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Antibiotic resistance among salmonella from human and other sources in New Zealand

H. M. HEFFERNAN

New Zealand Communicable Disease Centre (formerly National Health Institute), PO Box 50 348, Porirua, New Zealand

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SUMMARY

Of 2210 salmonella isolates referred to the New Zealand Communicable Disease Centre for epidemiological surveillance during 1987, 147 (6·7%) were resistant to one or more of 10 antibiotics. Resistance to streptomycin was most common (4·5%), followed by sulphamethoxazole (3·4%), tetracycline (3·3%), ampicillin (1·5%), and kanamycin (1·4%). Resistance to cephalothin, chloramphenicol, gentamicin and trimethoprim occurred in less than 1% of isolates. There was no resistance to norfloxacin. Isolates from human sources were significantly ($P < 0·001$) more resistant (10%) than those from other sources (3·2%). The majority of resistant isolates were resistant to more than one antibiotic, but multiresistance to five or more antibiotics occurred only among human isolates. Comparison of these results with data from earlier years shows that there has been little change in the incidence of resistance among salmonella in this country over the last 10 years. The prevalence of antibiotic resistance among salmonella in New Zealand is low relative to many other countries.

INTRODUCTION

Except for the typhoidal salmonellas, salmonella infection in humans usually results in a gastrointestinal illness for which antibiotic therapy is contraindicated. Despite this, antibiotic resistance among salmonella is a concern to public health authorities for several reasons. Firstly, salmonella may rarely cause invasive disease such as septicaemia for which antibiotic therapy is indicated. Secondly, as food animals are thought to be the source of many salmonella infections in humans, antibiotic resistance in salmonella raises questions about the use of antibiotics in the rearing of these animals. Thirdly, the genes for resistance in salmonella are often plasmid-borne and therefore potentially transmissible to other pathogenic organisms. As salmonella isolates are often routinely collected by public health authorities monitoring salmonellosis, they can be a convenient indicator of antibiotic resistance that may be commonly occurring among enteric pathogens.

The majority of salmonella isolated in New Zealand from human, animal, food and environmental sources are referred to the New Zealand Communicable Disease Centre for national epidemiological surveillance purposes. Between 1972

and 1982 inclusive, the antimicrobial susceptibility of these isolates was tested as part of our ongoing surveillance of antibiotic resistance among salmonella in New Zealand. After 1982 this continuous surveillance was rationalized to testing isolates every fifth year. Isolates received in 1987 were tested, and the results are reported and compared with data from previous years.

MATERIALS AND METHODS

Salmonella from human, animal, food and environmental sources throughout New Zealand, routinely referred in 1987 to the New Zealand Communicable Disease Centre, were tested for their susceptibility to ten antibiotics: ampicillin, cephalothin, chloramphenicol, gentamicin, kanamycin, norfloxacin, streptomycin, sulphamethoxazole, tetracycline, and trimethoprim. Minimum inhibitory concentrations (MICs) were determined by a standard agar dilution technique on Mueller-Hinton agar, supplemented with 5% lysed horse blood when testing sulphamethoxazole and trimethoprim [1]. The criteria used to define resistance are indicated in Table 1. An isolate was defined as multiresistant if it was resistant to five or more antibiotics.

Statistical analyses were performed with the χ^2 test.

RESULTS

The antimicrobial susceptibility of a total of 2210 isolates was tested. Just over half, 1122 (50·8%) of the isolates were from human sources. Of the 1088 isolates from non-human (animal, food, environmental) sources, 52·8% were from poultry and poultry processing sources, 26·7% from animals other than poultry (37·2% bovine, 19·0% ovine), and 20·4% from non-poultry foods or food processing facilities.

Resistance to one or more antibiotics occurred in 147 (6·7%) of isolates. The frequency of resistance to each of the ten antibiotics tested is shown in Table 1 with the antibiotics in order of decreasing frequency of resistance. The most common patterns of resistance were SmSf (1·1%) and SmTc (0·8%). Multiresistance was not prevalent: only 10·2% (15/147) of the resistant isolates were multiresistant (Table 2).

Resistance among isolates from human sources compared with isolates from other sources

Ten percent (112/1122) of human isolates were resistant compared with 3·2% (35/1088) of isolates from other sources (Table 2). Among the isolates from non-human sources, 3·7% of those from poultry and 4·5% of those from other animals, including 7·3% of bovine isolates, were resistant. Just one isolate from a food source other than poultry was resistant. Table 3 compares the frequency of resistance among human and other isolates for each antibiotic. With the exception of cephalothin, for all antibiotics for which there were sufficient numbers of resistant isolates to make a statistically valid comparison, resistance was higher among salmonella from human sources. All multiresistant isolates were from human sources (Table 2).

Table 1. *Antibiotic resistance among salmonella isolates in New Zealand in 1987* (n = *2210*)

Antibiotic		Resistance defined as MIC (mg/l) >	Resistant isolates	
			Number	%
Streptomycin	(Sm)	16	99	4·5
Sulphamethoxazole	(Sf)	256	74	3·4
Tetracycline	(Tc)	8	73	3·3
Ampicillin	(Ap)	16	33	1·5
Kanamycin	(Km)	16	30	1·4
Chloramphenicol	(Cm)	16	19	0·9
Cephalothin	(Cp)	16	13	0·6
Trimethoprim	(Tm)	8	11	0·5
Gentamicin	(Gm)	8	1	0·05
Norfloxacin	(Nx)	8	0	0

Table 2. *Multiresistance among salmonella isolates*

Resistant to (no. of antibiotics)	Isolates from: All sources (*n* = 2210)		Human sources (*n* = 1122)		Other sources (*n* = 1088)	
	Number	%	Number	%	Number	%
1	41	1·9	32	2·9	9	0·8
2	56	2·5	41	3·7	15	1·4
3	19	0·9	13	1·2	6	0·6
4	16	0·7	11	1·0	5	0·5
5	13	0·6	13	1·2	0	
6	1	0·05	1	0·1	0	
7	0		0		0	
8	1	0·05	1	0·1	0	
Total	147	6·7	112	10·0	35	3·2

Table 3. *Antibiotic resistance among salmonella isolates from human sources compared with isolates from other sources*

Antibiotic	Percent resistance among isolates from: Human sources (*n* = 1122)	Other sources (*n* = 1088)	χ^2	*P*
Ampicillin	2·5	0·5	15·57	< 0·001
Chloramphenicol	1·7	0	18·58	< 0·001
Kanamycin	2·0	0·7	6·20	0·013
Streptomycin	6·6	2·3	23·84	< 0·001
Tetracycline	5·0	1·6	20·33	< 0·001
Sulphamethoxazole	5·2	1·5	23·35	< 0·001
Trimethoprim	1·0	0	10·72	0·001
Cephalothin	0·6	0·6	0·05	0·824
Gentamicin	0·1	0	nv*	nv
Norfloxacin	0	0	nv	nv

* nv, insufficient numbers in cells to calculate valid χ^2.

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Table 4. *Antibiotic resistance among* S. typhimurium *compared with other salmonella serotypes*

		Isolates		Resistant isolates		
Serotype group	Source	Number	%	Number	%	% of resistant isolates
S. typhimurium	Human	734	33·2	42	5·7	28·6
	Other	501	22·7	16	3·2	10·9
	All	1235	55·9	58	4·7	39·5
Other salmonella serotypes	Human	388	17.6	70	18·0	47·6
	Other	587	26.6	19	3.2	12.9
	All	975	44·1	89	9·1	60·5

Table 5. *Serotype and resistance pattern of multiresistant isolates*

Serotype	Number of isolates	Resistance pattern*
blockley	3	CmKmSmSfTc
haardt	1	CmKmSmSfTc
hindmarsh	1	CmKmSmSfTc
panama	1	ApCpCmSmSfTc
saintpaul	4	ApKmSfTcTm
thompson	1	CmKmSmSfTc
typhimurium	1	ApCmGmKmSmSfTcTm
	1	ApCmSmSfTc
	1	ApKmSmSfTm
virchow	1	CmSmSfTcTm
Total	15	

* Refer to Table 1 for antibiotic abbreviations.

Resistance and serotype

An analysis of the isolates grouped according to whether they were *Salmonella typhimurium* or another serotype (Table 4) showed that only 4·7% of *S. typhimurium* were resistant compared with 9·1% of other serotypes. A total of 47·6% of all resistant isolates were human isolates of serotypes other than *S. typhimurium*, a group that comprised only 17·6% of the total isolates. In each of the serotype groupings, the rates of resistance were higher ($P < 0{\cdot}05$) among salmonella from human sources than from other sources.

Twelve of the 15 multiresistant isolates were serotypes other than *S. typhimurium*. The serotypes and resistance patterns of the multiresistant strains are shown in Table 5.

Resistance was not associated with any recognized *S. typhimurium* phage type. However, 16 isolates which all reacted with the same phages, but the reaction pattern did not conform to a recognized phage type, occurred over a limited time and geographical location, and were all resistant but had different resistance patterns: Sm, SmSf and SmSfTc.

All *S. blockley* ($n = 8$), *S. hadar* ($n = 11$) and *S. panama* ($n = 5$) were resistant. The isolates of these serotypes were not from any recognized outbreaks of infection. A high proportion, 38 and 27% respectively, of *S. brandenburg* ($n = 13$) and *S. saintpaul* ($n = 22$) were resistant. All resistant *S. brandenburg* were from

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Table 6. *Overseas travel or origin of human patients and frequency of resistance*

Patients	All serotypes		*S. typhimurium*		Other serotypes	
	Number	% resistant	Number	% resistant	Number	% resistant
Recently been overseas	121	29·8	15	33·3	106	29·3
Not recently been overseas	1001	7·6	719	5·2	282	13·8

Table 7. *Antibiotic resistance among salmonella in New Zealand, 1972–87*

	Isolates from					
	All sources		Human sources		Other sources	
Year	Number tested	% resistant	Number tested	% resistant	Number tested	% resistant
1972	283	16·2	262	16·4	21	14·2
1973	327	16·8	280	19·3	47	2·1
1974	453	19·4	408	19·3	45	20·0
1975	605	13·0	379	11·3	226	15·9
1976	679	5·9	326	6·1	353	5·6
1977	607	6·8	433	7·8	174	4·0
1978	1358	7·1	641	6·5	717	7·7
1979	1434	7·3	718	7·2	716	7·4
1980	2300	10·6	924	16·1	1376	6·9
1981	2615	11·3	1093	18·9	1522	5·8
1982	1916	5·6	1210	5·7	706	5·3
⋮						
1987	2210	6·7	1122	10·0	1088	3·2

one small institutional outbreak and had a SmSf resistance pattern. Four of the six resistant *S. saintpaul* were acquired from a common source, a refugee camp in Thailand, and had a resistance pattern of ApKmSfTcTm (Table 5).

Reported overseas travel or origin of people from whom salmonella was isolated

Table 6 shows the differences in the frequency of resistance among isolates from human sources depending on whether the patient was recorded as having recently been out of New Zealand. In all categories: all serotypes, *S. typhimurium* and other serotypes, there was significantly more resistance ($P < 0{\cdot}001$) among salmonella from people who had been overseas. When specified, most of these people had been in South East Asia and were notably Cambodians from refugee camps in Thailand, and visitors to Singapore and Indonesia. It is possible that some of the patients not recorded as having been out of New Zealand had in fact done so. The effect of this under-reporting would be to make these estimated differences in frequency of resistance less pronounced than they may really be. Eleven of the 15 multiresistant salmonella were from people recently overseas. Among the non-human sources of salmonella, only two foods were known to have an overseas origin.

Comparison with resistance data from previous years

Rates of resistance among salmonella isolated between the years 1972 and 1987 are presented in Table 7. The antibiotic sensitivity test methods used during these

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years have varied: (1972–4), Kirby Bauer disk test [2]; (1975–8), agar dilution tests [3]; (1979–82), Stokes disk test [4]. A decrease in the incidence of resistance is apparent between 1974 and 1976. As only small numbers of isolates from non-human sources were referred in the earlier years 1972–5, these data may not be representative. The apparent high incidence of resistance in 1980 and 1981 among isolates from human sources was due to a large outbreak of resistant *S. typhimurium* in both years.

DISCUSSION

Our results indicate that there is a low prevalence of antibiotic resistance among salmonella in New Zealand with overall just 6·7% of isolates sampled in 1987 being resistant to one or more of the ten antibiotics that we tested. Resistance to only three antibiotics, streptomycin, sulphamethoxazole and tetracycline, was recorded at a frequency greater than 2%. Notably no resistance to norfloxacin, representing the new fluorinated quinolone antibiotics, was found. Fluoroquinolones have been available in New Zealand for hospital and specialist use since early 1984. They were licensed for restricted use in animals in 1988.

Resistance was three times more common among the isolates from human sources (10%) than those from other sources (3·2%). Multiresistance to five or more antibiotics occurred only among salmonella from humans. The extremely low frequency of resistance among salmonella from non-human sources may in some part be due to the fact that although New Zealand has a large farming industry, animals are not intensively reared and the use of antibiotics for growth promotion and prophylaxis of disease is controlled by legislation [5]. As has been reported by others [6], resistance among salmonella from non-human sources varied depending on the specific source: isolates from non-poultry food sources were very sensitive, 3·7% of poultry-associated isolates were resistant and bovine isolates were the most resistant (7·3%).

S. typhimurium is reported world-wide to be the most antibiotic-resistant serotype [6, 7]. However, the reverse was observed in our sample: 4·7% of *S. typhimurium* were resistant compared with 9·1% of other serotypes. This was despite the fact that a greater proportion of *S. typhimurium* came from human sources and isolates from human sources were overall more resistant than those from other sources.

The significant differences in the rates of resistance and multiresistance in isolates from human sources compared with non-human sources may not be attributable solely to the immediate source of the isolate but rather confounded by other factors. The acquisition of the salmonella infection outside New Zealand would appear to be one factor. The frequency of resistance among salmonella from people who were known to have recently been overseas was 29·8% compared with 7·6% among other people. Except for two imported foods, none of the isolates from non-human sources was known to have an overseas origin. However, resistance among isolates from human patients who were not reported as having recently been overseas was still more common than resistance among isolates from non-human sources, 7·6 and 3·2% respectively.

The frequency of resistance among salmonella in New Zealand over the years 1972–87 has varied, with a notable decrease in the occurrence of resistance

occurring around 1975. Excepting the years 1980 and 1981, when large outbreaks of resistant *S. typhimurium* occurred each year among human isolates, the frequency of resistance among all isolates in 1987 was similar to the rates that had occurred since 1976, but was higher among isolates from human sources while lower among isolates from other sources. A variety of sensitivity test methods have been used over the years, and, although all methods have been well controlled, the notable drop in resistance in 1975 does coincide with a change from Kirby Bauer disk tests to agar dilution tests.

Comparison of antibiotic resistance data from different studies is often difficult and may not be valid because of such factors as (1) the use of different ranges of antibiotics; (2) the use of different resistance definition criteria; (3) the use of non-standardized test methods; and (4) differences in composition of the study sample, e.g. serotype distribution and source of isolates. Mindful of these limitations, comparison of our data with resistance rates reported in other countries suggests rates of resistance among salmonella in New Zealand are relatively low. For example, studies in the United States, using a similar range of antibiotics, for the periods 1979–80 and 1984–5 recorded resistance rates of 16 and 24% respectively for all salmonella serotypes from human sources [8]. The comparable rate for New Zealand in 1987 was 10%. An earlier study in 1973 in the United States reported resistance among 30% of salmonella from humans and 70% among isolates from animals [9]. In England and Wales in 1987, 23% of salmonella from human sources were antibiotic resistant. Fifty percent of isolates from food animals were resistant, with 66% and 13·0% resistance among bovine and poultry isolates respectively (data received from Central Public Health Laboratory, London).

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