

## Epidemiological Characteristics of *Salmonella* Strains Isolated recently in Korea

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The taxonomy and nomenclature of *Salmonella* have changed over the years and are still evolving. Currently the genus has two species, *enterica* and *bongori*.

*Salmonella enterica*, which is divided into six subspecies; *S. enterica* subsp. *enterica* (I), *S. enterica* subsp. *salmonella* (II), *S. enterica* subsp. *arizonae* (IIIa), *S. enterica* subsp. *diarizonae* (IIIb), *S. enterica* subsp. *hautena* (IV) and *S. enterica* subsp. *indica* (VI).

*Salmonella bongori* is formerly named subspecies V. These species and subspecies can be differentiated biochemically. A majority of *Salmonella* serotypes belongs to subspecies I and these serotypes are given names. Most *Salmonella* serotypes in the first nine O groups (A, B, C1, C2, D1, E1, E2, E3 and E4) belong to subspecies I and most of the *Salmonella* strains isolated in clinical laboratories belongs to this subspecies. Subspecies I strains are usually isolated from humans and worm-blooded animals. The antigenic formulas of *Salmonella* serotypes are listed in a document called the Kauffman-White scheme. The genus *Salmonella* has large number of serotypes which are currently known more than 2400 serotypes. Many *Salmonella* serotype strains such as *S. typhi*, *S. paratyphi-A*, *S. paratyphi-B*, *S. paratyphi-C*, *S. enteritidis*, *S. typhimurium* and other non-typhoidal *Salmonella* serotype

strains can cause human infection. Among various *Salmonella* serotypes, *S. typhi* had been most highly isolated from public health laboratories in Korea until late 1980s. However, this pattern had been changed since mid 1990s. In the last 3 years (1995-1997) investigations, *S. enteritidis* became most common serotype strain, secondly *S. typhimurium* and thirdly *S. typhi*. Out of 3,302 *Salmonella* strains which were isolated from public laboratories in 1995-1997, 40 serotypes were determined. Among the serotypes determined, *S. enteritidis* (1386 strains), *S. typhimurium* (798 strains) and *S. typhi* (637 strains) were found as major group of serotypes as shown nearly 86%.

*S. enteritidis* and *S. typhimurium* were traditionally known as typical food poisoning *Salmonella* agents, the isolation rate of which has rapidly been increased recently in Korea. Compared with the former pattern, the isolation rate of *S. paratyphi-A*, -B, -C was significantly decreased currently and the patients who infected with *S. paratyphi-A*, -B, -C became very rare. However, *S. typhi* has still been isolated constantly in a significant number from the patients in Korea (Table 1).

In public health point of view, chronic healthy typhoid carriers are particularly important because the carriers often cause the epidemic outbreak.

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**Table 1.** Most frequently encountered 10 *Salmonella* serotypes in Korea ('95-'97)

Serotypes	No. of strains isolated	Proportions (%)
<i>S. agona</i>	31	1.0
<i>S. derby</i>	43	1.4
<i>S. saintfaul</i>	28	0.9
<i>S. typhimurium</i>	798	25.7
<i>S. mbandaka</i>	25	0.8
<i>S. infantis</i>	25	0.8
<i>S. hadar</i>	57	1.8
<i>S. enteritidis</i>	1,386	44.6
<i>S. typhi</i>	637	20.5
<i>S. london</i>	37	1.2
<i>S. senftenberg</i>	41	1.3
Total	3,108	100.0

**Table 2.** Antimicrobial resistance patterns of *S. typhi* isolated in Korea ('95-'97)

Number of isolates tested	Resistance pattern	Number of strains	Total number (%) of drug resistance strains
79	TcTpCbCfAmxApSXTcmTi	2	15 (19.0%)
	TcTpCbSmCfAmxApSXTcm	1	
	TcTpCbAmxApSXTcmTi	5	
	TcCbAmxApSXTcmTi	1	
	TcCbAmxCm	1	
	CxCf	1	
	NaCm	1	
	Na	1	
	Cm	1	
	Tc	1	

# Abberviations: Ap; ampicillin, Amx; amoxicillin, Cb; carbenicillin, Cx; cefoxitin, Cp; cephalothin, Cm; chloramphenicol, Gm; gentamicin, Na; nalidixic acid, Sm; streptomycin, Tc; tetracycline, Ti; timentin (ticarcillin/clavulanic acid), Tp; trimethoprim, SXT; trimethoprim/sulfamethoxazole

Not only epidemiological marker of current *S. typhi* strains but epidemiologic characteristics of the disease occurrence gives very essential informations to prevent and control typhoid fever efficiently. In the recent our investigations, *S. typhi* strains were rather highly isolated in summer like former trend, but certain number of *S. typhi* strains could constantly be isolated from the patients through a year including winter. *S. typhi* strains were isolated from various age groups without significant difference

by sex or geography.

It is strongly suggested that certain number of healthy human typhoid carriers has sporadically populated over the country. As epidemiological marker of *S. typhi* strains, phage type MI (33.3%) was most prevalent. In the study of phage type of *S. typhimurium* strains, phage type 104L (52.3%) was most prevalent in Korea.

In antibiotic sensitivity test, a few *S. typhi* strains (16.4%) showed highly multi-drug resistance against Tc Tp Cb Cf Amx Ap SXT Cm

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**Table 3.** Antimicrobial resistance patterns of *S. enteritidis* isolated in Korea (95-97)

No. of isolates tested	Resistance pattern	No. of strains	Total number (%) of drug resistance strains
114	GmTcCbSmCfAmxApTi	1	14 (12.3%)
	GmTcCbAmxAp	1	
	GmTcTCbSmCfAmxAp	1	
	TcCbSmAmxApTi	1	
	TcCbSmAmxApTi	1	
	TcCbAmxAp	1	
	CbAmxAp	2	
	CbAp	1	
	TcCb	1	
	Cb	3	
	Cm	1	

# Abberviations: Ap; ampicillin, Amx; amoxicillin, Cb; carbenicillin, Cx; cefoxitin, Cp; cephalothin, Cm; chloramphenicol, Gm; gentamicin, Na; nalidixic acid, Sm; streptomycin, Tc; tetracycline, Ti; timentin (ticarcillin/clavulanic acid), Tp; trimethoprim, SXT; trimethoprim/sulfamethoxazole

**Table 4.** Antimicrobial resistance patterns of *S. typhimurium* isolated in Korea (95-97)

No. of isolates tested	Resistance pattern	No. of strains	Total number (%) of drug resistance strains
83	TcTpCbNaAmxApSXTcm	1	67 (80.7%)
	TcTpCbAmxApSXTTi	1	
	TcCbNaAmxApCmTi	1	
	TcCbSAmxApCmTi	1	
	TcCbSmAmxApTi	4	
	TcCbAmxApCmTi	3	
	TcCxCfAmxAp	1	
	TcCbCfAmxAp	1	
	TcCbAmxApTi	8	
	TcCbSmAmxAp	4	
	TcCbSmAmx	1	
	TcCbAmxAp	2	
	TcSmAmxAp	1	
	TcSmAmx	1	
	TcTbSXT	1	
	TcSm	25	
	TcAp	2	
	Tc	9	

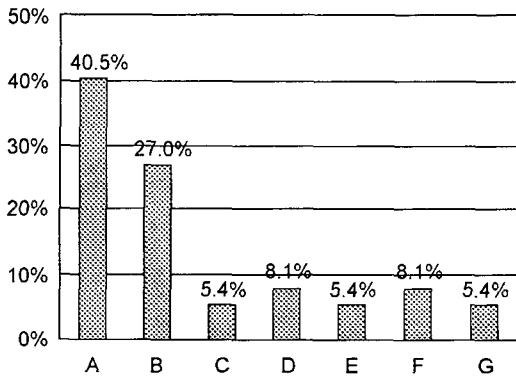
# Abberviations: Ap; ampicillin, Amx; amoxicillin, Cb; carbenicillin, Cx; cefoxitin, Cp; cephalothin, Cm; chloramphenicol, Gm; gentamicin, Na; nalidixic acid, Sm; streptomycin, Tc; tetracycline, Ti; timentin (ticarcillin/clavulanic acid), Tp; trimethoprim, SXT; trimethoprim/sulfamethoxazole

and Ti, Tc Tp Cb Sm Cf Amx Ap SXT and Cm, Tc Tp Cb Amx Ap SXT Cm and Ti, Tc Cb Amx Ap SXT Cm and Ti, Tc Cb Amx and Cm, Cx and Cf, or Na and Cm. There were

also a few strains which had single drug resistance against Na, Cm or Tc (Table 2). The antibiotic resistance rate of *S. enteritidis* and *S. typhimurium* showed 12.3% and 80.7% respec-

**Table 5.** Distribution of PFGE types from *Salmonella typhi* strains isolated in Korea

Type	No. of isolates	Type	No. of isolates	Type	No. of isolates
A1	10	A16	1	C3	1
A2	4	A17	1	C4	1
A3	3	A18	1	C5	1
A4	1	A19	1	D1	1
A5	1	A20	1	D2	1
A6	3	A21	1	F1	1
A7	1	B1	1	F2	1
A8	1	B2	1	G1	1
A9	1	B3	1	H1	1
A10	1	B4	7	I1	1
A11	4	B5	1	J1	1
A12	1	B6	1	K1	1
A13	1	B7	5	L1	1
A14	3	C1	1	M1	1
A15	1	C2	1	N1	1
Total 77					

**Figure.** Percent presentation of analyzed ribotype of *Salmonella typhi* strains isolated in Korea.

tively (Table 3, 4).

In PFGE analysis of *Xba*I digested DNA prepared from 77 *S. typhi* strains randomly selected over the country in 1997, nearly 52.5% of the strains belonged to one pattern named group A and 21.8% belonged to another pattern named group B, having suggested the prevalent clones of current *S. typhi* strains in Korea

(Table 5). In Ribotyping pattern of *Hind*III digested DNA prepared from 78 *S. typhi* strains isolated in 1997, seven patterns named group A to G were found. Prevalently 30 strains (40.5%) belonged to group A and 20 strains (27.0%) belonged to group B (Fig. 1).

In conclusion, *S. enteritidis* and *S. typhimurium* became most significant food poisoning *Salmonella* serotype strains rather than other non-typhoidal *Salmonella* agents. Typhoid healthy carriers still play an important role of causing significant number of typhoid patients in Korea.

Therefore, epidemiological markers of *S. typhi* strains, such as phage type, drug resistance pattern, ribotyping pattern and PFGE pattern can give useful informations to follow up investigating typhoid carriers to have caused the epidemic outbreak.

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