

Vital Surveillances

Epidemiological Features of Foodborne Disease Outbreaks in Catering Service Facilities — China, 2010–2020

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ABSTRACT

Introduction: In terms of food preparation settings, catering service facilities have been identified as locations with the highest incidence of foodborne disease outbreaks in China. Since 2010, the China National Center for Food Safety Risk Assessment has established the Foodborne Disease Outbreak Surveillance System (FDOSS) to monitor foodborne disease outbreaks. Consequently, data from the FDOSS has provided a more accurate depiction of the epidemic characteristics of outbreaks within these facilities.

Methods: From 2010 to 2020, the FDOSS gathered data related to the prevalence of outbreaks, cases, hospitalizations, and deaths linked to foodborne disease outbreaks in catering service facilities. This study examined the temporal and geographical distribution, pathogenic factors, and contributing variables of these outbreaks over the course of the decade.

Results: From 2010 to 2020, China's catering service facilities reported 18,331 outbreaks, which resulted in 206,718 illnesses, 68,561 hospitalizations, and 201 deaths. The second and third quarters of the year accounted for 76.12% of the outbreaks and 72.93% of the cases. The primary pathogenic factors were pathogenic organisms, which caused 4,883 (26.64%) outbreaks, 94,047 (45.50%) cases, 32,170 (46.92%) hospitalizations, and 21 (10.45%) deaths. There were 5,607 (30.59%) outbreaks in restaurants, 2,876 (15.69%) outbreaks from street vendors, and 2,560 (13.97%) outbreaks in employee canteens in China.

Conclusions: The implementation of relevant control methods, including health education and promotion, is critical for addressing foodborne diseases in catering service facilities. Regular food safety training sessions for restaurant personnel and managers are essential to ensuring the effective management of these health risks.

Outbreaks of foodborne diseases are of global concern, posing significant impacts on both human health and the economy (1–2). In the USA, an estimated 9.4 million cases of foodborne disease caused by identified pathogens occur annually (3). One of the most prevalent locations for foodborne illness outbreaks is a catering service facility. The estimated cost of a single outbreak of foodborne illness in a restaurant may exceed 1 million US dollar (USD) (4). Research has shown that factors such as inadequate time-temperature control, insufficient kitchen hygiene, and the presence of disease carriers among food handlers in catering service facilities, including restaurants, contribute to foodborne illnesses (5). The primary cause of these outbreaks is often faulty operation. Increasing awareness of food hygiene, etiologies, and contributing factors of foodborne diseases can serve as a guide for preventing foodborne outbreaks (6–7).

The China National Center for Food Safety Risk Assessment established the Foodborne Disease Outbreak Surveillance System (FDOSS) to collect data on foodborne diseases. The CDCs at various levels throughout China are responsible for conducting on-site investigations during outbreaks and entering relevant data into the FDOSS. The purpose of this study is to analyze the epidemiological characteristics of foodborne disease outbreaks occurring in catering service facilities between 2010 and 2020 using data from the FDOSS.

METHODS

Between 2010 and 2020, data were gathered on all foodborne disease outbreaks involving two or more patients or at least one death, which occurred in catering service facilities within China, not including Xizang (Tibet) Autonomous Region. These outbreaks

were investigated and reported to FDOSS by local CDCs. The information collected included the timing and location of the outbreaks, the number of cases, hospitalizations, and fatalities, as well as the causes, pathogens, and food production environments involved.

Prior to inclusion in the FDOSS database, all outbreak incidents occurring in catering service establishments underwent rigorous auditing and verification by both the prefecture- and the provincial-level CDCs. Data processing and storage were performed using Microsoft Excel 2019 (Microsoft Corporation, Redmond, Washington, USA). For analysis purposes, dichotomous variables were summarized by counts and percentages, whereas continuous variables were represented by means.

RESULTS

The FDOSS reported a total of 18,331 outbreaks in catering service facilities in China between 2010 and 2020, which resulted in 206,718 cases, 68,561 hospitalizations, and 201 deaths. Among all foodborne outbreaks reported in the same period, these figures accounted for 50.87% of total outbreaks, 75.36% of total cases, 66.04% of total hospitalizations, and 13.65% of total deaths during this period. The median

number of patients per outbreak was 15, with a median of 3 hospitalizations per outbreak.

Temporal Distribution

The number of outbreaks and cases climbed rapidly from 2010 to 2018, with a peak of 3,610 outbreaks and 31,230 cases in 2018. The third quarter demonstrated the highest frequency of outbreaks and cases, while the combined second and third quarters represented 76.12% of annual outbreaks and 72.93% of annual cases (Figure 1).

Geographic Distribution

Pathogenic organisms were the primary cause of outbreaks in southern (55.11%), northwestern (26.51%), eastern (26.40%), central (22.78%), and northern regions of China (20.44%), while toxic animals, plants, and poisonous mushrooms were the leading causes of outbreaks in northeastern (22.49%) and southwestern regions (29.54%), respectively. Chemical-related incidents resulted in the highest number of fatalities in northeastern (87.50%), northwestern (58.33%), central (55.00%), and northern regions of China (30.00%), whereas toxic animals and plants were the leading cause of deaths in southern (47.06%) and eastern regions (29.03%). Poisonous mushrooms accounted for the highest fatality rates in the southwestern region (30.00%).

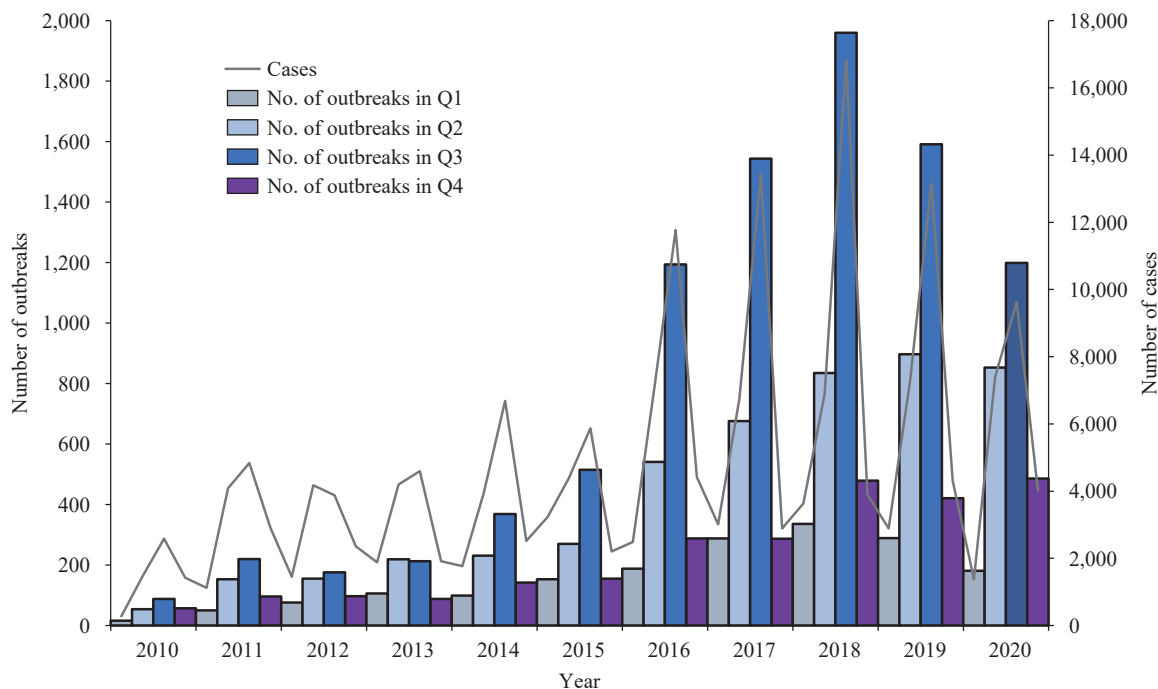


FIGURE 1. Number of reported foodborne disease outbreaks and cases in catering service facilities by quarters, China, 2010–2020.

Pathogenic Factors

The primary factors contributing to outbreak occurrences were pathogenic organisms, accounting for 4,883 (26.64%) outbreaks, 94,047 (45.50%) cases, 32,170 (46.92%) hospitalizations, and 21 (10.45%) deaths. Following this, toxic animals, plants, and mushrooms were responsible for 3,279 (17.89%) outbreaks, 30,698 (14.85%) cases, 12,338 (18.00%) hospitalizations, and 95 (47.26%) deaths (Table 1). Chemical substances, such as methanol and nitrite, caused the majority of fatalities (63). *Vibrio parahaemolyticus*, *Salmonella* spp. (species), and *Staphylococcus aureus* were the most prevalent pathogens, resulting in 3,333 outbreaks, 60,520 cases, 21,491 hospitalizations, and 9 deaths. The susceptibility of various food types to outbreaks was multifaceted, with meat products, aquatic goods, and vegetables associated with 2,724 (14.86%), 1,595 (8.70%), and 1,571 (8.55%) outbreaks, respectively, between 2010 and 2020.

Setting of Food Preparation

Catering service facilities encompass a range of establishments, including restaurants, street vendors, canteens, food stores, and rural banquets. Between 2010 and 2020, foodborne disease outbreaks in these facilities accounted for 5,607 (30.59%) incidents in restaurants, 2,876 (15.69%) in street vendors, and 2,560 (13.97%) in staff canteens (Figure 2). Among all

catering service facilities, rural banquets and street vendors were associated with the highest mortality rates, with 64 (31.84%) and 34 (16.92%) deaths, respectively.

A cross-tabulation analysis revealed that the leading causes of outbreaks in restaurants were incorrect processing (655), accidental ingestion (263), and cross-contamination (240). Conversely, the primary causes of outbreaks in street vendors were accidental ingestion (775), improper storage (250), and inadequate processing (227). Similarly, staff canteens experienced outbreaks mainly due to undercooking (737), accidental ingestion (369), and improper processing (191). The majority of deaths resulted from accidental ingestion (89) and improper processing (35).

Combinations of Factors

Using a multidimensional analysis approach, we identified outbreaks by determining pathogenic factors and associated food sources, comparing them with the corresponding settings, and selecting combinations responsible for more than 50 outbreaks. Our analysis revealed that aquatic products contaminated with *Vibrio parahaemolyticus* at restaurants (resulting in 342 outbreaks and 5,345 cases) and rural banquets (leading to 110 outbreaks and 2,062 cases), as well as bean poisoning caused by *Phaseolus vulgaris* in staff canteens (triggering 725 outbreaks and 9,739 cases), were the primary contributors to food-borne disease

TABLE 1. Foodborne disease outbreaks, cases, hospitalizations, and deaths by pathogenic factors in catering service facilities, China, 2010–2020.

Pathogenic Factor	Outbreak	Proportion (%)	Case	Proportion (%)	Hospitalization	Proportion (%)	Death	Proportion (%)
Pathogenic organism								
<i>Vibrio parahaemolyticus</i>	1,638	8.94	26,180	12.66	5,749	8.39	2	1.00
<i>Salmonella</i> spp.	1,118	6.10	25,248	12.21	12,027	17.54	5	2.49
<i>Staphylococcus aureus</i>	577	3.15	9,092	4.40	3,715	5.42	2	1.00
<i>Bacillus cereus</i>	347	1.89	7,432	3.60	2,585	3.77	1	0.50
<i>Escherichia coli</i>	308	1.68	6,842	3.31	2,468	3.60	1	0.50
Others	895	4.88	19,253	9.31	5,626	8.21	10	4.98
Toxic animals and plants	1,816	9.91	22,615	10.94	8,142	11.88	49	24.38
Poisonous mushrooms	1,463	7.98	8,083	3.91	4,196	6.12	46	22.89
Chemicals	616	3.36	7,564	3.66	5,076	7.40	63	31.34
Mycotoxin	5	0.03	103	0.05	46	0.07	1	0.50
Parasite	11	0.06	125	0.06	10	0.01	0	0.00
Other factors	1	0.01	2	0.00	0	0.00	0	0.00
Unknown reasons	9,536	52.02	74,179	35.88	18,921	27.60	21	10.45
Total	18,331	100.00	206,718	100.00	68,561	100.00	201	100.00

outbreaks in catering operations (Table 2).

CONCLUSIONS

Due to shifts in dietary patterns and the fast-paced nature of modern life, an increasing number of individuals have opted to dine at foodservice establishments in recent years. Consequently, these establishments have become the leading source of foodborne disease outbreaks in numerous regions. It

has been documented that a variety of food safety risks exist in foodservice facilities, such as restaurants, including those associated with food ingredients, handling practices, storage, and transportation. These risks may contribute to the occurrence of foodborne disease outbreaks. Moreover, the number of cases and hospitalizations associated with each outbreak at these facilities tends to surpass those resulting from household settings, ultimately leading to a more significant disease burden.

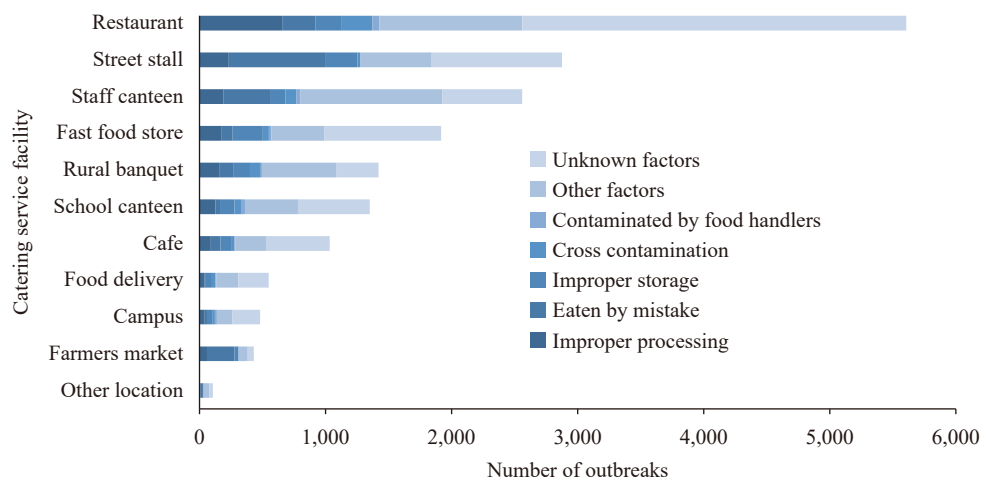


FIGURE 2. Reported foodborne disease outbreaks in catering service facilities by setting and causative factors in China, 2010–2020.

TABLE 2. Multidimensional analysis of settings, pathogenic factors, and food sources in foodborne disease outbreaks at catering service facilities in China, 2010–2020.

Settings	Pathogenic factor	Suspicious food	Outbreak	Case	Hospitalization	Death
Restaurant	<i>Vibrio parahaemolyticus</i>	Aquatic products	342	5,345	1,582	0
	Poisonous mushrooms	Mushrooms	175	1,107	550	0
	<i>Salmonella</i> spp.	Meat products	93	2,345	1,365	0
	Bean poisoning	<i>Phaseolus vulgaris</i>	87	718	231	0
Staff canteen	Bean poisoning	<i>Phaseolus vulgaris</i>	725	9,739	2,812	0
	Poisonous mushrooms	Mushrooms	249	1,783	899	15
Street vendor	Poisonous mushrooms	Mushrooms	622	2,322	1,118	10
	Bean poisoning	<i>Phaseolus vulgaris</i>	75	415	123	0
	Nitrite	Meat products	54	320	245	3
	<i>Salmonella</i> spp.	Egg foods	54	269	196	0
Farmers market	Poisonous mushrooms	Mushrooms	256	995	559	6
Rural banquet	<i>Vibrio parahaemolyticus</i>	Aquatic products	110	2,062	387	0
	<i>Salmonella</i> spp.	Meat products	101	3,603	2,482	2
	Poisonous mushrooms	Mushrooms	58	1,240	789	9
School canteen	Bean poisoning	<i>Phaseolus vulgaris</i>	73	1,931	712	0
	<i>Bacillus cereus</i>	Flour and rice products	51	1,489	751	0
Fast food store	<i>Salmonella</i> spp.	Cakes and pastries	58	1,035	525	0

In recent years, there has been a steady increase in the number of foodborne disease outbreaks and cases in catering service facilities due to the expansion of the reporting network. However, in 2020, there was a decrease in these incidents, with the primary pathogenic factor, *Vibrio parahaemolyticus*, dropping from first to second place, being replaced by *Salmonella* spp. This shift may be attributed to the impact of coronavirus disease 2019 (COVID-19) and its related prevention and control measures, which reduced the number of residents gathering and dining outside. Additionally, the decline in consumption of cold-chain transported aquatic products may have also played a role in this trend.

The peak of outbreaks and cases in catering service facilities occurred annually during the second and third quarters, aligning with the period of bacterial foodborne disease epidemics. This may be attributed to the increased temperature and humidity during this season, promoting bacterial growth and reproduction. *Vibrio parahaemolyticus*, *Salmonella* spp., and *Staphylococcus aureus*, the primary pathogens associated with outbreaks in food service facilities, also demonstrated increased activity during the summer and autumn. Concurrently, meat and aquatic products contaminated with bacteria were more prone to spoilage. The higher number of outbreaks and cases in eastern China may result from economic growth and a heightened focus on epidemiological investigations. Similar epidemiological characteristics have been observed in foodborne disease outbreaks in coastal regions (provinces, autonomous regions, and municipalities directly under the Central Government with coastline) (8–9). The findings suggest that targeted population education should be reinforced in catering service facilities in China.

Various pathogenic agents and food combinations, including *Vibrio parahaemolyticus*-contaminated aquatic products and *Salmonella*-contaminated meat items, have been found to be susceptible to causing outbreaks of foodborne illnesses in catering establishments. The primary causes of these outbreaks were related to food preparation management, such as improper processing, accidental consumption, and cross-contamination. Despite the presence of food safety management systems in many restaurants and cafeterias, their implementation was not always effective. To address this issue, it is recommended that the responsible departments enhance food safety management efforts among street vendors and rural banquets.

Accidental consumption of toxic mushrooms by Chinese families has been identified as a major cause of fatalities (10). Ingesting harmful chemicals, such as methanol and nitrite, along with poisonous mushrooms and improper food processing, contributed to most deaths in catering service facilities. This situation warrants the attention of authorities, as swift intervention could mitigate the related challenges.

Numerous interventions have demonstrated high effectiveness; thus, it is essential to implement control measures that integrate population science and management. Such measures include public health education on foodborne diseases in catering service facilities and regular food safety training for restaurant employees and managers. By mitigating cross-contamination and ensuring proper cooking and storage practices, the comprehensive implementation of exemplary sanitation procedures during food processing should decrease the incidence of foodborne disease outbreaks (11).

While there remain unidentified causes for numerous instances in the system, the data analyzed may not encompass all actual outbreaks. A thorough examination of high-risk factors necessitates an accurate attribution analysis, which relies on the collection of more specific information and samples throughout the investigation. Alternatively, the rapid detection technology of multi-pathogens, along with pulsed-field gel electrophoresis and whole-genome sequencing, could potentially enhance the laboratory diagnostic capabilities for outbreaks and provide confirmation for the results of epidemiological inquiries (12).

Acknowledgements: All members at all participating CDCs.

Conflicts of interest: No conflicts of interest.

Funding: Supported by the National Key Research and Development Program of China (Grant No. 2022YFC2602303).

doi: [10.46234/ccdcw2023.091](https://doi.org/10.46234/ccdcw2023.091)

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Submitted: March 21, 2023; Accepted: May 29, 2023

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