Original Article

Analysis of foodborne salmonellosis serotypes and drug resistance in children in Chenzhou City of China from 2017 through 2022

Yong Zhou[1], Bin Liao[2], Huilong Fang[3], Huiwen Zeng[1], Cuimei Chen[1], Zheng-Hang Huan[3], Wen Zheng[2], Xun Liu[2]

[1]School of Public Health, Xiangnan University, Chenzhou, China; [2]Chenzhou Center for Disease Control and Prevention, Chenzhou, China; [3]School of Basic Medical Sciences, Xiangnan University, Chenzhou, China

Contributions: (I) Conception and design: Y Zhou, W Zheng, X Liu; (II) Administrative support: W Zheng, X Liu; (III) Provision of study materials or patients: B Liao; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Wen Zheng, MD; Xun Liu, MD. Chenzhou Center for Disease Control and Prevention, No. 6 Hongxing Road, Suxian District, Chenzhou 423000, China. Email: zhw9558@hotmai.com; liuxun201314@163.com.

Background: *Salmonella* is a significant pathogens of foodborne illness. The widespread use of antibiotics in clinical practice and animal husbandry has resulted in increasing drug resistance of *Salmonella*. In this study, we examined the serotype distribution and drug resistance of *Salmonella* in pediatric patients with diarrhea in Chenzhou City to provide a basis for the scientific control and rational use of antibiotics in clinical practice in relation to *Salmonellosis*.

Methods: Stool *Salmonella spp*. were collected from patients younger than 18 years of age who met the definition for foodborne illness at two sentinel hospitals from 2017 through 2022 tested *Salmonella*, and a descriptive analysis of the epidemiologic characteristics. *Salmonella* strains isolated from the stool underwent serology and drug-sensitivity tests. The following 14 antibiotics were used for the drug-sensitivity tests: ampicillin (AMP), ampicillin/sulbactam (AMS), cefazolin (CFZ), cefoxitin, cefotaxime, ceftazidime, imipenem (IPM), tetracycline (TET), nalidixic acid, ciprofloxacin, chloramphenicol (CHL), gentamicin, trimethoprim/sulfamethoxazole (SXT), and azithromycin.

Results: Samples from 1,263 pediatric with diarrhea, and *Salmonella* was detected in 221 (17.5%) of these patients. Positive test results were principally observed in the second and third quarters of each year, accounting for 21.1% and 19.6% of the cases, respectively. The infection rates of infants aged less than 12 months and toddlers aged 1–3 years with diarrhea were the highest at 21.3% and 17.8%, respectively. The 221 *Salmonella* strains were divided into 32 serotypes, of which *Salmonella* Typhimurium (*S.* Typhimurium) was the dominant strain (79.2%). The resistance rates to TET (86.9%), AMP (75.6%), AMS (58.4%), CFZ (55.7%), CHL (54.3%), and SXT (45.2%) predominated, and the differences in the drug-resistance rates to 1st-, 2nd-, and 3rd-generation cephalosporins were high (2.3–55.7%). Only 0.9% of the strains were resistant to IPM. The multidrug resistance (MDR) rate was 76.5% (169/221), and 48.9% (108/221) of the strains were resistant to five or more classes of antibiotics, of which the most common drug-resistance profile was AMP-AMS-TET-CHL-CFZ-SXT, accounting for 10.9% of Salmonella strains (24/221).

Conclusions: Foodborne salmonellosis tended to occur during the summer and autumn in children, and infants and toddlers were more likely to develop salmonellosis than children in the other age groups. The dominant *Salmonella* serotype was *S.* Typhimurium. The drug-resistance rate of the tested strains was high, and the MDR problem was severe. We recommend that in the treatment of salmonellosis, antibiotics be selected rationally based on the drug-resistance status of local *Salmonella* resistance situation to ensure safety and efficacy.

Keywords: *Salmonella*; children; serotype; drug resistance

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Introduction

Salmonella is a non-capsulated, non-spore-forming, facultative anaerobic gram-negative rod. Most members of the *Salmonella* genus do not ferment lactose, and this characteristic is used for the isolation culture and identification of *Salmonella* (1). *Salmonella* is ubiquitous in nature and often resides in human and animal intestinal tracts. *Salmonella* is primarily transmitted via the fecal-oral route, and does not degrade protein, produce indoles, or cause sensory changes to food after contamination. *Salmonella* is one of the most common pathogens in bacterial foodborne illness (2) and can infect humans and animals. After humans are infected with *Salmonella*, the common symptoms include diarrhea, fever, stomach spasms and nausea, vomiting, and headache. Data from a previous study revealed that children below the age of five, immunocompromised individuals, and the elderly are susceptible to *Salmonella* (3). Self-limiting gastroenteritis is the most common presentation of salmonellosis in children; however, an invasive infection may occur in severe cases, and this may be accompanied by meningitis, arthritis, and osteomyelitis that may even be life threatening (4,5). Intestinal infection caused by *Salmonella* is a significant global public health issue, and the annual death toll due to salmonellosis is 155,000 people (6). Infectious diarrhea caused by *Salmonella* is a common health problem for children and is the leading cause of death in children below 5 years of age (7). In 2021, the World Health Organization reported that *Salmonella* caused 500 million infections worldwide, of which more than 200 million occurred in children [https://www.who.int/news-room/fact-sheets/detail/salmonella-(non-typhoidal)].

There are regional differences in the composition and dominance of *Salmonella* serotypes. A global survey of human *Salmonella* outbreaks conducted at the beginning of this century revealed that *S.* Enteritidis was the most common serotype, followed by *Salmonella* Typhimurium (*S.* Typhimurium) (8). In 2019, the top five *Salmonella* serotypes isolated in Europe were *Salmonella* Infantis (*S.* Infantis), *Salmonella* Enteritidis (*S.* Enteritidis), *Salmonella* enterica serovar Typhimurium monophasic variant (*S.* Typhimurium 1,4,[5],12:i-), *S.* Typhimurium, and *Salmonella* Derby (*S.* Derby) (9). The principal foodborne pathogen in the United States of America is *Salmonella* and mainly includes the following four serotypes: *S.* Enteritidis, *Salmonella* Newport (*S.* Newport), *S.* Typhimurium, and *Salmonella* Javiana (*S.* Javiana) (10). From 2016 to 2017, *S.* enterica serovar I 4,[5],12:i:-, *S.* Enteritidis and, *Salmonella* Bareilly (*S.* Bareilly) were also the most common *Salmonella* serotypes in patients with diarrhea and foodborne illnesses in South Korea (11). There are very few extant studies on salmonellosis in children in China; however, the results of an epidemiologic survey have shown differences between the *Salmonella* serotypes isolated from children and those isolated from adults (12). In addition, research has shown that after children were infected with *Salmonella*, the possibility of hospitalization was higher and the antibiotic treatment duration was longer for patients who were younger (13).

Antibiotics constitute the principal treatment for salmonellosis. However, the unregulated use of antibiotics in

Highlight box

Key findings

- We found that the dominant serotype of foodborne *Salmonella* infection in children in Chenzhou City was *S.* Typhimurium. The resistance rate of the tested strains was relatively high, and the problem of multidrug resistance was more serious.

What is known, and what is new?

- *Salmonella*-induced infectious diarrhea is one of the important reasons affecting the health of children under 5 years old. There is a certain regional specificity in the serotype composition and dominant types of *Salmonella*, and drug resistance is becoming increasingly severe. However, to date, little research has been conducted on *Salmonella* infection in children in China.
- This study explored the serotype distribution and drug resistance of *Salmonella* in children with foodborne diarrhea in Chenzhou City of China to provide a reference for the scientific prevention and control of *Salmonella* infection and the rational use of antibiotics in clinical practice.

What is the implication, and what should change now?

- In clinical practice, we recommend that during the treatment of salmonellosis in children, antibiotics be selected rationally based on the drug-resistance status of local *Salmonella* to ensure safety and efficacy.

clinical practice and widespread use of antibiotics in animal husbandry has worsened antibiotic resistance in *Salmonella*, causing an increase in multidrug resistance (MDR) and the drug-resistance spectrum. As an important foodborne pathogen, the issue of Salmonella resistance has become a global public health issue (14). In 2021, the European Food Safety Authority published a report (15) stating that the drug-resistance rates of *Salmonella* in human stool samples to sulfonamides, ampicillin (AMP), and tetracycline (TET) were 29.0%, 25.8%, and 25.6%, respectively. The results of a survey of five Chinese provinces showed that the drug-resistance rates of *Salmonella* to nalidixic acid (NAL) and sulfafurazole were 64% and 59%, respectively, and the MDR rate was 53.4% (16). In addition to drug resistance to traditional antibiotics, strains that are resistant to 3rd-generation cephalosporins, ciprofloxacin (CIP), and azithromycin (AZI) have continued to emerge in recent years (17), and the prevalence of these strains poses a severe threat to general public health safety and the health of minors particularly.

Thus, the analysis of the serotype-distribution characteristics and drug-resistance patterns of salmonella in children has important value in anti-infective treatment and the implementation of public health surveillance. This study was conducted to determine the distributional status and drug-resistance characteristics of foodborne salmonellosis in children and to curb the unnecessary use of antibiotics. We present this article in accordance with the STROBE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-24-120/rc).

Methods

Sample sources

To test for *Salmonella*, stool/anal swab samples were collected from patients under 18 years of age who with a chief complaint of diarrhea (≥3 episodes of diarrhea per day), or abnormal stools, and who were treated at two sentinel hospitals, Chenzhou No. 1 and No. 4 People's Hospital. Both hospitals are affiliated hospitals of Xiangnan University. These two hospitals are public tertiary comprehensive hospitals, covering approximately 6–7 million people throughout Chenzhou and surrounding areas from 2017 through 2022, and over the past 6 years, a total of 3,118 cases of diarrhea were monitored, including 1,263 cases of childhood diarrhea. We obtained general information, including their age, sex, and season of onset, from the inpatient and outpatient health records of the hospitals. A study reported that the infection rate of *Salmonella* in individuals under 19 years old was around 43.7% (12). Thus, the following method was used to estimate the minimum sample size required for this study: $n = 4p \times (1 - p)/d^2 = 600$, where p =0.4, and d =0.1p. This study was conducted in accordance with the Helsinki Declaration (as revised in 2013). This study was approved by ethics board of Xiangnan University (No. XNXY2017031), and informed consent was obtained from all the patients' parents.

Isolation and identification of Salmonella

Expansion

Stool swabs containing Cary-Blair transport culture medium were inoculated into selenite bright green (SBG) sulfonamide enrichment broth and cultured at 36 ℃ for 18 to 24 hours.

Isolation

An inoculating loop was used to inoculate the broth into *Salmonella* colorimetric culture medium, which was cultured at 36 ℃ for 18 to 24 hours.

Purification

Purple or wine-colored colonies on the *Salmonella* colorimetric culture medium were selected and transferred to a nutrient agar plate and cultured at 36 ℃ for 18 to 24 hours.

Biochemical identification

Single suspected colonies on the nutrient agar plate were selected and inoculated onto triple sugar iron (TSI) agar (K/A, gas production+, motile+, H2S+/– colonies), and the inoculum was then diluted with physiologic saline to a 0.5-McFarland standard of turbidity. A BioMérieux VITEK2 Compact biochemical analyzer (BioMérieux, Inc., Lyon, France) was subsequently used for identification.

Serotyping

Strains that were biochemically identified as *Salmonella* were adopted for serum coagulation tests, and the Kauffmann-White-LeMinor Serotyping Scheme was applied to determine the serotype.

Drug-sensitivity testing

The list of antibiotics for drug-resistance surveillance was

determined based on the drug-sensitivity test and antibiotic selection principles recommended in Clinical and Laboratory Standards Institute (CLSI) documents M100-S27 and M45-A3. We applied the broth microdilution method for the drug-sensitivity testing of *Salmonella* strains and employed *Escherichia coli* ATCC25922 as the quality-control strain. The minimal inhibitory concentration was determined based on the CLSI standards, and the results were classified as resistant (R), intermediate (I), and sensitive (S). According to international expert proposal (18) and Chinese experts' consensus on prevention and control of MDR organism healthcare-associated infection, 2015, strains that were resistant to ≥3 classes of antibiotics were defined as MDR strains.

A total of 10 classes and 14 antibiotics were tested: AMP, ampicillin/sulbactam (AMS), cefazolin (CFZ), cefoxitin (CFX), cefotaxime (CTX), ceftazidime (CAZ), imipenem (IPM), TET, NAL, CIP, chloramphenicol (CHL), gentamicin (GEN), trimethoprim/sulfamethoxazole (SXT), and AZI.

Statistical analysis

We used SPSS25.0 software (IBM Corp, New York, USA) for the statistical analysis of the data. The average age is presented as the median (P_{25}–P_{75}). The χ^2 test or Fisher's exact-probability test was used for the rate comparisons. The significance level was set at $\alpha = 0.05$, and a P value <0.05 was considered statistically significant.

Results

Salmonella detection

A total of 1,263 pediatric samples were collected from 2017 through 2022 at two sentinel hospitals in Chenzhou, and *Salmonella* was detected in 221 cases (detection rate: 17.5%). The temporal distribution of *Salmonella* revealed that the detection rate fluctuated each year, with the highest detection rates (20% and above) observed in 2019 and 2020. Notably, the pathogen was principally detected in the 2nd and 3rd quarters of the years. In terms of the positive-detection rates, no statistically significant difference between the male and female pediatric patients was observed using the population distributions. The youngest patient with *Salmonella* diarrhea was 20 days old and the oldest was 15 years of age. The median age of the patients was 12 months (P_{25}–P_{75}: 9–18 months). At 21.3% and 17.8%, respectively, the *Salmonella* detection rates were the highest in pediatric diarrhea patients aged <12 months and 1–3 years (see *Table 1*).

Salmonella serotype distribution

Serotyping was on the 221 *Salmonella* strains, was done 32 serotypes identified, of which *S.* Typhimurium was dominant (79.2%), followed by *S.* Enteritidis (2.7%), *Salmonella* Litchfield (*S.* Litchfield) (1.8%), and *S.* Derby (1.4%). The other 28 serotypes were detected in 1–2 strains (see *Table 2*).

Drug-sensitivity test results

The 221 *Salmonella* strains were used for drug-sensitivity testing using 10 classes and 14 antibiotics, and drug resistance was high. The following six antibiotics had drug-resistance rates >40%: TET (86.9%), AMP (75.6%), AMS (58.4%), CFZ (55.7%), CHL (54.3%), and SXT (45.2%). The resistance rates for AMP, AMS, CFZ, CAZ, and CTX fluctuated over the years (P<0.05), but drug-resistance changes for the remaining antibiotics in years 2017–2022 inclusive did not differ (see *Table 3*).

Of the 221 *Salmonella* strains, 169 (76.5%) were MDR strains, the most common strain of which exhibited resistance to six (22.2%) and five (16.3%) drug classes, while 48.9% (108/221) of the strains were resistant to five or more classes (see *Table 4*). The drug-resistance spectrum for MDR is complex and the most common drug-resistance spectrum was observed for AMP-AMS-TET-CHL-CFZ-SXT, accounting for 10.9% (24/221), followed by AMP-TET-CHL-CFZ-SXT, AMP-CAZ-TET-CTX-CFZ, AMP-AMS-TET, and AMP-CAZ-AMS-TET-CTX-CFZ in seven, seven, six, and six strains, respectively. The other drug-resistance spectra were not present in more than five strains. Notably, five strains were resistant to ≥10 antibiotics, of which the most robust strain was resistant to nine drug classes and 13 antibiotics with a resistance spectrum of AMP-CAZ-AMS-TET-NAL-CFX-CHL-CTX-CFZ-GEN-SXT-AZM-CIP.

Discussion

The results of this investigation showed that the *Salmonella* detection rate in pediatric patients with foodborne infectious diarrhea in Chenzhou from 2017 through 2022 was 18.2%. The analysis of its temporal distribution revealed that there were some fluctuations in the annual detection rate. In both

Table 1 *Salmonella* detection status in pediatric diarrhea patients in Chenzhou from 2017 through 2022

Category	Number of pediatric diarrhea patients	Number of cases with detected *Salmonella*, n (%)	χ^2	P value
Year			25.494	<0.001
2017	210	24 (11.4)		
2018	143	13 (9.1)		
2019	197	44 (22.3)		
2020	262	65 (24.8)		
2021	293	49 (16.7)		
2022	158	26 (16.5)		
Quarter			12.188	0.007
1st quarter	197	24 (12.2)		
2nd quarter	313	66 (21.1)		
3rd quarter	515	101 (19.6)		
4th quarter	238	30 (12.6)		
Sex			0.031	0.86
Male	761	132 (17.3)		
Female	502	89 (17.7)		
Age			20.752	<0.001
<12 months	530	113 (21.3) (of whom one patient was ≤28 days of age)		
1–3 years	506	90 (17.8)		
4–6 years	102	7 (6.9)		
7–14 years	92	10 (10.9)		
15–18 years	32	1 (3.1)		
Total	1,263	221 (17.5)	–	–

Table 2 *Salmonella* serotype distribution of pediatric diarrhea patients in Chenzhou from 2017 through 2022 [n (%)]

Year	*S*. Typhimurium	*S*. Enteritidis	*S*. Litchfield	*S*. Derby	Other *Salmonella* serotypes	Total
2017	20 (83.3)	1 (4.2)	0 (0.0)	1 (4.2)	2 (8.3)	24
2018	10 (76.9)	0 (0.0)	0 (0.0)	0 (0.0)	3 (23.1)	13
2019	36 (81.8)	3 (6.8)	0 (0.0)	1 (2.3)	4 (9.1)	44
2020	55 (84.6)	0 (0.0)	1 (1.5)	0 (0.0)	9 (13.8)	65
2021	38 (77.6)	1 (2.0)	1 (2.0)	1 (2.0)	8 (16.3)	49
2022	16 (61.5)	1 (3.8)	2 (7.7)	0 (0.0)	7 (26.9)	26
Total	175 (79.2)	6 (2.7)	4 (1.8)	3 (1.4)	33 (14.9)	221

Other serotypes included: *S*. Stanley (n=2), *S*. Rissen (n=2), *S*. Canastel (n=2), *S*. Give (n=2), *S*. Goldcoast (n=2), *S*. Bovismorbificans (n=2), *S*. Albany (n=2), *S*. Paratyphi B (n=1), *S*. Singapore (n=1), *S*. Virchow (n=1), *S*. Wandsworth (n=1), *S*. Nola (n=1), *S*. Rissen (n=1), *S*. London (n=1), *S*. Ruzizi (n=1), *S*. Riggil (n=1), *S*. Kisii (n=1), *S*. Heidelberg (n=1), *S*. Hato (n=1), *S*. Gueuletapee (n=1), *S*. Bournemouth (n=1), *S*. Ogonna (n=1), *S*. Orion (n=1), *S*. Obogus (n=1), *S*. Essen (n=1), and an unclassified S. serotype (n=1).

Table 3 *Salmonella* drug-sensitivity test results of pediatric diarrhea patients in Chenzhou from 2017 through 2022

Type of antibiotic	Name of antibiotic	Number of resistant strains, n (%)							χ^2	P value
		2017 (n=24)	2018 (n=13)	2019 (n=44)	2020 (n=65)	2021 (n=49)	2022 (n=26)	Total (n=221)		
Penicillin	AMP	23 (95.8)	7 (53.8)	40 (90.9)	45 (69.2)	30 (61.2)	22 (84.6)	167 (75.6)	22.295	<0.001
β-lactam antibiotics/ B-lactamase inhibitor combinations	AMS	13 (54.2)	6 (46.2)	32 (72.7)	36 (55.4)	14 (28.6)	18 (69.2)	129 (58.4)	21.756	0.001
Cephalosporins	First-generation, CFZ	18 (75.0)	6 (46.2)	31 (70.5)	20 (30.8)	33 (67.3)	15 (57.7)	123 (55.7)	27.088	<0.001
	Second-generation, CFX	0 (0.0)	0 (0.0)	1 (2.3)	1 (1.5)	1 (2.0)	2 (7.7)	5 (2.3)	–	0.57†
	Third-generation, CAZ	10 (41.7)	0 (0.0)	8 (18.2)	4 (6.2)	1 (2.0)	2 (7.7)	25 (11.3)	–	<0.001†
	Third-generation, CTX	14 (58.3)	1 (7.7)	15 (34.1)	6 (9.2)	1 (2.0)	4 (15.4)	41 (18.6)	–	<0.001†
Carbapenems	IPM	0 (0.0)	0 (0.0)	2 (4.5)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.9)	–	0.20†
Tetracyclines	TET	23 (95.8)	9 (69.2)	39 (88.6)	59 (90.8)	42 (85.7)	20 (76.9)	192 (86.9)	7.310	0.20
Quinolones and fluoroquinolones	NAL	4 (16.7)	3 (23.1)	16 (36.4)	12 (18.5)	8 (16.3)	4 (15.4)	47 (21.3)	7.875	0.16
	CIP	2 (8.3)	2 (15.4)	4 (9.1)	14 (21.5)	12 (24.5)	3 (11.5)	43 (19.5)	–	0.26†
Phenylpropanols	CHL	10 (41.7)	6 (46.2)	28 (63.6)	35 (53.8)	27 (55.1)	14 (53.8)	120 (54.3)	3.457	0.64
Aminoglycosides	GEN	3 (12.5)	0 (0.0)	8 (18.2)	8 (12.3)	8 (16.3)	7 (26.9)	34 (15.4)	–	0.34†
Folic acid inhibitors	SXT	11 (45.8)	3 (23.1)	22 (50.0)	31 (47.7)	22 (44.9)	11 (42.3)	100 (45.2)	3.234	0.67
Macrolides	AZM	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.5)	5 (10.2)	2 (7.7)	8 (3.6)	8.202	0.06

†, Fisher's exact-probability test was used, as the theoretical frequency was too low for the Chi-squared test. AMP, ampicillin; AMS, ampicillin/sulbactam; CFZ, cefazolin; CFX, cefoxitin; CAZ, ceftazidime; CTX, cefotaxime; IPM, imipenem; TET, tetracycline; NAL, nalidixic acid; CIP, ciprofloxacin; CHL, chloramphenicol; GEN, gentamicin; SXT, trimethoprim/sulfamethoxazole; AZM, azithromycin.

Table 4 Detection status of multidrug-resistant *Salmonella* strains in pediatric diarrhea patients in Chenzhou from 2017 through 2022

Number of antibiotic-resistant classes†	Number of strains (n=221)	%
0	8	3.6
1	24	10.9
2	20	9.0
3†	35	15.8
4	26	11.8
5	36	16.3
6	49	22.2
7	9	4.1
8	9	4.1
9	5	2.3

†, strains resistant to ≥3 antibiotic classes were defined as multidrug resistant.

2017 and 2018, the detection rate was approximately 10%, while after 2019, the detection rate was 15% or even 20%. Thus, the prevalence of salmonellosis in children showed an increase. Salmonellosis can occur anytime throughout the year, but it typically occurred from April to September, which is consistent with the findings of other related reports (19,20). This period comprises summer and autumn, and warm months with high environmental temperatures are conducive to the reproduction of *Salmonella*, and the overlap of summer and rainy season peaks which increases the risk of foodborne transmission of *Salmonella* (21).

The population-distribution results also revealed that there were no differences in salmonellosis between the children in terms of sex. Salmonellosis principally occurred in pediatric patients aged <3 years (i.e., 39.1% of the cohort), and was detected in only one neonate; and the overall detection rate in pediatric patients >4 years was significantly reduced. This might be due to the low degree

of hand hygiene practices in infants and toddlers in this age group (22). In addition, the immature gut microbiota of the infants and toddlers might be a reason for the high infection rate of this population, some researchers have found that *Clostridium sporogenes* and facultative anaerobic bacteria in the mature gut microbiota inhibited the growth of *Salmonella* by maintaining epithelial hypoxia and competitive oxygen consumption (23). Due to the immature gut microbiota of infants and toddlers, their bodies' ability to eliminate *Salmonella* that colonize the gut is likely reduced. In addition, severe acute gastroenteritis tends to occur after salmonellosis in high-risk populations, such as infants and toddlers, and other immunocompromised patients (24), resulting in higher-outpatient consultation and hospitalization rates relative to children in other age groups.

The circulating *Salmonella* serotypes differ worldwide and researchers have ascertained that the *Salmonella* serotypes isolated from children and adults are distinct (12); however, *S.* Typhimurium and *S.* Enteritidis nevertheless show a global prevalence (4) and have an extensive distribution in developing countries (24). In China, 70–80% of foodborne illness is caused by salmonellosis, and there are differences in *Salmonella* serotypes among different provinces, *S.* Typhimurium and *S.* Enteritidis are the classical and prevailing serotypes, particularly in those geographic regions in which *S.* Typhimurium constitutes the most common serotype (25-27). In the present study, the 221 *Salmonella* strains isolated from the pediatric diarrhea patients comprised 32 serotypes, of which *S.* Typhimurium accounted for 79.2% and was the absolute dominant *Salmonella* strain in Chenzhou, followed by *S.* Enteritidis (2.7%); these rates are generally consistent with those reported in the aforementioned studies. We also detected 30 other serotypes, including *Salmonella* Stanley (*S.* Stanley), *Salmonella* Goldcoast (*S.* Goldcoast), *Salmonella* Bovismorbificans (*S.* Bovismorbificans), *Salmonella* Albany (*S.* Albany), and *Salmonella* Paratyphi B (*S.* Paratyphi B), which shows the diverse distribution of *Salmonella* serotypes; we fully expect this to arouse attention.

Antibiotics are used to treat salmonellosis in children. The European Society for Pediatric Infectious Diseases recommends the use of antibacterial drugs for high-risk children to reduce the risk of bacteremia and extraintestinal infection (28). However, due to the extensive use of antibacterial drugs, *Salmonella* drug resistance is becoming progressively more serious, and the treatment has thus become increasingly difficult. Authors have discerned differences in drug-resistance rates in different geographic regions (29,30); however, this might be due to disparities in the types and doses of antibiotics used in the various regions. The results of this investigation showed that drug resistance was severe in the *Salmonella* strains isolated from pediatric diarrhea patients in Chenzhou from 2017 through 2022, of whom over 70% were resistant to TET and AMP, and more than 60% were resistant to six antibiotics. Third-generation cephalosporins are presently the drug of choice for treating *Salmonella* infection of the gut, and oral AZI is used as a substitute (28,31). The results of this investigation showed that the resistance rates for these drugs did not exceed 20%, and that the rate for AZM resistance was only 3.6%. We also ascertained that the drug-resistance rate for the 2nd-generation cephalosporin CFX was only 2.3%, which is far lower than that for 3rd-generation cephalosporins. We speculate that this might be due to the low usage frequency of these drugs in clinical practice. The drug-resistance rate for fluoroquinolone was only 20%; however, such drugs are not suitable for children, who may cause joint cartilage toxicity (32). In our study, the drug with the lowest drug-resistance rate was IPM, and only two strains were resistant (0.9%). However, this should also provoke scrutiny, as this antibiotic is strictly controlled in clinical practice, has a low rate of clinical usage, and is currently the last line of defense for treating MDR.

The MDR rate for foodborne salmonellosis in children in Chenzhou was 76.5%, and the most common drug-resistance spectrum was AMP-AMS-TET-CHL-CFZ-SXT. In addition, a considerable number of *Salmonella* strains were resistant to five or more antibiotics (48.9%), creating a dire situation. One group of authors demonstrated that the ratio of MDR strains was different among different *Salmonella* serotypes (33), and that the MDR rate for *S.* Typhimurium was significantly higher than the rate for other serotypes (34,35); *S.* Typhimurium was also the absolute dominant serotype in Chenzhou. However, a high population density, gross domestic product per capita, medical resources, and educational level may also affect the MDR level of foodborne pathogens (36). We expect to examine the relationships between these factors and MDR to provide a more solid foundation for clarifying the control of drug resistance in foodborne pathogens.

Conclusions

As the samples in the present study were primarily obtained from two sentinel hospitals as part of foodborne-illness

surveillance in this city, they may not be completely representative of the patients in the region. In addition, the coronavirus disease 2019 pandemic might have reduced the willingness of some patients to attend hospitals, which might have affected the detection rates of *Salmonella* and created a bias in our results. Therefore, there is a definite need to expand the current sample size and conduct multicenter studies in the future.

In summary, this study found that foodborne salmonellosis in children in Chenzhou mainly occurred in the 2nd and 3rd quarters of the year, and had a high prevalence overall in infants and toddlers. *S.* Typhimurium accounted for the absolute majority of pathogenic *Salmonella*. *Salmonella* drug resistance appears to be currently widespread in Chenzhou, and the MDR problem is quite serious. This study had some limitations, but we posit that it will nevertheless facilitate the optimization of public health policy and thus provide a reference for preventing salmonellosis in children, guide rational antibiotic use in clinical practice, and arrest the continuous spread of *Salmonella* drug resistance.

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Footnote

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tp.amegroups.com/article/view/10.21037/tp-24-120/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Helsinki Declaration (as revised in 2013). This study was approved by ethics board of Xiangnan University (No. XNXY2017031), and informed consent was obtained from all the patients' parents. The Chenzhou No. 1 and No. 4 People's Hospital were informed and agreed with this study.

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