

Content available at: <https://www.ipinnovative.com/open-access-journals>

IP International Journal of Medical Microbiology and Tropical Diseases

Journal homepage: <https://www.ijmmttd.org/>

Review Article

Non Typhoidal Salmonellae and its aetiological spectrum-An overview with Indian perspective

Beena Antony^{1,*}

¹Dept. of Microbiology, Fr.Muller Medical College, Mangalore, Karnataka, India



ARTICLE INFO

Article history:

Received 02-12-2021

Accepted 07-01-2022

Available online 12-02-2022

Keywords:

Extra intestinal Manifestations

Food Poisoning

Gastroenteritis

Non Typhoidal Salmonellae (NTS)

ABSTRACT

Background: Non Typhoidal Salmonellae (NTS) is emerging as a major health problem. NTS serovars have a wide variety of host range varying from domestic animals, aquatic fauna, reptiles, arthropods, leafy vegetables and many more. This zoonotic infection manifests as self limited gastroenteritis associated with food poisoning to fatal extra intestinal invasive infections.

Aim & Objective: In this overview, an attempt is made to compile the documented reports due to NTS from Indian subcontinent for the last 5 decades, searching the available databases. These reports emphasizes the role of NTS in diverse clinical infections and the possible links of transmission.

Conclusion: Prophylactic measures such as adoption of quality measures in fish and meat processing units, vaccination of farm animals, serotyping of all NTS strains, above all health education and public awareness program should be made mandatory to minimize the incidence of NTS in our country.

This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License](https://creativecommons.org/licenses/by-nc-sa/4.0/), which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprint@ipinnovative.com

1. Introduction

Non Typhoidal Salmonellae (NTS) which excludes *S.Typhi* & *S.Paratyphi*- is emerging as a major health problem across the globe. Salmonellae species are widely distributed in the environment and commonly found in farm effluents, human sewage as well as any material that is subjected to faecal contamination. These infections are also acquired through contact with pet animals or from veterinary clinics, zoological gardens, farm environments as a part of occupation. NTS species are mainly responsible for the food borne infections, gastroenteritis acquired through direct or indirect animal contact or by consumption of foods such as meat, sea foods, poultry products, leafy vegetables. Salmonellosis in animals always presents a potential zoonotic threat as these infected animals serve as a source of infections to humans. Subclinical infection in

farm animals may lead to the contamination of meat, eggs or milk. It can also cause secondary contamination of fruits and vegetables fertilized or irrigated with water containing faecal wastes. Bovine Salmonellosis manifests clinically resulting in septicemia, acute or chronic enteritis and abortion. Hence, Salmonellosis in farm animals will cause a huge economic burden to the farmers for the management of these infections.

There are many contributory factors in India for the development of NTS infections such as occupation, geographic and climatic conditions. Agriculture being the main occupation in India, contact with farm animals and inadequate sanitary conditions occur very often. Poultry and dairy farming are two important means of livelihood for numerous people in India. Indian peninsula is surrounded by water bodies such as lakes, river, sea, hence fish and seafood are used as a common accompaniment.

* Corresponding author.

E-mail address: beenafmmc@gmail.com (B. Antony).

Many species of NTS were reported to cause extra intestinal, invasive infections such as meningitis, septicaemia, bacteremia, septic arthritis as reported by various investigators from India. The severity of the NTS infection may vary from self limiting diarrhoeal diseases to fatal invasive infections which are more commonly found in immunocompromised patients or those who are with underlying diseases. In addition, many gastrointestinal outbreaks due to consumption of diverse foods were also documented in the literature.

Genus Salmonella includes more than 2500 serotypes which are potential human and animal pathogen. Taxonomy of Salmonella is complicated and undergoes periodical revisions. The designation of Salmonella serovars got the present Nomenclature status as adopted in WHO International Centre for Salmonella and the Centres for Disease Control and Prevention (CDC) which use shortened serovar nomenclatures. For example, S. enterica serotype typhimurium may be written as Salmonella Typhimurium for convenience. According to this, the name of the genus is written in italics but not the serotype name which starts with a capital letter.

In this overview, an attempt is made to compile the mushrooming, documented reports regarding gastroenteritis, extra intestinal infections and outbreaks due to NTS from Indian subcontinent for the last 5 decades, searching the available databases. The documented reports of NTS from India are shown in Table 1. As NTS infections are not notifiable and many of the isolates are not serotyped, this may be an underestimated data. All these reports are arranged in the alphabetical order of the Salmonella Serotypes, each report in the chronological order of occurrence and citing the reference number in the order that appears in the text.

2. NTS Infections Reported from India

As reported in most of the studies from other countries and also the results of our findings, S. Typhimurium was the most frequently encountered NTS in India followed by S. Senftenberg and S. Weltevreden. S. Typhimurium mainly causes outbreaks of Gastroenteritis, primarily in children.¹⁻⁶ Few extra intestinal manifestations are also reported which include neonatal septicemia⁷ neonatal septic arthritis⁸ scalp abscess⁹ and meningitis.¹⁰ In our study one isolate of S. Typhimurium was obtained from a suspected case of bacteremia. We have encountered

a sporadic outbreak of food poisoning associated with S. Typhimurium due to consumption of squid, during a get together in a reputed restaurant in Mangalore.

S. Senftenberg was the second most common NTS reported from India. It was responsible for Extraintestinal infections such as Septicemia^{11,12} Lung Abscess,¹³ Pleuro pulmonary infection¹⁴ Empyema,¹⁵ and ear infection.¹⁶ Many outbreaks were also documented, especially in neonatal or paediatric wards.¹⁷

S. Weltevreden is another predominant NTS responsible for outbreaks of Gastroenteritis and food poisoning.¹⁸⁻²⁰ An outbreak investigation of S. Weltevreden food poisoning in a tea garden of Assam was reported by Saikia et al²¹ Extra intestinal infections include enteric fever like infection, cholecystectomy surgical site infection.²² Sepsis in two newborns was reported by Patil²³ and ulcerative skin lesions by Desikan²⁴ An outbreak of food poisoning due to S. Weltevreden involving many nursing students had been occurred in our institute due to a non vegetarian dish, in a get together.²⁵

E. Enteritidis is usually causing extra intestinal manifestations and reported as aetiological agents of Septic arthritis,²⁶ complicated Aortic aneurism, meningitis,²⁷ polyserositis, arthritis following trauma in a child with Thalassemia Major.²⁸ Gastroenteritis due to S. Enteritidis was reported by Vijaya et. al.²⁹ We also experienced a small outbreak due to S. Enteritidis, probably associated with consumption of egg.

2.1. Rarely encountered NTS

S. Newport & S. Worthington are also reported from India, but not so frequently like other NTS. S. Newport was mainly causing Gastrointestinal epidemics^{30,31} and few Extraintestinal infections such as Neonatal septicemia.³² S. Worthington was more commonly encountered in Extraintestinal manifestations such as septicemia, meningitis³³⁻³⁵ An Outbreak of S. Worthington in a neonatal ward in a general hospital was reported by Muley et. al.³⁶

S. Oranienberg was responsible for Gastrointestinal outbreaks.^{37,38} S. Dublin was exclusively isolated from invasive infections like meningitis.³⁹ Dias et. al reported S. Dublin bacteremia mimicking Enteric fever from our institute.⁴⁰ S. Bareilly was isolated from pediatric infections,⁴¹ neonatal poly arthritis and septicemia⁴² by various investigators. It was reported as the second

highest organism isolated from faecal samples in Goa by Verenkar. Two case reports on *S. Virchow* causing invasive infections such as meningitis,⁴³ septicemia in an infant⁴⁴ were also documented in the literature. Devi from Manipal and Jesudason from Vellore isolated *S. Agona* from Gastroenteritis cases.^{45,46} In our experience one strain of *Agona* was isolated from a gastroenteritis case.

Panhotra et.al reported an outbreak of *S. Anatum* infection from a premature nursery at Chandigarh.⁴⁷ We could isolate *S. Anatum* from a bacteremia case in our institute. The rare isolates of NTS reported from our country include fatal gastroenteritis in an infant with microcephaly due to *S. Arizona* by Mahajan et.al,⁴⁸ *S. Bornheim* causing UTI in a diabetic patient with aplastic anemia,⁴⁹ *S. Branderup*,⁵⁰ *S. Cerro* causing pyaemia,⁵¹ *S. Havana* from a case of neonatal meningitis.⁵² *S. Mbandeka*, a rare serotype was isolated in Ambajogai, rural area by Fule and Kaundinya.⁵³ *S. Newbrunswick* causing infection in an old man was reported by Shrinivas in a hospital from Delhi.⁵⁴ Other unique strains of NTS reported include *S. Roan* from bacteraemia,⁵⁵ *S. Tamilnadu* from a gastroenteritis in a child.⁵⁶ A case of invasive gastroenteritis with acute kidney injury and hemiplegia was reported by Ballal et.al due to *S. Wangata*.⁵⁷ Three rare isolates such as *S. Augstenborg*, *S. Indiana*, *S. Regent* were reported by Basu et.al for the first time in India. In a 16 year study Basu et al described the prevalence of various new *Salmonella* serotypes in India.⁵⁸ A very interesting finding in this study was that out of 99 serotypes obtained from 8027 strains of *Salmonella*, 13 were isolated only from man and 49 exclusively from animals with *S. Weltevreden* being the commonest serotype. *S. Typhimurium* was the commonest species isolated from animals. Jain P et.al reported a blood and urine culture positive bacteremia by *S. Choleraesuis* for the first time in India.⁵⁹ A rare case of Pyogenic meningitis caused by *Salmonella choleraesuis* var. *Kunzendorf* had been reported by Prakash and Ray in 1970.⁶⁰

A South Indian Study describing the Seroprofiling of NTS isolated from Gastroenteritis, few rare serovars were reported which included *S. Bovismorbificans*, *S. Schleissheim*, *S. Wangata* and Ciprofloxacin resistant *S. Kentucky*. More recently, a case of Gastroenteritis in a 10 year old child, complicated by Severe Acute Kidney Injury and neurological dysfunction due to a new NTS species *S. Decatur* was reported by Krishnamurthy & Mandal from Pondicherry.⁶¹ Occasional reports regarding the changing pattern of *Salmonella* serovars from various geographical areas also appeared in the literature. Another rare serotype *S. Wien*, one of the epidemic clones which spread from North Africa through Europe in the 1970s was isolated from 10 cases of gastroenteritis in our hospital.⁶²

For the last 10 years duration, 145 NTS were isolated from feces and 8 strains of NTS from suspected cases of bacteremia, including 4 outbreaks occurred in our institute was presented in GISICON, 2021. *S. Oslo* was not so commonly reported from India. However in the recent past there was a sudden change in the pattern of NTS where we observed the emergence and prevalence of *S. Oslo* for a certain period of time. Rare serotypes such as *S. Bareilly*, *S. Anatum*, *S. Infantis*, *S. Hadar*, *S. Dunkuwa* and *S. Kentucky* were also obtained from Gastroenteritis cases during this period. Prevalence of *S. Oslo* was reported by Ballal et.al in Cancer patients, from a neighbouring district of Mangalore, Dakshina Kannada.⁶³

Emergence of multi drug resistance in NTS strains is a major concern nowadays. Many investigators reported MDR *Salmonellae* from various States in India.⁶⁴ A detailed Review describing the various mechanisms involved in the resistance in NTS is done by Bhaskar & Harish from Pondicherry.

3. Conclusions

The documented reports from Indian Subcontinent emphasizes the role of NTS in diverse clinical infections and the possible links of transmission. There are many contributory factors in our country for the occurrence of these infections. As NTS is widely distributed in animals and sea foods, it is very essential to adopt stringent quality measures in the poultry, fish, dairy and meat processing units. A structured questionnaire to the patients and the family, Vaccination of Farm animals and inclusion of NTS in the list of notifiable diseases will definitely be helpful to understand the magnitude of the problem. Many of the NTS species are biochemically similar, hence serotyping of all the isolates are to be made mandatory. In addition, strategies should be formulated by health education and public awareness program to sensitize the population and thereby minimising the incidence of NTS in our country.

Table 1: Documented Reports of NTS Infections from India:

Serotype	Clinical Manifestation	Author	Ref No.
S.Agona	Gastroenteritis	DeviJN et.al(1985)	45
	Gastroenteritis	Jesudasan M,(1988)	46
S.Anatum	Outbreak in Chandigarh	Panhotra et.al, (1979)	47
S.Arizona	Fatal Gastroenteritis	Mahajan et.al, (2003)	48
S.Augstenborg	First case from India	Basu S et al., 1972	58
	Paediatric Infections	Aggarwal et.al, (1983)	41
S.Bareilly	Septicaemia	Gupta et.al, (1997)	42
	UTI in DM & Aplastic Anaemia	Snehalatha et.al (1992)	49
S.Bornheim	Gastroenteritis	Ballal	63
S.Bovismorbificans	First case from India	Devi. JNS et.al, (1988)	50
S.Braenderup	Pyemia	Bhore et.al (1980)	51
S.Cerro	Isolation from blood & urine	Jain P et.al,2014	59
S. Decatur	Gastroenteritis	Krishnamurthy &, Mandal2020	61
	Meningitis	Diwan et.al (1997)	39
S.Dublin	Bacteremia	Dias et.al (2009)	40
	Bilateral septic Arthritis	John et.al (1993)	26
	Meningitis	Varaiya et.al (2001)	27
S.Enteritidis2	Arthritis	Behera et.al (2010)	28
	Gastroenteritis	Vijaya et.al, (2012)	29
	Meningitis	Menon et.al, (1994)	52
S.Havana	First report from India	Basu et.al., 1975	58
S.Indiana	gastroenteritis	Taneja	64
S.Infantis	gastroenteritis	Ballal	63
S.Kentucky	Pyogenic Meningitis	Prakash & Ray, 1970	60
S. Kunzendorf	Isolation of a rare serotype	Fule & Kaundinya, (1985)	53
S.Mbandeka	Infection in an old man	Shriniwas et.al (1983)	54
	Nursery Outbreak	Kumari S et.al (1980)	30
S.Newport	Epidemic	Dravid et.al (1989)	31
	Neonatal Septicaemia	Rao MR et al, (1991)	32
	Gastroenteritis	Aggarwal et.al (1980)	37
S.Oranienburg	Outbreak in NICU	Mehta et.al (1982)	38
	Gastroenteritis	Ballal	63
S.Regent	First report from India	Basu et.al , 1973	58
S.Roan	Bacteraemia	Sundaram et.al (1983)	55
S.Schleissheim	gastroenteritis	Ballal	63
	Nosocomial outbreak	Narang et al (1985)	17

Continued on next page

S.Senftenberg

<i>Table 1 continued</i>			
	Septicemia	Saigal et.al (1989)	11
	Septicaemia	Gupta P et.al, (1993)	12
	Lung Abscess	Gupta JP, (1994)	13
	Pleuropulmonary Infection	Nair D, (1999)	14
	Hospital acquired Empyema	Ramanathan et.al (2000)	15
	Ear Infection	Bairy I et.al (2000)	16
S.Tamilnadu	Gastroenteritis in a child	Nath ML et.al (1970)	56
S.Thompson	gastroenteritis	Taneja	64
	Nosocomial epidemic	Puri et.al, (1980)	1
	Outbreak of gastroenteritis	Bhat & Macaden(1983)	2
	Outbreak in Paediatric ward	Chaturvedi et.al, (1985)	3
	Outbreak in Solapur	Fule et.al (1988)	4
S.Typhimurium	Protracted diarrhoea in infants	Koshoo et.al (1990)	5
	Neonatal septicaemia	Rao PS (1993)	7
	Nosocomial outbreak	Mahajan R et.al, (1995)	6
	Neonatal septic arthritis	Sarguna &Lakshmi,(2005)	8
	Scalp Abscess	Baliga S et.al(2011)	9
	Meningitis in infancy	Adhikary R,(2013)	10
S.Virchow	Meningitis in an infant	Sachdeva et.al(1963)	43
	Sepsis in an infant	Randhawa et.al(2006)	44
S.Wangata	Invasive Gastroenteritis	Ballal et.al(2015)	57
	Outbreak of Gastroenteritis	Y.K.Chitkara,M K Gill(1976)	18
	Outbreak of food poisoning	Aggarwal,(1985)	19
	Post cholecystectomy surg.site inf.	Ashok R.et.al,(2005)	22
	Sepsis in 2 Newborns	Patil BA et.al,(2006)	23
	Sporadic outbreak of food poisoning	Antony.B.et.al,(2009)	24
	Ulcerative skin lesion	DesikanP et.al,(2009)	25
	Outbreak of food poisoning	Priyanka Jain, (2015)	20
	Outbreak in Tea Estate	Saikia et.al, (2015)	21
S.Wien	Gastroenteritis -10 cases	Antony B.et.al, (2009)	62
	Meningitis & septicaemia	Ayyagari et.al, (1990)	33
S.Worthington	Outbreak of Neonatal septicaemia	Rodrigues et.al, (1994)	34
	Outbreak of Neonatal Meningitis	Udani et.al, (1999)	35
	Neonatal outbreak	Muley et.al ,(2004)	36

4. Conflicts of Interest

The authors declare no potential conflict of interest with respect to research, authorship, and/or publication of this article.

5. Source of Funding

None.

References

- Puri V, Thirupuram S, Khalil A, Varghese A, Gupta SS. Typhimurium epidemic in a Neonatal special care unit. *Indian Pediatr.* 1980;17(3):233-9.
- Bhat P, Macaden R. Outbreak of gastroenteritis due to multidrug resistant Salmonella Typhimurium phage type 66/122 UT in Bangalore. *Indian J Med.* 1983;78:454-8.
- Chaturvedi P, Narang P, Khan MJ, Sharma S. An outbreak of Salmonella Typhimurium infection in a Paediatric ward. *Indian J Pathol Microbiol.* 1985;28(2):121-8.
- Fule RP, Ninawe RW, Saoji AM. Outbreak of gastroenteritis due to Salmonella Typhimurium in Solapur. *Indian Pediatr.* 1988;25:57-60.
- Koshoo V, Raj P, Srivastava R, Bhan MK. Salmonella Typhimurium associated severe protracted diarrhea in Infants & young children. *JPediatr Gastroenterol Nutr.* 1990;10(1):33-6.
- Mahajan R, Mathur M, Kumar A, Gupta P, Faridi MM, Talwar VJ, et al. Nosocomial outbreak of S.Typhimurium infection in a Nursery Intensive Care Unit (NICU) and Paediatric ward. *J Commun Dis.* 1995;27(10):10-4.
- Rao SP, Baliga M, Shivananda PG. Bacteriology of Neonatal Septicemia in a Rural Referral Hospital in South India. *J Trop Pediatr.* 1993;39(4):230-3.
- Sarguna P, Lakshmi V. Neonatal septic arthritis due to Salmonella Typhimurium. *Indian J Med Microbiol.* 2005;23(1):66-7.
- Baliga S, Shenoy S, Saldanha DRM, Prashanth HV. Scalp abscess due to Salmonella Typhimurium. *Indian J Pathol.* 2010;53(3):572-3.
- Adhikary R, Joshi S, Ramakrishnan M. Salmonella Typhimurium Meningitis in Infancy. *Indian J Crit Care.* 2013;17(6):392-3.
- Saigal RK, Kanta S, Gupta VK. Salmonella senftenberg septicemia- Report of two cases. *Indian J Med.* 1989;7:127-9.
- Gupta P, Ramachandran VG, Sharma PP, Faridi MMA, Talwar V, Mathur M, et al. Salmonella Senftenberg septicemia: A nursery outbreak. *Indian Pediatr.* 1993;30:514-5.
- Gupta JP, Borkar PB, Durairaj P. Salmonella Group E (Senftenberg) lung abscess. *Indian J Chest Dis Allied Sci.* 1994;34(2):83-6.
- Nair D, Kabra S, Gupta N, Prakash SK, Jain SK, Mathur MD, et al. Pleuro pulmonary infection with Salmonella group E. *Diagn Microbiol Infect Dis.* 1999;34(4):321-3. doi:10.1016/s0732-8893(99)00048-6.
- Ramanathan RMPL, Aggarwal AN, Dutta U, Ray P, Singh K. Pleural involvement by S.Senftenberg: A report of 2 cases. *Indian J Chest Dis Allied Sci.* 2000;42(1):31-3.
- Bairy I, Bhaskaranand N, Shivananda PS, Senftenberg. Ear infection - A case report. *Indian J Med Sci.* 2000;54(2):65-6.
- Narang P, Chaturvedi P, Bhatia BD, Dubey AP, Mathur NB. A nosocomial outbreak in pediatric ward due to Salmonella senftenberg. *Indian J Med Microbiol.* 1985;3:183-9.
- Chitkara YK, Gill MK. Outbreak of gastroenteritis due to Salmonella Weltevreden in a hospital. *Indian J Med Res.* 1976;64(9):1280-7.
- Aggarwal P, Singj SM, Bhattacharya MM. An outbreak of food poisoning in a family due to S.Weltevreden at Delhi. *J Diarrhoeal Dis Res.* 1985;3(4):224-5.
- Jain P, Nandy S, Bharadwaj R, Niyogi SK, Dutta S. Salmonella enterica serovar Weltevreden ST 1500 associated foodborne outbreak in Pune. *India Indian J Med Res.* 2015;141(2):239-41.
- Saikia L, Sharma A, Nath R, Choudhury G, Borah AK. Salmonella enterica serovar Weltevreden food poisoning in a tea garden of Assam. An Outbreak Investigation. *Indian J Med Microbiol.* 2015;33(4):503-6.
- Ashok R, Anuradha K, Lakshmi V, Kumar A, Bheerappa N, Sastry RA, et al. Post cholecystectomy surgical site infection by Salmonella enterica var. Weltevreden. *Surg Infect.* 2005;6(4):449-51.
- Patil BA, Krishna BV, Chandashekar MR. Neonatal sepsis caused by S.Enterica Serovar Weltevreden. *Southeast Asian J Trop Med Public Health.* 2006;37(6):1175-8.
- Desikan P, Kumar Y, Pande HK, Jain A, Panwalker N, Verma M, et al. Isolated Ulcerative skin lesion caused by Salmonella Weltevreden. *J Infect Developing Countries.* 2009;3(7):569-71.
- Antony B, Dias M, Shetty AK, Rekha B. Food poisoning due to Salmonella enterica serotype Weltevreden in Mangalore. *Indian J Med Microbiol.* 2009;27:257-8.
- John R, Mathai D, Daniel AJ, Lalitha MK. Bilateral septic arthritis due to Salmonella Enteritidis. *Diagn Microbiol Infect Dis.* 1993;17(2):167-9.
- Varaiyaa SK, Tendolkar U, De A, Shah S, Mathur M. Salmonella Enteritidis meningitis - A case report. *Indian J Med Microbiol.* 2001;19(3):151-2.
- Behera B, Mathur P, Farooquek, Sharma V, Bhardwaj N, Thakur YK, et al. Salmonella enterica Enteritidis Arthritis Following Trauma in a Child with Thalassemia Major. *Indian J Pediatr.* 2010;77(7):807-8.
- Vijaya D, Janakiram K, Satish JV, Mohan DR. Salmonella enteritidis causing gastroenteritis. A case report. *J Clin Diagn Res.* 2012;6(4):727-8.
- Kumari S, Gupta R, Bhargava SK. A nursery outbreak with Salmonella Newport. *Indian Paediatr.* 1980;17(1):11-6.
- Dravid M, Bhore AV, Joshi BN, Phadke SS. Newport Isolations from a general hospital in Pune. *J Commun Dis.* 1989;21:133-6.
- Rao MR, Purkayastha SB, Khurana RC, Raghunath D. Salmonella Newport Neonatal septicemia. *Med J Armed Forces India.* 1991;47:147-8.
- Ayyagari A, Chander J, Narang A, Banerjee CK, Panigrahi D, Bhakoo ON, et al. Outbreak of Salmonella worthington meningitis & septicaemia in a hospital at Chandigarh (north India). *Indian J Med Res.* 1990;91:15-7.
- Rodrigues C, Mehta AP, Bavdekar M, Lokeshhhwar M, Udani S, Prabhu SV. Neonatal outbreak of S.Worthington septicemia in the city of Mumbai. *Bombay Hosp J.* 1997;39:71-3.
- Udanirh, Kabra NS, Nanavati RN, Baweja S. Outbreak of Salmonella worthington meningitis in neonatal intensive care unit. *Indian Pediatr.* 1999;36(3):300-3.
- Muley VA, Pol SS, Dohe VB, Nagdawane RP, Arjunwadkar VP, Pandit D, et al. Neonatal outbreak of Salmonella worthington in a general hospital. *Indian J Med Microbiol.* 2004;22(1):51-3.
- Aggarwal P, Chowdhury ANR, Singh M, Dutta JK. Isolation of Salmonella oranienburg from three patients of gastroenteritis in North Delhi. *J Commun Dis.* 1980;12(4):212-3.
- Mehta G, Prakash K, Sharma KB. Salmonella Oranienburg infection in a neonatal unit in New Delhi. *Indian J Med Res.* 1982;75:480-4.
- Diwan N. Salmonella Dublin Meningitis, Report of a case. *Indian J.* 1977;44(351):110-1.
- Dias M, Antony B, Pinto H, Rekha B. Salmonella enterica Serotype Dublin Bacteremia mimicking Enteric Fever. *Indian J Med Microbiol.* 2010;27(4):365-7. doi:10.4103/0255-0857.55463.
- Aggarwal P, Sarkar R, Singh M, Grover BD, Anand BR, Chowdhury AN, et al. Salmonella Bareilly infection in a paediatric hospital of New Delhi. *Indian J Med Res.* 1983;78:22-5.
- Gupta P, Talwar V, Revathi G, Kumar A. Nosocomial Salmonella Bareilly septicemia. A Nursery outbreak. *Indian Pediatr.* 1997;34(2):144-6.
- Sachdeva LD, Malhotra OP. Meningitis due to Salmonella Virchow in an infant. *Indian J Pathol Bacteriology.* 1963;37:134-41.
- Randhawa VS, Mehta G, Das A, Chugh A, Aneja S. Rare serotype non-typhoidal Salmonella sepsis. *Indian J Pediatr.* 2006;73(11):1039-40. doi:10.1007/BF02758315.
- Devi JN, Murray CJ, Shivananda PG. Isolation of Salmonella agona (4, 12 : f, g, s:-) from a patient of gastroenteritis. *Indian J Med Res.*

- 1985;82:93–4.
46. Jesudason M, Kurian T, Pereira SM, Jayasheela M, Koshi G. Isolation of Salmonella Agona (4,12:f, g, s:) for the first time in India. *Indian J Pathol Microbiol.* 1988;31(4):303–5.
 47. Panhotra BR, Pandey D, Ayyagaria, Bhakoo ON, Agarwal KC. An Outbreak of S. Anatum infection in a premature nursery at Chandigarh. *Indian J Med Res.* 1979;69:901–6.
 48. Mahajan RK, Khan SA, Chandel DS, Kumar N, Hans C, Chaudhry R, et al. Fatal Case of Salmonella Enterica subsp. Arizonae Gastroenteritis in an Infant with Microcephaly. *J Clin Microbiol.* 2004;41(12):5830–2. doi:10.1128/JCM.41.12.5830-5832.2003.
 49. Snehalatha S, Mathai E, Jayasheela M, Chandy M, Lalitha MK, John TJ, et al. Salmonella choleraesuis subsp. Indica serovar Bornheim causing urinary tract infection. *J Clin Microbiol.* 1992;30(9):2504–5. doi:10.1128/jcm.30.9.2504-2505.1992.
 50. Devi JS, Murray CJ, Shivananda PG. Isolation of Salmonella Braenderup (6,7:e,h:e,n,z15) for the first time in India. *Indian J Med Sci.* 1988;40(7):177–8.
 51. Bhore AV, Phadke SA, Joshi BN. Salmonella cerro causing pyaemia in man—Report of a case. *Indian J Pathol.* 1980;23(4):309–11.
 52. Menon PK, Raghuram TS, Choudhury M, Kudesia S, Rao DV. Neonatal Salmonella Havana meningitis. *Indian J Pathol Microbiol.* 1994;37(4):435–8.
 53. Fule RP, Kaundinya DV. Salmonella Mbandeka, rare serotype isolated in Ambajogai- A rural area. *Indian J Pathol Microbiol.* 1985;28(2):175–6.
 54. Bhujwala R, Saxena SN, Mago ML, John PC, RaoBhau LN. Isolation of Salmonella New-Brunswick in Delhi Hospital. *Indian J Med Res.* 1983;78:756–7.
 55. Sundaram S, Venkatesh M, Murthy KV. Distribution of various Salmonella phage types in Madras, India: laboratory report. *Trans R Soc Trop Med Hyg.* 1983;77(5):722–3. doi:10.1016/0035-9203(83)90214-6.
 56. Nath ML, Singh J, Bhandari SK, Samuel M, Koshi G, Mammen KC, et al. Salmonella Tamilnadu (6,67: Z41:Z35) belonging to sub genus I.A new Salmonella serotype. *Indian J Med Res.* 1970;58(1):31–2.
 57. Ballal M, Devadas SM, Shetty V, Umakanth S, Ramamurthy T. Fatal Case of Diarrhea with Acute Kidney Injury and Hemiplegia Due to Salmonella enterica Serovar Wangata. The First Report from the Indian Subcontinent Jpn. *J Infect Dis.* 2015;68(6):530–1.
 58. Basu S, Dewan ML, Suri J. Prevalence of Salmonella serotypes in India. A 16-year study. *Bull World Health Organ.* 1975;52(3):331–6.
 59. Jain P, Das S, Ganguly SS. Dutta S First Case report of blood and urine cultures positive bacteremiaby Salmonella enterica serotype Choleraesuis from India. *JMM Case Rep.* 2014;doi:10.1099/jmmcr.0.003210.
 60. Prakash K, Ray BG. Pyogenic meningitis caused by Salmonella choleraesuis var. Kunzendorf. *Indian J Med Res.* 1970;58(2):158–60.
 61. Krishnamurthy S, Mandal J. Salmonella enterica Serotype Choleraesuis var Decatur Gastroenteritis Complicated by Severe Acute Kidney Injury and Neurological Dysfunction. *J Gastrointest.* 2020;10(1):36–8.
 62. Antony B, Scaria B, Dias M, Pinto H. Salmonella Wein from Gastroenteritis cases encountered in Mangalore, India: A report of 10 cases and review of literature. *Indian J Med Sci.* 2009;63(5):195–7.
 63. Ballal M, Devadas SM, Shetty V, Bangera SR, Ramamurthy T, Sarkar A, et al. Emergence and serovar profiling of non-typhoidal Salmonellae (NTS) isolated from gastroenteritis cases-A study from South India. *Infect Dis (Lond).* 2016;48(11-12):847–51.
 64. Taneja N, Appannanavar SB, Kumar A, Varma G, Kumar Y, Mohan B, et al. Serotype profile and molecular characterization of antimicrobial resistance in non-typhoidal Salmonella isolated from gastroenteritis cases over nine years. *J Med Microbiol.* 2014;63(1):66–73. doi:10.1099/jmm.0.061416-0..

Author biography

Beena Antony, Professor of Microbiology

Cite this article: Antony B. Non Typhoidal Salmonellae and its aetiological spectrum-An overview with Indian perspective. *IP Int J Med Microbiol Trop Dis* 2022;8(1):3-9.