Antimicrobial susceptibility of *Salmonella*, 2010

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 *S.* Typhimurium clones is tested. These clones include *S.* Typhimurium phage types DT104, U302, DT12, DT120 and DT193. Another multiresistant *Salmonella* clone has been recognised recently – *Salmonella enterica* serovar 4,[5],12:i:-.[1] *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. In 2010, the antimicrobial susceptibility of all *S. enterica* serovar 4,[5],12:I:- isolates was tested.

Susceptibility to 12 antimicrobials (Table 1) is determined by the Clinical and Laboratory Standards Institute's disc diffusion method.[2] All cephalothin-resistant isolates are further tested for the production of extended-spectrum β-lactamase (ESBL) and plasmid-mediated AmpC β-lactamase.

Non-typhoidal Salmonella

In 2010, the susceptibility of a representative sample of 487 non-typhoidal *Salmonella* was tested. The sample comprised 235 human and 252 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 92.0% (86.4% of human isolates and 97.2% of animal/environmental isolates) fully susceptible to all 12 antimicrobials.

Salmonella from human sources were significantly ($P < 0.05$) more resistant to ampicillin, nalidixic acid, sulphonamides and tetracycline, and more multiresistant, than *Salmonella* from other sources (ie, animal and environmental sources) (Table 1). Except for sulphonamide resistance, these significant differences in resistance remained 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.

Two (0.9%) of the 235 *Salmonella* from human sources produced ESBL. None of the *Salmonella* produced plasmid-mediated AmpC β-lactamase. The two ESBL-producing *Salmonella* were *S. enterica* serotype 4,[5],12:i:-, and both had a Group 9 CTX-M-type ESBL.

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[1] Hopkins KL, Kirchner M, Guerra B, et al. Multiresistant *Salmonella enterica* serovar 4,[5],12:i:- in Europe: a new pandemic strain? Eurosurveillance 2010; 15 922):pii=19580. Available at http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19580 [accessed 4 October 2011].

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

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 (0.4%) of the human isolates of non-typhoidal *Salmonella* tested in 2010 was ciprofloxacin resistant, an additional 18 (7.7%) were nalidixic acid resistant and therefore could fail fluoroquinolone treatment if causing an extra-intestinal infection.

Table 1. Antimicrobial resistance among non-typhoidal *Salmonella*, 2010

	Percent resistance			P value for significance of any difference in resistance between human and other isolates[1]
Antimicrobial	**All isolates n = 487**	**Human isolates n = 235**	**Animal and environmental isolates n = 252**	
Ampicillin	4.1	7.7	0.8	0.0001
Cephalothin[2]	0.6	1.3	0.0	0.1116
Chloramphenicol	0.8	1.3	0.4	0.3568
Ciprofloxacin	0.2	0.4	0.0	0.4825
Co-amoxiclav	0.4	0.4	0.4	1.0000
Co-trimoxazole	0.6	0.9	0.4	0.6115
Gentamicin	0.6	1.3	0.0	0.1116
Nalidixic acid	3.9	8.1	0.0	<0.0001
Streptomycin	2.7	3.8	1.6	0.1250
Sulphonamides	3.7	5.5	2.0	0.0381
Tetracycline	3.7	6.0	1.6	0.0106
Trimethoprim	0.6	0.9	0.4	0.6115
Multiresistant to ≥3 antimicrobials[3]	3.1	5.1	1.2	0.0124

1 Chi-square test or Fisher's Exact test as appropriate.

2 There were three cephalothin-resistant isolates from human sources. These three isolates were tested for the production of extended-spectrum β-lactamase (ESBL) and plasmid-mediated AmpC β-lactamase. Two of the three cephalothin-resistant isolates produced a Group 9 CTX-M-type ESBL. None of the cephalothin-resistant isolates produced 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. Only nalidixic acid resistance 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, 2010

	Percent resistance		P value for significance of any difference in resistance between travellers and non-travellers[1]
Antimicrobial	**Cases who had travelled overseas n = 35**	**Cases who had not travelled overseas n = 200**	
Ampicillin	8.6	7.5	0.7370
Cephalothin	0.0	1.5	1.0000
Chloramphenicol	2.9	1.0	0.3850
Ciprofloxacin	0.0	0.5	1.0000
Co-amoxiclav	0.0	0.5	1.0000
Co-trimoxazole	2.9	0.5	0.2762
Gentamicin	0.0	1.5	1.0000
Nalidixic acid	25.7	5.0	<0.0001
Streptomycin	2.9	4.0	1.0000
Sulphonamides	8.6	5.0	0.4178
Tetracycline	8.6	5.5	0.4445
Trimethoprim	2.9	0.5	0.2762
Multiresistant to ≥3 antimicrobials[2]	5.7	5.0	0.6951

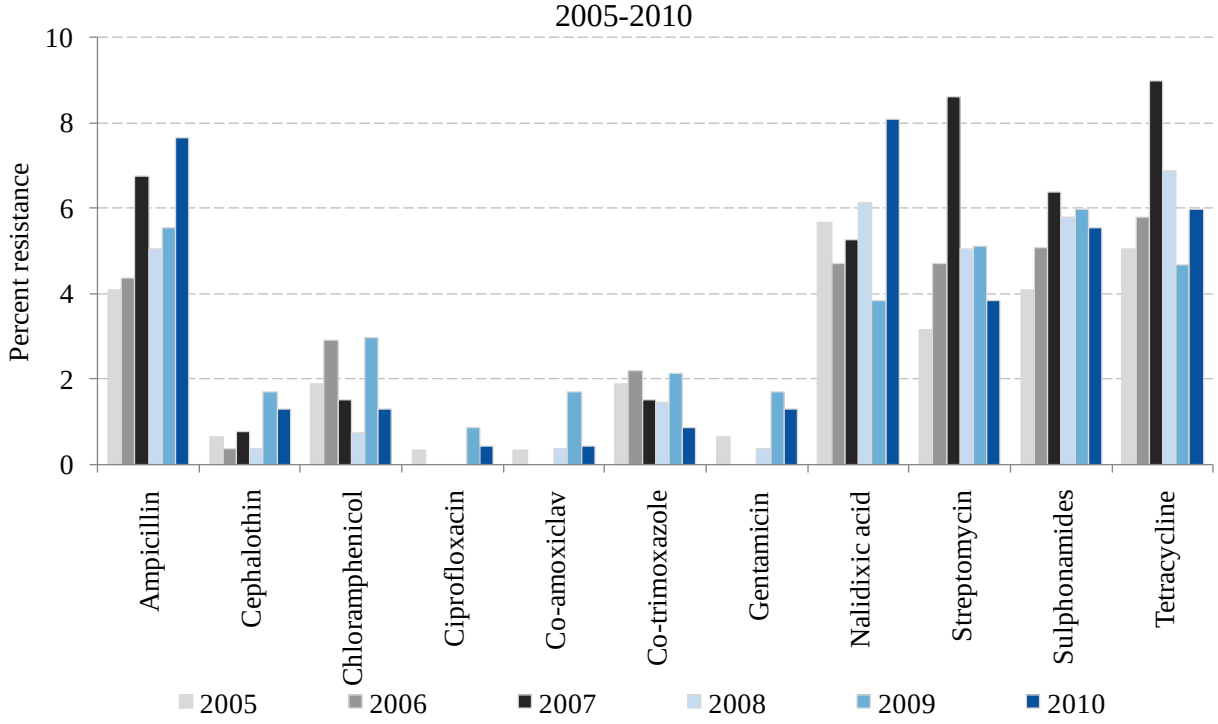
1 Chi-square test or Fisher's Exact test as appropriate.
2 For estimates of multiresistance, ciprofloxacin and nalidixic acid resistance, and co-trimoxazole and trimethoprim resistance, was counted as one resistance.

In 2010, one isolate of the internationally recognised multiresistant *S.* Typhimurium phage type DT104, two of U302, one of DT120 and one of DT193 were identified. All isolates of these types were from human salmonellosis cases. The DT104 and DT120 isolates were multiresistant. No travel history was recorded for any of the cases except the DT120 case who had been in Africa.

Twenty-one isolates of *S. enterica* serovar 4,[5],12:i:- were identified in 2010. All isolates of this serovar were from human salmonellosis cases. Thirteen (61.9%) were multiresistant, with the resistance pattern typical for this *Salmonella*, that is, resistant to at least ampicillin, streptomycin, sulphonamides and tetracycline. Five of the 13 multiresistant isolates produced a CTX-M-type ESBL. Seven (33.3%) of the patients with this *Salmonella* serovar were reported to have recently been overseas: South East Asia (5 cases), Tonga (1) and Australia (1).

Trends in resistance among *Salmonella* from human cases since 2005 are shown in Figure 1. The only significant (P <0.05) overall change in resistance during the last 6 years has been an increase in ampicillin resistance.

Figure 1. Resistance among non-typhoidal *Salmonella* from human cases, 2005-2010



Trimethoprim resistance not included as the rates of co-trimoxazole and trimethoprim resistance are almost invariably the same.

Typhoidal Salmonella

In 2010, 30 *S.* Typhi, 7 *S.* Paratyphi A and 2 *S.* Paratyphi B (not including *S*. Paratyphi B var Java) isolates were referred to ESR. One of the 30 *S.* Typhi was not available for antimicrobial susceptibility testing. Resistance to each of the 12 antimicrobials tested is shown in Table 3.

Two (6.9%) of the *S*. Typhi isolates were ciprofloxacin resistant. These two ciprofloxacin-resistant isolates were also multiresistant. One of the ciprofloxacin-resistant *S*. Typhi was from a patient who had been in India and the other from a patient who had been in an unspecified part of Asia. As has been noted in previous years, in 2010 there was a clear association between nalidixic acid resistance and *S*. Typhi acquired in India and South East Asia: 15 of the 16 patients with nalidixic acid-resistant *S*. Typhi had a history of travel to India or South East Asia. In contrast, *S* Typhi apparently acquired in the Pacific Islands remain susceptible to nalidixic acid. All *S*. Paratyphi A isolates were nalidixic acid resistant and all cases had been in the Indian sub-continent or South East Asia.

Table 3. Antimicrobial resistance among *Salmonella* Typhi and *S*. Paratyphi, 2010

	Percent resistance		
Antimicrobial	***S*. Typhi n = 29**	***S*. Paratyphi A n = 7**	***S*. Paratyphi B[1] n = 2**
Ampicillin	3.4	0.0	0.0
Cephalothin	0.0	0.0	0.0
Chloramphenicol	0.0	0.0	0.0
Ciprofloxacin	6.9	0.0	0.0
Co-amoxiclav	0.0	0.0	0.0
Co-trimoxazole	3.4	0.0	0.0
Gentamicin	0.0	0.0	0.0
Nalidixic acid	55.2	100.0	0.0
Streptomycin	13.8	0.0	0.0
Sulphonamides	6.9	0.0	0.0
Tetracycline	6.9	0.0	0.0
Trimethoprim	3.4	0.0	0.0
Multiresistant to ≥3 antimicrobials[2]	6.9	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 For estimates of multiresistance, ciprofloxacin and nalidixic acid resistance, and co-trimoxazole and trimethoprim resistance, was counted as one resistance.