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NON-TYPHOIDAL SALMONELLA INFECTIONS & ANTIBIOTIC SUSCEPTIBILITY PATTERN IN CHILDREN WITH ACUTE GASTROENTERITIS

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ABSTRACT

Aims: To study the proportion of non-typhoidal salmonellae & their antimicrobial susceptibility in children presenting with acute gastroenteritis.

Materials and methods: It is a cross-sectional observational study with a sample size of 100 over a period of 12 months. Children under 6 years of age suffering with acute gastroenteritis or dysentery admitted to the wards or presenting at the outpatient unit were included in the study. Stool specimens were collected by the microbiology lab attached to a tertiary care hospital.

Results: Among the 100 cases, 57 are males and 43 are female children. Identification of NTS was based on colony morphology on selective media and a battery of biochemical tests. One NTS was isolated. Prevalence being 1%. Antibiotic susceptibility profiles were obtained against 12 antibiotics. NTS isolate was sensitive to all the drugs tested. The serotyping result of the NTS isolate is *Salmonella enterica* serovar Enteritidis 1,9,12, g,m,-

Conclusions: Outbreaks of NTS have been reported in neonatal units, paediatric wards and childcare facilities. However, despite the frequency of asymptomatic NTS excretion following acute infection, the risk of transmission from asymptomatic health care workers to patients appears to be small when strict adherence to hand hygiene is observed.

Keywords: Salmonella enterica, Antibiotic susceptibility, Non-typhoidal Salmonellae, Antimicrobial Resistance

INTRODUCTION

The genus *Salmonella* includes two species, *Salmonella enterica* and *Salmonella bongori*. *Salmonella* strains belong to over 50 serogroups based on the O antigen, and to over 2500 serotypes (each having a unique combination of somatic O, and flagellar H1 and H2 antigens). Most of these serotypes belong to one single *Salmonella* subspecies, enterica, and are associated with >99% of *Salmonella*-caused diseases in humans. *S. enterica* is categorized into typhoidal and non-typhoidal. While *S. enterica* Typhi and *S. enterica* Paratyphi have host specificity for humans and can cause typhoid, all other serotypes can be acquired from both animals and humans and are classified as non-typhoidal.

Non-typhoidal Salmonellae (NTS) are a group of pathogens that cause acute gastroenteritis. Ubiquitous serotypes, such as *S.* Enteritidis or *S.* Typhimurium, which affect both man and animals, generally cause gastrointestinal infections with less severity than enteric fever.[2] It is mostly spread through contaminated food; other modes of transmission include contaminated water, contact with infected animals and nosocomial exposure. Transmission of NTS can occur through ingestion of contaminated food products or by contact with animals. Farm animals are the major reservoirs for NTS in industrialized countries, and with mass food production and distribution, contamination of the food chain supply results in rapid dissemination of NTS to communities, locally and internationally. Children can also acquire NTS infection through contact with reptiles, animal feces and live poultry. International travel is a well-described risk factor for NTS and children under 6 years are at a higher risk than older travelers. International travel, particularly to Southeast Asia, is also a risk factor for acquiring multi-drug-resistant NTS (MDR-NTS) infection and invasive disease.[1,2]

In healthy children, NTS infections are usually confined to the gastrointestinal tract; however, several factors, including age, underlying diseases and immunosuppression, predispose to invasive disease. Salmonellae are unable to survive at a gastric pH less than 2.5 and patients with anatomical or functional achlorhydria are at increased risk of developing infection. This is especially relevant to neonates where the combination of relative achlorhydria and frequent milk feeds may contribute to their increased risk of NTS bacteraemia.[3]

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Optimal antibiotic treatment of NTS gastroenteritis or invasive NTS (iNTS) disease in children has not been established. NTS invades the intestinal epithelium and triggers a massive neutrophil influx in the intestine, resulting in inflammatory diarrhoea. Subsequent to invasion, it traverses the epithelium to reach the lamina propria and resides intracellularly within phagocytes. Typhoidal strains, in contrast, evade the gut mucosal immune response and progress to a systemic infection with initial colonization of the submucosal lymphoid tissues and then liver, spleen and bone marrow.

Host protection against NTS requires intact, innate and adaptive defense mechanisms as illustrated by increased susceptibility to iNTS in children with HIV infection, congenital defects in humoral immunity and chronic granulomatous disease. Sickle cell disease is thought to predispose to NTS bone infections due to vaso-occlusive crises.

The high rates of iNTS observed in young African children are partly attributed to risk factors including HIV, severe malarial anemia and malnutrition. Malaria may predispose to iNTS via macrophage dysfunction secondary to changes in iron metabolism as well as increased translocation through disordered gut barrier from sequestration of parasitized red blood cells in the intestine. In contrast to *Salmonella* Typhi and *Salmonella* Paratyphi, which are rarely encountered outside endemic countries or in returned travelers, NTS has a worldwide distribution. Each year, it is estimated 94 million cases of gastroenteritis are caused by NTS worldwide, with 1,55,000 mortalities. According to SalmSurv (a World Health Organization-supported food-borne disease surveillance network), *S*. Enteritidis and *S*. Typhimurium cause approximately 80% of all human cases.[3,4]

A recent United States' study of children under 5 years of age with laboratory- confirmed bacterial enteric illness reported that NTS was the most commonly isolated (42%) bacterial enteric pathogen, well ahead of *Campylobacter* (28%), *Escherichia coli* 0157, *Shigella* and *Yersinia enterocolitica*.[3] Similarly, a study from Shanghai found NTS to be the leading bacterial pathogen causing acute childhood enteritis with an isolation frequency of 17.2%, surpassing *Campylobacter* spp. (7.1%) and *Shigella* spp. (5.7%). In high-income countries, NTS causes a self-limiting enterocolitis in immunocompetent individuals; secondary bacteremia occurs in up to 5% of patients, with an attributable mortality of 1–5%. However, primary NTS bacteremia can occur in the immunocompromised, and mortality is significantly higher in this group (up to 21% in some case series).[4,5]

In low-income or developing countries, there is not sufficient data for estimating the extent of spread of NTS causing gastroenteritis. In contrast, in low-income countries, there is increased recognition of NTS as a major cause of severe febrile illness. Studies of bacteremia in Africa report NTS as one of the most commonly isolated pathogens in both adults and children. The estimated annual incidence of iNTS infection in Africa is 175–388 cases per 1,00,000 children aged 3–5 years, 7.8 cases per 1,00,000 infants (aged less than 1 year) and 1.6 cases per 1,00,000 toddlers (aged 1–4 years) in the US. There is a clear bimodal age distribution of iNTS disease in Africa, in which children aged 6–36 months and adults in their third or fourth decade of life are at the greatest risk. In contrast to high-income countries, the case fatality rate from iNTS is over 20% in African adults and children. The high burden of NTS in the African continent is not seen in Asia. A pediatric fever surveillance study involving five Asian centers found that *S*. Typhi and *S*. Paratyphi dominate community-acquired invasive salmonellosis and iNTS disease, which is generally uncommon. The reason for such distinct differences between Africa and Asia remains unclear; however, the lower prevalence of malaria and HIV in Asia may play a part.[3]

An inevitable side effect of antibiotic use, which is associated with the adaptability of bacteria and microbial genome evolution, is the emergence and dissemination of resistant bacteria, not only in pathogenic bacteria but also in the endogenous flora of man and animals. Resistant commensal bacteria of food animals, such as zoonotic bacteria, might contaminate meat products, thus reaching the intestinal tract of humans. Resistance genes against antibiotics that are or have only been used in animals were soon after their introduction found not only in animal bacteria, but also in the commensal flora of humans, in zoonotic pathogens such as *Salmonella*, and in strictly human pathogens, such as *Shigella*. There is evidence that resistance determinants can transfer between unrelated bacteria, such as *Bacteroides*, on the one hand, and *Salmonella* and *Escherichia* on the other. Therefore, not only may the clonal spread of resistant strains occur, but there is also a transfer of resistance genes between human and animal bacteria.[2] Antimicrobial therapy is indicated only for severe or invasive salmonellosis. Indiscriminate use of antimicrobials in both humans and veterinary has led to emergence of antimicrobial resistance (AMR) to both conventional (Ampicillin, Chloramphenicol, Tetracycline, and Co-Trimoxazole) and newer (third-generation Cephalosporins, Fluoroquinolones, and Azithromycin) drugs in NTS, which is a global concern. Since the resistance rate in NTS varies with different serotypes and in various geographical regions, knowledge on prevalent serovars and their AMR profiles is useful in formulating appropriate treatment (empirical) guidelines and controlling spread of the organisms in the community. Antimicrobial resistance to Ampicillin, Trimethoprim Sulfamethoxazole and Chloramphenicol is common. The US National Antimicrobial Resistance Monitoring System recently reported that approximately 5% of all NTS blood isolates from 2003 to 2013 were resistant to Ceftriaxone. The increasing rates of resistance to traditional agents (i.e., Ampicillin, Chloramphenicol, and Trimethoprim– Sulfamethoxazole) have turned the treatment of invasive salmonellosis into a clinical dilemma. [3,5]

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The emergence of resistance to Fluoroquinolones among NTS is of particular concern, since this class of antimicrobial agents constitutes the drug of choice for treating potentially life-threatening *Salmonella* infections caused by multiple-antibiotic resistant strains in adults. All Fluoroquinolones have the same mechanisms of action regardless of whether they are in clinical or veterinary medicine. These antibiotics inhibit the topoisomerase genes, leading to inhibition of DNA replication. This common mechanism of action means that resistance to one Fluoroquinolone will confer resistance to all other Fluoroquinolones. Another worrisome situation is the emergence of Ceftriaxone resistance in NTS, which is a big problem in Asian countries. For patients with invasive *Salmonella* infections that are resistant to both Ciprofloxacin and Ceftriaxone, Carbapenems may be the last drug of choice. However, in 2010, a Carbapenem-resistant *S*. Typhimurium was identified from a patient with urinary tract infection.[2]

There is not sufficient data on the prevalence of NTS serovars and their antibiotic susceptibility pattern from India. A study from North India showed NTS resistant to Amoxicillin (62.5%), Nalidixic Acid (66.7%), Cotrimoxazole (34.6%), Cefotaxime (48.1%), Chloramphenicol (37%) and Ciprofloxacin (18.5%).[4] The emergence and dissemination of multidrug resistance in non-typhoid *Salmonella* poses a serious threat to the public health and warrants continuous surveillance. Hence this topic was taken up for this dissertation.

MATERIALS AND METHODS

Children under 6 years of age suffering with acute gastroenteritis or dysentery admitted to the wards or presenting at the outpatient unit were included in the study. Stool specimens were collected by the microbiology lab attached to a tertiary care hospital. Exclusion criteria was antibiotic usage within 48 hours of admission and parents who did not give consent.

Patients' clinico-demographic details such as age and sex, dietary habits, travel history, and any underlying conditions were recorded. A detailed clinical history regarding the nature, frequency, and duration of diarrhea, frequency of vomiting, abdominal pain, pyrexia, and degree of dehydration were recorded in a standard proforma.

It is a cross-sectional observational study conducted from 1st July 2022 to 1st July 2023 at Niloufer hospital, Lakdi-ka-pul, Hyderabad with a sample size of 100 over a period of 1 year.

Sample Processing

Samples were immediately transported to the lab after collection and primary inoculation was carried on selective media (HiMedia Laboratories) - MacConkey agar, XLD (Xylose Lysine Deoxycholate) agar, SS (Salmonella Shigella) agar. TCBS agar was used to isolate Vibrio species.

Enrichment was performed on Selenite-F broth for 12h at 37°C which was sub-cultured after overnight incubation. Both primary and secondary culture plates were incubated at 37°C for 18–24 h. The presumptive identification of *Salmonella* spp. was based on colony morphology on MacConkey agar, XLD/SS agar plates; Motility by Hanging drop preparation and Gram staining. Biochemical tests performed were Catalase test, Oxidase test, Indole test, Citrate test, Urease test and Triple sugar iron (TSI) test.

Sugar fermentation tests were performed using Glucose, Sucrose Lactose, Maltose, Mannitol and Xylose. Amino acid decarboxylation/hydrolysis tests were performed using Lysine, Ornithine and Arginine.

Antimicrobial Susceptibility Test

Antibiotic susceptibility profiles were obtained against 12 antibiotics using the VITEK2 (bioMerieux) system. The antibiotics tested against the isolate were - Amoxicillin/Clavulanic acid, Piperacillin/Tazobactam, Cefuroxime, Cefoperazone/Sulbactam, Ceftriaxone, Cefepime, Imipenem, Amikacin, Gentamicin, Ciprofloxacin, Tegecycline, Trimethoprim/Sulfamethoxazole. The results were statistically analyzed using SPSS (Statistical Package for the Social Sciences) software for Windows.

Antigenic Profiling

Isolates of *Salmonella* were serotyped with specific polyvalent O and H antisera (Remel Diagnostics, Fisher Scientific). The strains confirmed as *Salmonella enterica* subspecies enterica were further serovar identified and antigenic profiling was done at the national reference center, NICED (National Institute of Cholera and Enteric Diseases), Kolkata, India.

RESULT

During the study period, 100 cases with suspected NTS were seen. Table 1 lays out the demographic and clinical characterization data of the patients.

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Table 1: Demographic and clinical characterization data of patients

S. No.	Factors	(n=100)
A.	Demographic characteristics	
1.	Age:	
	< 1 month (neonates)	7
	1 month to < 12 months (infants)	46
	1 year to < 3 years (toddlers)	23
	3 years - 6 years (preschoolers)	24
2.	Gender:	
	Male	57
	Female	43
B.	Clinical characteristics	
1.	Type of stool sample:	
	Diarrhea	23
	Semi-formed	45
	Formed	32
2.	Frequency of stools:	
	3-4 times	79
	5-6 times	12
	>6 times	9
3.	Degree of dehydration:	
	Mild	78
	Moderate	18
	Severe	4
4.	Fever:	
	Present	54
	Absent	46
5.	Abdominal pain:	
	Present	6
	Absent	94
6.	Vomiting:	
	Present	12
	Absent	88

Among these 100 cases, 57 are males and 43 are female children. Chart 1 shows the gender distribution of suspected cases.

Among these 100 cases, neonates (< 1 month) were 7, infants (1 month to < 12 months) were 46, toddlers (1 year to < 3 years) were 23 and preschoolers (3 years to 6 years) were 24. Chart 2 shows Age Distribution of suspected cases.

Identification of the isolates from the patient sample was done as per methodology. See Chart 3 for Organisms isolated.

Preliminary tests were performed on suspected NTS isolate - positive catalase test, negative oxidase test, nitrates were reduced to nitrites. Motile bacteria were visualized under the microscope after making a hanging drop preparation. Gram staining revealed gram negative bacteria.

Presumptive identification of NTS was based on colony morphology: Non- lactose fermenting (NLF) colonies on MacConkey agar plates, red colonies with black center from XLD agar plates and colorless colonies with black center from SS agar plates.

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Figure 1 shows the growth of NLF colonies on MacConkey agar plate

Figure 2 shows the growth of red colonies with black centers on XLD agar plate

Figure 3 shows the biochemical reactions (Indole, Citrate, Urease & TSI)

- Indole ring not formed
- Citrate is utilized
- Urease is not produced

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- TSI: K/A with H2S

Figure 4 shows Triple Sugar Iron (TSI) reaction

TSI: K/A with H2S

Sugars fermented by the isolate were Glucose, Maltose, Mannitol and Xylose. Lactose and Sucrose were not fermented. The amino acids Lysine and Ornithine were decarboxylated while Arginine was not hydrolyzed. shows the sugar fermentation (Glucose, Sucrose, Maltose, Mannitol & Xylose) and amino acid decarboxylation tests (Lysine, Ornithine & Arginine)

Antibiotic susceptibility profiles were obtained against 12 antibiotics using the VITEK2 (bioMerieux) system. The antibiotics tested were: Amoxicillin/Clavulanic acid, Piperacillin/Tazobactam, Cefuroxime, Cefoperazone/Sulbactam, Ceftriaxone, Cefepime, Imipenem, Amikacin, Gentamicin, Ciprofloxacin, Tigecyclin, Trimethoprim/ Sulfamethoxazole. The NTS isolate was sensitive to all the drugs tested.

Isolates of *Salmonella* were serotyped with specific polyvalent O and H antisera (Remel Diagnostics, Fisher Scientific). The strains confirmed as *Salmonella enterica* subspecies enterica were further serovar identified and antigenic profiling was done at the national reference center, NICED (National Institute of Cholera and Enteric Diseases), Kolkata, India.
The serotyping result of the NTS isolate is *Salmonella enterica* serovar Enteritidis 1,9,12, g,m, -

DISCUSSION

In contrast to *Salmonella* Typhi and *Salmonella* Paratyphi, which are rarely encountered outside endemic countries or in returned travelers. NTS has a worldwide distribution, but is more common during the rainy season. Each year, it is estimated 94 million cases of gastroenteritis are caused by NTS worldwide, with 1,55,000mortalities. A hospital-based study was carried out in suspected NTS patients to determine clinico-epidemiological profile, serotyping and antibiotic susceptibility pattern of the isolates. In the present study, out of 100 patients, 57% were males and 43% were females. According to the study done by Katz *et al*, patients with NTS bacteremia were 52% male and 48% female. According to the study done by subbur *et al*, patients with NTS bacteremia were 54% male and 46% female.

In the present study, the age distribution of the patients was, < 1 month (neonates) were 7%, 1 month to < 12 months (infants) were 46%, 1 year to < 3 years (toddlers) were 23% and 3 years - 6 years (preschoolers) were 24%. The youngest patient being 3 days old and oldest patient being 6 years old. According to the study done by Katz *et al*, of the NTS bacteremia cases, 19% were children aged less than1 year, 27% were children aged 1–4 years, and 8% were children aged 5–18 years, while adults aged 19–59 years comprised 10% and those aged 60–97 years comprised 36% of the cases.

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According to the study done by Subbur *et al*, of the NTS bacteremia cases, 7.7% were children <1 month of age and 92.3% were children <3-12 months of age.

In the present study, the organisms isolated from suspected cases of NTS were *E. coli*, *Klebsiella* spp., *Proteus* spp., *Shigella* spp., *Pseudomonas* spp., *Enterococcus* spp., *Vibrio* spp., and *Salmonella* spp. Salmonella spp. was identified as *Salmonella enterica* subspecies enterica serovar Enteritidis (1,9,12, g,m, -) According to SalmSurv (a World Health Organization-supported food-borne disease surveillance network), *S.* Enteritidis and *S.* Typhimurium cause approximately 80% of all human cases. A recent United States study of children under 5 years of age with laboratory-confirmed bacterial enteric illness reported that NTS was the most commonly isolated (42%) bacterial enteric pathogen, well ahead of *Campylobacter* (28%), *Escherichia coli* 0157, *Shigella* and *Yersinia enterocolitica*.[3] Similarly, a study from Shanghai found NTS to be the leading bacterial pathogen causing acute childhood enteritis with an isolation frequency of 17.2%, surpassing *Campylobacter* spp. (7.1%) and *Shigella* spp. (5.7%). 1

The incubation for NTS gastroenteritis depends on the host and the inoculum. It is usually 12–36 h, although incubation periods of up to nearly 2 weeks have been reported with certain strains. Salmonellae are unable to survive at a gastric pH less than 2.5 and patients with anatomical or functional achlorhydria are at increased risk of developing infection. This is especially relevant to neonates where the combination of relative achlorhydria and frequent milk feeds may contribute to their increased risk of NTS bacteraemia.[1]

The median duration of NTS excretion in children less than 5 years of age is 7 weeks, with 18 % remaining culture positive at 6 months. Carriage is shorter in older children with a median duration of 3–4 weeks with only 0.3 % remaining culture positive at 6 months. In addition to younger age, factors associated with prolonged duration of excretion include symptomatic infection, treatment with antibiotics and infection with strains other than. Documented excretion of NTS for more than 1 year is defined as chronic carriage. This occurs in up to 2.6 % of children under 5 years of age and 0.3 % of older children.[1]

Children aged 12–23 months were found to be significantly more susceptible to Salmonella gastrointestinal (GI) infection. This age group is more vulnerable to GI infection due to reduced protective immunity caused by switch from breast to bottle feeding, habits of crawling, and tendency to put fingers or fomites inside the mouth.[5]

In one study, 7 of 12 (58 %) immunocompromised children developed focal infection compared with 5 of 132 (4 %) non-immunocompromised children. Overall, NTS bacteraemia is reported in up to 9% of patients with acute gastroenteritis.[1] Abdominal pain (6%) and fever (54%) were not reported to be the cardinal features of Salmonella gastroenteritis in the current study.

Surveillance data from the United States showed the incidence of iNTS was 7.8 cases per 100,000 in infants (aged less 1 year) compared to less than 0.8 cases per 100,000 in older children. Significant discordance in the burden of iNTS between continents exists with an estimated annual incidence of up to 388 per 100,000 children (aged less than 5 years) in Africa. The high prevalence of malaria in Africa, and its association with invasive NTS, has been postulated as one reason for this difference. Interestingly, recent studies in the Gambia, Kenya and Tanzania have shown that the marked decline in malaria prevalence has been paralleled by a similar reduction in invasive NTS.1 In this study NTS bacteraemia did not develop.

In the study done by Priyanka jain *et al*, S. Worthington, S. Enteritidis, S. Typhimurium, S. Bareilly, S. Virchow, and S. Weltevreden were the frequently isolated serovars. Presence of alocal animal reservoir or food greatly contributed towards dominance of certain serotypes in particular regions.

Interestingly, Salmonella serotype distribution at one place may vary over a course of time. In this study, S. Worthington dominated during 2000–2005 and was then gradually replaced by other serovars since 2007 and S. Typhimurium emerged as the most prevalent serovar during 2013–2016. Changes in meteorology, human food habits, international travel, and trade have been associated with the temporal dominance of certain serotypes followed by a decline and replacement with another. [5] In this study Salmonella enterica serovar Enteritidis (1,9,12, g,m, -) was isolated which is a common NTS serovar.

In India, NTS constitute approximately 20 % of the Salmonella serovars currently circulating. With respect to AMR in different serovars, 71.4% *S.* Virchow, 83.3% *S.* Typhimurium, and 100% *S.* Enteritidis studied isolates were pan-susceptible, which was in sharp contrast to multiple resistances reported in these serovars world- wide.[5] In this study NTS isolate was sensitive to all the antibiotics tested.[6]

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Agents for treatment of NTS can be divided into non-absorbable (colistin and neomycin), absorbable (ampicillin, amoxicillin, tetracycline, macrolide and trimethoprim- sulfamethoxazole) and those with potent intra-cellular activity (fluoroquinolones. As Salmonellae are intracellular pathogens, it is postulated that the latter may be more effective in treatment of this infection and is specifically recommended for treatment of immunocompromised patients in two sources. Antibiotic agents with in vitro and in vivo activity against NTS include ampicillin/amoxicillin, trimethoprim-sulfamethoxazole, tetracyclines, third generation cephalosporins, macrolides and fluoroquinolones. Aminoglycosides show good in vitro activity but poor clinical efficacy and are not recommended.[1]

A Cochrane review of trials investigating antibiotic treatment of NTS concluded that there was no evidence to support antibiotic therapy in otherwise healthy children and adults with non-severe diarrhoea. The review did not identify significant differences in length of illness, diarrhoea or fever between any antibiotic regimen and placebo. Furthermore, although antibiotics were associated with more negative stool cultures during the first week of treatment, clinical relapse was more common and there were more cases of positive cultures at three weeks in the antibiotic-treated group. Adverse drug reactions, including rash, gastrointestinal upset and headache, were also more common in the antibiotic group.[7,8,9]

Despite this variability, recommendations for the treatment of infants under 3– 6 months of age and immunocompromised patients are consistent between all identified references. A 1988 consensus statement for the management of Salmonella infections in the first year of life similarly recommends treatment in infants less than 3 months following a blood culture irrespective of the severity of illness. Other conditions where treatment has been recommended, albeit less consistently, include haemoglobinopathies, chronic gastrointestinal disease (for example inflammatory bowel disease), severe infection, malnourished state and vascular or joint disease.[11]

The optimal duration of treatment of NTS gastroenteritis has not been studied. Recommendations vary amongst sources between 3 and 14 days depending on the underlying condition. Of the trials included in the Cochrane review, duration varied between 1 and 14 days, with 5 days being the most common treatment regimen. The authors commented that the two studies with longer antibiotic treatment duration (10 and 14 days) showed an apparent benefit of antibiotics at 8–21 days. After this review, a study reported that 10 days of ofloxacin compared with 5 days resulted in earlier eradication of NTS without an increase in carriage. However, this study was relatively small and did not include a placebo arm.[1]

Antibiotic-resistant NTS are associated with increased treatment failure and risk of invasive disease. Worldwide surveillance data has demonstrated an overall increase in antibiotic resistance among NTS, although significant geographical and serotype variability exist. The widespread use of antibiotics in food animals has been implicated in the increasing prevalence of antibiotic resistant NTS. The European Centre for Disease Control (formally Enter-net) and the National Antimicrobial Resistance Monitoring System (NARMS) provide comprehensive surveillance data on rates of NTS drug resistance in Europe and the United States. Data from these studies, as well as reports from middle to low-income countries, indicate high rates of ampicillin, amoxicillin and trimethoprim-sulfamethoxazole resistance, particularly among the globally prevalent serotypes *Salmonella* Enteritidis and *Salmonella* Typhimurium. Of particular concern is the emergence of extended spectrum beta-lactamase (ESBL) genes in NTS, as well as reports of carbapenemase-containing NTS isolates, both of which confer high level antimicrobial resistance.[12]

Fluoroquinolones and third generation cephalosporins are frequently used for the treatment of NTS that are resistant to conventional antibiotics, although reports of increasing resistance to these second line agents are emerging. Isolates resistant to nalidixic acid are frequently resistant to fluoroquinolones, and this is a recommended screening test for ciprofloxacin resistance. However, although a study found the nalidixic acid disk diffusion method was 100 % sensitive for the detection of reduced ciprofloxacin susceptibility (defined as MIC> 0.125 μg/ml), there have been subsequent reports of isolates that are susceptible to nalidixic acid but exhibit reduced susceptibility to ciprofloxacin.

In the study done by Menezes *et al*, Nine of the 21 non-typhoidal Salmonella isolates were found to possess the SHV-12-type ESBL gene. SHV-12 is currently one of the most common non-CTX-M ESBLs circulating, and has been identified in many Gram-negative species, including Salmonella serovars.[13]

CONCLUSION

A cross-sectional observational study was done to determine the proportion of NTS & their antimicrobial susceptibility in children presenting with acute gastroenteritis. Outbreaks of NTS have been reported in neonatal units, paediatric wards and childcare facilities. However, despite the frequency of asymptomatic NTS excretion following acute infection, the risk of transmission from asymptomatic health care workers to patients appears to be small when strict adherence to hand hygiene is observed. Similarly, transmission from asymptomatic food handlers is rare, with one survey identifying only 2 % of food handlers as the source of 566 NTS outbreaks.

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Methods to control the spread of Salmonella include appropriate food preparation, water sanitation and strict hand hygiene. Most resources recommend exclusion of children, health care workers and food handlers from childcare/school or work until 24–48 h after resolution of symptoms. For symptomatic hospitalised patients, standard and contact precautions are recommended. There are also some non- randomised data that suggest the prophylactic use of antibiotics (trimethoprim- sulfamethoxazole or ciprofloxacin) in addition to strict barrier nursing, may control nosocomial Salmonella epidemics. Antibiotic susceptibility profiles were obtained against 12 antibiotics. NTS isolate was sensitive to all the drugs tested in this study. The serotyping result of the NTS isolate is *Salmonella enterica* serovar Enteritidis 1,9,12, g,m.

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