Antimicrobial susceptibility of *Salmonella*, 2011

Hospital and community laboratories are requested to refer all *Salmonella* isolated from human salmonellosis cases to ESR for serotyping and the laboratory-based surveillance of this disease. *Salmonella* from other sources, including food, animal and environmental sources, are also referred to ESR for typing. The antimicrobial susceptibility of a sample (approximately 20%) of non-typhoidal *Salmonella* isolates and all typhoidal isolates is routinely tested at ESR. In addition, the susceptibility of all isolates belonging to internationally recognised multiresistant *Salmonella* clones is tested. These clones include *S.* Typhimurium phage types DT12, DT104, DT120, DT193 and U302, and *S. enterica* serovar 4,[5],12:i:-.

Susceptibility to 12 antimicrobials (Table 1) is determined by the Clinical and Laboratory Standards Institute's disc diffusion method.[1] All cephalothin-resistant isolates are further tested for the production of extended-spectrum β-lactamase (ESBL) and plasmid-mediated AmpC β-lactamase. Multiresistance was defined as resistance to ≥3 antibiotic classes.

Non-typhoidal Salmonella

In 2011, the susceptibility of a representative sample of 506 non-typhoidal *Salmonella* was tested. The sample comprised 222 human and 284 animal/environmental isolates.

Resistance to each of the 12 antimicrobials tested and multiresistance is shown in Table 1. Antimicrobial resistance among *Salmonella* remains relatively low, with 90.3% (82.9% of human isolates and 96.1% of animal/environmental isolates) fully susceptible to all 12 antimicrobials. None of the *Salmonella* tested in 2011 produced ESBL or plasmid-mediated AmpC β-lactamase.

Salmonella from human sources were significantly (P <0.05) more resistant to ampicillin, chloramphenicol, nalidixic acid, streptomycin, sulphonamides and tetracycline, and more multiresistant, than *Salmonella* from other sources (ie, animal and environmental sources) (Table 1). When the comparison between *Salmonella* from human sources and other sources was confined to only human salmonellosis cases who had no reported recent overseas travel, only ampicillin, streptomycin, tetracycline and multiresistance was significantly greater among *Salmonella* from human sources.

Fluoroquinolone (ciprofloxacin)-susceptible strains of *Salmonella* that are resistant to the older-generation quinolone nalidixic acid may be associated with clinical failure or delayed response when fluoroquinolones are used to treat extra-intestinal *Salmonella* infections. While only one (0.5%) of the human isolates of non-typhoidal *Salmonella* tested in 2011 was ciprofloxacin resistant, an additional 18 (8.1%) were nalidixic acid resistant and therefore could fail fluoroquinolone treatment if causing an extra-intestinal infection.

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[1] Clinical and Laboratory Standards Institute. Performance standards for antimicrobial disks; approved standard - tenth edition. Wayne, PA, USA: CLSI; 2009. CLSI document M2-A10.

Table 1. Antimicrobial resistance among non-typhoidal *Salmonella*, 2011

Antimicrobial	Percent resistance			P value for significance of any difference in resistance between human and other isolates[1]
	All isolates n = 506	Human isolates n = 222	Animal and environmental isolates n = 284	
Ampicillin	5.5	10.4	1.8	<0.0001
Cephalothin[2]	0.8	0.5	1.1	0.6348
Chloramphenicol	1.4	3.2	0.0	0.0030
Ciprofloxacin	0.2	0.5	0.0	0.4387
Co-amoxiclav	0.2	0.5	0.0	0.4387
Co-trimoxazole	1.0	1.8	0.4	0.1739
Gentamicin	1.2	1.4	1.1	1.0000
Nalidixic acid	4.4	8.6	1.1	<0.0001
Streptomycin	5.1	8.1	2.8	0.0075
Sulphonamides	4.9	8.1	2.5	0.0037
Tetracycline	6.1	11.3	2.1	<0.0001
Trimethoprim	1.0	1.8	0.4	0.1739
Multiresistant to ≥3 antimicrobials[3]	5.3	9.9	1.8	<0.0001

1 Chi-square test or Fisher's Exact test as appropriate.
2 There were four cephalothin-resistant isolates. These four isolates were tested, and were negative, for the production of extended-spectrum β-lactamase (ESBL) and plasmid-mediated AmpC β-lactamase.
3 For estimates of multiresistance, ciprofloxacin and nalidixic acid resistance, and co-trimoxazole and trimethoprim resistance, was counted as one resistance.

Table 2 shows a comparison of resistance among isolates from salmonellosis cases reported to have travelled overseas with isolates from cases for whom no recent overseas travel was reported. Resistance to ampicillin, chloramphenicol, gentamicin, nalidixic acid, sulphonamides and tetracycline, and multiresistance was significantly higher ($P < 0.05$) among *Salmonella* from cases who had travelled.

Table 2. Antimicrobial resistance among non-typhoidal *Salmonella* from cases who had travelled overseas compared with non-travellers, 2011

Antimicrobial	Percent resistance		P value for significance of any difference in resistance between travellers and non-travellers[1]
	Cases who had travelled overseas n = 28	Cases who had not travelled overseas n = 194	
Ampicillin	32.1	7.2	<0.0001
Cephalothin	0.0	0.5	1.0000
Chloramphenicol	17.9	1.0	<0.0001
Ciprofloxacin	0.0	0.5	1.0000
Co-amoxiclav	0.0	0.5	1.0000
Co-trimoxazole	7.1	1.0	0.0785
Gentamicin	7.1	0.5	0.0426
Nalidixic acid	39.3	4.1	<0.0001
Streptomycin	17.9	6.7	0.0586
Sulphonamides	25.0	5.7	0.0029
Tetracycline	28.6	8.8	0.0058
Trimethoprim	7.1	1.0	0.0785
Multiresistant to ≥3 antimicrobials[2]	28.6	7.2	0.0022

1   Chi-square test or Fisher's Exact test as appropriate.
2   For estimates of multiresistance, ciprofloxacin and nalidixic acid resistance, and co-trimoxazole and trimethoprim resistance, was counted as one resistance.

In 2011, four isolates of the internationally recognised multiresistant *S.* Typhimurium phage type DT193, three of DT120, two of DT104 and one of U302 were identified. All isolates of these types were from human salmonellosis cases. The DT120, DT104 and U302 isolates were multiresistant. Two of the four cases with DT193 were reported to have recently travelled overseas (Indonesia and Australia), as had two of the three DT120 cases (Asia and South East Asia) and one of the two DT104 cases (South East Asia/Middle East/Europe).

S. enterica serovar 4,[5],12:i:- is considered a monophasic variant of *S.* Typhimurium, and multiresistant isolates are typically resistant to ampicillin, streptomycin, sulphonamides and tetracycline. Twenty-two isolates of *S. enterica* serovar 4,[5],12:i:- were identified in 2011: 21 from human salmonellosis cases and one from a 'poultry environment'. All 22 isolates were multiresistant; 20 of which had the resistance pattern typical for this *Salmonella*, that is, resistant to at least ampicillin, streptomycin, sulphonamides and tetracycline. Eleven of the patients with this *Salmonella* serovar were reported to have recently been overseas: South East Asia (7 cases), Hong Kong (1), Asia - not specified (1), Australia (1), and country not specified (1).

Trends in resistance among *Salmonella* from human cases since 2006 are shown in Figure 1. There have been significant (P <0.05) increases in resistance to ampicillin, gentamicin and nalidixic acid during the last 6 years.

Figure 1. Resistance among non-typhoidal *Salmonella* from human cases, 2006-2011
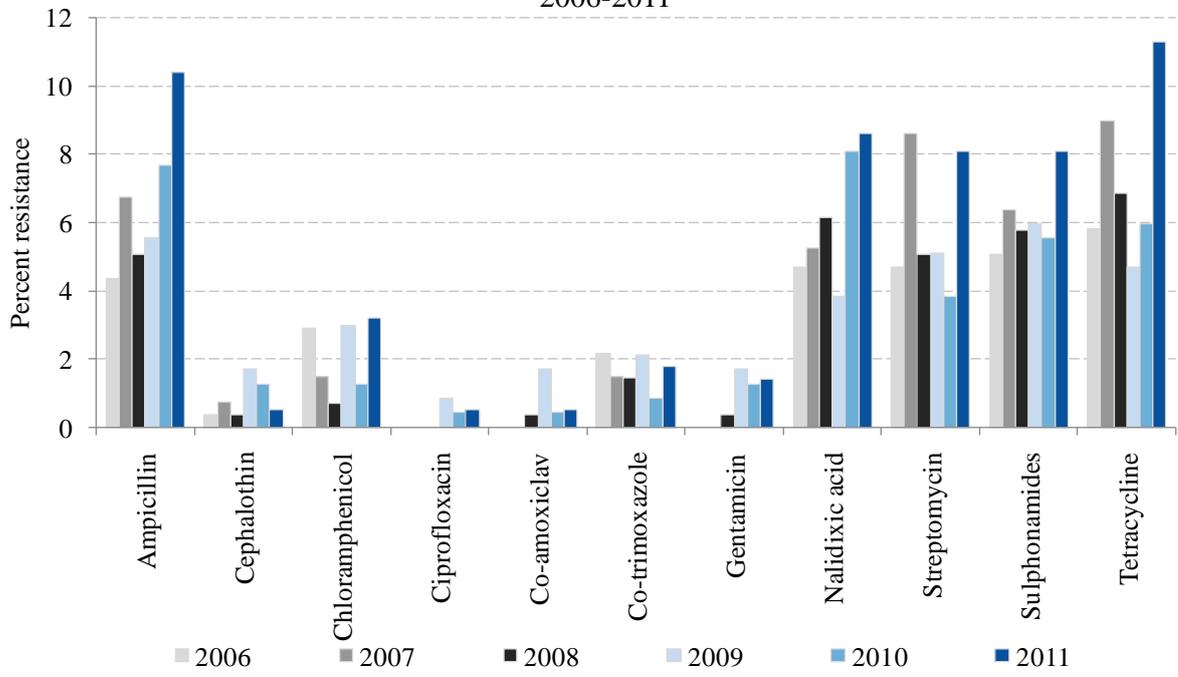
Trimethoprim resistance not shown as the rates of co-trimoxazole and trimethoprim resistance are almost invariably the same.

Typhoidal Salmonella

In 2011, 42 *S.* Typhi, 6 *S.* Paratyphi A and 2 *S.* Paratyphi B (not including *S.* Paratyphi B var Java) isolates were referred to ESR. Resistance to each of the 12 antimicrobials tested is shown in Table 3.

Five patients had multiresistant *S.* Typhi, four of whom had recently travelled to India and the fifth had travelled to the Middle East. In previous years, nalidixic acid resistance in *S.* Typhi has been associated with infections acquired in India and South East Asia, but not infections acquired in the Pacific Islands. While again in 2011, most (15) of the 20 patients with nalidixic acid-resistant *S.* Typhi had travelled to the Indian sub-continent, 2 of the patients had a history of travel to Samoa, with the remaining 3 patients having travelled to the Middle East, South America and Central America.

All six *S.* Paratyphi A isolates were nalidixic acid resistant, and the five cases for whom a travel history was reported had been in the Indian sub-continent or South East Asia.

Table 3. Antimicrobial resistance among *Salmonella* Typhi and *S.* Paratyphi, 2011

Antimicrobial	Percent resistance		
	S. Typhi n = 42	*S.* Paratyphi A n = 6	*S.* Paratyphi B[1] n = 2
Ampicillin	9.5	0.0	0.0
Cephalothin	0.0	16.7[2]	0.0
Chloramphenicol	9.5	0.0	0.0
Ciprofloxacin	0.0	0.0	0.0
Co-amoxiclav	0.0	0.0	0.0
Co-trimoxazole	11.9	0.0	0.0
Gentamicin	0.0	0.0	0.0
Nalidixic acid	47.6	100.0	0.0
Streptomycin	16.7	0.0	0.0
Sulphonamides	11.9	0.0	0.0
Tetracycline	4.8	0.0	0.0
Trimethoprim	11.9	0.0	0.0
Multiresistant to ≥3 antimicrobials[3]	11.9	0.0	0.0

1   *S.* Paratyphi B var Java isolates are not included with the other *S.* Paratyphi B isolates, as they are no longer considered to belong to the 'typhoidal' *Salmonella*.
2   There was one cephalothin-resistant *S.* Paratyphi A isolate. This isolate were tested for, and was negative for, the production of extended-spectrum β-lactamase (ESBL) and plasmid-mediated AmpC β-lactamase.
3   For estimates of multiresistance, ciprofloxacin and nalidixic acid resistance, and co-trimoxazole and trimethoprim resistance, was counted as one resistance.