Antibiotic-resistant Salmonella spp. from human and non-human sources in Oman

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ذراري السالمونيلات المقاومة للمضادات الحيوية من مصادر بشرية وغير بشرية في سلطنة عُمان

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الخلاصة: قام الباحثون بدراسة مقاومة مختلف ذراري السلمونيلات المستفرَدة من مصادر متنوعة في سلطنة عُمان؛ مثل مياه الصرف، ومتداولي الأغذية، والدواجن. فوجدوا من بين 1242 مُستَفرَدة من متداولي الأغذية، نحو 15 (1.2٪) ذرية مقاومة لنوع أو أكثر من أنواع المضادات الحيوية، وكان 41٪ من هذه الذراري مقاوماً للأمبيسيلين، و42٪ مقاوماً للكوتريموكسازول، و22٪ مقاوماً للكلورامفينيكول، بينما لم تكن أي من المستفرَدات مقاومة للسيبروفلوكساسين. كما كان نحو 23.7٪ من بين 515 ذرية تم استفرادها من الدجاج مقاوماً لنوع أو أكثر من أنواع المضادات الحيوية، في حين كانت نسبة 14.1٪ من أصل 432 ذرية مستفردة من مياه المجاري مقاومة لنوع أو أكثر من أنواع المضادات الحيوية. وقد تفاوتت الحساسية تجاه مختلف أنواع المضادات الحيوية، في حين لم تكن أي مستفرَدة من الدجاج مقاومة للأميكاسين.

ABSTRACT We investigated the antibiotic resistance of various strains of Salmonella isolated from different sources in Oman, namely sewage water, chicken and food handlers. Of 1242 isolates from food handlers, 15 (1.2%) were resistant to one or more antibiotic. Of these, 41% were resistant to ampicillin, 42% to co-trimoxazole and 22% to chloramphenicol. None of the isolates was resistant to ciprofloxacin. Of 515 isolates from chicken and 432 from sewage water, 23.7% and 14.1% respectively were resistant to one or more antibiotic. Susceptibility to the different antibiotics varied but none of the isolates from chicken was resistant to amikacin.

L'antibiorésistance de Salmonella spp. d'origine humaine et non humaine en Oman

RÉSUMÉ Nous avons étudié l'antibiorésistance de plusieurs souches de Salmonella isolées de différentes sources en Oman, notamment d'eaux usées, de poulets et de personnes qui manipulent les aliments. Sur 1242 isolats provenant de manipulateurs d'aliments, 15 (1,2 %) se sont avérés résistants à un ou plusieurs antibiotiques. Parmi ceux-ci, 41 % étaient résistants à l'ampicilline, 42 % au cotrimoxazole et 22 % au chloramphénicol. Aucun de ces isolats n'était résistant à la ciprofloxacine. Sur les 515 isolats provenant de poulets et les 432 autres prélevés dans les eaux usées, respectivement 23,7 % et 14,1 % étaient résistants à un ou plusieurs antibiotiques. La sensibilité aux différents antibiotiques s'est révélée variable, toutefois aucun des isolats prélevés chez le poulet ne s'est montré résistant à l'amikacine.

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Introduction

Most members of the genus *Salmonella* are potentially pathogenic to humans and vertebrates and cause salmonellosis. Infected humans and animals shed salmonellae into the environment via faeces and reinfection takes place by ingestion of salmonellae-contaminated food and water [*1*].

Strains of *Salmonella* spp. have been isolated from different sources; natural waters [*2*], North Sea water [*3*], sewage water [*2*], chickens [*4*] and food handlers [*5*]. Salmonellosis due to infected food handlers has been reported by many authors in different countries [*5–9*].

In spite of laws and measures set up by many countries for food hygiene and proper use of antibiotics, antibiotic-resistant salmonellae have been isolated from chicken carcasses, meat and humans in Greece, Italy, Thailand, South Africa and Ethiopia [*4,10–14*]. Antimicrobial resistance of the *Salmonella* strains has been found to vary significantly according to the primary isolation sources [*2*], and isolates of human origin have been reported to be less resistant than those of animal or food-feed origin [*10*].

However, because of the abuse of antimicrobial drugs, the antibiotic resistance of *Salmonella* strains from humans is expected to increase. It has been reported that there has been an increase in antibiotic resistance of *Salmonella* isolates from humans [*12*].

In the Gulf region, very few studies have been carried out on antibiotic-resistant salmonellae [*15–17*]. A few limited outbreaks of salmonellosis have occurred in the region, but were reported and covered only in local daily newspapers.

We investigated and compared the antibiotic resistance of various strains of *Salmonella* isolated from different sources in Oman: sewage water, chickens and food handlers.

Methods

Salmonella strains were isolated from samples taken from human faeces, chicken carcasses and chicken faeces, and sewage water in Oman during the period 1998–99. Samples were obtained from all 100 000 food handlers working at different places in the country who are annually checked according to Omani regulations: salmonellae isolates were obtained from 1242 of these samples. The isolation and identification were done according to the standard procedure [*18*]. Biochemical identification was carried out using API 20E strips (bioMérieux, Hazelwod, USA), then confirmed serologically by polyvalent O and H antisera. The human isolates were typed to O serological groups using slide agglutination test [*19*] and then screened for sensitivity to 4 antibiotics (ampicillin, chloramphenicol, ciprofloxacin and co-trimoxazole) following the disk diffusion method [*20*]. Different public health laboratories of the Ministry of Health were involved in this screening. *Salmonella* isolates were obtained from 123 imported frozen chicken carcasses, 191 live chickens at private chicken farms and 201 live chickens from commercial chicken farms. In addition, *Salmonella* isolates were collected from 232 samples taken from different sewage treatment plants in the Muscat area.

We screened 17 antibiotics widely used in Oman for antibiotic resistance to theses isolate: amikacin, ampicillin, chloramphenicol, carbenicillin, ciprofloxacin, co-trimoxazole, cefotaxime, gentamicin, kanamycin, minocycline, neomycin, nalidixic acid, streptomycin, sulfamethoxazole, tetracycline, trimethoprim, and tobramycin.

Results

Among the human isolates, the strains were serologically grouped into groups A

(0.72%), B (16.7%), C (25.3%), D (9.2%), E and G (38.4%) and others (9.5%) belonged to groups I, K, L, M, and O. Group B showed highest resistance (43%) followed by the group C (38%). The number and percentages of resistance to 1 or more antibiotic of *Salmonella* strains isolated from food handlers, chickens and sewage water are shown in Table 1. The number of resistant strains (resistant to 1 or more antibiotic) isolated from samples of imported frozen chicken, live chickens from private farms, live chickens from commercial farms, sewage water and food handlers were 18, 54, 50, 61 and 15 respectively. Isolates of imported chicken, private farm chicken, commercial farm chicken and sewage water were found to be resistant to 5 (29%), 14 (82%), 16 (94%), and 14 (82%) antibiotics respectively out of the 17 antibiotics tested (Table 1). The human isolates were resistant to 3 out of the 4 (75%) antibiotics tested.

The proportion of *Salmonella* isolates resistant to ampicillin was very similar for chicken from private farms and commercial farms (76% and 78% respectively) and much higher than the sewage (21%) and food handler (41%) isolates. All imported frozen chicken isolates were susceptible to ampicillin, chloramphenicol, ciprofloxacin and co-trimoxazole. All *Salmonella* isolates, with the exception of those from chicken from commercial farms (4% resistant) were susceptible to ciprofloxacin. Food handler isolates were more resistant to chloramphenicol (22%) than commercial farm chicken isolates (14%), and sewage isolates (3%), and imported and private farm chicken (0% each). Resistance of isolates to co-trimoxazole was 42% for food handlers, 14% for chicken from commercial farms, 6% for chicken from private farms and 0% for imported chickens and sewage water

Table 1 Antibiotic resistance of Salmonella isolates of chicken, sewage water and food handlers

Source	Total isolates	Isolates resistant to 1 or more antibiotic		Ampicillin	Chloramphenicol	Ciprofloxacin	Co-trimoxazole	Antibiotics to which the isolates are resistant	
	No.	No.	%	%	%	%	%	No.	%
Imported frozen chicken	123	18	14.6	0	0	0	0	5/17	29
Live chicken (private farm)	191	54	28.3	76	0	0	6	14/17	82
Live chicken (commercial farm)	201	50	24.9	78	14	4	14	16/17	94
Sewage water	432	61	14.1	21	3	0	0	14/17	82
Food handlers	1242	15	1.2	41	22	0	42	3/4	75

Table 2 shows the resistance of the *Salmonella* isolates obtained from samples of imported frozen chicken, live chickens from private farms, live chickens from commercial farms and sewage water to the 17 antibiotics tested. Different antibiotics showed varying degrees of effectiveness when tested on different *Salmonella* isolates. Amikacin was found to be 100% effective against all chicken isolates.

Discussion

In spite of the routine checking of food handlers, one of the causes of salmonellosis could be *Salmonella*-infected food handlers. Food handlers have been thought as the victims rather than the causes of *Salmonella* outbreaks. In this study 1.2% of the food handlers were found infected with *Salmonella* although they are annually checked. As regards antibiotic resistance, 22% of the food handler isolates were resistant to chloramphenicol. Many countries have reported conflicting results concerning chloramphenicol-resistant salmonellae [*21–24*]. About 40% of the food-handler isolates were resistant to ampicillin and co-trimoxazole. There was no resistance to ciprofloxacin.

The human isolates were less resistant to ampicillin and ciprofloxacin than the commercial farm chicken isolates while the human isolates were more resistant to chloramphenicol and co-trimoxazole than chicken isolates. Our results disagree with the findings of some workers [*10*] who found that isolates of human origin were overall less resistant than those of animal origin. It appears that the degree of resistance depends upon the type of antibiotic and the strain.

As regards chicken isolates, 28.3% of *Salmonella* isolates from chicken from pri-

Table 2 Antibiotic resistance (percentage resistance) of Salmonella isolates of chicken and sewage water

Source (total no. of samples)	Antibiotic																	
	Ak	Amp	C	Car	Cip	Ctx	Ctz	Gm	K	Min	N	Na	S	Smx	Te	Tmp	Tob	
Imported frozen chicken (123)	0	0	0	0	0	0	0	0	0	44	0	0	100	94	28	28	0	
Live chicken (private farm) (191)	0	76	0	15	0	6	46	13	6	66	2	19	35	44	65	30	2	
Live chicken (commercial farm) (201)	0	78	14	26	4	14	36	20	20	68	28	22	38	88	90	72	16	
Sewage water (432)	16	21	3	93	0	0	38	0	23	39	36	15	74	89	30	8	8	

Ak = amikacin, Amp = ampicillin, C = chloramphenicol, Car = carbenicillin, Cip = ciprofloxacin, Ctz = co-trimoxazole, Ctx = cefotaxime, Gm = gentamicin, K = kanamycin, Min = minocycline, N = neomycin, Na = nalidixic acid, S = streptomycin, Smx = sulfamethoxazole, Te = tetracycline, Tob = tobramycin, Tmp = trimethoprim.

vate poultry farms were resistant to 1 or more antibiotic and 24.9% isolated from chicken from commercial poultry farms were resistant. This is almost double the proportion of isolates from imported frozen chicken (14.6%) that were resistant, probably due to the cleaning and freezing processes that eliminate most viable bacteria [*25*]. Furthermore, the strains isolated from Oman were about twice as resistant to the antibiotics tested as the isolates from imported frozen chicken probably due to the freezing process that affects the plasmid content [*26*]. In addition to the freezing effect on microbes present in chicken carcasses, there is probably antibiotic abuse especially in poultry farms in Oman. During our visits to poultry farms we observed that antibiotics were mishandled by unqualified personnel who did not abide by the standard regulations of the country. Antibacterial drugs are readily available over the counter in many countries. Such drugs can be easily obtained by the community and used improperly, which contributes to the selection of resistant strains [*27*] and multiple drug-resistant strains, especially when a broad-spectrum antibiotic, such as tetracycline, is used [*28,29*].

Some antibiotics were found to be more effective against the *Salmonella* strains studied (amikacin and ciprofloxacin) while others were less so. Some single *Salmonella* strains isolated from private and commercial poultry farms were resistant to up to 11 different antibiotics while those from imported frozen chicken were resistant to up to 4 antibiotics only. Compared to a similar study conducted in Oman in 1986, only 30% of the isolates were resistant to at least 2 of the 18 tested antibiotics [*15*]. In our study, all of the isolates from non-human sources were resistant to at least 2 antibiotics. The mechanism of resistance of a single *Salmonella* strain to a large number of antibiotics cannot be explained by random mutations, but rather by R-plasmids, which can pass the genes for resistance to other strains.

The antibiotic resistance of *Salmonella* strains appears to be increasing which is of concern. We recommend that a programme of health education be given to food preparers and handlers in which they are taught proper means of food handling, hygiene and storage as well as preventive control measures. We also recommend more restrictions on the irrational use of antibiotics, and public awareness activities should be undertaken to alert the public to the risks of the unnecessary use of antibiotics

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International Network to Promote Household Water Treatment and Safe Storage

Every year there are 1.6 million diarrhoeal deaths related to unsafe water, sanitation, and hygiene, the vast majority among children under 5 years. Household water treatment and safe storage interventions can lead to dramatic improvements in drinking water quality and reductions in diarrhoeal disease, making an immediate difference to the lives of those who rely on water from polluted rivers, lakes and, in some cases, unsafe wells or piped water supplies.

To accelerate health gains to those without reliable access to safe drinking water, WHO has established a network aimed at promoting household water treatment and safe storage. The network format optimizes flexibility, participation and creativity to support coordinated action.

More information on the network is available at:
http://www.who.int/household_water/network/en/index.html