Salmonella spp. in the global food trade S8-1

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Abstrak

Pencatatan epidemiologi nasional terus menunjukkan pentingnya Salmonella *spp sebagai penyebab utama penyakit bakteri yang ditularkan melalui makanan pada manusia. Terdapat kecenderungan secara global peningkatan salmonellosis yang ditularkan melalui makanan. Selain daging mentah dan produk-produk susu yang merupakan jalur utama infeksi salmonellosis pada manusia, komoditi lain seperti buah, sayur dan produk akuakultur mengalami peningkatan sebagai sumber penularan* Salmonella. *Situasi yang mencemaskan ini semakin bertambah dengan penyalahgunaan antibiotika yang penting di bidang kedokteran untuk binatang dan peternakan akuakultur untuk meningkatkan hasil, profilaksis atau untuk terapi. Kebiasaan ini menyebabkan timbulnya Salmonella yang ditularkan melalui makanan, yang resisten terhadap berbagai antibiotika termasuk fluorokuinolon jenis baru.*

Abstract

National epidemiological registries continue to underline the importance of Salmonella *spp as the leading cause of foodborne bacterial disease in humans. Global trends of foodborne salmonellosis are generally on the increase. Although raw meats and milk products figure prominently as vehicles of human* Salmonella *infections, other commodities including fruits, vegetables, and aquacultural products have gained notoriety in recent years as potential reservoirs of human* Salmonella *infections. This disquieting situation is further compounded by the widespread use and abuse of medically important antibiotics in animal and aquacultural husbandry for the purpose of growth promotion, prophylaxis and therapy. Such practices have led to the emergence of foodborne* Salmonella *spp that are resistant to multiple antibiotics including the new fluoroquinolones.*

The ubiquity of *Salmonella* spp. in the natural environment and in the global food chain continue to underline the importance of this infectious agent as the leading cause of foodborne bacterial infections in humans[1,2,3]. National registries on the reported prevalence of human salmonellosis from all causes vary widely (Table 1). This situation likely arises from the endemicity of salmonellae in individual countries and from the quality of epidemiological data and the timely identification and reporting of human infections. An explanation for the significantly higher rate of salmonellosis in the Czech Republic compared to that in other European countries remains elusive.

Two clinical forms of human salmonellosis can be distinguished. Enteric fever follows from an infection with typhoid and paratyphoid salmonellae and is a potentially fatal systemic infection that requires aggressive antimicrobial therapy. Clinical symptoms include prolonged and spiking fever, abdominal pain and diarrhea which usually appear 8-28 days following contact with the infectious agent. In contrast, the clinical symptoms of enterocolitis associated with nontyphoid *Salmonella* spp. appears within a shorter (8-72h) period of incubation and typically consists of severe abdominal pains, watery diarrhea and low frequency of fever of short duration[1,2]. The clinical management of enterocolitis is based on fluid and electrolyte replacement. Treatment with antibiotics is contraindicated because it tends to prolong the convalescent carrier stage that follows the acute phase of the disease. Although the mainstay of therapy for enteric fever and systemic presentations of nontyphoid

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Table 1. Reported incidence of human salmonellosis

Country	Year	Rate*	Reference
Canada	1993	29.7	4
Czech Republic	1992	422.0	5
England/Wales	1994	60.8	6
Germany	1993	175.5	5
Hong Kong	1993	40.0	7
Israel	1992	100.9	5
Italy	1992	41.3	5
Scotland	1993	58.0	8
Sweden	1991	69.0	9
United States	1995	17.7	10

Rate per 100,000 population.

Table 2. Temporal Changes in the Antibiotic Resistance of *Salmonella spp.*

Country	Year	Serovar	No. Strains Tested	Antibiotic resistance (%) A[a]	C[a]	Tp[b]/SXT[c]	Multiple[d]	Reference
HUMAN								
Hong Kong	1985	multiple	89	6.7	13.5	1.1[c]	NL[e]	11
	1988		299	27.1	34.4	8.4[c]	NL	
Spain	1980-82	S. typhimurium	66	15.2	7.2	<1.0[c]	10.6	12
	1992-94		30	73.3	46.7[c]	6.0[c]	60.0	
United Kingdom	1986-89	S. typhi	790	1.0	1.5	0.0[b]	NL	13
	1993		194	25.0	25.0	25.0[b]	NL	
United States	1979-80	multiple	378	9.5	1.1	0.0[c]	17.0	14
	1989-90		484	14.5	2.9	0.4[c]	31.0	
NON HUMAN								
England/Wales	1981	S. typhimurium	1,157[f]	13.0	15.0	8.0[b]	15.0	15
	1990		1,178[f]	66.0	45.0	53.0[b]	66.0	
	1981	S. typhimurium	49[g]	22.0	22.0	35.0[b]	22.0	
	1990		144[g]	19.0	3.0	35.0[b]	35.0	
	1981	S. typhimurium	117[h]	<1.0	<1.0	0.0[b]	1.0	
	1990		1,187[h]	6.0	2.0	7.0[b]	8.0	

[a]*Ampicillin (A); chloramphenicol (C).*
[b]*Trimethoprim.*
[c]*Trimethoprim sulfamethoxazole.*
[d]*Resistant to 2 antibiotics that may not be listed above.*
[e]*Not listed.*
[f]*Bovine.*
[g]*Porcine.*
[h]*Poultry.*

salmonellosis in humans has relied on chloramphenicol, ampicillin and trimethoprim-sulfamethoxazole, the emergence and persistence in many countries of *Salmonella* strains that are resistant to one or more of these antibacterial agents (Table 2) has dramatically undermined their clinical efficacy in favor of newer cephalosporins and fluoroquinolones[1-16].

Table 3. *Salmonella* in meat animals

Meat animal	No. samples tested	Percent positive	Reference
On farm (herds, flocks)			
Beef/cattle			
Indonesia (1986)	77	3.9	17
Malta (1993)	300	41.3	18
Pork			
Denmark (1995)	15,797	5.5	19
Indonesia (1989)	236	11.0	17
United States (ca 1995)	140	35.7	20
Chicken (broilers)			
Denmark (1995)	4,168	24.0	19
Japan (ca 1990)	286	24.1	21
Switzerland (1991)	92	16.6	22
Buffaloes			
Indonesia (1986)	14	35.7	17
Post Slaughter			
Beef			
Germany (1991)	18,242	5.1	23
Portugal (1987-88)	408	20.3	24
United States (1993)	2,112	2.7	20
Pork			
Australia (ca 1995)	1,428	13.1	20
Canada (1985-86)	448	10.0	25
Japan (1992)	69	5.8	26
Romania (1989-90)	260	13.1	27
Chicken			
Cuba (ca 1990)	200	62.5	28
Denmark (1995)	4,099	45.7	19
Japan (1992)	238	33.6	26
Portugal (1986-87)	300	55.0	24
Thailand (1991-92)	353	51.0	29
United States (1990-91)	200	34.9	30

The global problem of human foodborne salmonellosis stems mainly from the widespread occurrence of *Salmonella* spp. in the farm environment and in agricultural products. Although national data on the farm prevalence of salmonellae in meat animals appear to vary widely (Table 3), such differences may arise from variable sampling intensities applied to herds and flocks, from the nature of the test sample used to assess the bacteriological status of meat animals, and from the use of widely different analytical methods for the detection of the target microorganism. Fecal contamination of external surfaces such as animal hides, feathers and limbs at the farm level together with the stress-induced shedding of salmonellae during the pre-slaughter transportation and holding of animals contribute to the potential cross-contamination of meat carcasses in slaughtering operations. The marked increases in the prevalence of salmonellae in poultry from the farm to the processing facility (Table 3) delineates the importance of this transmission mechanism.

Table 4. Prevalence of *Salmonella* in Aquacultural Species

Product	Country	No.of Samples Tested	Positive (%)	Reference
Tilapia	South Africa	22	12 (54.5)	31
Catfish	United States	412	13 (3.2)	32
Catfish	United States	52	11 (21.2)	33
Eel[a]	Japan	23	6 (26.1)	34
Prawns	Philippines	NS[b]	NS (16.0)	35
Shrimp	India	NS	NS (37.5)	36

[a] *Includes samples of pond water and sludge.*
[b] *Not stated.*

The rapid depletion of feral stocks and the growing international demand for fish and shellfish products have greatly favored the rapid development of the aquacultural industry. The prominence of this industry in Asiatic countries, notably the Republic of China which produces approximately half of the world's aquacultural output, is of concern because of the prevailing hygienic conditions and the propensity for product contamination in this and in other third world countries[3]. Although reports on the *Salmonella* status of aquacultural fish and shellfish are generally lacking, isolated studies indicate that the importance

Table 5. Growth and survival of *Salmonella* spp.[a]

Growth limits			
	Temperature	2.0 - 54.0 C	
	pH	3.99 - 9.50	
	a_w	> 0.93	
Survival			
	Food	Storage Temperature	Storage Period
	Snails	-10 C	9 yr
	Chocolate	ambient	13 yr
	Pasta	ambient	10 yr
	Tea	ambient	4 yr

[a] *Adapted from reference 2.*

of these products as potential vehicles of human salmonellosis cannot be minimized (Table 4).

Salmonellae are highly resilient microorganisms that effectively cope with hostile microenvironments. Such adaptability arises partly from a capacity to grow at temperatures ranging from 2.0 to 54.0°C, at pH values of 3.99 to 9.5, and at water activities (a_w) above 0.93 (Table 5). Other physiological attributes of *Salmonella* spp. such as the log and stationary phase-dependent acid tolerance responses[2], increasing heat resistance with decreasing water activity of the external medium[1], and ability to survive prolonged periods of storage at freezer and ambient temperatures (Table 5) contribute to the continued prominence of salmonellae as the leading cause of foodborne bacterial diseases in humans. It is noteworthy that the incidence of foodborne salmonellosis is generally on the increase worldwide[2]. The reported annual number of *Salmonella* incidents clearly dwarfs that reported for other bacterial etiological agents (Table 6). Several major outbreaks that occurred in recent years are noteworthy (Table 7). In 1984, Cana-

Table 6. Epidemiology of Foodborne Bacterial Pathogens

Country	Year	Annual number of incidents[a] Salmonella	S. aureus	Campylobacter	Bacillus	E. coli	Listeria	Reference
Canada	1989	51.0	21.0	13.0	19.0	9.0	3.0	37
England/Wales	1989-91	922.0	8.3	5.0	24.7	1.0	0.0	5
Japan[c]	1991	159.0	95.0	24.0	9.0	30.0	NL[b]	38
Spain	1994	379.0	39.0	2.0	1.0	9.0	NL	39
United States	1992	81.0	6.0	6.0	3.0	3.0	0.0	40

[a] *Mean annual number of incidents (outbreaks and single cases) where applicable.*
[b] *Not listed or possibly no reported incidents.*
[c] *A total 247 incidents of Vibrio spp. enteritis were reported.*

Table 7. Major foodborne outbreaks of human salmonellosis

Year	Country[a]	Vehicle	Serovar	Number		Reference
				Cases[b]	Deaths	
1984	Canada	cheddar cheese	*S. typhimurium* PT 10	2,700	0	41
1985	United States	pasteurized milk	S. typhimurium	16,284	7	42
1987	Republic of China	beverage (egg)	S. typhimurium	1,113	NS[c]	43
1988	Japan	cooked eggs	*Salmonella* spp.	10,476	NS	38
1991	United States/Canada	cantaloupes	S. poona	>400	NS	44
1993	Germany	paprika potato chips	S. saintpaul S. javiana S. rubislaw	1000	0	45
1994	United States	ice cream	S. enteritidis	740	0	46

[a]*Country where outbreak occurred; most episodes were due to domestic products.*

[b]*Confirmed cases.*

[c]*Not specified.*

Table 8. *Salmonella* outbreaks from imported foods[a]

Year	Country		Vehicle	Serovar	Number		Reference
	Exporting	Importing			Cases[b]	Deaths	
1973	Canada	United States	chocolate	S. eastbourne	122	0	47
1982	Italy	United Kingdom	chocolate	S. napoli	245	0	48
1982	Brazil	Norway	black pepper	S. oranienburg	126	1	49
1984	France	United Kingdom	pâté	S. gold coast	506	0	50
1984	United Kingdom	International	aspic glaze	S. enteritidis PT 4	766	2	51
1988	Australia	England	mungbean sprouts	S. saintpaul	143	0	52
1989-90	Mexico	United States	cantaloupe	S. chester	>245	2	53
1994	Australia	Finland/Sweden	alfalfa sprouts	S. bovismorbificans	492	0	54
1995	The Netherlands	United States	alfalfa sprouts	S. stanley	>230	0	55
1996	The Netherlands	Canada /United States	alfalfa sprouts	S. newport	>137	0	55
1996	France	United Kingdom	Infant milk formula	S. anatum	>12	0	56

[a]*Adapted from reference 3.*

[b]*Confirmed cases.*

dian cheddar cheese made from pasteurized and unpasteurized milk was identified as the cause of 2,700 confirmed human cases of *S. typhimurium* phagetype 10 infections. An investigation of the incriminated cheese plant determined that the manual overide of a flow diversion valve had permitted entry of raw milk into vats of pasteurized milk destined for cheese production[41]. The largest outbreak of human foodborne salmonellosis ever recorded in the United States occurred in 1985 and was associated with pasteurized milk. The episode reportedly originated from cross-connections between raw and pasteurized milk lines in the fluid milk plant[42]. More recently, fresh cantaloupes produced in the United States led to an international outbreak of *S. poona*[44]. Seemingly the bacterial pathogen located on the surface of the fruit was inoculated into the edible tissues during cutting of the fruit. In the German outbreak, paprika contaminated with multiple *Salmonella* serovars was sprinkled onto cooked potato chips prior to packaging[45]. In 1994, ice cream was implicated in a major outbreak of human *S. enteritidis* infections in the United States. The cause of this episode was ascribed to the cross-contamination of ice cream mix transported in a truck that had not been properly sanitized after an earlier delivery of raw liquid eggs[46]. A variety of internationally distributed foods have been implicated in episodes of human salmonellosis (Table 8). It is noteworthy that the incriminated foods were all ready-to-eat products and that fresh fruit and vegetables appear to be increasing in importance as vehicles of human infection.

Table 9. Ciprofloxacin-resistant *Salmonella* from humans: England and Wales[a]

Serovar	Number Tested (% resistant)	
	1991	1994
S. enteritidis	17,456 (0.1)	17,701 (0.4)
S. typhimurium	5,331 (0.3)	5,603 (1.4)
S. virchow	766 (2.5)	144 (5.1)
S. newport	331 (1.5)	294 (5.1)
S. hadar	294 (2.0)	298 (39.6)

[a]*Adapted from reference 57.*

Table 10. Enrofloxacin-resistant *Salmonella* in Germany[ab]

Source	Year	No. isolates Tested	Percent Resistant[c]
Bovine	1987	1,739	0.0
	1988	2,055	1.8
	1989[d]	2,720	4.4
	1990	2,160	15.9

[a]*Adapted from reference 58.*
[b]*Multiple serovars with predominance of S. typhimurium.*
[c]*Most strains showed cross-resistance to nalidixic acid and to other fluoroquinolones.*
[d]*Therapeutic veterinary use of enrofloxacin licenced in 1989.*

The widespread use and abuse of antibiotics in human medicine and in various food producing sectors is of considerable concern because such practices have led to the emergence and persistence of *Salmonella* spp. and other bacterial pathogens that are resistant to medically important drugs. The phenomenon has diverted medical, veterinary and aquacultural interests towards the fluoroquinolones as replacements for traditional antimicrobials that are no longer effective. The growing preference for fluoroquinolones in human medicine has already triggered an increasing prevalence of ciprofloxacin-resistant *Salmonella* spp. in England and Wales (Table 9). Similarly, the recently approved therapeutic and/or prophylactic use of enrofloxacin (Europe) and sarafloxacin (United States) in animal husbandry is currently selecting for fluoroquinolone resistant salmonellae in the agricultural industry (Table 10). This alarming situation is further compounded by the use of fluoroquinolones in the vast aquacultural industry which flourishes in third world countries. Clearly, the prevalence of multiple antibiotic-resistant *Salmonella* spp. in the global food chain represents a major threat to public health and must now be factored into the food safety equation. Stringent control measures in the production, harvesting and distribution of foods and food ingredients remain key determinants in effective food safety programs. Current information indicating that the ingestion of very low numbers of foodborne salmonellae can result in human illness (Table 11) should further strengthen the resolve of the food industry to market bacteriologically safe products.

Table 11. Human infectious doses of *Salmonella* spp.[a]

Food	Serovar	Infectious dose
Eggnog	S. meleagridis	10^6 - 10^7
	S. anatum	10^5 - 10^7
Goat cheese	S. zanzibar	10^5 - 10^{11}
Imitation ice cream	S. typhimurium	10^4
Chocolate	S. eastbourne	10^2
Hamburger	S. newport	10^1 - 10^2
Cheddar cheese	S. heidelberg	10^2
Chocolate	S. napoli	10^1 - 10^2
Cheddar cheese	S. typhimurium	10^0 - 10^1
Chocolate	S. typhimurium	$\leq 10^1$
Paprika potato chips	S. saintpaul	$\leq 4.5 \times 10^1$
	S. javiana	
	S. rubislaw	

[a]*Adapted from reference 3.*

REFERENCES

1. D'Aoust JY. *Salmonella.* In: Foodborne Bacterial Pathogens (ed. M.P. Doyle). Marcel Dekker Inc., New York, Basel. 1989; 327-445.
2. D'Aoust JY. *Salmonella* species. In: Food Microbiology. Fundamentals and Frontiers (eds M.P. Doyle, L.R. Beuchat and T.J. Montville). Washington DC: ASM Press 1997; 129-58.
3. D'Aoust JY. *Salmonella* and the international food trade. Int J Food Microbiol 1994; 24: 11-31.
4. Health Canada. Salmonellae, Shigellae, Pathogenic *E. coli*, Campylobacters and Aeromonas identified in Canada, December 1993. Laboratory Centre For Disease Control Monthly Report, Ottawa 1993.
5. World Health Organization. WHO Surveillance Program for Control of Foodborne Infections and Intoxications in Europe (ed. K. Schmidt). Federal Institute for Health Protection of Consumers and Veterinary Medicine, Berlin, 1995; 1-340.
6. Anon. *Salmonella* in humans, England and Wales: quarterly report. Comm Dis Rep 1995; 5: 43-50.
7. Wong SSY, Yuen KY, Yam WC, Lee TY, Chau PY. Changing epidemiology of human salmonellosis in Hong Kong. Epidemiol Infect 1994; 113: 425-34.
8. Sharp JCM, Reilly WJ . Recent trends in foodborne infections in Europe and North America. Brit Food J 1994; 96: 25-34.

9. Andersson Y, Bottiger M, de Jong B. An increase of domestic cases of *S. enteritidis* in Sweden. In: Proceedings of the 3rd World Congress on Foodborne Infections and Intoxications. Institute of Veterinary Medicine, Berlin, 1992; 111-4.
10. Anon. Summary of notifiable diseases, United States 1995. Morb Mortal Wkly Rep 1996; 44: 1-87.
11. Ling JM, Zhou GM, Woo THS, French GL. Antimicrobial susceptibilities and lactamase production of Hong Kong isolates of gastroenteric salmonellae and *Salmonella typhi*. J Antimicrob Chemother 1991; 28: 877-85.
12. Ramos JM, Ales JM, Cuenca-Estrella M, Fernandez-Roblas R, Soriano F. Changes in susceptibility of *Salmonella enteritidis, Salmonella typhimurium* and *Salmonella virchow* to six antimicrobial agents in a Spanish hospital, 1980-1994. Eur J Clin Microbiol Infect Dis 1996; 15: 85-8.
13. Threlfall EJ, Ward LR, Frost JA, Rowe B.1995 Typhoid fever and other salmonellosis: a changing pattern of drug susceptibilities. Southeast Asian J Trop Med Publ Hlth 1996; 26: 13-6.
14. Lee LA, Puhr ND, Maloney EK, Bean NH, Tauxe RV. Increase in antimicrobial-resistant *Salmonella* infections in the United States, 1989-1990. J Infect Dis 1994; 170: 128-34.
15. Threlfall EJ, Rowe B, Ward LR. A comparison of multiple drug resistance in salmonellas from humans and food animals in England and Wales, 1981 and 1990. Epidemiol Infect 1993; 111: 189-97.
16. D'Aoust J-Y. Pathogenicity of foodborne *Salmonella*. Int J Food Microbiol 1991; 12: 17-40.
17. Nakamura M, Nakashima N, Kaji T, Sato S. Isolation of salmonellae from clinically normal cattle and pigs in Indonesia in 1986, and detection of plasmids in the isolates. Jpn J Vet Sci 1989; 5: 1059-61.
18. Vella L, Cushieri P. *Salmonella* excretion in adult cattle on the Maltese island of Gozo. Rev Sci Technol Off Int Epiz 1995; 14: 777-87.
19. Anon. Annual report on zoonoses in Denmark 1995. (eds H.C. Wegener, S.K. Larsen and J. Flensburg). Danish Zoonosis Center and Danish Veterinary Laboratory, Copenhagen 1996; 1-12.
20. Anon. Swine *Salmonella* research subject of Iowa conference. Food Chem News 1996; 38: 30-4.
21. Tokumaru M, Konuma H, Umesako M, Konno S, Shinagawa K. Rates of detection of *Salmonella* and *Campylobacter* in meats in response to the sample size and the infection level of each species. Int J Food Microbiol 1990; 13, 41-6.
22. Baumgartne A, Heimann P, Schmid H, Liniger M, Simmen A. Salmonella contamination of poultry carcasses and human salmonellosis. Arch für Lebensmitt 1992; 43: 123-4.
23. Hartung M. Control of enteritis salmonellae in foods and animals. Dtsch Tierärztl Wschr 1993; 100: 259-61.
24. Bernardo FMA, Machado JCC. *Salmonella* in Portugal: a slaughterhouse survey. Rev Portuguesa Cienc Vet 1990; 85: 94-102.
25. Mafu AA, Higgins R, Nadeau M, Cousineau G. The incidence of *Salmonella Campylobacter*, and *Yersinia enterocolitica* in swine carcasses and the slaughterhouse environment. J Food Prot 1989; 52: 642-5.
26. Ishizaki N, Kaneko S, Itoh T, Jinbo K, Kataoka J, Kokubo Y. The detection and serotyping of *Salmonella* from commercial meat from 1989 to 1992 in Tokyo. Ann Rep Tokyo Metr Res Lab PH 1993; 44: 101-4.
27. Pantiru CS, Trif R. Aspects regarding the carriage of *Salmonella* at normally sacrificed swines and the possibilities of contamination of meat products during the technologic process. In: Proceedings of the 3rd World Congress on Foodborne Infections and Intoxications. Institute of Veterinary Medicine Berlin 1992; 345-7.
28. Dominguez AC, Valdes-Dapena M, Guardia A, Pérez G. Determinacion de *Salmonella* en aves en ciudad de La Habana. Rev Cubana Hig Epidemiol 1990; 28: 296-303.
29. Jerngklinchan J, Koowatananukul C, Daengprom K, Saitanu K. Occurrence of salmonellae in raw broilers and their products in Thailand. J Food Prot 1994; 57: 808-10.
30. Brewer RL, James WO, Prucha JC, Johnston RW, Alvarez CA, Kelly W, et al. Poultry processing line speeds as related to bacteriologic profile of broiler carcasses. J Food Sci 1995; 60: 1022-4.
31. Mackenzie CR, Livingstone DJ. Salmonellae in fish and food. South African Med J 1968; 42: 999-1003.
32. Andrews WH, Wilson CR, Poelma PL, Romero A Bacteriological survey of the channel catfish (*Ictalurus punctatus*) at the retail level. J Food Sci 1977; 42: 359-63.
33. Wyatt LE, Nickelson II R, Vanderzant C. Occurrence and control of *Salmonella* in freshwater catfish. J Food Sci 1979; 44: 1067-73.
34. Saheki K, Kobayashi S, Kawanishi T. *Salmonella* contamination of eel culture ponds. Nippon Suisan Gakkaishi 1989; 55: 675-9.
35. Reilly PJA, Twiddy DR. *Salmonella* and *Vibrio cholerae* in brackishwater cultured tropical prawns. Int J Food Microbiol 1992; 16: 293-301.
36. Bhaskar N, Rudra Setty TM, Vidya Sagar Reddy G, Manoj YB, Anantha CS, Raghunath BS, et al. Incidence of *Salmonella* in cultured shrimp Peneus monodon. Aquaculture 1995; 138: 257-66.
37. Foodborne and Waterborne Disease in Canada Annual Summaries 1988 and 1989. Health Protection Branch, Health Canada, Ottawa 1996.
38. Miyagawa S, Miki A. The epidemiological data of food poisoning in 1991. Food Sanit Res 1992; 42: 78-104.
39. Pezzi GH, Gallardo IM, Ontanon, SM, Anchuela OT, Montalvo VR. Vigilancia de brotes de infecciones eintoxicaciones de origen alimentario, Espana, Ano 1994 (excluye brotes hidricos). Boletin Epidemiol Semanal 1995; 3: 293-9.
40. Bean NH, Goulding JS, Lao C, Angulo F. Surveillance for foodborne disease outbreaks - United States, 1988-1992. In: CDC Surveillance Summaries. Morb Mortal Wkly Rep 1996; 45: 1-66.
41. D'Aoust JY, Warburton DW, Sewell AM. *Salmonella typhimurium* phage-type 10 from cheddar cheese implicated in

a major Canadian foodborne outbreak. J Food Prot 1985; 48: 1062-6.

42. Lecos C. Of microbes and milk: probing America's worst *Salmonella* outbreak. Dairy and Food Sanit 1986; 6: 136-40.
43. Ye XL, Yan CC, Xie HH, Tan XP, Wang YZ, Ye LM. An outbreak of food poisoning due to *Salmonella typhimurium* in the People's Republic of China. J Diarrhoeal Dis Res 1990; 8: 97-8.
44. Francis BJ, Altamirano JV, Stobierski MG, Hall W, Robinson B, Dietrich S, et al. Multistate outbreak of *Salmonella poona* infections United States and Canada, 1991. Morb Mortal Wkly Rep 1991; 40: 549-52.
45. Lehmacher A, Bockemühl J, Aleksic S. A nationwide outbreak of human salmonellosis in Germany due to contaminated paprika and paprika-powdered potato chips. J Infect Dis 1995; 115: 501-11.
46. Henkel, J. Ice cream firm linked to *Salmonella* outbreak. FDA Consumer 1995; 29: 30-1.
47. D'Aoust JY, Aris BJ, Thisdele P, Durante A, Brisson N, Dragon D, et al. *Salmonella eastbourne* outbreak associated with chocolate. Can Inst Food Sci Technol J 1975; 8: 181-4.
48. Gill ON, Sockett PN, Bartlett CLR, Vaile MSB, Rowe B, Gilbert RJ, et al. Outbreak of *Salmonella napoli* infection caused by contaminated chocolate bars. Lancet, 1983; 1: 574-7.
49. Gustavsen S, Breen O. Investigation of an outbreak of *Salmonella oranienburg* infections in Norway, caused by contaminated black pepper. Am J Epidemiol 1984; 119: 806-12.
50. Bouvet E, Jestin C, Ancelle R.Importance of exported cases of salmonellosis in the revelation of an epidemic. In: Proceedings of the 2nd World Congress on Foodborne Infections and Intoxications. Institute of Veterinary Medicine, Berlin, 1986; 303.
51. Burslem CD, Kelly MJ, Preston FS. Food poisoning a major threat to airline operations. J Soc Occup Med 1990; 40: 97-100.
52. O'Mahony M, Cowden J, Smyth B, Lynch D, Hall M, Rowe B, et al. An outbreak of *Salmonella saint-paul* infection associated with bean sprouts. Epidem Infect 1990; 104: 229-35.
53. Ries AA, Zaga S, Langkop C, Tauxe RV, Blake PA A multistate outbreak of *Salmonella chester* linked to imported cantaloupe. In: Interscience Conf Antimicrobial Agents and Chemotherapy, Washington DC 1990; 238.
54. Pönkä A, Andersson Y, Siitonen A, de Jong B, Jahkola M, Haikala O, et al. *Salmonella* in alfalfa sprouts. Lancet 1995; 345: 462-3.
55. Strang R Bell A, King A, Werker D, Kelly M, Matheson T, et al. International outbreak of *Salmonella newport* associated with alfalfa sprouts. British Columbia Hlth Dis Surveillance 1996; 5: 40-6.
56. Anon *Salmonella anatum* infection in infants linked to dried milk. Comm Dis Rep 1997; 7: 33 and 36.
57. Frost JA, Kelleher Am, Rowe B. Increasing ciprofloxacin resistance in *salmonellas* in England and Wales 1991-1994. J Antimicrob Chemother 1996; 37: 85-91.
58. Helmuth R, Protz D. How to modify conditions limiting resistance in bacteria in animals and other reservoirs. Clin Infect Dis 1997; 24(Suppl.1): 136-8.