

# Prevalence of *Salmonella* serotypes in India: a 16-year study\*

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*During the period 1958–73, 8 027 strains of Salmonella were tested at the National Salmonella and Escherichia Centre: 3 834 strains from man, 3 018 from animals, 839 from sewage and water sources, and 336 of unknown origin. A total of 99 serotypes were identified: 47 from man, 83 from animals, and 35 from sewage and water sources. S. typhi was the commonest serotype in man, followed by S. weltevreden and S. paratyphi A. S. typhimurium was the commonest serotype isolated from animals, followed by S. weltevreden and S. anatum. In sewage and other water sources S. weltevreden was the commonest serotype identified followed by S. typhimurium and S. bareilly. Infection due to S. weltevreden in both man and animals increased considerably after 1970. Out of a total of 99 serotypes isolated from different sources, 13 were isolated from man only, 49 from animals only, 34 from both man and animals, 30 from both animals and water sources, and 22 from man, animals, and water sources.*

Salmonellosis has been recognized as a world-wide problem in both man and animals. In India many investigators have described the isolation of *Salmonella* from different sources (5, 6, 9). The *Salmonella* pattern in India as reflected by the strains received at the National *Salmonella* and *Escherichia* Centre at the Central Research Institute, Kasauli, was studied by Agarwal (1, 2) and Nath et al. (7, 8). The present report summarizes the prevalence of *Salmonella* serotypes in India from 1958, the year the National *Salmonella* and *Escherichia* Centre was established, to 1973.

## MATERIALS AND METHODS

A total of 8 027 strains of *Salmonella* were received at the National *Salmonella* and *Escherichia* Centre during 1958–1973 for identification: 3 834 strains from man, 3 018 from animals, and 839 from sewage and other water sources. There were 336 strains whose source was not known; these have not been included in the present report. The bacterial strains were received mostly from the States of

Himachal Pradesh, Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, West Bengal, Tamil Nadu, and Maharashtra. Comparatively fewer strains were received from Gujarat, Karnataka, Kerala, Andhra Pradesh, Madhya Pradesh, and Rajasthan.

Although about 8 000 strains have been tested, the distribution of strains cannot be considered as the actual distribution of *Salmonella* in India because representative strains were received from only 15 of the 22 states.

Identification and serotyping of the strains was based on the method of Edwards & Ewing (3).

## RESULTS

During the period 1958–1973, 7 691 strains belonging to 99 serotypes isolated in India from different sources were tested at the Centre. A total of 47 serotypes of human origin were identified, as shown in Table 1. The 5 common serotypes in India, in order of prevalence, are *S. typhi*, *S. weltevreden*, *S. paratyphi A*, *S. typhimurium*, and *S. enteritidis*.

The *Salmonella* serotypes of animal origin are presented in Table 2. To facilitate the presentation of the data, these strains have been placed in 5 groups, namely: those obtained from laboratory animals such as mice, rabbits, guinea pigs, etc.; those from cattle; those from goats, sheep and pigs; those from poultry; and those from other animals such as reptiles, dogs, camels, and wild rodents.

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Table 1. *Salmonella* serotypes isolated from man in India during 1958–1973

Serotype	No. of strains isolated during :														Total		
	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971		1972	1973
<i>S. adelaide</i>	—	—	—	—	—	—	1	1	—	1	1	—	—	3	—	—	7
<i>S. anatum</i>	—	—	—	—	—	—	3	1	—	4	11	2	—	—	—	26	47
<i>S. bareilly</i>	—	2	—	—	4	2	—	1	—	2	25	1	2	2	20	24	85
<i>S. barmbek</i>	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	2
<i>S. bovismorbificans</i>	—	2	—	—	—	—	—	—	—	—	—	—	—	—	3	—	5
<i>S. brandenburg</i>	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	2
<i>S. bronx</i>	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	2
<i>S. brunei</i>	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
<i>S. californica</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3
<i>S. ceyco</i>	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	2
<i>S. chester</i>	—	—	—	—	6	14	8	1	—	2	4	1	2	13	19	—	70
<i>S. choleraesuis</i>	—	—	—	—	2	1	3	—	3	—	1	2	6	9	3	7	37
<i>S. cubana</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	12
<i>S. dublin</i>	—	—	—	—	1	2	2	2	—	1	1	—	3	6	—	—	18
<i>S. enteritidis</i>	—	—	—	1	3	6	12	3	5	8	1	4	1	—	6	39	89
<i>S. gallinarum</i>	—	—	—	—	—	—	—	—	—	2	—	—	—	3	2	—	7
<i>S. give</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	3
<i>S. heidelberg</i>	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
<i>S. inpraw</i>	—	—	—	—	—	—	1	—	—	—	2	—	—	—	—	—	3
<i>S. jaffna</i>	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	2
<i>S. kentucky</i>	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	4
<i>S. london</i>	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
<i>S. muenster</i>	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
<i>S. nchanga</i>	—	—	—	—	—	—	—	—	—	—	1	1	1	10	—	—	13
<i>S. newport</i>	—	—	—	—	2	1	9	12	4	9	3	4	8	23	3	—	78
<i>S. oranienburg</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	3
<i>S. paratyphi A</i>	6	—	—	50	2	—	3	3	8	22	48	25	53	52	55	37	364
<i>S. paratyphi B</i>	—	—	—	2	2	—	1	2	—	1	—	1	2	8	—	4	23
<i>S. paratyphi C</i>	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2
<i>S. poona</i>	—	—	—	—	—	—	2	1	4	—	—	—	2	—	5	3	21
<i>S. pullorum</i>	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
<i>S. reading</i>	—	—	—	—	—	—	—	—	—	—	1	—	2	—	—	8	11
<i>S. regent</i>	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	2
<i>S. richmond</i>	—	—	—	2	—	—	2	—	—	—	1	—	2	—	—	13	20
<i>S. saintpaul</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4
<i>S. sandiego</i>	—	—	—	—	—	—	—	—	4	1	—	1	—	—	—	—	6
<i>S. senftenberg</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	5	11	12	28
<i>S. singapore</i>	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
<i>S. stanley</i>	—	—	—	—	—	—	3	—	—	—	2	1	—	—	—	7	13
<i>S. talmilnadu</i>	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
<i>S. tennessee</i>	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	8	16
<i>S. typhi</i>	3	100	55	478	2	20	25	22	74	116	231	145	210	294	318	104	2 197
<i>S. typhimurium</i>	—	2	7	3	11	6	19	9	3	9	6	8	20	31	52	40	226
<i>S. vellore</i>	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
<i>S. virchow</i>	—	—	—	—	4	1	3	—	—	—	—	6	—	2	1	7	24
<i>S. virginia</i>	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
<i>S. weltevreden</i>	4	1	—	—	1	1	—	1	4	2	7	3	8	49	205	83	369
Total	19	107	64	537	43	55	99	59	110	180	349	216	321	532	704	439	3 834

The distribution by states of predominant *Salmonella* serotypes in both man and animals is presented in Fig. 1.

A total of 839 strains belonging to 35 serotypes

isolated from sewage during 1967–1973 were serotyped. The results are presented in Table 3. From 1958 to 1966 and in 1968 no isolate from sewage or other water sources was received at the Centre.

Table 2. *Salmonella* serotypes isolated from animals in India during 1958–1973

Serotype	No. of strains isolated from:					Total	Serotype	No. of strains isolated from:					Total
	labo- ratory animals	cattle	goats sheep, & pigs	poultry	other animals			labo- ratory animals	cattle	goats sheep, & pigs	poultry	other animals	
<i>S. aberdeen</i>	—	—	6	—	—	6	<i>S. infantis</i>	—	2	5	—	—	7
<i>S. abortusequi</i>	—	42	—	—	—	42	<i>S. kandla</i>	—	—	—	—	7	7
<i>S. adelaide</i>	—	2	4	—	—	6	<i>S. karachi</i>	—	—	6	—	4	10
<i>S. alachua</i>	5	—	—	2	—	7	<i>S. kentucky</i>	—	15	4	5	—	23
<i>S. anatum</i>	14	16	149	27	29	235	<i>S. limete</i>	—	1	—	—	—	1
<i>S. augostonborg</i>	—	—	1	—	—	1	<i>S. london</i>	—	6	7	—	—	13
<i>S. bahrenfeld</i>	—	—	—	—	1	1	<i>S. magwa</i>	—	2	—	—	3	5
<i>S. barmbek</i>	—	—	1	1	2	4	<i>S. matopeni</i>	—	—	1	1	—	2
<i>S. bareilly</i>	4	3	25	13	5	50	<i>S. millesi</i>	—	—	4	—	9	13
<i>S. bere</i>	—	—	2	—	—	2	<i>S. minnesota</i>	—	—	—	—	23	23
<i>S. berta</i>	—	—	—	1	—	1	<i>S. muenchen</i>	—	—	3	—	—	3
<i>S. bovismorbificans</i>	—	1	12	18	—	31	<i>S. nchanga</i>	4	5	3	4	5	21
<i>S. bredney</i>	9	—	—	5	7	21	<i>S. newport</i>	41	35	73	64	20	203
<i>S. brijbhumi</i>	—	—	—	—	1	1	<i>S. onderstepoort</i>	—	—	2	—	5	7
<i>S. butantan</i>	—	5	7	3	2	17	<i>S. oranienburg</i>	—	1	5	2	10	18
<i>S. californi</i>	—	—	1	—	—	1	<i>S. paratyphi A</i>	—	—	5	—	—	5
<i>S. cerro</i>	1	—	—	—	—	1	<i>S. paratyphi B</i>	—	1	7	14	—	22
<i>S. champaign</i>	—	—	—	5	3	8	<i>S. paratyphi C</i>	—	—	—	1	—	1
<i>S. charity</i>	—	—	17	5	31	48	<i>S. pomona</i>	1	—	—	—	52	53
<i>S. chester</i>	5	2	29	17	37	90	<i>S. poona</i>	2	9	49	—	3	63
<i>S. choleraesuis</i>	6	—	61	—	5	72	<i>S. pullorum</i>	—	8	7	43	—	58
<i>S. colombo</i>	—	—	11	—	—	11	<i>S. reading</i>	—	—	40	31	37	108
<i>S. concord</i>	—	—	—	3	—	3	<i>S. richmond</i>	—	9	35	27	7	78
<i>S. cubana</i>	—	3	—	—	11	14	<i>S. rostock</i>	—	1	6	—	—	7
<i>S. derby</i>	—	—	14	—	—	14	<i>S. rubislaw</i>	—	—	2	—	—	2
<i>S. dublin</i>	2	6	8	3	4	23	<i>S. saintpaul</i>	—	3	—	125	13	141
<i>S. enteritidis</i>	107	31	26	21	24	209	<i>S. salford</i>	—	—	2	—	—	2
<i>S. fremantle</i>	1	—	—	—	—	1	<i>S. sandiego</i>	—	1	—	3	—	4
<i>S. fresno</i>	—	1	—	—	—	1	<i>S. senftenberg</i>	—	3	7	2	5	17
<i>S. friedenau</i>	—	—	—	—	1	1	<i>S. stanley</i>	—	31	75	35	—	141
<i>S. frintrop</i>	—	2	—	—	2	4	<i>S. telhashomer</i>	—	—	—	—	1	1
<i>S. gallinarum</i>	—	—	42	67	—	100	<i>S. tennessee</i>	—	—	3	—	—	3
<i>S. gaminara</i>	—	—	1	—	—	1	<i>S. tshiongwe</i>	—	1	1	—	—	2
<i>S. goverdhan</i>	—	—	—	—	1	1	<i>S. typhi</i>	1	10	1	—	—	12
<i>S. havana</i>	—	—	5	—	—	5	<i>S. typhimurium</i>	73	37	119	133	10	372
<i>S. hessarek</i>	—	—	—	—	1	1	<i>S. urbana</i>	—	1	1	—	—	2
<i>S. hissar</i>	—	—	—	—	1	1	<i>S. virchow</i>	3	5	6	42	—	56
<i>S. houten</i>	—	—	—	—	6	6	<i>S. virginia</i>	—	—	31	—	—	31
<i>S. hvitvingfoss</i>	—	3	11	—	109	123	<i>S. weltevreden</i>	81	21	44	23	117	286
<i>S. illala</i>	—	—	—	—	1	1	<i>S. wichita</i>	—	—	—	3	—	3
<i>S. india</i>	—	—	1	—	1	2	<i>S. worthington</i>	4	6	1	—	—	11
<i>S. indiana</i>	4	—	—	—	—	4							

## DISCUSSION

Out of 3 834 isolates of human origin, 47 different serotypes were isolated (Table 1). The survey confirmed earlier reports that *S. typhi* is the commonest serotype responsible for human infection in India. This serotype comprises 57% of the total *Salmonella* isolates whereas *S. choleraesuis*, which ranks tenth in order of frequency, constitutes less than 1%. The

remaining 37 serotypes comprise only about 8% of the total isolates. Salmonellosis due to *S. weltevreden*, which was first isolated from man in India in 1953 (4) and was very uncommon as a pathogen of man until 1970, has increased considerably and *S. weltevreden* is now the second most common *Salmonella* serotype responsible for human infection. The third most common serotype is *S. paratyphi A*. Infection due to *S. paratyphi B* in India is very rare,

Table 3. *Salmonella* serotypes isolated from sewage and other water sources in India during 1967 and 1969–1973

Serotype	No. of strains isolated during:						Total
	1967	1969	1970	1971	1972	1973	
<i>S. alachua</i>	—	—	—	—	—	16	16
<i>S. anatum</i>	—	17	12	7	9	15	60
<i>S. bareilly</i>	—	—	—	35	17	45	97
<i>S. bovismorbificans</i>	—	—	—	11	8	26	45
<i>S. bredney</i>	—	—	—	7	—	—	7
<i>S. butantan</i>	—	6	2	—	7	13	28
<i>S. ceyco</i>	—	—	1	—	—	—	1
<i>S. chester</i>	—	3	—	—	11	14	28
<i>S. choleraesuis</i>	6	—	—	—	—	—	6
<i>S. derby</i>	—	—	—	—	19	3	22
<i>S. enteritidis</i>	—	—	—	—	—	21	21
<i>S. give</i>	—	1	—	3	—	5	9
<i>S. havana</i>	—	—	—	—	5	3	8
<i>S. hvittingfoss</i>	—	—	—	—	3	14	17
<i>S. kentucky</i>	—	—	—	—	—	1	1
<i>S. litchfield</i>	—	2	—	1	—	—	3
<i>S. london</i>	—	—	—	—	7	11	18
<i>S. meleagridis</i>	—	1	—	—	—	—	1
<i>S. minnesota</i>	—	—	1	—	—	—	1
<i>S. muenchen</i>	—	1	—	—	—	—	1
<i>S. newport</i>	—	4	—	9	7	20	40
<i>S. onrison</i>	—	1	—	—	—	—	1
<i>S. oranienburg</i>	—	—	—	—	11	—	11
<i>S. paratyphi B</i>	—	26	—	1	—	—	27
<i>S. poona</i>	—	—	—	—	35	—	35
<i>S. reading</i>	—	6	1	—	—	37	44
<i>S. richmond</i>	—	—	—	—	3	5	8
<i>S. saintpaul</i>	—	—	—	8	5	—	13
<i>S. senftenberg</i>	—	—	—	19	17	14	50
<i>S. stanley</i>	—	1	—	—	—	—	1
<i>S. tennessee</i>	—	—	—	9	—	5	14
<i>S. typhi</i>	—	—	—	—	1	—	1
<i>S. typhimurium</i>	1	3	3	33	11	47	98
<i>S. virchow</i>	—	1	—	—	—	—	1
<i>S. weltevreden</i>	—	7	—	50	31	17	105
<b>Total</b>	<b>7</b>	<b>80</b>	<b>20</b>	<b>193</b>	<b>207</b>	<b>332</b>	<b>839</b>

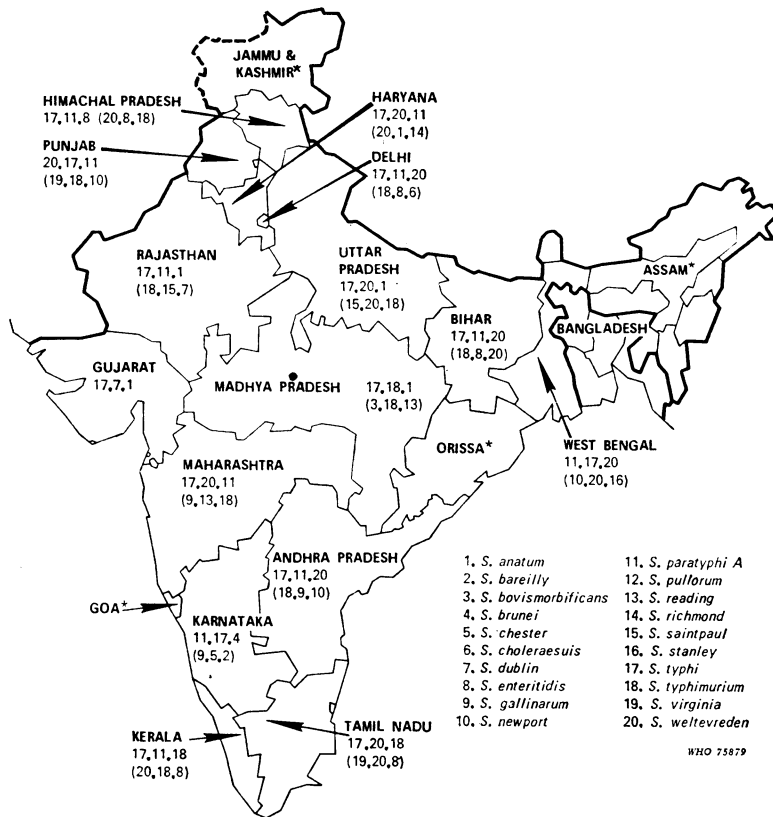


Fig. 1. Distribution by states of the most prevalent *Salmonella* serotypes in India. The first 3 figures represent the most common serotypes isolated from man, those in parentheses the most common serotypes isolated from animals. An asterisk following the name of a state indicates that no strains were available for study.

whereas this serotype is one of the commonest in Burma. *S. typhi* is the commonest serotype in almost all the states except Punjab and Chandigarh, West Bengal, and Karnataka. It is possible that fewer strains of *S. typhi* were referred to the Centre from these states.

Out of 3 018 strains from animal sources, 83 serotypes of *Salmonella* were identified (Table 2). Of these *S. typhimurium* has been found to be the commonest serotype causing infection in animals. In descending order of prevalence the other serotypes are *S. weltevreden*, *S. anatum*, *S. enteritidis*, *S. newport*, and *S. saintpaul*. *S. typhimurium* is the predominant serotype in causing salmonellosis in animals in general, and is also the commonest in poultry. In laboratory animals, *S. enteritidis* has

been found to be the commonest serotype, followed by *S. weltevreden* and *S. typhimurium*. In cattle, *S. abortusequi* is the most common, followed by *S. typhimurium*, *S. newport*, *S. enteritidis*, and *S. stanley*. In goats, sheep and pigs, *S. anatum* is the commonest serotype associated with infection, followed by *S. typhimurium*, *S. stanley*, *S. newport*, and *S. choleraesuis*.

In poultry the commonest serotypes after *S. typhimurium* are *S. saintpaul*, *S. gallinarum*, *S. newport*, and *S. pullorum*. It is interesting to note that *S. gallinarum* and *S. pullorum*, which are considered the commonest serotypes associated with salmonellosis in poultry, are in order of frequency third and fifth, respectively. Though *S. saintpaul* is the second most common serotype, its prevalence in states other than

Uttar Pradesh is negligible. In Uttar Pradesh it is the commonest serotype owing to the fact that in 1969 there was a severe outbreak of *S. saintpaul* in poultry in Pant Nagar. From this outbreak, 111 isolates of *S. saintpaul* were received that have changed the overall pattern of salmonellosis in poultry.

Out of the 35 different serotypes isolated from sewage and water sources all except 3 (*S. litchfield*,

*S. meleagridis*, and *S. onrimon*) were also isolated from man and/or animals.

Out of a total of 99 serotypes isolated from different sources, 13 were isolated from man only, 49 from animals only, 34 from both man and animals, 30 from both animals and water sources, and 22 from man, animals, and water sources.

## ACKNOWLEDGEMENTS

The authors wish to thank the heads of all the laboratories who kindly sent cultures to this Centre, and Dr L. Le Minor, Pasteur Institute, Paris, for confirming some of the serotypes. The technical assistance of Mr P. C. John, Mr Bant Ram, Mr D. Mahadevan, Mr Hardayal Singh, and Mr Chattar Singh is acknowledged. Thanks are also due to Miss Uma Rani for helping with the preparation of the manuscript.

## RÉSUMÉ

### PRÉVALENCE DES SÉROTYPES DE *SALMONELLA* EN INDE : RÉSULTATS D'UNE ÉTUDE ÉCHELONNÉE SUR SEIZE ANS

Pendant la période 1958-1973, 8027 souches de *Salmonella* ont été soumises à des épreuves au Centre national des *Salmonella* et *Escherichia*: 3834 souches provenant de l'homme, 3018 d'animaux, 839 d'eaux d'égout et de nappes d'eau et 336 d'origine inconnue. Au total, 99 sérotypes ont été identifiés: 47 provenant de l'homme, 83 d'animaux et 35 d'eaux d'égout et de nappes d'eau.

*S. typhi* était le sérotype le plus répandu chez l'homme, suivi de *S. weltevreden* et *S. paratyphi A*.

Parmi les sérotypes provenant d'animaux en général, *S. typhimurium* est celui qu'on a le plus souvent isolé; venaient ensuite *S. weltevreden* et *S. anatum*. *S. typhimurium* était le sérotype le plus répandu chez les volailles,

*S. gallinarum* et *S. pullorum* étant respectivement les troisième et cinquième sérotypes. Chez les animaux de laboratoire, chez les bovins, ainsi que chez les caprins, ovins et porcins, le sérotype le plus répandu était *S. enteritidis*, suivi de *S. abortusequi* et *S. anatum*.

Les 35 sérotypes provenant d'eaux d'égout ont tous été isolés également à d'autres sources, à l'exception de *S. litchfield*, *S. meleagridis* et *S. onrimon*.

Sur un total de 99 sérotypes isolés à différentes sources, 13 provenaient de l'homme seulement, 49 d'animaux seulement, 34 à la fois de l'homme et d'animaux, 30 d'animaux et de nappes d'eau, et 22 à la fois de l'homme, d'animaux et de nappes d'eau.

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