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Original Article

Foodborne illness outbreaks in China, 2000-2014

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Abstract: The Ministry of Health in China has been releasing statistical bulletins of foodborne illness outbreaks quarterly and annually on its website to keep foodborne illnesses under constant surveillance. In this study, we summarized reports concerning all foodborne illness outbreaks in China announced by the Ministry of Health during 2000-2014. Published reports from 2000 to 2014 were also included to explore the general characteristics and trends of outbreaks of China's foodborne illnesses. Results showed that the total incidence of foodborne illness outbreak has a downward trend and that outbreaks mainly occurred in April to September, clustered in the Yunnan, Sichuan, Guangdong, Guizhou, and Guangxi provinces. More than half of foodborne illness outbreaks were caused by bacteria, whereas poisonous animals and plants and chemicals accounted for approximately 80% of the reported deaths. The laws and regulations related to food safety in China were also presented.

Keywords: Foodborne illness, China, food safety, law, regulation

Introduction

Foodborne illness is an acute disease caused by ingestion of food that contains or is contaminated by toxic materials or infectious organisms. In China, tens of thousands of people suffer from foodborne illnesses, hundreds of which die each year [1]. The Chinese government has given particular attention to foodborne illnesses. These illness outbreaks are monitored in real time, recorded by the *National Public Health Emergency Network Reporting System*, and announced each quarter by the Ministry of Health (recombined and renamed as National Health and Family Planning Commission in 2014) since 2003 (Public health emergency countermeasure ordinance, http://www.nhfpc.gov.cn/yjb/s3580/200804/b41369aac27847dba3e6aebccc72e2f8.shtml). To explore the general characteristics and trends of China's foodborne illness, we summarized all reported outbreaks of foodborne illness in China that were announced officially and those published in literature from 2000 to 2014. In additon, the laws and regularities related to food safety in China were presented.

Methods

Data were obtained from two sources. The first source was the statistical bulletins of foodborne illness outbreaks released quarterly and annually on the official database of the National Health and Family Planning Commission of the People's Republic of China (http://www.nhfpc.gov.cn). The statistical bulletins are prepared by the national health authority based on the data from two reporting systems, namely, the *National Public Health Emergency Network Reporting System* and the *National Food Safety Risk Assessment Network Reporting System*, which are both affiliated with the National Center for Disease Control (CDC) and the National Food Safety Risk Assessment Center, respectively. The procedure is as follows: (1) the local medical institution submit reports to the local health authority whenever foodborne illness breaks out; (2) the local health authority requires local CDC to handle the outbreak; (3) local CDC reports the outbreak to the two reporting networks when the outbreak is defined as foodborne illness related; and (4) the national health sector makes the statistical bulletins based on the data from the two reporting networks (**Figure 1**). The second source was published articles. Two independent Chinese periodical database, namely, CNKI (http://oversea.cnki.net/kns55/default.aspx) and WANFANG (http://www.wanfangdata.com.cn/), were examined for published papers concerning outbreaks of foodborne illness in China during

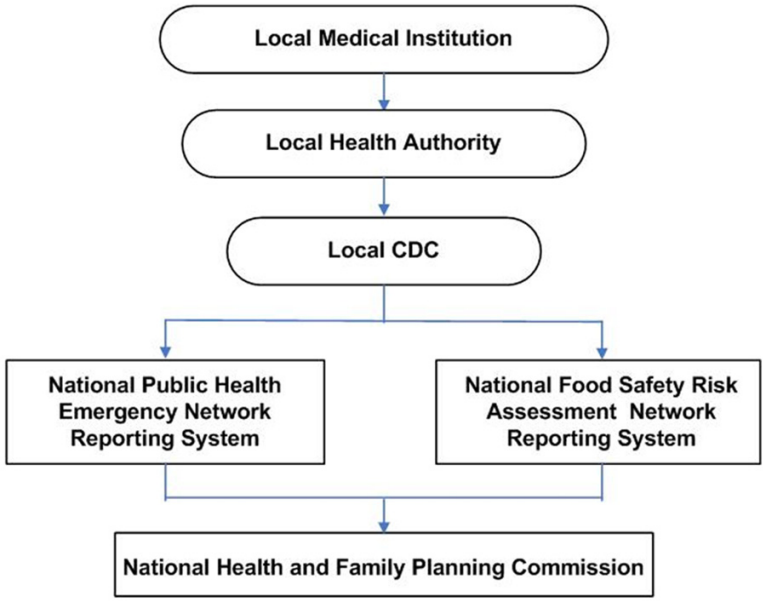

Figure 1. Schematic diagram of the workflow of the current food safety surveillance system in China. The workflow of the foodborne illness surveillance system in China is as follows: (1) Local medical institutions report to the local health authority whenever they identify a foodborne illness outbreak; (2) Local health authority requires local CDC to handle the outbreak; (3) Local CDC reports the outbreak to the two reporting networks, namely, the National Public Health Emergency Network Reporting System and National Food Safety Risk Assessment Network Reporting System, when the outbreak is related to foodborne illnesses; and (4) The National Health Instruction prepares statistical bulletins according to the data from the two reporting networks.

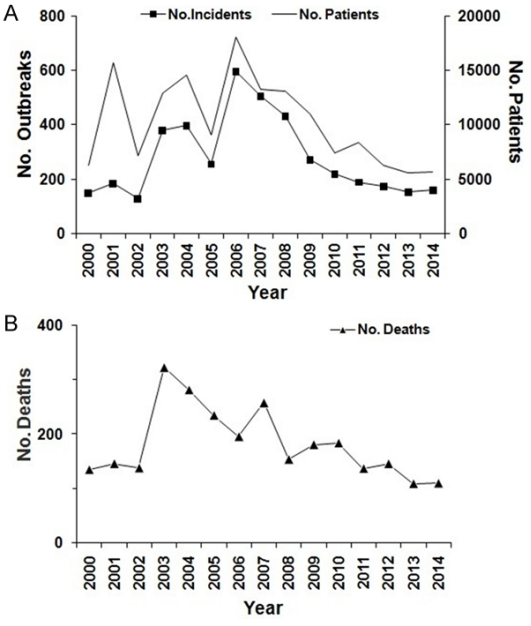

Figure 2. Trends of foodborne illness outbreaks in China, 2000-2014. A. Numbers of incidents and patients of foodborne illness outbreaks; B. Number of mortality of foodborne illness. In 2000-2014, the annual numbers of outbreaks, patients, and deaths in parallel peaked in 2003-2004 and 2006-2007.

2000-2014. Data were inputted into Excel and checked by two persons. Statistical analysis was performed using SPSS 17.0 software. Heterogeneity of incidence or mortality among different years, regions and pathogenies were assessed using chi-square test. $P<0.05$ was considered to be statistically significant. The collected data had two limitations. First, according to current foodborne illness reporting system, only a foodborne illness incident in accordance with specific requirements can be defined as an outbreak and be incorporated into the reporting system. There must be at least one death or thirty patients in one incident. Second, according to the existing classification criteria of foodborne disease, several important foodborne illnesses, such as viral foodborne illness, are relegated to infectious diseases and recorded in another disease reporting system, that is, the *National Notifiable Infectious Disease Reporting System*.

Results

Incidence and mortality

From 2000 to 2014, the total number of reported foodborne illness outbreaks, patients, and deaths were 4193, 154202, and 2734 respectively, and the average annual incidence and patients were 0.021 case/100,000 population and 0.779 case/100,000 population, respectively (The notification of national foodborne illness incidents report issued by Chinese Ministry of Health, http://www.nhfpc.gov.cn/zhuzhan/zcjd/201304/c6f67e05fc904865b14305bef626e2a0.shtml; http://www.nhfpc.gov.cn/zhuzhan/zcjd/201304/abbede83f3ac4a6384450f5442da0150.shtml; http://www.nhfpc.gov.cn/mohwsbwstjx xzx/s7967/201103/50819.shtml; http://www.nhfpc.gov.cn/mohwsbwstjxxzx/s7967/201202/54200.shtml; http://www.nhfpc.gov.cn/mohwsbwstjxxzx/s7967/201303/b70872682e614e418 9d0631-

Table 1. Seasonality distribution of foodborne illness in China, 2000-2014

Months	No. of outbreaks (%)	No. of patients (%)	No. of deaths (%)
Jan to Mar	552 (13.16)	14242 (9.22)	518 (18.34)
Apr to Jun	1192 (28.42)	43314 (28.03)	716 (25.35)
Jul to Sep	1590 (37.91)	64853 (41.97)	1091 (38.64)
Oct to Dec	860 (20.51)	32116 (20.78)	499 (17.67)

ae5527625.shtml; http://www.nhfpc.gov.cn/yjb/s3585/201402/f54f16a4156a460790caa3e991c0abd5.shtml; http://www.nhfpc.gov.cn/yjb/s3585/201502/91fa4b047e984d3a89c161 94722ee9f2.shtm), [2-6]. The annual number of reported outbreaks, patients, and deaths had two peaks in parallel, that is, in 2003-2004 and 2006-2007 (**Figure 2**). Since 2006, the number of reported foodborne illness outbreaks declined by 18.07% per year on average, from 596 in 2006 to 160 in 2014. The number of patients simultaneously decreased by 14.75% annually, from 18063 in 2006 to 5657 in 2014. The mortality rapidly decreased from 258 in 2007 to 154 in 2008 and was then maintained below 200 during the remaining five-year intervals.

Seasonality and geographic distribution

Within the 15-year study period, more than half of the reported foodborne illness outbreaks (4194, 68.96%) and deaths (2824, 66.58%) was clustered in April to September (second and third quarters), which were significantly higher than in the other months (χ^2=837.88, P<0.01) (**Table 1**). According to the national reporting data for 2003-2007 and Chu's study for 2008-2010 [7], we summarized the geographic distribution of reported foodborne illness during 2003-2010. Foodborne illness outbreaks predominantly occurred in Yunnan province (431), Sichuan province (289), Guangdong province (286), Guizhou province (217), and Guangxi province (196), which all accounted for 46.43% of the total number of outbreaks in China. More than 1/3 of patients (39577, 39.85%) were clustered in Yunnan province (12231), Sichuan province (10165), Hunan province (7049), Guangdong province (5690), and Hubei province (4442).

Bacteria-induced foodborne illness outbreaks

As shown in **Table 2**, during the 15-year study period (2000-2014), the leading cause of foodborne illness outbreak in China was bacteria, which accounted for 37.78% of all reported outbreaks and 6.18% of all reported patients. Previous epidemiologic studies have identified the species of pathogens that cause foodborne illness in the 2008-2010 period (**Table 3**) [7]. Of the 320 reported outbreaks of bacterial foodborne illness, *Vibrio parahaemolyticus* was implicated in 77 (24.06%), followed by *Salmonella* (70, 21.88%) and *Bacillus cereus* (54, 16.88%). In addition, *Clostridium botulinum* was the most toxic pathogenic bacterium with a fatality rate of up to 29.73%.

Chemical-induced foodborne illness outbreaks

Chemicals were the predominant cause of deaths related to foodborne illnesses before 2005, and remained relatively highly lethal during 2005-2010, and have again been the leading killer since 2011 (**Table 2**). Pesticides and raticides, nitrites, and medicinal liquor (a kind of traditional Chinese medicine which is made by soaking various medical materials into alcohol) were the most common chemicals involved in foodborne illnesses; such chemicals are responsible for 86.07% of all chemical foodborne illness incidents (**Table 3**).

Foodborne illnesses caused by poisonous animals, plants, and mushrooms

Poisonous animals and plants and mushrooms have continuously been the chief causes of foodborne illness during 2006-2010 and accounted for 64.73% of all foodborne illness deaths in 2007 (**Table 2**). A variety of animals and plants were implicated in foodborne illness incidents, including mushrooms, kidney beans, *Solanum tuberosum, Gelsemium elegans,* castor beans, and puffer fish. The toxicity of different types of poisonous animals and plants was assessed using data from the 2008-2010 period, with incidence and mortality as the evaluating indicators (The notification of national foodborne illness incidents report issued by Chinese Ministry of Health, http://www.nhfpc.gov.cn/yjb/s3585/201502/91fa4b047e984d3a89c16194722ee9f2.shtm), as shown in **Table 3**. Of the 296 reported foodborne illness outbreaks caused by poisonous animals and plants and mushrooms, 144 (48.65%) were attributed to poisonous mushrooms, which accounted for 22.84% of the overall case fatality, followed by *Phaseolus vulgaris* (76, 25.68%) and *China*

Table 2. Causes of foodborne illness outbreaks in China, 2000-2014

Year	Bacteria			Chemicals			Poisonous animals, plants, and mushrooms			Unidentified		
	No. of Outbreaks (%)	No. of Patients (%)	No. of Deaths (%)	No. of Outbreaks (%)	No. of Patients (%)	No. of Deaths (%)	No. of Outbreaks (%)	No. of Patients (%)	No. of Deaths (%)	No. of Outbreaks (%)	No. of Patients (%)	No. of Deaths (%)
2000	251 (36.06)	9323 (51.06)	13 (8.28)	200 (28.74)	3189 (17.46)	36 (22.94)	128 (18.39)	2075 (11.36)	100 (63.69)	117 (16.81)	3675 (20.12)	8 (5.09)
2001	215 (35.19)	8456 (42.76)	3 (2.22)	172 (28.15)	3541 (17.90)	62 (45.92)	105 (17.18)	1536 (7.76)	57 (42.23)	119 (19.48)	6248 (31.58)	13 (9.63)
2002	164 (35.35)	6320 (54.61)	6 (8.82)	129 (27.80)	2332 (20.16)	36 (52.95)	83 (17.89)	1319 (11.40)	20 (29.41)	88 (18.96)	1601 (13.83)	6 (8082)
2003	590 (39.84)	16038 (54.08)	12 (4.58)	294 (19.85)	3605 (12.15)	100 (38.17)	275 (18.57)	3895 (13.13)	120 (45.80)	322 (21.74)	6122 (20.64)	30 (11.45)
2004	884 (38.35)	21767 (50.78)	10 (3.92)	498 (21.61)	5545 (12.93)	148 (58.05)	420 (18.22)	6313 (14.72)	72 (28.23)	503 (21.82)	9251 (21.57)	25 (9.80)
2005	51 (19.93)	3882 (43.03)	10 (4.26)	84 (32.81)	1721 (19.08)	106 (45.10)	65 (25.39)	1426 (15.81)	76 (32.34)	56 (21.87)	1992 (22.08)	43 (18.30)
2006	265 (44.46)	11053 (61.19)	18 (9.18)	103 (17.28)	1671 (9.25)	78 (39.80)	151 (25.34)	3158 (17.48)	85 (43.37)	77 (12.92)	2181 (12.08)	15 (7.65)
2007	174 (34.39)	7816 (58.86)	5 (1.94)	89 (17.59)	1502 (11.31)	74 (28.68)	189 (37.35)	2789 (21.00)	167 (64.73)	54 (10.67)	1173 (8.83)	12 (4.65)
2008	172 (39.91)	7595 (58.00)	5 (3.24)	79 (18.33)	1274 (9.73)	57 (37.02)	125 (29.00)	2823 (21.56)	80 (51.95)	55 (12.76)	1403 (10.71)	12 (7.79)
2009	118 (43.24)	7882 (71.61)	20 (11.05)	55 (20.23)	1103 (10.02)	66 (36.46)	81 (29.84)	1269 (11.53)	93 (51.38)	17 (6.69)	753 (6.84)	2 (1.11)
2010	81 (36.82)	4585 (62.10)	16 (8.70)	40 (18.18)	682 (9.24)	48 (26.09)	77 (35.00)	1151 (15.59)	112 (60.86)	22 (10.00)	965 (13.07)	8 (4.35)
2011	78 (41.28)	5133 (61.67)	14 (10.22)	30 (15.87)	730 (8.77)	57 (41.61)	53 (28.04)	1543 (18.54)	51 (37.22)	28 (14.81)	918 (11.02)	15 (10.95)
2012	56 (32.18)	3749 (56.08)	16 (10.96)	21 (12.07)	395 (5.91)	19 (13.01)	72 (41.38)	990 (14.81)	99 (67.81)	25 (14.37)	1551 (23.20)	12 (8.22)
2013	49 (32.23)	3359 (60.42)	1 (0.91)	19 (12.50)	262 (4.71)	26 (23.85)	61 (40.13)	718 (12.92)	79 (72.48)	23 (15.13)	1220 (21.94)	3 (2.75)
2014	68 (42.50)	3831 (67.72)	11 (10.00)	14 (8.75)	237 (4.19)	16 (14.55)	61 (38.12)	780 (13.78)	77 (70.00)	17 (10.63)	809 (14.30)	6 (5.45)

Table 3. Species of pathogens causing foodborne illness outbreaks in China, 2008-2010

Causes		No. of Outbreaks (%)	No. of Patients (%)	No. of Deaths (%)	Case-fatality rate (%)
Bacteria	*Vibrio parahaemolyticus*	77 (6.32)	3352 (9.40)	0 (0.00)	0.00
	Salmonella	70 (5.75)	4151 (11.64)	4 (0.77)	0.10
	Bacillus cereus	54 (4.43)	1473 (4.13)	1 (0.19)	0.07
	Bacillus proteus	36 (2.96)	1581 (4.43)	0 (0.00)	0.00
	Staphylococcus	35 (2.87)	1152 (3.23)	1 (0.19)	0.09
	Escherichia coli	25 (2.05)	895 (2.51)	1 (0.19)	0.11
	Shigella flexneri	13 (1.07)	417 (1.17)	0 (0.00)	0.00
	Botulism	8 (0.66)	37 (0.10)	11 (2.12)	29.73
	Others	2 (0.16)	41 (0.12)	2 (0.39)	4.88
	Total	320 (26.27)	13099 (36.73)	20 (3.86)	0.15
Chemical	Pesticides & raticides	71 (5.83)	793 (2.22)	72 (13.90)	9.08
	Nitrites	34 (2.79)	621 (1.74)	18 (3.47)	2.90
	Medicinal liquor	5 (0.41)	22 (0.06)	8 (1.54)	36.36
	Carbamate	2 (0.16)	93 (0.26)	1 (0.19)	1.08
	Barium	2 (0.16)	28 (0.08)	2 (0.19)	7.14
	Others	8 (0.66)	112 (0.31)	8 (0.36)	7.14
	Total	122 (10.02)	1669 (4.68)	109 (21.04)	6.53
Plants and mushroom	Poisoning mushrooms	144 (11.82)	880 (2.47)	201 (38.80)	22.84
	Kidney beans	76 (6.24)	2677 (7.50)	2 (0.39)	0.07
	China wood oil	17 (1.40)	398 (1.12)	0 (0.00)	0.00
	Solanum tuberosum	11 (0.90)	464 (1.30)	0 (0.00)	0.00
	Castor-oil lpant	6 (0.49)	182 (0.51)	0 (0.00)	0.00
	Cyanogenic plants	3 (0.25)	20 (0.06)	4 (0.77)	20.00
	Gelsemium elegans	2 (0.16)	7 (0.02)	5 (0.97)	71.43
	Datura stramonium	2 (0.16)	9 (0.03)	1 (0.19)	11.11
	Aconitine	2 (0.16)	23 (0.06)	2 (0.39)	8.70
	Others	16 (1.31)	407 (1.14)	9 (1.74)	2.21
	Total	279 (22.91)	5067 (14.20)	224 (43.24)	4.42
Animals	Puffer fish	8 (0.66)	38 (0.11)	6 (1.16)	15.79
	Shellfish	3 (0.25)	12 (0.03)	2 (0.39)	16.67
	Others	6 (0.49)	55 (0.15)	5 (0.97)	9.09
	Total	17 (1.40)	105 (0.29)	13 (2.51)	12.38
Unidentified		480 (39.41)	15732 (44.10)	152 (29.34)	0.96

wood oil (17, 5.74%). However, *Gelsemium elegans* was the most deadly plant with a fatality rate of up to 71.43%.

Places of foodborne illness outbreak

The places of foodborne illness in China are classified into four categories according to the *National Public Health Emergency Network Reporting System*, namely, cafeterias, homes, restaurants, and others. Before 2000, foodborne illness mainly broke out in cafeterias, restaurants, and many vendors. Thereafter, the home became the place with the highest incidence (**Figure 3**). From 2000 to 2014, cafeterias were the places with the largest foodborne illness population (accounted for 37.27% of the total number), followed by restaurants (25.56%). Instead of cafeterias and restaurants, homes had become the highest risk of foodborne illness after 2000, which accounted for about 82.87% of all reported deaths during 2000-2014 with a case-mortality rate of up to 5.92%. In recent years, schools have gradually become the "hot spots" of foodborne illness outbreak and have been incorporated by the

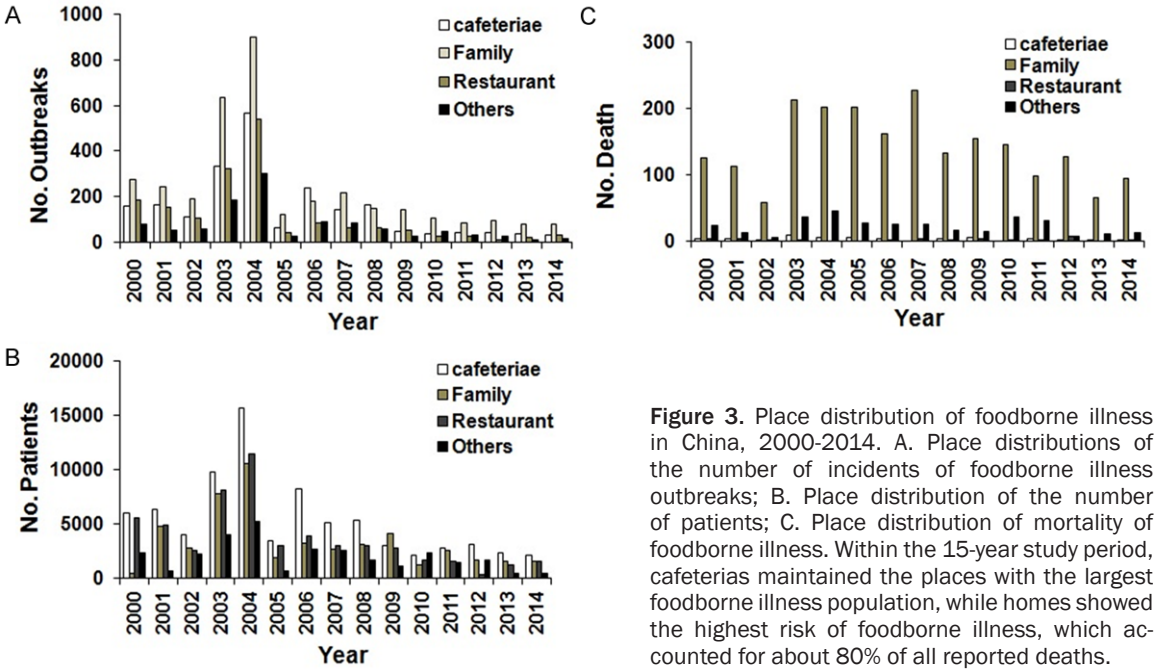

Figure 3. Place distribution of foodborne illness in China, 2000-2014. A. Place distributions of the number of incidents of foodborne illness outbreaks; B. Place distribution of the number of patients; C. Place distribution of mortality of foodborne illness. Within the 15-year study period, cafeterias maintained the places with the largest foodborne illness population, while homes showed the highest risk of foodborne illness, which accounted for about 80% of all reported deaths.

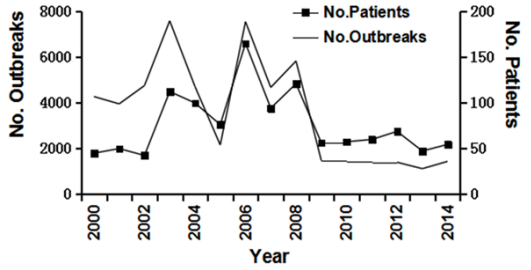

Figure 4. Trends of foodborne illness outbreaks in schools in China, 2000-2014. During the 2000-2014 study period, both the numbers of outbreaks and patients showed wide fluctuation, peaking in 2003, 2006, and 2008, and then exhibited relatively stable rate until 2012.

Chinese government into the national reporting system since 2005. During the 2000-2014 study period, both the numbers of outbreaks and patients in schools showed wide fluctuations and peaked in 2003, 2006, and 2008 and then remained low until 2013 (**Figure 4**). Cafeterias, restaurants, and market-stalls near schools are areas of high risk of foodborne illness.

Discussion

Analysis of foodborne illness outbreaks in China from 2000 to 2014

Within the 15-year study period, the annual number of foodborne illness outbreaks, patients, and deaths had peaks at 2003-2004 and 2006-2007. The first peak may be due to the *Public Health Emergency Regulation* promulgated by the Chinese government in 2003, which officially prescribed the regulation of management of foodborne illness outbreaks, including reporting and surveying, information management and notice, as well as punishment of responsible persons and/or organizations, etc (Public health emergency countermeasure ordinance, http://www.nhfpc.gov.cn/yjb/s3580/200804/b41369aac27847dba3e6aebccc72e2f8.shtml). This regulation strengthened the surveillance and reporting system of foodborne illness formulated by the *Measures on food poisoning investigation and reporting (1981).* Thus, to an extent, the longstanding problem of underreporting has been redressed (Public health emergency countermeasure ordinance, http://www.nhfpc.gov.cn/yjb/s3580/200804/b41369aac27847dba3e6aebccc72e2f8.shtml). The overall decrease in foodborne illness outbreaks and deaths since 2006 can reflect the gradually standardized laws and regulations regarding food safety and improved public health consciousness (Major national food safety accident emergency plans, http://www.gov.cn/yjgl/2006-02/27/content_21274.htm; Food safety law of the People's Republic of China, http://www.gov.cn/jrzg/2009-06/01/content_1329247.htm).

A majority of foodborne illness outbreaks occurred in April to September during 2000-2014, which may be explained by the following reasons. One reason is that the high environment temperature in summer and autumns facilitates microorganism proliferation such that food is prone to spoilage in these seasons. Another reason is that summer and autumns in each year are the seasons for wild plants picking, which increases the risk of eating poisonous plants, especially poisonous mushrooms. From 2003 to 2010, more than half of the reported foodborne illness outbreaks were clustered in Yunnan, Sichuan, Guangdong, Guizhou and Guangxi provinces, which may primarily be due to specific local eating habits. For instance, Yunnan, Sichuan, Guizhou and Hunan are the regions where many minorities live together, and the dietetic cultures of the ancient people at those areas has been kept so far, such as eating wild plants and undercooked meat. For instance, in Yunnan, eating wild mushrooms was linked with the most reported foodborne illness outbreaks and was responsible for the deaths of up to half of the people who suffered from foodborne illness. According to statistics in Yunnan, during 2009-2010, mushrooms accounted for 54.69% of all reported deaths related to foodborne illness [8, 9]. Similarly, people in Guangdong like eating seafood and wild animals, including snake, sparrow, and pangolin, which all contain toxic substances. Therefore, theoretically speaking, these people are predominantly exposing themselves to the risk of foodborne illness when consuming traditionally prepared food [10].

In 2003, China's Ministry of Health originally classified the causes of foodborne illness into five categories as follows: bacteria, pesticides, chemicals, poisonous animals and plants, and unidentified. Pesticides were further incorporated into the chemicals in 2005, and in consideration of the high contribution of poisonous mushrooms in foodborne illness incidents, poisonous animals and plants were re-classified as poisonous animals and plants and mushrooms in 2010. By now, foodborne illnesses are divided into four categories in the Chinese reporting system as follows: bacteria, chemicals, poisonous animals and plants and mushrooms, and unidentified. Within the 15-year study period, bacteria were the leading causes of foodborne illness outbreaks in China. *Vibrio parahaemolyticus, Salmonella*, and *Bacillus cereus* were the top three pathogens [7]. The main reason for food microbe contamination would be improper food processing in production, preservation, and transportation. For example, throughout the study period, unpasteurized dairy products and undercooked animals food were persistently incriminated in foodborne illnesses in China [11], and problems such as insufficient disinfection of cooking utensils and freezing appliances were always noted in Chinese food manufacturers and restaurants [12]. *C. botulinum* was the most toxic pathogenic bacterium with a fatality rate of up to 29.73%, which was significantly higher than that of Canada (below 6%) [13]. Human botulism is a medical emergency requiring rapid interventions, and immediate administration of anti-toxin can reduce the severity of the disease and reduce mortality [14]. In China, the foodborne botulism outbreak mainly occurs in rural areas where the diagnosis and treatment level are relatively low, which leads to a high fatality rate. For instance, in 2010, a foodborne botulism outbreak occurred in a poor mountain area, Quma'er country, Qinghai province, with five persons affected and four killed. The patients began to show gastro-intestinal symptoms after eating smoked beef and died two days later. Only when it came to the postmortem examination did the health workers find that these patients died from botulinum toxin [15]. The improvements in botulism case identification and early treatment in rural areas, therefore, are urgently needed.

The two categories, namely, chemicals and poisonous animals and plants and mushrooms, were the other two main causes of foodborne illness in China and were recognized to be more toxic than bacteria because they accounted for approximately 80% of the reported deaths. Foodborne illness caused by chemicals took place frequently in rural areas, which may due to a high utilization of these agents in those areas [16]. For example, the foodborne illness outbreaks caused by pesticides and raticides were mainly attributed to the misuse and abuse of insecticides or intentional human poisoning, and the ones caused by nitrites and medicinal liquor are closely associated with eating habits involving pickled vegetables and meat or consuming inferior wine blended with methyl alco-

hol, respectively [16]. One of the major factors that contributed to foodborne illness caused by poisonous animals and plants may be a lack of recognition of poisonous wildlife, which are predominant in remote and underdeveloped areas [17]. Another key reason may be an ignorance of hygiene consciousness. *Kidney bean*, for example, is a popular Chinese food but contains considerable amounts of toxic ingredients, e.g., saponins, phytohaemagglutinin, and trypsin inhibitors. Consuming raw or insufficiently cooked *kidney beans* can produce poisoning symptoms of acute abdominal disease such as diarrhea and vomiting and may develop to severe symptoms such as muscular pain, rhabdomyolysis, toxic myocarditis, or even death if rapid intervention cannot be done [18]. In the past decade, *kidney bean*-caused foodborne illness has occurred many times in China, most of which are attributed to the negligence in food processing. In 2003, for instance, 38 reported foodborne illness outbreaks associated with *kidney bean* have been reported in China with 1474 person affected [1]. In recent years, the Chinese government has provided continuous education to inform food producers and consumers of the potential risks and the proper handling of *kidney bean*, which may help to reduce the incidence of *kidney bean*-caused foodborne illness [11].

Of the total number of foodborne illness outbreaks, 18.23% were unidentified, especially in 2008-2010 with a peak at 39.41%. This incidence may be due to the following factors. First, the causes of foodborne illness are often complex and difficult to confirm. Identification of the causes requires the combination of epidemiologic information, clinical diagnosis, as well as laboratory confirmation. However, the current identification of foodborne illness is mainly conducted by local CDC and township health centers, the employees of which often lack professional skills and the equipments and materials are relatively subpar [11]. Second, given the existing classification criteria of foodborne diseases, the causes of foodborne illness are classified into four categories in the current *Chinese National Public Health Emergency Network Reporting System* (bacteria, chemicals, poisonous animals and plants and mushroom, and unidentified). However, specific pathogens that can cause foodborne illness are not included in this reporting system, such as virus and parasite. In fact, virus is a common cause of foodborne illness. For example, virus accounted for 49% and 65% of laboratory-confirmed foodborne outbreaks in American and Canada during 2006-2008, respectively [19, 20] and accounted for about 34% of outbreaks in Japan in 2010 [21]. In China, viral food illnesses were reported in 2004 and were recorded into another Chinese disease reporting system, namely, the *National Notifiable Infectious Disease Reported System*. Thus, the data collected from the current reporting system cannot completely reflect the overview of foodborne illness in China and might underestimate the scale of the foodborne illness. Third, whenever foodborne illness incident breaks out, some food producers and marketers attempt to conceal the truth by putting off reporting, obstructing surveys, and destroying food samples to escape from punishment, which adds difficulty in the etiological confirmation of the foodborne illness [11, 12].

Food service supply, especially cafeterias and restaurants, are potential risk settings where widespread public exposure to contaminated foods may occur. During 2000-2014, cafeterias and restaurants accounted for 60.55% of the total number of foodborne illness population. This data is mainly caused by the high number of diners and a high consumption of food at these places, coupled with a lack of food safety consciousness and improper food processing. Food preservation is a common problem in many Chinese cafeterias and restaurants. For instance, in many foodborne illness outbreaks that had happened in these places, products that were intended to be refrigerated were kept at room temperature, and out-of-date foods were still sold for commercial interests [11, 12]. Moreover, based on an epidemiological study, the leading cause of foodborne illness in cafeterias and restaurants was bacteria, e.g., *Vibrio parahaemolyticus, Salmonella, and Bacillus cereus,* which were caused by a lack of food processing control and tableware disinfection [7]. For example, in 2011, a foodborne outbreak in a primary school was recorded to be caused by substandard table-ware disinfection with 34 persons being affected [17]. In addition, food bacterial contamination mainly cause gastro-intestinal symptoms but with low mortality (below 0.08%) [16]. Therefore, these symptoms are quite easy to be ignored and these

cases are not recorded. This situation may explain the long-standing problem of a constantly high incidence of foodborne illness at these sites because of a lack of hygienic awareness. Instead of cafeterias and restaurants, homes had become the place with the highest risk of foodborne illness after 2000, which accounted for over 80% of all reported deaths during 2000-2014. A previous epidemiological study revealed that most family foodborne illness occurred in remote rural areas where there are always dozens or even hundreds of people attending local weddings, birthdays, and funeral parties [22]. Thus, a high incidence of foodborne illness outbreaks with high fatality was reported in these areas because of a lack of food-safety consciousness and identification knowledge of poisonous plants/animals, misuse of pesticides and raticide, as well as the relatively low medical service and poor transportation [22].

Laws and regulations in China that are related to foodborne illness

The first national legislation regarding food safety, i.e., the Measures on Food Poisoning Investigation and Reporting, was issued in 1981, which officially formulated the Foodborne Illness Reporting System [1]. Subsequenly, the General rules of diagnostic criteria and technical treatment of food poisoning was issued in 1994, which standardized the diagnosis of foodborne illness [1]. In 1995, the Food Safety Law of the People's Republic of China was issued, which, for the first time, ensured China's food safety at the state level (Food safety law of the People's Republic of China, http://www.gov.cn/banshi/2005-08/31/content_68767.htm). Further, the Food poisoning incidents treatment measures carried out in 2000 abolished the Measures on food poisoning investigation and reporting, which further strengthened the management on foodborne illness incidents [1].

On the basis of the foodborne illness reporting system, the Public health emergency countermeasure ordinance on emergency response to large foodborne illness incidents, which prescribed the measure rules of foodborne illness incidents, including incidents reporting, surveying and information, was issued by the State Council of the People's Republic of China in 2003 (The notification of national foodborne illness incidents report issued by Chinese Ministry of Health, http://www.nhfpc.gov.cn/zhuzhan/zcjd/201304/c6f67e05fc904 865b-14305bef626e2a0.shtml). In 2004, the State Council promulgated the Decision of the State Council about Further Strengthening Food Safety, which clearly stipulated a multi-department management in food safety (Decision of the State Council about Further Strengthening Food Safety; http://www.gov.cn/xinwen/2015-04/24/content_ 2852826.htm). In 2006, the Major National Food Safety Accident Emergency Plan was issued, which classified food safety accidents into four levels based on their characteristics and severity and clarified the functions and working measures of the Emergency Response Administrations (Major national food safety accident emergency plans, http://www.gov.cn/yjgl/2006-02/27/content_ 21274.htm). In 2008, a reform of government agencies in China was implemented, and the Food and Drug Administration was incorporated into the Ministry of Health, with the latter being responsible for the comprehensive coordination among government departments regarding food safety supervision. After that, the National Food Safety Commission was established in 2009, and the revised Food Safety Law of the People's Republic of China (2009) was launched and implemented (Food safety law of the People's Republic of China, http://www.gov.cn/jrzg/2009-06/01/content_1329247.htm). This law further established the food production records system, strengthened the surveillance on food advertisements, and clearly defined the civil remedy system. Most importantly, this law formally defines the State Council and the Ministry of Health as the main management body in food safety surveillance systems, thereby regulating multi-sector cooperation. In addtion, the law hold local government responsible for food safety incidents. In 2015, the Food Safety Law of the People's Republic of China (2015) was revised again. This revised law added more issues on food additives, health food products, infantal food, transgene food, and network transactions (Food safety law of the People's Republic of China, http://www.gov.cn/jrzg/2009-06/01/content_ 132-9247.htm).

Summary

In this study, we summarized all reported foodborne illness outbreaks in China announced by

the Ministry of Health and those published in literature from 2000 to 2014. A total of 4193 reported foodborne illness outbreaks occurred in China, involving 154202 patients and 2734 deaths. Most of the reported foodborne illness outbreaks occurred in April to September and were clustered in Yunnan, Sichuan, Hunan, Guangdong, and Hubei provinces. Of the reported outbreaks, nearly 60% were caused by bacteria, whereas poisonous animals and plants and chemicals accounted for approximately 80% of the reported deaths. We have described the development of China's food safety surveillance system and proposed suggestions to enhance the surveillance and control of foodborne illnesses.

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Disclosure of conflicts of interest

None.

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