	97.5
Caesarean section	1,603	12	0.8	1,548	96.6
Timely receipt of HBIG					
No	60	1	1.7	59	98.3
Yes	3,183	25	0.8	3,088	97.0
Timely receipt of first HepB dose					
No	181	3	1.7	176	97.2
Yes	3,062	23	0.8	2,971	97.0

Univariate analysis results: * HbsAg group: $P<0.05$; † HBsAb group: $P<0.05$.
Abbreviation: PVST=post vaccination serological testing; HBV=hepatis B virus; DNA=deoxyribonucleic acid; HBsAg=hepatitis B surface antigen; HBsAb=hepatitis B surface antibody; HepB=hepatitis B vaccine; HBIG=hepatitis B immunoglobulin; HBeAg=hepatitis B e-antigen.

HBs seropositivity reported in Zhejiang (*8*). PVST effectively identifies infants who remain susceptible to HBV and need revaccination. Our finding that 2.2% of vaccinated HBV-exposed infants required revaccination is consistent with reported HepB vaccine non-response rates of 2.6%–10% (*12*).

Our study demonstrated high adherence to the WHO-recommended passive-active immunization protocol (HepB1 + HBIG1 within 24 hours of birth), with 95% timely HBIG1 administration and 95% timely co-administration of HepB1 and HBIG. Preterm infants had lower co-administration rates (89.33% *vs.* 95.01% in term infants) (*13*), consistent with findings from Anhui Province. China's rising preterm birth rate (*14*) poses a challenge to MTCT prevention (*15*–*16*).

Maternal antenatal interventions, including HBV DNA testing (14.46%) and antiviral therapy (6.23%), were underutilized. Among the 26 HBsAg-positive infants, 22 and 24 were born to mothers who did not receive DNA testing or antiviral treatment during pregnancy, respectively. Antiviral therapy in HBsAg-positive mothers with high viral loads reduces intrauterine and perinatal transmission risk (*17*–*18*). Limited access to HBV DNA testing in rural healthcare facilities may contribute to this gap (*8*), underscoring the need to strengthen prenatal screening and treatment infrastructure.

This study was subject to at least two limitations. Missing data on the exact timing of HepB1 administration (i.e., <12 or <24 hours after birth) precluded evaluating strategy effectiveness with a first dose timing at shorter intervals within the first day of life. The number of breakthrough infections was too small to determine factors associated with breakthrough infection other than maternal HBeAg status. For example, there were too few breakthrough infections to evaluate shorter time frames for administration of HepB1 and HBIG. Because HBV DNA testing was not standard of care, we were unable to analyze breakthrough infections by quantitative DNA analysis. Future research with larger study populations is needed to address these limitations.

In conclusion, the MTCT prevention strategy in China is highly effective, with only 0.8% of infants born to HBV-infected mothers experiencing breakthrough infections. PVST monitoring for children born to HBsAg-positive mothers enables collection of MTCT prevention data and evaluation of revaccination effectiveness in HBV-exposed infants, enhancing HBV MTCT prevention. However, PVST is underutilized, and PVST compliance rates vary by province. We recommend strengthening training and supervision of PVST to increase use of properly conducted PVST in China. Evaluation of PVST results is critically important to strengthen the HBV MTCT prevention strategy and to evaluate progress toward WHO's target of 0.1% HBsAg prevalence among all

children five years and under.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Maternal and infant characteristics for infants completing and not completing post-vaccination serologic testing.

Variable	PVST completion			χ^2	*P*
	No (*N*=4,182)	Yes (*N*=3,243)	Total (*N*=7,425)		
Province				2710.5	<0.001
Zhejiang	0 (0.0)	496 (15.3)	496 (6.7)		
Fujian	3,371 (80.6)	716 (22.1)	4,087 (55.0)		
Henan	252 (6.0)	889 (27.4)	1,141 (15.4)		
Sichuan	358 (8.6)	635 (19.6)	993 (13.4)		
Gansu	201 (4.8)	507 (15.6)	708 (9.5)		
Maternal age (years)				7.0	0.071
15–24	221 (5.3)	215 (6.6)	436 (5.9)		
25–29	1,275 (30.5)	963 (29.7)	2,238 (30.1)		
30–34	1,779 (42.5)	1,340 (41.3)	3,119 (42.0)		
35–50	907 (21.7)	725 (22.4)	1,632 (22.0)		
Maternal ethnicity				2.7	0.1
Han	3,984 (95.3)	3,115 (96.1)	7,099 (95.6)		
Other	198 (4.7)	128 (3.9)	326 (4.4)		
Maternal education				43.7	<0.001
Junior high school and below	3,112 (74.4)	2,187 (67.4)	5,299 (71.4)		
High school and above	1,069 (25.6)	1,056 (32.6)	2,125 (28.6)		
Maternal occupation				192.8	<0.001
Farmer	594 (14.2)	881 (27.2)	1,475 (19.9)		
Other	3,588 (85.8)	2,362 (72.8)	5,950 (80.1)		
HBV infected time (years)				14.2	<0.001
≤5	2,002 (47.9)	1,410 (43.5)	3,412 (46.0)		
>5	2,180 (52.1)	1,833 (56.5)	4,013 (54.0)		
Maternal receipt of HBV DNA test				56.7	<0.001
Yes	373 (8.9)	469 (14.5)	842 (11.4)		
No	3,807 (91.1)	2,761 (85.5)	6,568 (88.6)		
Maternal receipt of antiviral therapy during pregnancy				12.4	<0.001
Yes	184 (4.4)	202 (6.2)	386 (5.2)		
No	3,998 (95.6)	3,040 (93.8)	7,038 (94.8)		
Maternal HBeAg status during pregnancy				1.2	0.557
Negative	3,162 (75.6)	2,420 (74.6)	5,582 (75.2)		
Positive	930 (22.2)	745 (23.0)	1,675 (22.6)		
Unknown	89 (2.1)	77 (2.4)	166 (2.2)		
Infant sex				3.8	0.051
Male	2,271 (54.3)	1,687 (52.1)	3,958 (53.3)		
Female	1,909 (45.7)	1,554 (47.9)	3,463 (46.7)		
Birth weight (kg)				8.8	0.003
≥2.50	4,077 (97.5)	3,121 (96.3)	7,198 (97.0)		
<2.50	105 (2.5)	120 (3.7)	225 (3.0)		

Continued

Variable	PVST completion			χ^2	*P*
	No (*N*=4,182)	Yes (*N*=3,243)	Total (*N*=7,425)		
Pregnancy duration (weeks)				0.7	0.412
≥37	3,964 (94.8)	3,058 (94.4)	7,022 (94.6)		
<37	218 (5.2)	183 (5.6)	401 (5.4)		
Maternal parity				42.3	<0.001
1	1,063 (25.4)	1,042 (32.2)	2,105 (28.4)		
2	2,290 (54.8)	1,646 (50.8)	3,936 (53.0)		
≥3	829 (19.8)	552 (17.0)	1,381 (18.6)		
Mode of delivery				14.9	<0.001
Vaginal delivery	2,303 (55.1)	1,639 (50.6)	3,942 (53.1)		
Caesarean section	1,879 (44.9)	1,603 (49.4)	3,482 (46.9)		
HepB1+HBIG co-administration				13.9	<0.001
No	181 (4.3)	203 (6.3)	384 (5.2)		
Yes	4,001 (95.7)	3,040 (93.7)	7,041 (94.8)		
HepB full course				2.6	0.108
No	17 (0.4)	22 (0.7)	39 (0.5)		
Yes	4,165 (99.6)	3,221 (99.3)	7,386 (99.5)		

Abbreviaiton: PVST=post-vaccination serological test; HBV=hepatitis B virus; HBeAg=HBV e-antigen; HepB1+HBIG=first dose of hepatitis B vaccine plus hepatitis B immunoglobulin; DNA=deoxyribonucleic acid.

Preplanned Studies

A Retrospective Analysis of 112 Mushroom Poisoning Patients — Guangzhou City, Guangdong Province, China, 2016–2023

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Summary

What is already known about this topic?

Mushroom poisoning is a significant food safety issue with an increasing incidence, with Southwest China being the most severely affected region.

What is added by this report?

This study analyzed 112 cases of mushroom poisoning admitted to a specialized toxicology hospital in Guangzhou City, Guangdong Province, China. A total of 9 mushroom species were identified across 4 poisoning types. Among 51 poisoning incidents, gastroenteritis was the most common presentation. However, acute liver failure caused by lethal *Amanita* spp. accounted for all mortality in this cohort. Shorter latency periods were associated with less severe poisoning outcomes. Our study applied the HOPE6 and TALK Chinese clinical assessment protocols to evaluate poisoning severity and prioritize multidisciplinary diagnostic processes. Initial treatment decisions based on poisoning type classification, consumption history, and latency period were key factors in preventing further morbidity in clinical management of mushroom poisoning.

What are the implications for public health practice?

Clinical management of mushroom poisoning requires improved diagnostic processes, particularly in mushroom species identification for informed clinical decision-making. Excessive medical interventions and their associated risks should be avoided during clinical management.

ABSTRACT

Introduction: Mushroom poisoning remains a significant food safety concern in China, particularly in southern regions like Guangzhou City, Guangdong Province. Accidental consumption of toxic mushrooms often leads to severe health outcomes, including gastroenteritis, liver failure, renal failure, and psycho-neurological disorders. This study analyzes cases of mushroom poisoning admitted to the Guangzhou Twelfth People's Hospital between 2016 and 2023, focusing on mushroom species, poisoning types, clinical trends, treatment outcomes, and diagnostic challenges.

Methods: This retrospective study included 112 patients with confirmed mushroom poisoning. Demographic, clinical, and epidemiological data were extracted from medical records, including age, gender, type of mushroom consumed, latency period, symptoms, and treatment outcomes. Statistical analyses examined the relationships between latency period, symptom severity, and hospitalization outcomes. Identification of mushroom species and toxicity classification was supported by the HOPE6 and TALK Chinese clinical assessment protocols.

Results: The cohort had a median age of 45 years, with a male-to-female ratio of 1.4:1. May and June were peak months for incidents. Four poisoning types were identified: gastroenteritis (62.5%), liver failure (25.0%), psycho-neurological disorders (9.8%), and renal failure (2.7%). Patients with delayed symptom onset (median latency of 10 hours) experienced more severe complications and prolonged hospital stays. Acute liver failure accounted for all 12 fatalities, predominantly linked to *Amanita* species. Prompt gastric lavage correlated with lower mortality in gastroenteritis and psycho-neurological cases, while blood purification showed efficacy for renal and liver failure patients.

Discussion: The study underscores the critical role of latency period and initial clinical assessment in determining treatment outcomes for mushroom poisoning. Enhanced diagnostic capabilities and multidisciplinary approaches are essential to reduce mortality. Future efforts should focus on improving mushroom identification protocols and expanding the

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application of standardized clinical assessment tools like HOPE6 and TALK*.

Mushroom poisoning has emerged as a significant food safety concern with a notable increase in incidence over the past four years in China (*1*). Guangzhou, the capital city of Guangdong Province, has recorded a significant number of mushroom poisoning cases annually. These incidents typically result from accidental consumption and can occur throughout the year (*2*). This retrospective observational study aimed to investigate the diagnosis, prognosis, and outcomes of mushroom poisoning. We analyzed 112 cases admitted to Guangzhou Twelfth People's Hospital from 2016 to 2023, providing key epidemiological data for Southern China. The study employed the HOPE6 (Supplementary Table S1, available at https://weekly.chinacdc.cn/) and TALK (Supplementary Table S2, available at https://weekly.chinacdc.cn/) Chinese clinical assessment systems to assist with diagnosis and prognosis in clinical evaluations (*2*). Four types of mushroom poisoning were identified based on clinical consultation and mycological testing (*2–3*). Acute liver failure contributed to the most severe outcomes of mushroom poisoning. Nine poisonous mushroom species were identified, with *Amanita exitialis* (*A. exitialis*), *Amanita rimosa* (*A. rimosa*), and *Amanita fuligineoides (A. fuligineoides)* being the major species causing acute liver injury and leading to the highest mortality rates in the cohort. Our analysis revealed significant gaps in early diagnosis and initial treatment decision-making, particularly in cases of acute liver failure. Future efforts should focus on expanding collaboration to validate the HOPE6 and TALK system and improving prognostic accuracy.

In this study, retrospective data from 2016 to 2023 were systematically reviewed from the Guangzhou Twelfth People's Hospital. Patients of all ages with a history of suspected poisonous mushroom ingestion, especially wild or self-collected specimens, and exhibiting symptoms consistent with known poisoning syndromes after a latency period were included. Cases without symptoms attributable to mushroom poisoning or with hospitalization stays less than 3 days were excluded.

Poisonous mushroom species and poisoning types were systematically classified. Species identification employed both morphological and molecular methods. Morphological identification referenced literature including the "Atlas of Chinese Macrofungal Resources" and "Poisonous Mushrooms: Recognition and Poisoning Treatment" (*4–5*). Macro- and micro-morphological observations were recorded, with tissues stained with 5% Potassium Hydroxide (KOH) and 1% aqueous Congo red. DNA extraction was performed using a commercial kit, and primer pairs ITS5/ITS4 were used for sequencing (*6*).

Clinically, mushroom poisoning was categorized into four types based on syndromic diagnosis (*7*). Treatment strategies were determined by symptomatology, latency period, and pathological findings (*2–3*). Gastric lavage and activated charcoal were administered initially within 6 hours of ingestion. Blood purification was reserved for severe cases involving acute liver or kidney injury. Liver transplantation is an effective treatment for liver failure, with identified survival rates of up to 80% (*8*). In our cohort, liver transplantation was administered as part of intensive care in select cases.

All statistical analyses were conducted using R (version 4.2.3, R Foundation, Vienna, Austria). For patients with different types of mushroom poisoning, continuous data were presented as the median and interquartile range (IQR), while categorical data were presented as numbers and percentages. A scatter plot and Pearson correlation analysis were performed to explore the relationship between latency period and hospitalization length among all patients with mushroom poisoning. Multivariate logistic regression was used to examine the association between latency period and fatal mushroom poisoning. The latency period of various toxic mushroom species was presented as the median and range, and mortality rates were calculated for each species. Statistical significance was set at $P<0.05$ (two-tailed).

A total of 112 patients were included in the present study (Table 1), comprising 66 males (58.93%) and 46 females (41.07%), with a median age of 45 years. Incidence of mushroom poisoning peaked in May and June, with over 30 cases recorded in May. Four types

* The HOPE6 and TALK scoring system, developed in 2019 based on both domestic and international literature along with clinical experience from specialists, is an assessment tool used to evaluate patients with suspected mushroom poisoning in order to identify fatal mushroom poisoning conditions, and has been recommended by Chinese mushroom experts. HOPE6: Medical history (H); Organ damage (O); Picture Identification (P); Eruption of symptom >6 hours (E6). TALK: Toxicant identification (T); APTT extension (A); Liver dysfunction (L); Kidney dysfunction (K).

TABLE 1. Information of patients with 4 types of mushroom poisoning (*N*=112).

Variables	Types of mushroom poisoning				All patients (*N*=112)
	Gastroenteritis (*n*=70)	Acute liver failure (*n*=28)	Acute kidney injury (*n*=3)	Psycho neurological disorder (*n*=11)	
Age (IQR)	45.5 (34.2, 54.0)	37.5 (28.5, 55.5)	66.0 (55.5, 66.0)	49.0 (42.0, 56.0)	45.0 (34.0, 55.2)
Gender					
Male (%)	41 (58.57)	15 (53.57)	2 (66.67)	8 (72.73)	66 (58.93)
Female (%)	29 (41.43)	13 (46.43)	1 (33.33)	3 (27.27)	46 (41.07)
Hospitalization length [day (IQR)]	3.0 (1.0, 3.0)	10.0 (6.0, 12.2)	24.0 (23.5, 25.5)	6.0 (2.5, 6.0)	3.0 (2.0, 6.0)
Latency period [hour (IQR)]	1.8 (0.6, 3.0)	10.0 (7.0, 10.0)	7.0 (4.0, 9.5)	2.0 (1.0, 7.5)	2.0 (1.0, 7.0)
Gastric lavage					
Yes (%)	58 (82.86)	8 (28.57)	0 (0)	7 (63.64)	73 (65.18)
No (%)	12 (17.14)	20 (71.43)	3 (100.00)	4 (36.36)	39 (34.82)
Blood purification					
Yes (%)	0 (0)	27 (96.43)	3 (100.00)	0 (0)	30 (26.79)
No (%)	70 (100.00)	1 (3.57)	0 (0)	11 (100.00)	82 (73.21)
Liver transplantation					
Yes (%)	0 (0)	3 (10.71)	0 (0)	0 (0)	3 (2.68)
No (%)	70 (100.00)	25 (89.29)	3 (100.00)	11 (100.00)	109 (97.32)
Fatal mushroom poisoning*					
Yes (%)	1 (1.43)	28 (100.00)	3 (100.00)	5 (45.45)	37 (33.04)
No (%)	69 (98.57)	0 (0)	0 (0)	6 (54.55)	75 (66.96)
Outcome					
Non-survival (%)	0 (0)	12 (42.86)	0 (0)	0 (0)	12 (10.71)
Survival (%)	70 (100.00)	16 (57.14)	3 (100.00)	11 (100.00)	100 (89.29)

* Fatal mushroom poisoning is ascertained from the HOPE6 and TALK scoring outcomes of patients (Supplementary Material, Supplementary Table S1-S2, available at https://weekly.chinacdc.cn/).
Abbreviation: IQR=Interquartile range.

of mushroom poisoning were identified: gastroenteritis (*n*=70), acute liver failure (*n*=28), acute kidney injury (*n*=3), and psycho-neurological disorder (*n*=11). The median hospitalization duration was 3.0 days, and the median latency period was 2.0 hours. Gastric lavage was performed in 65.18% of cases (*n*=73), and 26.79% underwent blood purification (*n*=30). Among all cases, 37 (33.04%) were recognized as fatal mushroom poisoning, with 75.68% (28/37) associated with acute liver failure. The overall inpatient mortality was 10.71% (*n*=12), with all deaths attributable to liver failure complications.

Nine species of poisonous mushrooms were identified (Table 2). Predominant symptoms included nausea, vomiting, dizziness, and abdominal pain. Among gastroenteritis cases, *Entoloma omiense* (*n*=24), *Boletus* spp. (*n*=7), and *Chlorophyllum molybdites* (*C. molybdites*) (*n*=23) were implicated, with *C. molybdites* accounting for the highest incidence, indicating its significant role in mushroom poisoning related to gastrointestinal distress. In cases of acute liver failure, 8 cases were associated with *A. exitialis*, 5 with *A. rimosa*, and 15 with *A. fuligineoides*. *A. rimosa* exhibited the highest mortality rate (100%), followed by *A. fuligineoides* (40.0%) and *A. exitialis* (12.5%). The longest latency periods were observed in cases involving *A. exitialis* and *A. fuligineoides*, with median times of 10.0 hours (Min=4.0, Max=14.0) and 10.0 hours (Min=7.0, Max=12.0), respectively. These prolonged latency periods may have delayed clinical recognition and intervention, potentially exacerbating disease severity. Additionally, one case of acute kidney injury was reported involving *Amanita neoovoidea*, with a latency period of seven hours. Regarding psycho-neurological disorders, the mushrooms identified included *Amanita sychnopyramis* (*n*=3), *Lanmaoa asiatica* (*L. asiatica*) (*n*=3), and *Boletus* spp. (*n*=5), with *L. asiatica* demonstrating the longest latency period

TABLE 2. Toxic mushroom species causing poisoning incidents and mortality in Guangzhou, China, 2016–2023.

Mushroom species	Symptoms	Latency hours [Median (Min, Max)]	Number of incidents	Number of patients	Number of deaths	Mortality (%)
Gastroenteritis						
Entoloma omiense	Nausea, Vomiting, Dizziness, Somnolence, Abdominal pain, Abdominal distension, Diarrhea	0.6 (0.3, 3.0)	9	24	0	0
Neoboletus venenatus	Nausea, Vomiting, Abdominal pain, Diarrhea, Chills	2.0 (1.5, 3.0)	3	7	0	0
Chlorophyllum molybdites	Nausea, Vomiting, Dizziness, Abdominal pain, Diarrhea	2.0 (0.2, 3.0)	12	23	0	0
Unknown	Nausea, Vomiting, Dizziness, Fatigue, Abdominal pain, Diarrhea, Chest Tightness	2.3 (0.5, 24.0)	12	16	0	0
Acute Liver Failure						
Amanita exitialis	Nausea, Vomiting, Abdominal pain, Diarrhea	10.0 (4.0,14.0)	2	8	1	12.5
Amanita rimosa	Nausea, Vomiting, Diarrhea	1.0 (1.0,1.0)	1	5	5	100.0
Amanita fuligineoides	Nausea, Vomiting, Diarrhea	10.0(7.0,12.0)	2	15	6	40.0
Acute Kidney Injury						
Amanita neoovoidea	Nausea, Vomiting, Altered Consciousness, Convulsions	7.0 (7.0,7.0)	1	1	0	0
Unknown	Nausea, Vomiting, Oliguria, Diarrhea	7.5 (1.0,12.0)	2	2	0	0
Psycho-neurological Disorder						
Amanita sychnopyramis	Sialorrhea, Nausea, Vomiting	0.5 (0.5, 0.5)	1	3	0	0
Lanmaoa asiatica	Fatigue, Hallucinations, Visual Hallucinations, Auditory Hallucinations, Agitation, Psychosis	10.0 (2.0,16.0)	3	3	0	0
Boletus sp.	Dizziness, Chest Tightness, Nausea, Vomiting, Diarrhea, Auditory Hallucinations, Hallucinations	5.0 (1.5, 12.0)	3	5	0	0

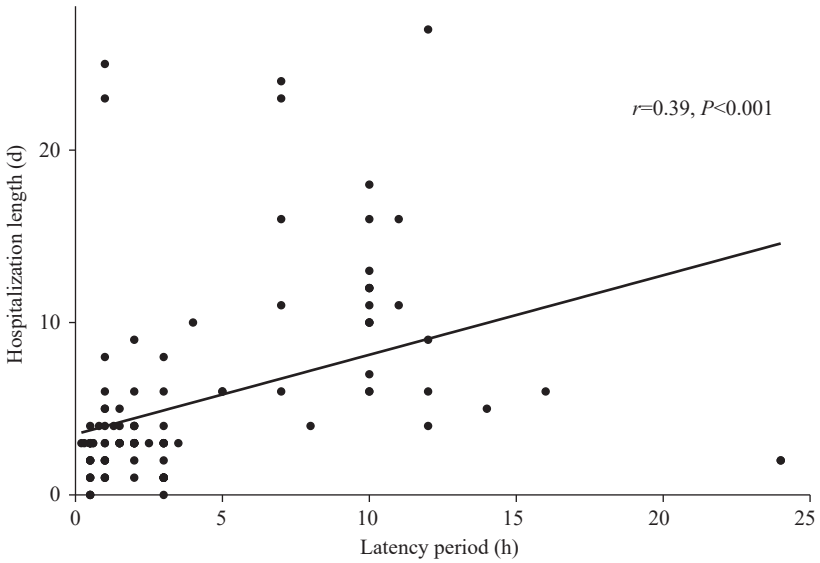


FIGURE 1. Scatter plot for latency period in hours versus hospitalization length in days among 112 mushroom poisoning patients.

[Median (M)=10.0 hours, Min=2.0, Max=16.0]. A limitation of the analysis was that 23 cases did not have a specific mushroom type identified. Most of these unidentified cases presented with gastroenteritis (n=16), with fewer cases of acute kidney injury (n=2) and psycho-neurological disorders (n=5).

In this study, a linear relationship was observed between latency period and hospitalization length (P for linear <0.05). As both variables are quantitative, Pearson correlation analysis was conducted, revealing a moderate positive correlation between delayed symptom onset following mushroom ingestion and

hospitalization stays (r=0.39, *P*<0.001). A non-parametric method (Spearman's rank correlation) was used to verify the robustness of prior findings (r=0.50, *P*<0.001). Furthermore, a multivariate logistic regression indicated that patients with an hour increase in latency period were likely to have a 40% increase in the risk of being identified as fatal mushroom poisoning, after adjusting for age and gender [odds ratio (*OR*)=1.40, 95% confidence interval (*CI*): 1.24, 1.62, *P*<0.001]. Figure 1 illustrates that most patients clustered at less than ten days hospitalization stay with less than five hours latency period.

DISCUSSION

Mushroom poisoning remains a significant public health challenge and a notable food safety issue in China. Our study spans a 7-year period, encompassing 112 cases of mushroom poisoning reported between 2016 and 2023. Since 2002, Guangzhou Twelfth People's Hospital has implemented comprehensive treatment protocols for acute mushroom poisoning in collaboration with the Institute of Microbiology, Guangdong Academy of Sciences, which assists with mushroom identification. Our methodology integrates three domestic scoring systems — HOPE6, TALK, and CGAMPS (*3*) (Supplementary Table S3, available at https://weekly.chinacdc.cn/) — to evaluate mushroom poisoning severity and guide clinical interventions. This study analyzes disease progression patterns, optimal treatment timelines, and predictive markers through retrospective case reviews from our hospital database. The integrated framework aims to evaluate poisoning severity and inform treatment strategies across different stages of intoxication.

Our study identified May and June as peak months for mushroom poisoning in Guangzhou, attributable to the region's high humidity and heat during these months. These seasonal patterns align with observations from other regions and countries (*9–11*). The mortality rate in our cohort was 10.6%, with all fatalities resulting from acute liver injury. This mortality rate falls between those reported in Yunnan (23.5%) and other Chinese provincial-level administrative divisions including Zhejiang (6.8%), Jiangxi (4.1%), and Guizhou (1.8%) during comparable periods (*9,12–14*). Internationally, our findings are consistent with a 12.0% mortality rate in Iran, where all deaths were similarly linked to liver encephalopathy (*10*), and a 23.0% mortality rate among delayed liver failure patients in India, underscoring the detrimental impact of prolonged latency periods and delayed medical intervention (*11*). In Turkey, mortality rates were 6.8% for self-harvested and 15.2% for purchased wild mushrooms, with a 9.9% mortality and complication rate among gastrointestinal cases (*15*). These studies collectively highlight the negative impact of prolonged latency periods, mushroom source, and timing of initial interventions on patient outcomes. The liver-related mortality pattern in our cohort mirrors findings from Iran and India, reinforcing the severe hepatotoxicity of species such as *A. rimosa*. Previous research has also emphasized the importance of thorough clinical consultation and detailed patient histories in poisoning assessment, which are integral components of the HOPE6 and TALK evaluation frameworks (*15*).

Latency period emerged as a critical survival factor in our cohort, with patients experiencing symptoms after six hours showing significantly higher risk of fatal poisoning (*2*). Patients with acute liver injury exhibited the longest latency periods [M=10.0, Interquartile range (IQR): 7.0, 10.0] and highest mortality rates, followed by those with acute kidney injury (M=7.0, IQR: 4.0, 9.5), with both groups reporting 100% fatal poisoning. In contrast, patients with gastroenteritis (M=1.8, IQR: 0.6, 3.0) and psycho-neurological disorders (M=2.0, IQR: 1.0, 7.5) demonstrated shorter latency periods and substantially lower fatality rates (1.43% and 45.45%, respectively). Early gastric lavage was associated with improved survival, being performed in 82.86% of gastroenteritis cases and 63.64% of psycho-neurological cases. Blood purification therapy resulted in 100% survival among kidney injury patients.

Additionally, our study reveals that certain mushroom species can induce multiple types of complications. For instance, *Boletus* species triggered either gastroenteritis or psycho-neurological disorders. This highlights the complexity of mushroom poisoning cases and underscores the importance of multidisciplinary consultation based on poisoning type. Our analysis preliminarily determined mushroom types through assessment of latency period and symptomatology, which guided treatment strategies alongside morphological and molecular identification methods supported by the Institute of Microbiology Guangdong Academy of Sciences. This decision-

making process aligned with the HOPE6 and TALK frameworks. Therefore, in mushroom poisoning diagnosis, HOPE6 and TALK standardized the process of clinical consultation, mushroom identification, and treatment strategy formulation. We recommend broader adoption of this system by hospitals and institutions, especially those with limited resources for mushroom identification support.

This study has several limitations. First, the retrospective design inherently carries risks of data accuracy and selection bias. Reliance on existing medical records means data may be inconsistently recorded or subject to documentation errors. For instance, HOPE6 and TALK scores were manually recorded by physicians upon patient admission, potentially introducing variability due to differences in record-keeping practices. Moreover, undocumented confounding factors, such as undiagnosed or pre-existing chronic conditions, may have influenced patient outcomes and prognostic assessments. Second, although the study spans 7 years, the sample size of 112 patients remains relatively small, limiting statistical power. Additionally, as data were collected from a single hospital in Guangzhou, the findings may not be generalizable to other regions. Selection bias also exists as patients presenting to our hospital may not reflect the broader population affected by mushroom poisoning.

Mushroom poisoning presents significant challenges in early diagnosis and treatment, particularly when the ingested mushroom species is unknown or identified late. This study implemented the HOPE6 and TALK Chinese clinical assessment protocols to identify mushroom poisoning types, demonstrating their potential to enhance multidisciplinary diagnostic processes. Future research should focus on prospective, multi-center collaborations to expand sample sizes, validate these scoring systems, and improve diagnostic accuracy. Strengthening collaboration across hospitals, toxicology centers, and CDC will be essential for integrating clinical and environmental data, ultimately improving national preparedness and outcomes in mushroom poisoning management.

Conflicts of interest: No conflicts of interest.

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SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Initial assessment of HOPE6.

Observation	Description	Scores
Medical history (H)	A clear history of mushroom consumption	1
Organ damage (O)	Vital signs are unstable, or there is damage to one or more organ functions, such as liver, kidney, or coagulation.	1
Picture Identification (P)	Physical or picture comparison, identifies the lethal species of mushroom	1
Eruption of symptoms >6 hours (E6)	Period between mushroom ingestion and symptoms occurrence is greater than 6 hours	1

SUPPLEMENTARY TABLE S2. Reassessment of TALK.

Observation	Description	Scores
Toxicant identification (T)	Toxicology testing confirms the presence of lethal toxins, such as amatoxins.	1
APTT extension (A)	Coagulation disorders are present, particularly with prolonged APTT, PT, and TT.	1
Liver dysfunction (L)	Liver dysfunction is present, such as AST, ALT increased, PTA decreased	1
Kidney dysfunction (K)	Levels of Creatinine and Urea nitrogen progressively increased	1

Note: Fatal mushroom poisoning should be considered under the following conditions:
1) HOPE6 score ≥2.
2) HOPE6 score <2, but subsequent reassessment TALK score ≥1.
3) Mushroom samples identified in the laboratory as lethal species, or lethal toxins such as amatoxins detected in the submitted samples.
Abbreviation: APTT=Activated Partial Thromboplastin Time; PT=Prothrombin time (s); TT=Thrombin time (s); AST=Aspartate Aminotransferase (U/L); ALT=Alanine Aminotransferase (U/L); PTA=Prothrombin Time Activity.

SUPPLEMENTARY TABLE S3. Clinical grading of amanita mushroom poisoning severity (CGAMPS).

Clinical grading	GIT	ALT	Serum Bilirubin (μmol/l)	PT	MODS	Risk level
Ⅰ	+	Normal	Normal	Normal	-	Low
Ⅱ	+	Abnormal and <500 U/L	Normal or increased <34	Normal or prolonged <6 S	-	Moderate
Ⅲ	+	>500 U/L	Constantly increased	Prolonged >6 S	±	Severe
Ⅳ	+	Rapidly increased or occurred enzyme-bile decoupling	Rapid increased	Prolonged >6 S	+	Most Severe

Abbreviations: ALT=Alanine Aminotransferase; PT=Prothrombin Time; MODS=Multiple Organ Dysfunction Syndrome; S=Second.

Perspectives

Food Education for Infants and Young Children Aged 0–3 Years in China

Qiong Wu[1,&]; Shimiao Gong[2,&]; Xuening Li[1]; Chen Zhao[2]; Lin Li[2]; Yiwen Huang[3,#]; Yanfeng Zhang[1,#]

ABSTRACT

The concept of Food Education (食育, Shiokuiku), first proposed by Japanese researcher Sagen Ishizuka in 1861, has evolved globally over the years, encompassing food knowledge, healthy dietary behaviors, food preparation, and food safety. Professor Li Lite introduced this concept to China in 2006. This article specifically addresses food education for infants and young children.

In 2022, the National Health Commission of China issued Guidelines on Feeding and Nutrition of Infants and Young Children in Nursery Institutions. These guidelines delineate the scope of Food Education for infants and young children as encompassing food cognition, eating behaviors, and dietary culture.

Early childhood represents a critical period for establishing food preferences and dietary habits. Food education plays a pivotal role in familiarizing infants and young children with new foods and promoting healthy eating patterns. Without structured food education, young children are more susceptible to developing food neophobia and other unhealthy eating habits.

We propose strategies to enhance Food Education for infants and young children in China by establishing a comprehensive food education system that leverages multiple channels including families, nursery institutions, early childhood education institutions, and healthcare facilities. Additionally, we emphasize the need for targeted research on food education specifically designed for this age group.

The term Food Education (食育, Shiokuiku) was first proposed by Japanese researcher Sagen Ishizuka in 1861, who posited that "physical and intellectual education, as well as education in particular skills, all stem from food education" (*1*). By the late 1990s, Japan had developed a mature theoretical framework and practice of food education, culminating in the 2005 promulgation of the "Basic Law on Shiokuiku." This legislation aimed to foster gratitude and understanding of food through comprehensive education encompassing food production, circulation, consumption, nutritional knowledge, food safety, and the promotion of healthy food culture (*2*). Throughout American and European countries, food education has been systematically integrated into primary and secondary education systems, cultivating children's understanding of food sources, preparation techniques, and healthy dietary decision-making. In 2006, Professor Li Lite from China Agricultural University introduced the concept of "food education" to China (*3*), defining it as "the cultivation of good dietary habits." More broadly, food education encompasses all food-based educational initiatives, including aspects of nutrition, food safety, dietary habits, and the preservation of food culture.

Scope of Food Education for Infants and Young Children Aged 0–3 Years

The first 1,000 days of life represent a critical developmental period during which appropriate feeding and nutrition are fundamental to infant and young child development. In 2022, the National Health Commission of China issued the Guidelines on Feeding and Nutrition of Infants and Young Children in Nursery Institutions, mandating that these institutions provide age-appropriate feeding practices aligned with children's physiological characteristics and nutritional requirements, while simultaneously implementing food education programs (*4*). These guidelines delineate three core components of food education for infants and young children: Food Cognition, Eating Behavior, and Dietary Culture (*4*). Food Cognition involves sensory exploration and learning about food through the five senses, participation in planting activities, and food preparation experiences, enabling children to understand fundamental food properties such as type,

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color, texture, and taste while stimulating their interest in food. Eating Behavior focuses on cultivating positive dietary habits including regular meal patterns, mindful eating, self-feeding skills, and appropriate snack selection. Dietary Culture encompasses dining etiquette and fosters attitudes of appreciation and gratitude toward food.

Importance of Food Education for Infants and Young Children

Early childhood represents a critical period for establishing food preferences and dietary habits, which significantly influence children's growth, general health, and developmental trajectories with effects that persist into adulthood. The period between 6 and 23 months is particularly crucial because it is when complementary foods are introduced, providing essential opportunities for infants to encounter and learn about new foods (*5*). Implementing structured food education during this developmental window not only facilitates infants' and young children's gradual acceptance of diverse foods, but also promotes the development of taste discrimination, chewing capacity, swallowing coordination, and digestive function (*6*), ultimately fostering lifelong healthy eating patterns.

Currently, food education initiatives in China predominantly target kindergartens and primary schools, with minimal attention directed toward children under the age of 3 resulting in concerning patterns of unhealthy eating behaviors among this vulnerable population. Recent national surveillance data revealed that 39.4% of Chinese children aged 6–23 months failed to meet minimum dietary diversity requirements, while 51.7% consumed sweet beverages and 31.2% consumed unhealthy foods (*7*). Furthermore, more than one-third of children aged 12–36 months across 10 Chinese cities exhibited more selective eating behaviors, which have been associated with increased risks of underweight status and compromised growth trajectories, or conversely, overweight status (*8*). Additionally, high food neophobia — characterized by a reluctance to try unfamiliar foods — was observed in 25.1% of children aged 12–36 months in Hunan Province. Food neophobia not only restricts an individual's food choices, but also diminishes overall food intake (*9*). Previous research has demonstrated that educational interventions utilizing storybooks and sensory play can effectively reduce food neophobia and increase consumption of unfamiliar vegetables among preschool children (*10*–*11*).

Therefore, implementing comprehensive food education programs for children aged 0–3 years represents an urgent public health priority. Such initiatives would not only foster healthy eating habits during this formative period, but also enhance early food cognition and establish foundations for lifelong healthy dietary practices.

Multi-channel Strategies to Improve Food Education for Infants and Young Children in China

The enrollment rate for children aged 0–3 years in nursery institutions was reported to be only 7.98% in China by the end of 2023 (*12*), indicating that the majority of infants and young children under 3 years old are cared for at home. Consequently, families serve as the primary environment for early food learning and should function as the principal setting for implementing food education. During the first years of life, children do not make independent food choices; therefore, parents bear the responsibility for providing appropriate nutrition. Parents should introduce a diverse array of healthy and nutritious foods at developmentally appropriate times, in suitable frequencies, textures, and quantities, facilitating the establishment of taste preferences and promoting children's cognitive understanding of different foods. Moreover, children learn about food through observation and imitation, making it necessary for parents to model positive eating behaviors. As children develop, parents can engage them in simple food preparation activities, such as washing vegetables or setting the table, which simultaneously cultivates table manners. Additionally, parents can enhance children's understanding of dietary culture by introducing seasonal and festival-related foods, thereby stimulating curiosity about healthy nutrition and fostering a sense of responsibility and ownership toward healthy dietary practices.

China places significant emphasis on nursery development, and an increasing number of infants and young children will attend nursery institutions in the future. Therefore, nursery institutions should become integral venues for implementing comprehensive food education. These institutions should incorporate structured food education programs into daily activities and teach children about healthy diets, food origins, and fundamental nutrition concepts through experiential, hands-on learning approaches. First, nurseries should provide balanced, age-appropriate, and diverse meals. Second, staff should receive

specialized training in food education, including understanding the nutritional requirements of infants and young children, learning how to foster positive dietary behaviors during mealtimes, and implementing responsive feeding practices. Third, they should maintain regular communication with families regarding children's eating habits and provide evidence-based recommendations to reinforce healthy eating practices at home. Additionally, establishing small garden areas where children can cultivate fruits, vegetables, or herbs provides invaluable experiential learning opportunities. This approach enhances children's understanding of food origins and strengthens their connection to healthy eating practices.

Early childhood education institutions should serve as additional venues for food education and support families in implementing comprehensive food education practices. These institutions should organize specialized courses for caregivers to facilitate the integration of food education into daily routines, enhancing their understanding of its significance and providing practical strategies for conducting age-appropriate food education activities with infants and young children at home. They should also develop and implement food education programs specifically designed for infants and young children, with the explicit aims of enhancing children's food cognition, improving their eating behaviors, and deepening their understanding of dietary culture.

Health care institutions, as professional entities, should regularly provide expert consultations to parents and nurseries regarding infant and young child feeding and food education, addressing common concerns such as selective eating, food allergies, and developmental growth requirements. Children's growth trajectories and eating patterns should be systematically monitored through regular health check-ups, with personalized recommendations provided to parents to optimize or modify their children's feeding practices and eating behaviors.

Enhancing food education for infants and young children necessitates coordinated efforts across families, nurseries, early childhood education institutions, and health care facilities. Unlike feeding and nutrition, research on food education for children under 3 years old remains scarce, and systematic, standardized food education curricula or programs are currently unavailable. Therefore, rigorous research should be conducted to develop evidence-based, developmentally appropriate, and effective programs that align with and implement the guidelines of the National Health Commission.

Conflicts of interest: No conflicts of interest.

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Methods and Applications

The iCARE-DM Model for Five-Year T2DM Risk Prediction in the Elderly Population from Chinese Routine Public Health Services — China, 2017–2024

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ABSTRACT

Introduction: Risk assessment for high-risk populations is critical for preventing Type 2 Diabetes Mellitus (T2DM). Although China's public health services have continuously contributed to early grass-roots diagnosis of diabetes for years, universally applicable tools for identifying latent high-risk elderly populations urgently need to account for heterogeneity, robustness, and generalizability. Therefore, this study developed and validated the integrated Chinese Adapted Risk Evaluation for Diabetes Mellitus (iCARE-DM) model for elderly Chinese individuals.

Methods: The iCARE-DM model was developed based on pooled effect estimates from a meta-analysis of cohort studies that identified T2DM risk factors in East Asian populations and validated in three multicenter Chinese populations. Predictive performance was evaluated using area under the curve (AUC), sensitivity, specificity, accuracy, log-rank tests, and compared with the guideline-recommended model (i.e., New Chinese Diabetes Risk Score, NCDRS) as well as four machine learning (ML) models.

Results: The iCARE-DM model achieved AUC values of 0.741, 0.783, and 0.766, outperforming the NCDRS model by at least 12%. Although the best-performing ML model achieved AUC values comparable to the iCARE-DM model, its performance varied significantly across populations (with a range as high as 9%). Subgroup analyses of the iCARE-DM model confirmed consistent performance across age, gender and rural-urban groups.

Conclusion: The iCARE-DM model demonstrated higher accuracy than the NCDRS model and exhibited superior robustness and generalizability compared to the ML models. The iCARE-DM model provides a robust, culturally adapted tool for T2DM risk assessment in elderly Chinese individuals.

The primary objective of basic public health services is to enhance population health by preventing and controlling chronic diseases through risk factor management. In China, the national program provides free health examinations for individuals aged 65 and above and those with chronic conditions such as diabetes and hypertension, with 120 million elderly people aged 65 and above receiving health management services in 2021 (*1*). However, considering that the prevalence of diabetes among the elderly in China exceeded 30% in 2017 (*2*), and the diabetes incidence per 1,000 person-years among the 60–69 years-old was greater than 6 (*3*), much greater attention should be directed toward health management and early-stage intervention for the entire elderly population (*4*). A document jointly issued by the National Health Commission and eight other departments emphasized the importance of implementing national basic public health service projects and strengthening health management for the elderly, including assessments, examinations, and health guidance (*5*). Therefore, effective diabetes management should be extended to high-risk populations, necessitating an efficient, user-friendly diabetes risk assessment tool to help implement community-level interventions for elderly individuals and healthcare workers.

In recent years, numerous risk prediction models have been developed for diabetes risk assessment. For example, the 2020 Chinese Guidelines for Type 2 Diabetes Prevention and Treatment recommend a screening model (*2*) based on epidemiological data from 14 Chinese provinces and cities collected between 2007 and 2008 (*6*). This model, known as the New Chinese Diabetes Risk Score (NCDRS), demonstrated an area under the curve (AUC) of 0.748 in its initial validation. However, like many other similar models

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(*7*), it was limited by unverified applicability to elderly populations (*8*). As noted in our previous research on the global population, even the simplest logistic model identified risk factors for Type 2 Diabetes Mellitus (T2DM) in the Chinese population, which helped improve predictive performance (*9*), highlighting the potential for developing a T2DM prediction model tailored to elderly Chinese individuals. Therefore, this study aimed to further construct a model based on a combination of evidence-based and empirical approaches, and conduct in-depth comparisons across broader populations.

According to the aim of this study, we developed and validated the integrated Chinese Adapted Risk Evaluation for Diabetes Mellitus (iCARE-DM) model for elderly Chinese individuals. This model was first constructed based on the pooled effect estimates from a meta-analysis of cohort studies that identified T2DM risk factors in East Asian populations, followed by validations for generalizability and robustness using three Chinese datasets with regional and economic disparities, and was compared with the NCDRS model and four machine learning (ML) models. Finally, we also provide a discussion on how to offer a practical tool for community healthcare practitioners to identify high-risk populations and inform evidence-based T2DM prevention strategies.

METHODS

Screening of Risk Factors Based on Meta-Analysis

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (*10*–*11*), with the protocol registered on PROSPERO (CED42023490828). We conducted a comprehensive search of peer-reviewed literature databases — CNKI, WanFang Data, VIP, SinoMed, PubMed (Medline), EMBASE, Web of Science, and the Cochrane Library — using a comprehensive set of search terms (see https://github.com/791115271/iCARE-DM-Model-Supplementary-File.git for more details). The review focused on studies reporting risk factors for T2DM published from 1964 to 2024. Study quality was assessed using the Ottawa Scale (*12*), and only studies with medium or higher quality ratings were included. We selected either random effects or fixed effects models based on heterogeneity assessment. For risk factors with effect size β reported in at least four studies, we performed meta-analysis to identify statistically significant (P<0.05) risk factors.

Model Construction

The iCARE-DM model The iCARE-DM model is a 5-year diabetes risk prediction scoring model developed based on the Framingham Heart Study methodology (*13*). The model determines regression coefficients for each risk factor through meta-analysis and assigns scores based on the corresponding β coefficients to estimate diabetes risk. The detailed steps for constructing the risk scoring model are provided (see https://github.com/791115271/iCARE-DM-Model-Supplementary-File.git for more details).

T2DM prediction model based on ML This study employed four classic ML algorithms as benchmarks to compare with our proposed iCARE-DM model: Logistic Regression (LR), Support Vector Machines (SVM), eXtreme Gradient Boosting (XGBoost), and Random Forest (RF). These algorithms were used to establish predictive models for T2DM in the Hongguang population. Four resampling techniques were also implemented to improve model performance. Subsequently, external validation was conducted using both the Bao'an and Kailuan populations. Detailed information regarding these methods is provided in Supplementary File C.

Multicenter External Validation

The iCARE-DM model was externally validated in three Chinese populations (Kailuan, Hongguang, and Bao'an). Hongguang is an urban-rural integrated community in Chengdu with a balanced demographic structure and a large elderly population. The Bao'an population, from the economically advanced Shenzhen region, had access to high-quality healthcare. The Kailuan population, comprising active and retired employees from a major coal mining enterprise in Tangshan, provided comprehensive baseline and follow-up data on demographics, lifestyle, medical history, and laboratory measures, as documented in prior studies (*14*–*15*).

These populations all shared characteristics of large size, high participation rates, and strong follow-up continuity, allowing for validation of the risk scoring model across diverse geographical locations, economic conditions, and other factors. The Supplementary Material documents the introduction, inclusion and exclusion criteria, data collection, and definitions for the three populations.

Statistical Analysis

Baseline differences between the T2DM onset and non-onset groups were assessed using the Wilcoxon rank-sum test for continuous variables and the chi-squared test for categorical variables. Subgroup analyses by age and gender were conducted to assess model performance across different demographics. Statistical analyses were performed using R software (version 4.2.1, R Foundation for Statistical Computing, Vienna, Austria), with a two-tailed $P<0.05$ considered statistically significant. Model performance was evaluated via Receiver Operating Characteristic curves (ROC), AUC, accuracy (ACC), sensitivity (SEN), specificity (SPE), C-index, and the Hosmer–Lemeshow test. Kaplan−Meier curves were used to assess risk stratification.

RESULTS

Screening of Risk Factors Based on Meta-Analysis

Our literature search identified 6,757 articles, of which 4,530 remained after removing duplicates. We excluded 4,218 articles that were reviews, conference abstracts, studies on diabetic complications, or literature that did not match our study criteria. After full-text screening of 312 records, we ultimately included 70 reports from 80 articles in the meta-analysis. A PRISMA flowchart detailing the selection process is shown in https://github.com/791115271/iCARE-DM-Model-Supplementary-File.git.

The risk factors identified through meta-analysis included gender, age, smoking, central obesity, exercise, BMI, WHtR, hypertension, fatty liver, family history of diabetes, FBG, TG, TYG, HDL-C, and uric acid level. The effect values and corresponding references are presented in Table 1. Detailed information about the literature included in the meta-analysis and the references for each risk factor are provided in https://github.com/791115271/iCARE-DM-Model-Supplementary-File.git.

The Risk Score of iCARE-DM Model

The risk score for each factor was calculated based on the β coefficient obtained from the meta-analysis, with a total maximum score of 54. The risk factors and their corresponding point values are presented in Table 1.

Performance Evaluation and Validation of the ML Model

The LR model built with SMOTE oversampling achieved the highest AUC (0.777) in the Hongguang population. In external validation cohorts (Kailuan and Bao'an), the AUC values were 0.735 and 0.686, respectively. Detailed results for all model combinations are presented in Table 2.

Performance Evaluation and Validation of the iCARE-DM Model

Multicenter external validation After developing the iCARE-DM model, we comprehensively validated its performance across three external populations. Baseline characteristics of these populations are presented in https://github.com/791115271/iCARE-DM-Model-Supplementary-File.git. Preliminary validation revealed an optimal risk score cutoff value of 22.5 with an AUC of 0.741. Using available data from both Hongguang and Bao'an populations, we compared the performance of the iCARE-DM model with the NCDRS model using the C-index and Hosmer–Lemeshow test. The iCARE-DM model demonstrated optimal cutoff values of 24.5 (AUC: 0.783) and 25.5 (AUC: 0.766) in Hongguang and Bao'an populations, respectively, as detailed in Table 3. Risk stratification based on these cutoffs classified populations into low- and high-risk groups, with Kaplan−Meier curves presented in https://github.com/791115271/iCARE-DM-Model-Supplementary-File.git. In contrast, the NCDRS model showed lower performance, with optimal cutoff values of 35.5 (AUC: 0.660) and 33.5 (AUC: 0.606) in the Hongguang and Bao'an populations, respectively, as summarized in Table 3. These results underscore the superior predictive accuracy of the iCARE-DM model.

Subgroup analysis Subgroup analyses demonstrated consistent superiority of the iCARE-DM model over the existing NCDRS model across all populations. Notably, the iCARE-DM model showed 18.3% (0.787 *vs.* 0.665) and 26.7% (0.768 *vs.* 0.606) higher AUC values in the Hongguang and Bao'an populations, respectively, with the most significant improvement observed in subjects aged <75 years (21.5%–27.3% AUC improvement). The predictive advantage was particularly prominent in female participants (17.7%–26.3% AUC improvement). The urban-rural subgroup analysis demonstrated superior predictive accuracy of the iCARE-DM model compared to the NCDRS model in both populations,

TABLE 1. Summary characteristics of included studies and points of the iCARE-DM model.

Risk factor	Risk factor group	*RR* (95% *CI*)	I^2	*P*	β	Points
Gender	Female	1	−	−	−	0
	Male	1.288 (1.023, 1.622)	0.973	0.032	0.25	1
Age		1.042 (1.023, 1.061)	0.963	<0.001	0.04	
	60–69	/				1
	70–79	/				3
	≥80	/				5
Smoking	No	1	−	−	−	0
	Yes	1.433 (1.187, 1.73)	0.963	<0.001	0.36	2
Central obesity	No	1	−	−	−	0
	Yes	1.666 (1.132, 2.45)	0.967	<0.001	0.51	3
Exercise	Yes	1	−	−	−	0
	No	1.233 (1.032, 1.475)	0.927	0.021	0.21	1
BMI (kg/m^2)	<18.5	1	−	−	−	−2
	18.5–23.9	0.673 (0.602, 0.752)	0.231	<0.001	−0.40	0
	24.0–27.9	1.74 (1.417, 2.137)	0.936	<0.001	0.55	3
	≥28	2.492 (1.87, 3.32)	0.940	<0.001	0.91	5
WHtR	≤0.5	1	−	−	−	0
	>0.5	2.509 (1.649, 3.817)	0.899	<0.001	0.92	5
Hypertension	No	1	−	−	−	0
	Yes	1.379 (1.121, 1.697)	0.976	0.002	0.32	2
Fatty liver	No	1	−	−	−	0
	Yes	2.427 (1.753, 3.359)	0.939	<0.001	0.89	4
Family history of diabetes	No	1	−	−	−	0
	Yes	1.621 (1.514, 1.737)	0.498	<0.002	0.48	2
FBG (mg/dL)	<100	1	−	−	−	0
	100–110	3.637 (2.405, 5.501)	0.979	<0.003	1.29	6
	>110	11.767 (8.28, 16.722)	0.970	<0.004	2.47	12
Low HDL−C	No	1	−	−	−	0
	Yes	1.128 (1.05, 1.213)	0.010	0.001	0.12	1
TG (mmol/L)	<1.7	1	−	−	−	0
	≥1.7	1.783 (1.451, 2.191)	0.883	<0.001	0.58	3
High Uric Acid	No	1	−	−	−	0
	Yes	1.203 (1.066, 1.358)	0.640	0.003	0.18	1
TYG	<8.25	1	−	−	−	0
	8.25–8.6	1.73 (1.245, 2.406)	0.614	0.001	0.55	3
	8.6–9.0	2.426 (2.027, 2.904)	0.409	<0.001	0.89	4
	≥9.0	3.993 (2.971, 5.368)	0.557	<0.001	1.38	7

Note: "−" means the reference group in this analysis. "/" means the *RR* was modeled as a continuous variable.
Abbreviation: *RR*=risk ratio; *CI*=confidence interval; BMI=body mass index; WHtR=Waist-to-Height Ratio; FBG=Fasting Blood Glucose; HDL-C=High-Density Lipoprotein Cholesterol; TG=Triglycerides; TYG=Triglyceride-Glucose Index.

TABLE 2. The results of T2DM prediction models based on machine learning.

Resampling method	ML model	AUC			SEN			G-mean			ACC			SPE		
		Hong guang	Kailuan	Bao'an	Hong guang	Kailuan	Bao'an	Hong guang	Kailuan	Bao'an	Hong guang	Kailuan	Bao'an	Hong guang	Kailuan	Bao'an
ADASYN	LR	0.773	0.735	0.686	0.595	0.611	0.528	0.679	0.677	0.633	0.764	0.740	0.740	0.774	0.749	0.759
	SVM	0.636	0.518	0.513	0.244	0.068	0.000	0.474	0.257	0.000	0.881	0.919	0.917	0.920	0.978	1.000
	XGB	0.680	0.700	0.653	0.191	0.092	0.067	0.428	0.300	0.255	0.918	0.922	0.892	0.962	0.979	0.967
	RF	0.746	0.651	0.746	0.298	0.018	0.166	0.527	0.136	0.398	0.896	0.932	0.890	0.933	0.995	0.956
SMOTE	LR	0.777	0.735	0.686	0.557	0.611	0.528	0.662	0.677	0.633	0.774	0.740	0.740	0.787	0.749	0.759
	SVM	0.643	0.522	0.498	0.252	0.064	0.000	0.483	0.250	0.000	0.886	0.920	0.917	0.925	0.979	1.000
	XGB	0.706	0.702	0.621	0.206	0.084	0.271	0.446	0.288	0.466	0.923	0.925	0.757	0.967	0.983	0.802
	RF	0.750	0.651	0.734	0.122	0.019	0.010	0.346	0.137	0.100	0.932	0.932	0.915	0.981	0.995	0.997
BLSMOTE	LR	0.769	0.735	0.686	0.511	0.611	0.528	0.661	0.677	0.633	0.834	0.740	0.740	0.853	0.749	0.759
	SVM	0.681	0.533	0.522	0.206	0.054	0.000	0.441	0.229	0.000	0.903	0.916	0.917	0.945	0.976	1.000
	XGB	0.729	0.600	0.556	0.206	0.093	0.012	0.445	0.299	0.108	0.918	0.905	0.900	0.962	0.961	0.981
	RF	0.760	0.675	0.737	0.115	0.010	0.004	0.336	0.099	0.061	0.938	0.934	0.916	0.988	0.998	0.999
DBSMOTE	LR	0.705	0.735	0.686	0.481	0.611	0.528	0.623	0.677	0.633	0.788	0.740	0.740	0.807	0.749	0.759
	SVM	0.592	0.513	0.509	0.214	0.032	0.000	0.449	0.177	0.000	0.900	0.929	0.917	0.941	0.991	1.000
	XGB	0.660	0.668	0.648	0.137	0.137	0.441	0.363	0.361	0.571	0.910	0.899	0.715	0.957	0.952	0.740
	RF	0.744	0.663	0.732	0.046	0.007	0.012	0.213	0.086	0.110	0.936	0.935	0.914	0.990	0.999	0.996

Abbreviation: AUC=Area Under the Receiver Operating Characteristic Curve; ACC=Accuracy; SEN=Sensitivity; SPE=Specificity; T2DM=Type 2 Diabetes Mellitus; SMOTE=Synthetic Minority Over-sampling Technique; BLSMOTE=Borderline-SMOTE; DBSMOTE=Density-Based SMOTE; LR=Logistic Regression; SVM=Support Vector Machine; XGB=eXtreme Gradient Boosting; RF=Random Forest.

with robust applicability across both urban and rural subpopulations (AUCs consistently exceeding 0.76). More details are presented in Table 3 and Figure 1.

DISCUSSION

This study identified 15 risk factors for T2DM through a meta-analysis of 70 findings. The identified risk factors included gender, age, smoking, central obesity, exercise, BMI, WHtR, hypertension, fatty liver, family history of diabetes mellitus, FBG, TG, TYG, low HDL-C, and uric acid level. Elevated FBG was assigned the highest risk score (score=12), as elevated FBG is a common early indicator of prediabetes or incipient diabetes (*16*).

Based on routinely available data, we developed the iCARE-DM model, a T2DM prediction model suitable for the elderly Chinese population. External validation of the iCARE-DM model in three independent populations yielded AUC values of 0.741, 0.783, and 0.766, demonstrating strong predictive accuracy. Comparative analysis with the NCDRS model revealed superior performance of our model, which can be attributed to its age-specific design (focused on individuals >50 years old) and the inclusion of additional risk factors (e.g., smoking, fatty liver, FBG, and TYG index). These inclusions reflect recent findings in T2DM risk research and increase the model's relevance to contemporary populations. For the LR model with ADASYN algorithm, the AUC (0.777) in the original population was comparable to that of the iCARE-DM model (0.783). However, an approximately 9% AUC difference was observed across validation datasets. For example, the LR model achieved an AUC of 0.777 in the original test dataset, while its AUC decreased to 0.686 in the Bao'an external validation dataset. This indicates that the generalizability and robustness of the ML model were inferior to those of the iCARE-DM model.

Subgroup analyses stratified by age and gender indicated that the meta-analysis model outperformed the NCDRS model across all subpopulations, including individuals aged <75 years and ≥75 years, as well as both male and female participants. These findings underscore the universal applicability of our model across diverse demographic groups.

The iCARE-DM model proposed in this study demonstrated significant practical utility through several key aspects: 1) The model identified 15 risk factors through high-quality cohort studies of East Asian populations, enhancing its representativeness. Comparative analyses with the NCDRS model

TABLE 3. The results of external validation and comparison results with NCDRS model.

Population	Subgroup	iCARE-DM model							NCDRS model						
		Cutoff	AUC (95% *CI*)	ACC (95% *CI*)	SEN (95% *CI*)	SPE (95% *CI*)	C-index	HL test	Cutoff	AUC (95% *CI*)	ACC (95% *CI*)	SEN (95% *CI*)	SPE (95% *CI*)	C-index	HL test
Kailuan	Entire Population	22.5	0.741 (0.734, 0.749)	0.700 (0.700, 0.700)	0.657 (0.643, 0.671)	0.703 (0.699, 0.706)	–	–	–	–	–	–	–	–	–
Hong guang	Entire Population	24.5	0.783 (0.760, 0.807)	0.761 (0.680, 0.853)	0.664 (0.553, 0.756)	0.767 (0.676, 0.871)	0.809 (0.785, 0.833)	0.241	35.5	0.660 (0.634, 0.686)	0.622 (0.503, 0.690)	0.634 (0.541, 0.793)	0.621 (0.487, 0.697)	0.670 (0.643, 0.697)	0.347
	50–74 years old	24.5	0.787 (0.761, 0.814)	0.767 (0.680, 0.873)	0.664 (0.541, 0.763)	0.773 (0.676, 0.892)	0.811 (0.784, 0.838)	0.047	35.5	0.665 (0.635, 0.694)	0.630 (0.512, 0.695)	0.649 (0.558, 0.778)	0.629 (0.499, 0.701)	0.673 (0.642, 0.704)	0.072
	≥75 years old	24.5	0.763 (0.712, 0.815)	0.737 (0.549, 0.841)	0.663 (0.522, 0.870)	0.742 (0.527, 0.862)	0.798 (0.750, 0.846)	0.905	33.5	0.640 (0.586, 0.693)	0.494 (0.332, 0.722)	0.750 (0.467, 0.924)	0.476 (0.292, 0.737)	0.659 (0.605, 0.713)	0.169
	Male	27.5	0.766 (0.732, 0.800)	0.820 (0.735, 0.866)	0.596 (0.513, 0.691)	0.834 (0.738, 0.885)	0.791 (0.757, 0.825)	0.012	36.5	0.642 (0.605, 0.678)	0.694 (0.488, 0.710)	0.530 (0.483, 0.757)	0.703 (0.473, 0.719)	0.649 (0.611, 0.687)	0.912
	Female	23.5	0.803 (0.771, 0.836)	0.767 (0.641, 0.836)	0.706 (0.627, 0.858)	0.771 (0.629, 0.848)	0.831 (0.798, 0.864)	0.675	35.5	0.682 (0.646, 0.718)	0.613 (0.438, 0.677)	0.681 (0.603, 0.877)	0.608 (0.411, 0.680)	0.696 (0.659, 0.733)	0.193
	Rural	25.5	0.787 (0.749, 0.824)	0.863 (0.577, 0.903)	0.564 (0.508, 0.873)	0.879 (0.563, 0.923)	0.815 (0.779, 0.851)	<0.05	36.5	0.650 (0.609, 0.690)	0.687 (0.517, 0.701)	0.569 (0.514, 0.762)	0.693 (0.507, 0.708)	0.654 (0.612, 0.696)	0.437
	Urban	24.5	0.778 (0.748, 0.809)	0.751 (0.660, 0.821)	0.684 (0.593, 0.787)	0.756 (0.652, 0.837)	0.806 (0.775, 0.837)	0.796	33.5	0.666 (0.633, 0.700)	0.504 (0.449, 0.688)	0.775 (0.557, 0.846)	0.485 (0.423, 0.695)	0.683 (0.648, 0.718)	0.296
Bao'an	Entire Population	25.5	0.766 (0.761, 0.771)	0.756 (0.753, 0.759)	0.654 (0.645, 0.667)	0.766 (0.762, 0.768)	0.781 (0.776, 0.786)	<0.05	33.5	0.606 (0.600, 0.612)	0.599 (0.475, 0.602)	0.547 (0.540, 0.699)	0.604 (0.455, 0.607)	0.618 (0.611, 0.625)	0.140
	50–74 years old	25.5	0.768 (0.763, 0.774)	0.761 (0.732, 0.763)	0.657 (0.647, 0.687)	0.770 (0.736, 0.773)	0.786 (0.781, 0.791)	<0.05	33.5	0.606 (0.599, 0.612)	0.601 (0.476, 0.604)	0.544 (0.536, 0.697)	0.607 (0.457, 0.609)	0.617 (0.610, 0.624)	0.120
	≥75 years old	26.5	0.755 (0.742, 0.767)	0.761 (0.755, 0.792)	0.628 (0.579, 0.654)	0.773 (0.767, 0.810)	0.749 (0.735, 0.763)	<0.05	32.5	0.622 (0.591, 0.652)	0.497 (0.344, 0.639)	0.722 (0.533, 0.874)	0.475 (0.290, 0.645)	0.628 (0.592, 0.664)	0.379
	Male	25.5	0.755 (0.748, 0.762)	0.739 (0.736, 0.772)	0.659 (0.611, 0.671)	0.747 (0.744, 0.786)	0.772 (0.765, 0.779)	<0.05	33.5	0.595 (0.586, 0.603)	0.548 (0.485, 0.636)	0.591 (0.479, 0.673)	0.544 (0.468, 0.650)	0.609 (0.600, 0.618)	0.533
	Female	25.5	0.777 (0.770, 0.784)	0.773 (0.741, 0.777)	0.654 (0.643, 0.699)	0.784 (0.746, 0.787)	0.791 (0.784, 0.798)	<0.05	31.5	0.617 (0.608, 0.625)	0.527 (0.523, 0.656)	0.653 (0.495, 0.668)	0.516 (0.511, 0.669)	0.630 (0.620, 0.640)	0.781
	Rural	25.5	0.773 (0.766, 0.780)	0.747 (0.743, 0.778)	0.679 (0.636, 0.693)	0.752 (0.749, 0.789)	0.781 (0.774, 0.788)	<0.05	31.5	0.612 (0.604, 0.621)	0.452 (0.449, 0.578)	0.731 (0.578, 0.744)	0.429 (0.426, 0.577)	0.617 (0.607, 0.627)	<0.05
	Urban	25.5	0.762 (0.755, 0.769)	0.768 (0.737, 0.771)	0.634 (0.621, 0.677)	0.781 (0.745, 0.785)	0.781 (0.774, 0.788)	<0.05	32.5	0.606 (0.597, 0.614)	0.572 (0.567, 0.632)	0.580 (0.500, 0.598)	0.572 (0.566, 0.644)	0.618 (0.608, 0.628)	0.709

Abbreviation: AUC=Area Under the Receiver Operating Characteristic Curve; ACC=Accuracy; SEN=Sensitivity; SPE=Specificity; HL test=Hosmer-Lemeshow test; NCDRS=New Chinese Diabetes Risk Score.

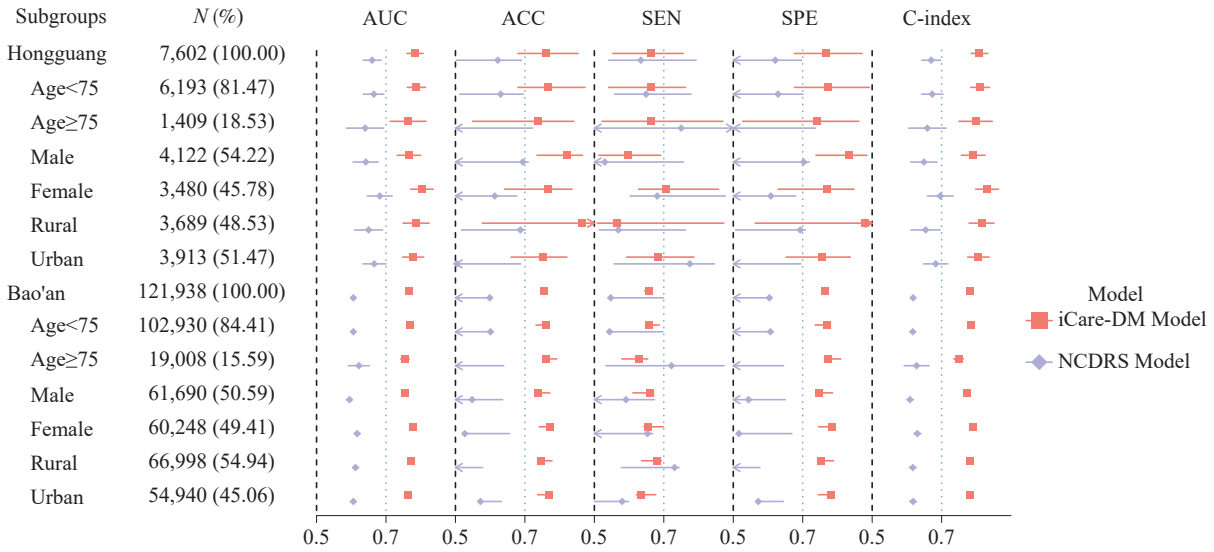


FIGURE 1. Forest plot for subgroup analysis.
Abbreviation: AUC=Area Under the Receiver Operating Characteristic Curve; ACC=Accuracy; SEN=Sensitivity; SPE=Specificity.

confirmed its superior predictive accuracy. External validation across three geographically and economically diverse Chinese populations (from southwestern, southeastern, and northern regions) further confirmed its robustness and efficacy in identifying high-risk populations; 2) Its variables aligned with those of routine Chinese public health data, ensuring accessibility and ease of use for grassroots healthcare workers and elderly individuals; 3) By synthesizing recent T2DM research, our study contributed to refining screening tools and updating guidelines for elderly populations; 4) The scoring scale supported targeted health recommendations, enabling personalized health programs. In summary, the iCARE-DM model offered high accuracy, robustness, variable accessibility, and practical applicability.

This study had several limitations. First, a comprehensive bias assessment could not be made in the meta-analysis due to the limited variability in study characteristics. However, all included studies underwent rigorous quality evaluation and were derived from large-scale East Asian populations, demonstrating minimal heterogeneity in genetic and demographic backgrounds. Secondly, the meta-analysis primarily incorporated studies targeting populations aged 35 years and above, rather than specifically focusing on elderly individuals. However, this limitation actually reflects the scarcity of current research on diabetes risk assessment dedicated to populations over 50 years, which conversely highlights the necessity of our study. More importantly, despite this limitation, the predictive model still maintained accuracy, robustness, and consistent performance across various subgroups, suggesting that the applicability of the iCARE-DM model can be guaranteed in practice. Thirdly, the iCARE-DM model did not propose an exact overall cutoff value for T2DM diagnosis since this was beyond the scope of our study. However, our findings revealed comparable threshold ranges across different populations, which provides a foundation for future diagnostic research. In summary, these limitations illuminate directions for future exploration, and more in-depth research is highly anticipated to improve precision health management of T2DM for elderly people in China and beyond.

Conflicts of interest: No conflicts of interest.

Ethical statement: All participants provided informed consent. The study was approved by the Ethics Committee of West China Fourth Hospital and West China School of Public Health, Sichuan University (Approval Number Gwll2024175); the Ethics Committee of School of Public Health, Sun Yat-Sen University (Approval Number 2022-091); and the Ethics Committee of Kailuan General Hospital (Approval Number: 2006-05).

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Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, March 2025

Diseases	Cases	Deaths
Plague	0	0
Cholera	0	0
SARS-CoV	0	0
Acquired immune deficiency syndrome[†]	4,852	1,709
Hepatitis	153,083	163
Hepatitis A	1,919	0
Hepatitis B	128,992	41
Hepatitis C	17,661	122
Hepatitis D	18	0
Hepatitis E	3,748	0
Other hepatitis	745	0
Poliomyelitis	0	0
Human infection with H5N1 virus	0	0
Measles	272	0
Epidemic hemorrhagic fever	229	0
Rabies	13	9
Japanese encephalitis	0	0
Dengue	38	0
Anthrax	13	0
Dysentery	2,036	0
Tuberculosis	59,479	239
Typhoid fever and paratyphoid fever	270	0
Meningococcal meningitis	17	1
Pertussis	4,186	0
Diphtheria	0	0
Neonatal tetanus	3	0
Scarlet fever	4,689	0
Brucellosis	5,575	0
Gonorrhea	8,367	0
Syphilis	55,907	6
Leptospirosis	2	0
Schistosomiasis	1	0
Malaria	213	1
Human infection with H7N9 virus	0	0
COVID-19	56,286	7
Monkey pox[§]	71	0
Influenza	354,842	1

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Continued

Diseases	Cases	Deaths
Mumps	6,652	0
Rubella	63	0
Acute hemorrhagic conjunctivitis	2,044	0
Leprosy	34	0
Typhus	33	0
Kala azar	26	0
Echinococcosis	445	0
Filariasis	0	0
Infectious diarrhea[¶]	239,224	1
Hand, foot and mouth disease	12,203	0
Total	971,168	2,137

* According to the National Bureau of Disease Control and Prevention.
† The number of deaths of Acquired immune deficiency syndrome (AIDS) is the number of all-cause deaths reported in the month by cumulative reported AIDS patients.
§ Since September 20, 2023, Monkey pox was included in the management of Class B infectious diseases.
¶ Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever.
The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the Chinese mainland are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan, China are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

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