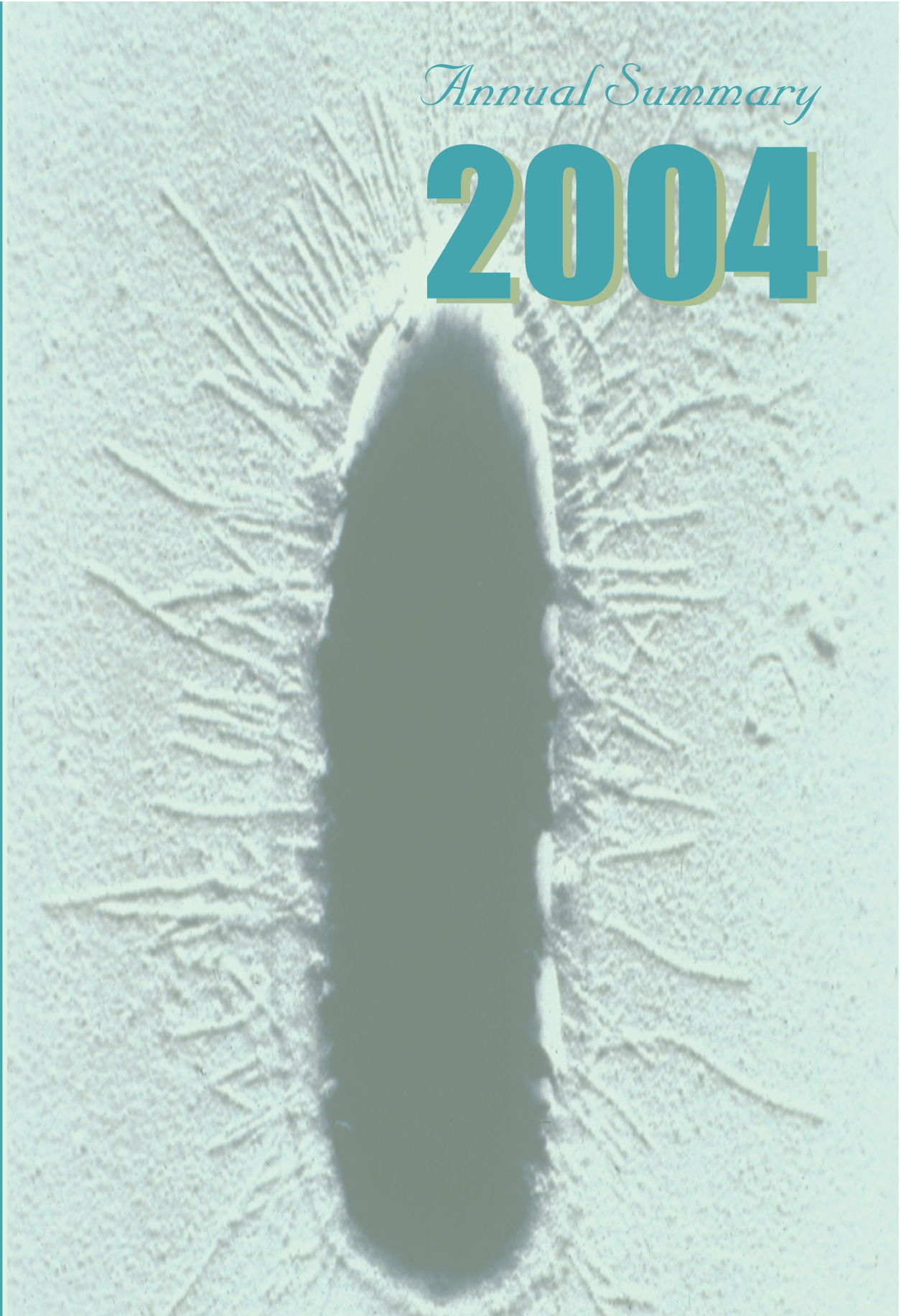
Salmonella

Annual Summary

2004



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The Adobe Acrobat (PDF) version of this document can be viewed on the world-wide web at http://www.cdc.gov/ncidod/dbmd/phlisdata/salmonella.htm. Further information concerning data described in this report, including the Kauffmann-White Scheme or the changes in serotype classification instituted in this report, can be obtained by contacting the Foodborne and Diarrheal Diseases Branch at telephone number (404) 639-2206. For further information concerning PHLIS please contact the PHLIS Help Desk at telephone number (404) 639-3365.

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National *Salmonella* Surveillance System
Annual Summary, 2004

This issue of the Annual Summary of the National *Salmonella* Surveillance System presents surveillance data on reported laboratory-confirmed *Salmonella* isolates in the United States for the year 2004. The National *Salmonella* Surveillance System collects reports of isolates of *Salmonella* from human sources from the United States. This information is reported through the Public Health Laboratory Information System (PHLIS), an electronic reporting system, by the State Public Health Laboratory Directors and State and Territorial Epidemiologists to the Foodborne and Diarrheal Diseases Branch (FDDB) and the Biostatistics Office (BSO) of the Division of Bacterial and Mycotic Diseases in the National Center for Infectious Diseases.

The National *Salmonella* Surveillance System is based on data collected by state and territorial public health laboratories. *Salmonella* isolates are submitted to the state public health laboratory by clinical diagnostic laboratories. The state and territorial laboratories confirm the isolates as *Salmonella*, perform serotyping according to the Kauffmann-White scheme, and submit the data for reporting through PHLIS. Unusual or difficult isolates are forwarded to the National *Salmonella* Reference Laboratory at the Centers for Disease Control and Prevention for further characterization or confirmation. These results are reported back to the state laboratory, where they are reported through PHLIS.

The capture of isolates in the National *Salmonella* Surveillance System is considered to be fairly complete. However, some *Salmonella* isolates may not be forwarded to public health laboratories, and therefore are not ascertained In addition, irrespective of the surveillance system, many cases of Salmonellosis are not confirmed and reported because the ill person does not seek medical care, the health-care provider does not obtain a specimen for diagnosis, or the laboratory does not perform the necessary diagnostics tests. The results of surveillance reported herein should be considered a fraction of all *Salmonella* infections.. In addition, not every state submitted data in 2004.

The National *Salmonella* Surveillance System database is dynamic; the number of isolates reported for previous years may change according to the addition or correction of isolate reports. For example, the number of human *Salmonella* isolates published in the 2003 Annual Summary for 2003 was 33,747. Since publication of the 2003 annual summary, several states provided Salmonella isolate reports for 2003, thereby increasing the yearly total for 2003 to 37,442 as depicted in Table 3 of this report.

Integrated surveillance system software development in several states and at the Centers for Disease Control and Prevention has interrupted the normal use of the PHLIS system such that some *Salmonella* surveillance reports are delayed or obtained in a variety of formats outside of the PHLIS system. We encourage our reporting partners to use the PHLIS reporting system if serotype specific *Salmonella* reports cannot be transmitted to CDC via new integrated surveillance systems. If PHLIS reporting is impossible, please contact the PHLIS Help Desk (404-639-3365) to arrange alternative data submission pathways.

The number of isolates reported by geographical area (e.g. state) represents the area where laboratory confirmation and serotyping was performed. In some instances, the reporting area is not the same as the area of residence of the person from whom the isolate was obtained. For *Salmonella* serotype Typhi, only the first isolation in a year for each person is counted. For non-Typhi serotypes, only the first isolation within a thirty day period for each person is counted, provided that the serotype and clinical source (e.g. stool or blood) are the same.

The data presented for *Salmonella* isolates from animals and related sources (i.e. environment and feeds) are gathered from isolates submitted to the U.S. Department of Agriculture, Animal and Plant Health Inspection Services, National Veterinary Services Laboratories (USDA/APHIS/NVSL) for serotyping. These isolates are submitted by animal disease diagnostic laboratories and the USDA, Food Safety and Inspection Service (FSIS) laboratories throughout the United States. Data from other United States laboratories that serotype *Salmonella* from animals and related sources and submit isolates to the NVSL are also included in this report. *Salmonella* serotyping results from clinical cases of animal disease are designated as "clinical" and shown in Table 6. Serotyping results from herd and flock monitoring and surveillance, feed sample testing, environmental testing, research projects, and isolates from USDA, FSIS food testing programs are designated as "nonclinical" (Table 7). Samples from non-human sources are tested for *Salmonella* for a variety of purposes and are obtained in a variety of ways. The sampling is therefore neither complete nor random and undoubtedly has sampling biases. Any interpretation of data should consider these limitations.

The Statistical Outbreak Detection Algorithm (SODA), developed by BSO and FDDB, is a statistical algorithm based on the National *Salmonella* Surveillance System. It is designed to detect unusual clusters of isolates of *Salmonella* infection. SODA compares current *Salmonella* isolates reported through PHLIS by serotype to a 5-year historical baseline for that serotype and week to detect unusual increases from the baseline. Analyses can be conducted at state, regional, or national levels. Since 1996, SODA has been implemented at CDC and selected state health departments. If you would like more information on SODA, please call the PHLIS Helpdesk at telephone number (404) 639-3365.

Changes to the National *Salmonella* Surveillance System

In 2002, the National *Salmonella* Surveillance System implemented several changes in nomenclature and in surveillance practices. i) In order to improve the comparability of United States surveillance data with data from other countries, serotypes are now designated according to the Kauffmann-White Scheme (see below). ii) Reporting of S*almonella* serotype I 4,[5],12:i:- (see discussion of this serotype below) was inconsistent in the past due to variability in the nomenclature used to report this serotype. This resulted in many isolates of this serotype being reported as "Group B" or "Subspecies I". Beginning with the 2002 data, the submitted designation for this serotype was converted to the standard formula whenever possible. iii) Many non-subspecies I serotypes were not listed in the surveillance summaries in the past; instead, these isolates were reported by O group or subspecies only. Beginning with the 2002 surveillance data, all serotype formulas that were submitted to the national surveillance system, regardless of subspecies, were incorporated into the surveillance database. iv) Similarly, most "variants" of serotypes (monophasic, nonmotile or rough isolates) were not listed by their variant formulas in the past; instead, these isolates were reported by O group or subspecies only. Beginning with the 2002 surveillance data, all serotype variants that were submitted to the national surveillance system were converted to standard serotype formulas whenever possible and incorporated into the surveillance database. Since the 2003 *Salmonella* Surveillance Summary was published, we have updated the nomenclature for many isolates that were submitted in 1995 through 2003 when possible using additional information submitted to PHLIS. We hope that the changes in nomenclature and surveillance practices will improve the accuracy of the surveillance data and enhance the detection of newly emerging serotypes. However, these changes should be kept in mind when comparing 1995 to 2003 data to other years. Increases in the number of isolates of specific serotypes, e.g. *Salmonella* serotype I 4,[5],12:i:- , may in part reflect improved surveillance.

In order to improve the utility of partial serotype data, we are changing the way that isolates that are not fully serotyped are designated and reported in PHLIS. In the past, these isolates were reported primarily by serogroup. While serogroups A through E are composed mainly of subspecies I serotypes, many of the other O serogroups are represented in several different subspecies. Most of the serogroups higher than E include serotypes from more than one subspecies, and nearly half (15 of 37) include serotypes from five different subspecies. Reporting isolates by serogroup alone combines unrelated isolates of different subspecies in the same serogroup category. Thus, we would like to move away from the "serogroup" categories. When full serotype information is not available, isolates are identified first by subspecies, then O serogroup and any additional serotype antigens. All available serotype information should be submitted to PHLIS (subspecies, O serogroup, O antigens, H antigens, whether one or two H antigens are detected, rough or mucoid status if appropriate). Partially serotyped isolates are listed in Table 3a.

Annual Summary Highlights for 2004

Human Sources

A total of 35,661 *Salmonella* isolates were reported from participating public health laboratories in 2004. Forty-nine states and the District of Columbia reported isolates; Florida, Montana and the District of Columbia reported partial serotype information. This represents a 5% decrease compared with 1994 and a 5% decrease compared to 2003 (3%). The national rate of reported *Salmonella* isolates in 2004 was 12.1 per 100,000 based on 2004 census population figures for the United States.

Similar to other years, *Salmonella* was isolated most frequently from children under 5 years of age, accounting for 27% of isolates (Table 2). About 10% of isolates came from persons in each of the second through fifth decades of life, with declining numbers thereafter. The distribution of isolates between the sexes was different, with a greater number of isolates from male infants and children and fewer isolates from male adults and older persons (Table 2).

The twenty most common serotypes of *Salmonella* in 2004 are listed in Table 1. These represent 75% of all *Salmonella* isolates. Of the top twenty serotypes, the two most common serotypes, *S.* Typhimurium and *S*. Enteritidis, had substantial decreases in numbers from 1994-2004; the largest percent decrease in numbers compared with 1994 were *S*. Hadar and *S*. Enteritidis (Table 8). A dramatic increase in *S.* Mississippi (267% from 1994 to 2004) mainly occurred before 1999. *S.* Javiana, *S*. Paratyphi B var. L(+) tartrate+ (formerly *S*. Java) and *S*. Newport had important increases in numbers from 1994 to 2004 (228%, 106% and 99% respectively). In 2004, serotypes *S*. Berta and *S*. Anatum increased in rank to be included in the top twenty serotypes, whereas *S*. Bareilly and *S*. Stanley dropped from the top twenty serotypes compared with 2003.

Salmonella serotype I 4,[5],12:i:- was introduced as the 18th most common serotype in 2002 and has increased in rank to 7th in 2004. This serotype was first tracked in the National *Salmonella* Surveillance database in 1998, though many isolates may have been classified as only "Subspecies I" or "Group B" before then. Since the 2003 *Salmonella* Surveillance Summary was published, we examined the 1995 to 2003 surveillance data and were able to reclassify isolates submitted in these years as I 4,[5],12:i:- based on additional data submitted with individual isolates. Efforts to correctly classify this serotype are responsible for at least some of its increase that has been documented in recent years. It is unknown how many isolates reported as "Subspecies I, Group B" could be this serotype (Table 3a). In 1998, this serotype was the fourth most commonly identified in Spain; genetic analysis of the Spanish isolates revealed a close relationship to *S*. Typhimurium (1). Many U.S. isolates of this serotype were characterized by pulsed field gel electrophoresis (PFGE) and the patterns submitted to PulseNet, the National Molecular Subtyping Network for Foodborne Disease Surveillance. The PFGE patterns for most *S*. I 4,[5],12:i- isolates were closely related to *S*. Typhimurium PFGE patterns, indicating that they are most likely variants of *S*. Typhimurium.

The three most common serotypes of *Salmonella* in 2004 (Typhimurium, Enteritidis, and Newport) accounted for 43% of isolates. Compared with 1994, the frequency rank of *S*. Typhimurium and *S*. Enteritidis in 2004 remained first and second respectively, though in 1994-1996 their rank was temporarily reversed (Figure 4). A large proportion of *S*. Typhimurium isolates were resistant to multiple antimicrobial drugs; in 2002, 21.1% of *S*. Typhimurium isolates characterized in the National Antimicrobial Resistance Monitoring System (NARMS) were resistant to one or more drugs and 30% had a five-drug resistance pattern characteristic of a commonly recognized phage type, DT104 (2). Similarly, *S*. Newport has emerged as a major multidrug-resistant pathogen. In 2002, 53 (23%) of 239 *S*. Newport isolates submitted to NARMS were resistant to at least nine of 17 antimicrobial agents tested, including extended spectrum cephalosporins (2,3). Similar to other years, there were marked regional differences in the frequency of *Salmonella* isolates among serotypes. The rate of isolations by region has been followed closely for *S*. Enteritidis as a means of assessing the impact of egg safety regulations and industry improvements. As indicated in Figure 2, *S*. Enteritidis rates of isolation had been relatively high in New England, Mid Atlantic and Pacific regions, but have shown significant decreases since 1995. Though New England had an increase in *S*. Enteritidis in 2000 and 2001 compared to 1999, the isolation rate has decreased since 2001.

Non-human Sources

Data on *Salmonella* isolates obtained from non-human sources can help identify possible sources of human illness. *S*. Typhimurium, the most common serotype in humans, is identified most commonly from clinical samples from bovine sources, and from non-clinical samples from chicken sources. *S*. Enteritidis and S. Heidelberg, the second and fourth most common serotype in humans, respectively, are identified most commonly from clinical and non-clinical chicken sources (Table 6 and 7).

Adoption of the Kauffmann-White Scheme for designation of *Salmonella* serotypes

Salmonella serotyping has been the cornerstone for epidemiological surveillance and outbreak investigations for this important pathogen. The National *Salmonella* Surveillance System has tracked *Salmonella* isolates by serotype since 1968. New subtyping methods have come and gone, but serotyping continues to provide essential subtype information for *Salmonell*a. For example, PulseNet, our state-of-the-art genotyping system for *Salmonella*, relies on accurate serotype information as the "first-tier" subtype information. PFGE pattern determination, by itself, does not replace serotyping, but rather subdivides within serotype.

The Kauffmann-White Scheme for designation of *Salmonella* serotypes is maintained by the WHO Collaborating Centre for Reference and Research on *Salmonella* at the Institut Pasteur and is used by most of the world. Up until 2002, the CDC used a slightly different version of the scheme, the "Modified Kauffmann-White Scheme". A unified format for

serotype designation is essential for accurate surveillance via PulseNet, Global SalmSurv, and other international networks. Therefore, to improve the accuracy of our surveillance data and to make us in-step with the rest of world with respect to *Salmonella* serotype designation, the CDC adopted the Kauffmann-White Scheme on January 1, 2003.

The adoption of the Kauffmann-White Scheme affected only a few of the more common serotypes. The primary differences between the two schemes are:

i) *Salmonella* are divided into six subspecies that can be differentiated by biochemical and genetic tests. Under the Kauffmann-White Scheme, subspecies I serotypes are named; subspecies II through VI serotypes are identified by formula. The Modified Kauffmann-White Scheme used names for those subspecies II through VI serotypes that were designated before 1968 and formulas for those serotypes identified after 1968. With the adoption of the Kauffmann-White scheme, all named serotypes are subspecies I; serotypes from all other subspecies are designated by formula. In 2002, there were four named serotypes among the top 100 serotypes that did not belong to subspecies I and were effected by this change.

- *S*. Marina is now designated as *S*. IV 48:g,z51:-
- *S*. Flint is now designated as *S*. IV 50:z4,z23:-
- *S*. Kralendyk is now designated as *S*. IV 6,7:z4,z24:-
- *S*. Chameleon is now designated as *S*. IV 16:z4,z32:-

ii) Under the Kauffmann-White Scheme, serogroups E2 and E3 were combined with serogroup E1. This reflects the fact that the antigenic changes in serogroups E2 and E3 are the result of lysogenic conversion by bacteriophages and thus represent minor variants of serogroup E1 serotypes. The Modified Kauffmann-White Scheme used separate serotype names for these variants. Two serotypes in the top 100 in 2002 that were affected by the merging of serogroups E2 and E3 with serogroup E1.

- *S*. Newington is now *S*. Anatum variety (var.) 15+
- *S*. Newbrunswick is now *S*. Give var. 15+.

iii) Under the Kauffmann-White Scheme, two biotypes of *S*. Paratyphi B are recognized; they are differentiated primarly by the ability to ferment tartrate. *S*. Paratyphi B is tartrate negative and is associated with more severe, typhoid fever-like disease. *S*. Paratyphi B var. L-tartrate + (also referred to as "*S*. Paratyphi var. Java") is tartrate positive and commonly associated with gastroenteritis. *S*. Paratyphi B var. L-tartrate + was known as "*S*. Java" in the Modified Kauffmann-White Scheme. The two biovars of *S*. Paratyphi B have been a source of confusion in the past because they have the same antigenic formula (I 1,4,[5],12:b:1,2), and are differentiated only by biotype. It is essential that the tartrate test be performed to accurately identify and report the two biotypes.

The *Salmonella* serotypes in this summary that were reported under differenct designations in the 2001 and earlier United States surveillance data are listed on the next page.

Table of obsolete *Salmonella* Serotype names and their current designations

Serotype	Obsolete Name		Serotype	Obsolete Name
Amager var. 15+	Tuebingen		II 4,12,[27]:z:e,n,x	Nordenham
Amsterdam var. 15+	Drypool		II 4,12:l,w:e,n,x	Kilwa
Anatum var. 15+	Newington		II 3,10:g,t:-	Islington
Anatum var. 15+, 34+	Minneapolis		II 3,10:m,t:e,n,x	Stikland
Butantan var. 15+	Rosenthal		II 6,7:l,z28:1,5:[z42]	Heilbron
Choleraesuis var. Decatur	Decatur		II 6,7:z39:1,5,7	Gilbert
Duisburg	Salinatis		II 9,12:d:e,n,x	Rhodesiense
Finkenwerder	Heves		II 9,12:g,m,[s],t:[1,5,7]:[z42]	Hamburg
Gallinarum	Pullorum		II 9,12:g,s,t:e,n,x	Neasden
Give var. 15+	Newbrunswick		II 9,12:l,w:e,n,x	Daressalaam
Give var. 15+, 34+	Menhaden		II 9,12:z39:1,7	Wynberg
Lexington var. 15+	Manila		II 9,46:g,[m],[s],t:[e,n,x]	Duivenhoks
Lexington var. 15+, 34+	Illinois		II 35:z29:e,n,x	Utbremen
Lille var. 14+	Bornum		II 40:c:e,n,x,z15	Suarez
Livingstone var. 14+	Eimsbuettel		II 40:z4,z24:z39	Degania
London var. 15+	Portsmouth		II 41:z10:1,2	Negev
Meleagridis var. 15+	Cambridge		II 41:z10:z6	Lichtenberg
Muenster var. 15+	Newhaw		II 42:b:e,n,x,z15	Uphill
Muenster var. 15+, 34+	Arkansas		II 42:g,t:-	Fremantle
Nyborg	Selandia		II 47:b:1,5	Phoenix
Ohio var. 14+	Nienstedten		II 47:d:z39	Quimbamba
Oranienburg var. 14+	Thielallee		II 48:d:1,2	Etosha
Orion var. 15+	Binza		II 48:d:z6	Hagenbeck
Orion var. 15+, 34+	Thomasville		II 48:g,m,t:-	Erlangen
Paratyphi B var. L(+) tartrate+	Java		II 48:k:z39	Sakaraha
Typhimurium var. 5-	Typhimurium var. Copenhagen		II 60:g,m,t:z6	Setubal
Uganda var. 15+	Kinshasa		IV 6,7:z4,z23:-	Roterberg
Weltevreden var. 15+	Lanka		IV 6,7:z4,z24:-	Kralendyk
Westhampton var. 15+	Halmstad		IV 11:z4,z23:-	Parera
II 11:g,[m],s,t:z39	Grabouw		IV 16:z4,z23:-	Ochsenzoll
II 11:m,t:e,n,x	Lincoln		IV 16:z4,z32:-	Chameleon
II 13,22:g,m,t:[1,5]	Limbe		IV 21:z4,z23:-	Soesterberg
II 13,22:z29:1,5	Clifton		IV 40:z4,z32:-	Bern
II 13,23:a:z42	Tygerberg		IV 43:z36,z38:-	Volksdorf
II 13,23:b:[1,5]:z42	Acres		IV 43:z4,z23:-	Houten
II 13,23:g,m,[s],t:[e,n,x]	Luanshya		IV 43:z4,z32:-	Tuindorp
II 13,23:z:1,5	Nachshonim		IV 44:z4,z32:-	Lohbruegge
II 16:l,w:z6	Noordhoek		IV 48:g,z51:-	Marina
II 16:z4,z23:-	Haddon		IV 50:g,z51:-	Wassenaar
II 17:g,t:-	Bleadon		IV 50:z4,z23:-	Flint
II 17:g,t:[e,n,x,z15]	Bleadon		IV 50:z4,z32:-	Bonaire
II 21:z10:[z6]	Wandsbek		IV 51:z4,z23:-	Harmelen
II 4,12,[27]:b:[e,n,x]	Sofia		*S. bongori* ser. 48:z35:-	Bongor
II 4,12,[27]:e,n,x:1,[5],7	Makumira			

Overview of *Salmonella* Serotype Designation

1) *Salmonella* Taxonomy

The **genus *Salmonella*** divided into two species, *Salmonella enterica* and *Salmonella bongori.*

Salmonella enterica is further subdivided into 6 subspecies that are designated by names or Roman numerals. The Roman numerals are simpler and more commonly used. Subspecies IIIa and IIIb were historically considered a separate genus, *Arizonae*, and are still sometimes referred to by this name. Despite their common history, subspecies IIIb is more closely related to the other *Salmonella* subspecies than to subspecies IIIa, so the two should be considered distinct entities.

***Salmonella enterica* subspecies**	
I	*enterica*
II	*salamae*
IIIa	*arizonae*
IIIb	*diarizonae*
IV	*houtenae*
VI	*indica*

Salmonella bongori was originally designated *S. enterica* **subspecies V**. It has since been determined to be a separate species of *Salmonella*. However, for simplicity and convenience, these strains are commonly referred to as "subspecies V" for the purpose of serotype designation.

2) *Salmonella* Serotype Antigens

Salmonella serotype is based on the immunoreactivity of two surface structures, **O** and **H antigen.**

O antigen is a carbohydrate antigen (also called a polysaccharide) that is the outermost component of lipopolysaccharide (LPS). It is a polymer of **O subunits**; each O subunit is typically composed of four to six sugars depending on the O antigen. Variation in O antigen results from variation in the sugar components of the O subunit, from variation in the nature of the covalent bond between the sugars of the subunit, and from variation in the nature of the linkage between the O subunits that form the O antigen polymer.

O antigens are designated by numbers and are divided into **O serogroups** or **O groups**. O groups are designated by the primary **O factor(s)** that are associated with the group. Many of the common O groups were originally designated by letter and are still commonly referred to by letter (e.g., *S*. Typhimurium belongs to Group O:4 or Group B, *S*. Enteritidis belongs to group O:9 or Group D1; *S*. Paratyphi A belongs to Group O:2 or Group A).

Additional O factors are associated with some O groups and are often variably present or variably expressed. The O groups and the additional O antigens that may be present in serotypes of that group are listed in the table below. When multiple O factors are present, they are listed sequentially and separated by commas.

H antigen is the filamentous portion of the bacterial flagella; H antigen is made up of protein subunits called flagellin. The ends of flagellin are conserved and give the flagella its characteristic filament structure. The antigenically variable portion of flagellin is the middle region, which is surface-exposed. *Salmonella* is unique among the enteric bacteria in that it can express two different flagellin antigens. Typically, this is coordinated so that only one antigen is expressed at time in a single bacterial cell. The two antigens are referred as Phase 1 and Phase 2. **"Monophasic"** isolates are those that express only a single flagellin type. These occur naturally for some serotypes (e.g., *S*. Enteritidis, *S*. Typhi, and most subspecies IIIa and IV serotypes are monophasic), or can occur through the inactivation of the gene encoding the Phase 1 or Phase 2 antigen.

The H antigens of Salmonella are listed in the table below. Some antigens are composed of multiple **factors**, which are separated by commas; for example, the second phase antigen of *S*. Typhimurium is composed of factors 1 and 2, which is

represented as "1,2". Related antigens are grouped into **complexes**.

3) *Salmonella* Serotype Identification

Salmonella serotypes are typically identified in a cascade of tests. First, an isolate is identified and the subspecies is determined, typically by biochemical testing. O antigens and H antigens are detected in independent agglutination assays using antisera that react with groups of related antigens or a single antigen. Both H antigens can sometimes be detected in a single culture, particularly for older strains or for isolates that have been passed multiple times. When only one H antigen is detected, the isolate is inoculated onto the top of a tube of **phase reversal media**, a semisolid media containing antisera to the H antigen that has already been identified. Organisms expressing the previously detected H antigen are immobilized by the added antisera and grow only at the top of the tube. Organisms expressing the second H antigen are able to move away from the top of tube, evidenced by growth throughout the tube. The second H antigen is then determined using organisms recovered from the bottom of the phase reversal media.

4) *Salmonella* Serotype Designation

Salmonella serotypes are designated according to the conventions of the Kauffmann-White Scheme. All *Salmonella* serotypes can be designated by a formula. Additionally, subspecies I serotypes are given a name (e.g., Typhimurium, Enteritidis, Typhi, etc). Before 1968, all serotypes were given names; as a result, some serotypes of subspecies II and IV were originally designated by name. Some of the obsolete names can still be found in the literature (e.g., Salmonella IV 48:g,z51:- was formerly known as Salmonella Marina); but, subspecies II through VI serotype should be designated by formula only.

The typical format for a serotype formula is:

Subspecies [space] O antigens [colon] Phase 1 H antigen [colon] Phase 2 H antigen

Examples:
I 4,5,12:i:1,2 (*S. enterica* serotype Typhimurium or *Salmonella* Typhimurium)
I 4,12:i:1,2 (*S. enterica* serotype Typhimurium or *Salmonella* Typhimurium)
I 9,12:g,m:- (*S. enterica* serotype Enteritidis or *Salmonella* Enteritidis)
II 47:b:1,5 (*S. enterica* serotype II 47:b:1,5 or *Salmonella* II 47:b:1,5)
IV 48:g,z51:- (*S. enterica* serotype IV 48:g,z51:- or *Salmonella* IV 48:g,z51:-)
IIIb 65:(k):z (*S. enterica* serotype IIIb 65:(k):z or *Salmonella* IIIb 65:(k):z)

Other conventions:

- Some O and H factors are variably present. This is indicated in the generic serotype formula by underline when the variable factor is known to be encoded on a bacteriophage (e.g., O factor 1; only described for O antigens) or by square brackets (e.g., O factor [5] or H antigen [1,2]) when it is not. For an individual isolate, if the variable factor is detected it is included in the formula without additional notation. If the variable factor is not detected, it is not listed in the formula.

- Some O and H factors are variably expressed. Weakly recognized antigens are indicated by parentheses; e.g., O antigen (6),14 or H antigen (k).

- In monophasic isolates, the absence of an H antigen is indicated by a minus sign ("-") for the particular phase.

- Variants of serotypes that do not express all the recognized antigens characteristic of a particular serotype are not uncommon. This is a particular issue for subspecies I serotypes, where a serotype name cannot be designated without the detection of all the antigens specified in the Kauffmann-White scheme for that serotype. Isolates missing one or more antigens are designated by a formula. For example:

  i. Monophasic variants are variants of typically diphasic serotypes that lack the expression of either the flagellar Phase 1 or Phase 2 antigen; these are indicated by a minus sign ("-") in place of the missing phase; e.g., monophasic variants of S. Typhimurium that lack the second phase H antigen 1,2 are

designated as S. I 4,5,12:i:- or S. I 4,12:i:-; monophasic variants of S. Typhimurium that lack the first phase H antigen i are designated as S. I 4,5,12:-:1,2 or S. I 4,12:-:1,2.

ii. Nonmotile variants express no H antigens and are indicated by minus signs in both phases or by "nonmo tile" in place of the H antigens; e;g., S. I 4,5,12:nonmotile or S. I 4,5,12:-:-.

iii. Rough variants are isolates that do not express O antigen. This is indicated by "Rough" in place of the O antigen in the antigenic formula; e.g., I Rough:i:1,2.

iv. Mucoid variants express a capsule that prevents immunologic detection of the O antigen. They are indicated by "Mucoid" in place of the O antigen in the antigenic formula; e.g., I Mucoid:i:1,2.

- Rarely, isolates express a third H antigen that is noted by a colon followed by the antigen after the Phase 2 H antigen (e.g., S. II 9,12:g,m,[s],t:1,5,7:z42)

5) *Salmonella* Serotype Statistics

There were 2541 *Salmonella* serotypes as of 2002; approximately 60% belong to subspecies I. In the US, approximately 99% of reported human isolates belong to subspecies I. The "top 10" serotypes account for approximately 74% of all isolates reported in the US; the "top 100" serotypes account for about 98% of all isolates. Among the top 100 serotypes, only *S*. IV 48:g,z51:- (formerly *S*. Marina), *S*. IV 50:z4,z23:- (formerly *S*. Flint), *S*. IV 6,7:4,z24:- (formerly *S*. Kralendyk), and *S*. IV 16:z4,z32:- (formerly *S*. Chameleon) are not subspecies I. Among the non-subspecies I isolates, subspecies IV isolates are the most common, followed by subspecies IIIb, IIIa, and II. Subspecies VI and *S. bongori* isolates are very rare.

Salmonella O serogroups and associated O antigens

O Group (number designation)	O Group (letter designation)	Antigens present in all serotypes	Additional antigens that may be present in some serotypes
2	A	2,12	1
4	B	4,12	1; 5; 27
7	C1	6,7	14; (Vi)
8	C2	8	6; 20
9	D1	9,12	1; (Vi)
9,46	D2	9,46	none
9,46,27	D3	9,12,46,27	1
3,10	E1	3,10	15; 15,34
1,3,19	E4	1,3,19	10; 15
11	F	11	none
13	G	13	1; 22; 23
6,14	H	6,14	1; 24; 25
16	I	16	none
17	J	17	none
18	K	18	6; 14
21	L	21	none
28	M	28	none
30	N	30	none
35	O	35	none
38	P	38	none
39	Q	39	none
40	R	40	1
41	S	41	none
42	T	42	1
43	U	43	none
44	V	44	1
45	W	45	none
47	X	47	1
48	Y	48	none
50	Z	50	none
51		51	1
52		52	none
53		53	1
54 (provisional)		54	21; 3; 3,15; 4,12; 8,20; 6,7
55		55	none
56		56	none
57		57	none
58		58	none
59		59	1
60		60	none
61		61	none
62		62	none
63		63	none
65		65	none
66		66	none
67		67	none

H (flagellar) antigens of *Salmonella*

1 complex:	1,2	Other antigens (not part of a complex):	a
	1,5		b
	1,6		c
	1,7		d
	1,2,5		e,h
	1,2,7		i
	1,5,7		k
	1,6,7		(k)
EN complex:	e,n,x		r
	e,n,x,z15		r,i
	e,n,z15		y
G complex:	f,g		z
	f,g,m,t		z6
	f,g,s		z10
	f,g,t		z29
	g,m		z35
	g,m,p,s		z36
	g,m,q		z36,z38
	g,m,s		z38
	g,m,s,t		z39
	g,m,t		z41
	g,p		z42
	g,p,s		z44
	g,p,u		z47
	g,q		z50
	g,s,q		z52
	g,s,t		z53
	g,t		z54
	g,z51		z55
	g,z62		z56
	g,z63		z57
	g,z85		z60
	m,p,t,u		z61
	m,t		z64
L complex:	l,v		z65
	l,w		z67
	l,z13		z68
	l,z13,z28		z69
	l,z28		z71
Z4 complex:	z4,z23		z81
	z4,z23,z32		z83
	z4,z24		z87
	z4,z32		z88

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Suggested Reading

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These websites contain an excellent overview of the history and current status of Salmonella taxonomy and nomenclature:

http://www.bacterio.cict.fr/salmonellanom.html
http://www.bacterio.cict.fr/s/salmonella.html