

Testing for *Salmonella* in Raw Meat and Poultry Products Collected at Federally Inspected Establishments in the United States, 1998 through 2000[†]

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ABSTRACT

The Food Safety and Inspection Service (FSIS) issued *Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems; Final Rule* (the PR/HACCP rule) on 25 July 1996. To verify that industry PR/HACCP systems are effective in controlling the contamination of raw meat and poultry products with human disease-causing bacteria, this rule sets product-specific *Salmonella* performance standards that must be met by slaughter establishments and establishments producing raw ground products. These performance standards are based on the prevalence of *Salmonella* as determined from the FSIS's nationwide microbial baseline studies and are expressed in terms of the maximum number of *Salmonella*-positive samples that are allowed in a given sample set. From 26 January 1998 through 31 December 2000, federal inspectors collected 98,204 samples and 1,502 completed sample sets for *Salmonella* analysis from large, small, and very small establishments that produced at least one of seven raw meat and poultry products: broilers, market hogs, cows and bulls, steers and heifers, ground beef, ground chicken, and ground turkey. *Salmonella* prevalence in most of the product categories was lower after the implementation of PR/HACCP than in pre-PR/HACCP baseline studies and surveys conducted by the FSIS. The results of 3 years of testing at establishments of all sizes combined show that >80% of the sample sets met the following *Salmonella* prevalence performance standards: 20.0% for broilers, 8.7% for market hogs, 2.7% for cows and bulls, 1.0% for steers and heifers, 7.5% for ground beef, 44.6% for ground chicken, and 49.9% for ground turkey. The decreased *Salmonella* prevalences may partly reflect industry improvements, such as improved process control, incorporation of antimicrobial interventions, and increased microbial-process control monitoring, in conjunction with PR/HACCP implementation.

The Food Safety and Inspection Service (FSIS) is the U.S. Department of Agriculture (USDA) agency that is responsible for ensuring the safety, wholesomeness, and accurate labeling of meat, poultry, and egg products. On 25 July 1996, the FSIS issued *Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems; Final Rule (the PR/HACCP rule)* (10). This rule (i) requires all meat and poultry establishments to develop and implement written sanitation standard operating procedures; (ii) requires meat and poultry slaughter establishments to conduct microbial testing of carcasses for generic *Escherichia coli* to verify the adequacy of their process controls for the prevention of fecal contamination; (iii) requires all meat and poultry establishments to develop and implement a system of preventive controls, known as HACCP, to improve the safety of their products; and (iv) sets performance standards for *Salmonella* prevalence that must be met by slaughter establishments and establishments producing raw ground products.

The requirements of the PR/HACCP rule were implemented in stages. The requirements for sanitation standard operating procedures in all establishments and for generic

E. coli testing in slaughter establishments became effective on 27 January 1997. The requirements for PR/HACCP systems and the *Salmonella* performance standards were phased in on the basis of establishment size. All large establishments (those with 500 or more employees) were required to implement these requirements by 26 January 1998. Small establishments (those with 10 or more but fewer than 500 employees and having annual sales of >\$2.5 million) were required to implement these requirements by 25 January 1999. Very small establishments (those having fewer than 10 employees or annual sales of <\$2.5 million) were required to implement these requirements by 25 January 2000. The FSIS initiated *Salmonella* testing in very small establishments in May 2000.

The *Salmonella* performance standards are product specific and are based on the prevalence of *Salmonella* as determined from nationwide microbial baseline studies (3-9) conducted by the FSIS before PR/HACCP was implemented. Raw products currently covered by performance standards are carcasses of cows and bulls, steers and heifers, market hogs, and broilers, as well as ground beef, ground chicken, and ground turkey. The performance standards were established to verify that industry PR/HACCP systems are effective in controlling harmful bacterial contaminants on raw meat and poultry products. To verify that establishments are meeting the standards, federal inspection

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personnel collect randomly selected product samples and send them to FSIS laboratories for *Salmonella* analysis. *Salmonella* was selected as the target pathogen because it is one of the most common causes of foodborne illness, is present at varying frequencies on all types of raw meat and poultry products, and can be easily analyzed in a variety of products. In addition, various intervention strategies aimed at reducing *Salmonella* on raw products could also effectively reduce other foodborne pathogens.

This report presents the results of FSIS *Salmonella* testing of broilers, market hogs, cows and bulls, steers and heifers, ground beef, ground chicken, and ground turkey from federally inspected establishments from the beginning of PR/HACCP implementation through 31 December 2000.

MATERIALS AND METHODS

Sample collection and shipment. All samples were aseptically collected by FSIS inspectors following the procedures described in appendix E of the PR/HACCP rule (10) and instructions provided on computer-generated sample request forms. Compliance sets consisted of 51 samples for broiler carcasses, 55 samples for market hog carcasses, 58 samples for cow and bull carcasses, 82 samples for steer and heifer carcasses, and 53 samples for raw ground beef, ground chicken, and ground turkey. Inspection personnel were instructed to randomly collect one sample for each production day until sample sets were completed. Samples were placed in an insulated shipper with chilled gel-ice packs capable of maintaining refrigeration temperatures and shipped on the day of sample collection via an overnight delivery service to one of three FSIS Field Service Laboratories: the Eastern Laboratory, Athens, Ga.; the Midwestern Laboratory, St. Louis, Mo.; or the Western Laboratory, Alameda, Calif.

Broiler carcasses were randomly sampled after they emerged from the immersion chill tank at the end of the drip line or at the last readily accessible point prior to packing or cut-up. Each carcass was rinsed in a sterile 3,500-ml stomacher-type plastic bag with 400 ml of chilled buffered peptone water (BPW). At least 30 ml of the rinse fluid was decanted into a sterile sample container and shipped to an FSIS laboratory for analysis.

Market hog carcasses were randomly sampled from those that had been in the cooler for ≥ 12 h after slaughter. The carcasses were aseptically sampled by swabbing three 100-cm² sites (belly, ham, and jowls) with a sterile sponge moistened with 10 ml of chilled BPW. After swabbing, the sponge was placed in a sterile bag and shipped to an FSIS laboratory for analysis.

Cow and bull carcasses and steer and heifer carcasses were randomly sampled from those that had been in the cooler for ≥ 12 h after slaughter. The carcasses were aseptically sampled by swabbing three 100-cm² sites (flank, brisket, and rump) with a sterile sponge moistened with 10 ml of chilled BPW. After swabbing, the sponge was placed in a sterile bag and shipped to an FSIS laboratory for analysis.

Raw ground beef, ground chicken, and ground turkey samples were randomly selected and collected after the grinding process and, if possible, before any addition of spices or seasoning, but prior to final packaging. A 25-g sample of ground product was aseptically collected with a sterile rigid plastic ring template, placed in a plastic bag, chilled, and transported to a laboratory for analysis.

Sample preparation and analysis. At the laboratory, samples were prepared for *Salmonella* analysis by the addition of 30 ml of BPW to 30 ml of broiler carcass rinse fluid, 50 ml of BPW

to the premoistened sponge samples, or 225 ml of BPW to 25 g of ground product. The prepared samples were mixed well and then analyzed according to procedures described in the FSIS *Microbiology Laboratory Guidebook* (2). Sample enrichment cultures were screened with a commercially available automated immunoassay system (1). All presumptive positive samples were confirmed by culture as described in the *Microbiology Laboratory Guidebook*. *Salmonella* isolates from each of the three FSIS laboratories were forwarded for serotyping to the USDA Animal and Plant Health Inspection Service, National Veterinary Services Laboratories, Ames, Iowa.

***Salmonella* data selection criteria.** For an establishment to pass the performance standards established by the FSIS under the PR/HACCP rule, the maximum allowable numbers of *Salmonella*-positive samples in a sample set were 12 of 51 broiler carcasses, 6 of 55 market hog carcasses, 2 of 58 cow and bull carcasses, 1 of 82 steer and heifer carcasses, 5 of 53 ground beef samples, 26 of 53 ground chicken samples, and 29 of 53 ground turkey samples. The maximum number of positive samples allowed in a sample set was statistically designed to provide an 80% probability of passing the test when the establishment is operating at the standard established by the baseline prevalence.

Establishments are sampled under a series of enforcement sequence codes. They are initially sampled randomly under sequence code A. Most establishments that are subject to one or more of the *Salmonella* performance standards have been selected for testing at least once under sequence code A. If an establishment fails the test for sample set A, it must initiate corrective action and is then targeted for a second sample set under sequence code B. If an establishment passes the test for sample set B, it is returned to routine random testing status (code A) for the next sample set. If an establishment fails the test for sample set B, it must reassess its HACCP plan and is then tested for a third time under sequence code C to determine whether its changes to the HACCP plan have been effective. If an establishment exceeds the maximum positive samples allowed in the C set, the FSIS issues a notice of intended enforcement. If an establishment that has failed the test for sample set C takes appropriate action to correct the HACCP system and other measures to reduce the prevalence of pathogens, the enforcement action may be held in abeyance. In these cases, a subsequent sample set is begun under sequence code D to determine whether these changes are effective.

Data for sequence code A, B, and C sample sets are included in this report. Data on the prevalence of *Salmonella* include all sequence code A, B, and C sample sets collected during the indicated year(s). No consideration is given to whether a given sample is part of a complete or an incomplete sample set. The prevalence is estimated as the number of positive samples divided by the total number of samples analyzed and is expressed as a percentage.

Data on the percentages of sequence code A, B, and C sample sets meeting the *Salmonella* performance standards are also presented. These percentages are based on sample sets that were completed during the specified year(s), as defined by the collect date of the last sample in the sample set, and are computed by dividing the number of sample sets meeting the performance standard by the number of completed sample sets. Some sample sets were started during the previous year. Data from incomplete sample sets are not included. Only three sequence code D sample sets (two for ground beef and one for cow and bull carcasses) had been completed as of 31 December 2000.

RESULTS

From 26 January 1998 through 31 December 2000, federal inspectors collected 98,204 samples for *Salmonella* analysis from large, small, and very small establishments that produced one of seven products: broilers, market hogs, cows and bulls, steers and heifers, ground beef, ground chicken, and ground turkey. Of these 98,204 samples, 91,192 were from establishments being tested for sequence code A sets, 6,260 were from establishments being tested for sequence code B sets, and 752 were from establishments being tested for sequence code C sets. For the same 3-year period, 1,502 sample sets were completed, as indicated by the collection date of the last sample in the sample set. Of the 1,502 total sample sets, 1,393 were sequence code A sets, 96 were sequence code B sets, and 13 were sequence code C sets. The results of the *Salmonella* analyses of these samples and sample sets are summarized below by product category.

Broilers. The performance standard for *Salmonella* in broilers is 20.0%. From 26 January 1998 through 31 December 2000, federal inspectors collected 22,484 code A broiler carcass rinse samples for *Salmonella* analysis (Table 1). For large broiler establishments, *Salmonella* prevalence in code A carcass rinse samples declined from 10.8% in calendar year (CY) 1998 to 9.3% in CY 1999 to 7.5% in CY 2000. The overall *Salmonella* prevalence in broiler carcass rinse samples from large establishments was 9.1% for all 3 years combined. For small broiler establishments, *Salmonella* prevalence in code A carcass rinse samples declined from 15.6% in CY 1999 to 13.0% in CY 2000. The *Salmonella* prevalence in the limited number (14) of samples collected at volunteer (early HACCP implementation) small broiler establishments in CY 1998 was 7.1%. The overall *Salmonella* prevalence in broiler carcass rinse samples from small establishments was 14.1% for all 3 years combined. The prevalence of *Salmonella* in the limited number of code A carcass rinse samples collected at very small broiler establishments in CY 2000 was 18.0%. The overall prevalence of *Salmonella* in code A carcass rinse samples from broiler establishments of all sizes for all 3 years combined was 10.2%.

From 26 January 1998 through 31 December 2000, federal inspectors collected 418 complete code A sample sets from broiler establishments for *Salmonella* analysis, including 325 sets from large establishments, 93 from small establishments, and none from very small establishments (Table 2). For large broiler establishments, 90.9% of code A sample sets met the performance standard in CY 1998, 91.0% met the standard in CY 1999, and 96.4% met the standard in CY 2000. For all 3 years combined, 93.2% of code A sample sets from large broiler establishments met the performance standard. For small broiler establishments, the percentages of sample sets that met the performance standard were 85.0% in CY 1999, 79.2% in CY 2000, and 81.7% for the 2 years combined. The overall pass rate for code A sample sets from both large and small broiler establishments for all 3 years combined was 90.7%.

Federal inspection personnel collected 1,713 code B

broiler carcass rinse samples for *Salmonella* analysis from CY 1998 through CY 2000, including 1,104 samples from large establishments and 609 samples from small establishments (Table 3). The overall *Salmonella* prevalences in code B broiler carcass rinse samples for all years combined were 17.4% for large establishments and 14.6% for small establishments. Twenty-nine complete code B sample sets were collected from broiler establishments from CY 1998 through CY 2000, including 21 sets from large establishments and 8 sets from small establishments (Table 4). For all years combined, the percentages of code B sample sets that met the performance standard were 76.2% for large broiler establishments and 87.5% for small establishments. The overall pass rate for code B sample sets from both large and small broiler establishments for all 3 years combined was 79.3%.

Federal inspection personnel collected 255 code C broiler carcass rinse samples from large establishments for *Salmonella* analysis from CY 1998 through CY 2000 (Table 5). The overall *Salmonella* prevalence in these samples for all 3 years combined was 9.0%. Five complete code C sample sets were collected from large broiler establishments from CY 1999 through CY 2000 (Table 6), and all five sets met the performance standard.

Market hogs. The performance standard for *Salmonella* in market hogs is 8.7%. From 26 January 1998 through 31 December 2000, federal inspectors collected 8,483 code A market hog carcass sponge samples for *Salmonella* analysis (Table 1). For large market hog establishments, *Salmonella* prevalence in code A carcass sponge samples declined from 5.8% in CY 1998 to 1.8% in CY 1999 and then increased to 4.1% in CY 2000. The overall *Salmonella* prevalence in market hog carcass sponge samples from large establishments was 4.1% for all 3 years combined. For small market hog establishments, *Salmonella* prevalence in code A carcass sponge samples was 18.0% in CY 1999 but declined to 7.7% in CY 2000, with an overall prevalence of 10.9% for the 2 years combined. The prevalence of *Salmonella* in code A carcass sponge samples collected at very small market hog establishments in CY 2000 was 7.2%. The overall prevalence of *Salmonella* in code A carcass sponge samples from market hog establishments of all sizes for all 3 years combined was 7.0%.

From 26 January 1998 through 31 December 2000, federal inspectors collected 120 complete code A sample sets from market hog establishments for *Salmonella* analysis, including 74 sets from large establishments, 46 from small establishments, and none from very small establishments (Table 2). For large market hog establishments, 68.8% of code A sample sets met the performance standard in CY 1998, 100.0% met the standard in CY 1999, and 93.8% met the standard in CY 2000. For all 3 years combined, 90.5% of code A sample sets from large market hog establishments met the performance standard. For small market hog establishments, the percentages of sample sets that met the performance standard were 50.0% in CY 1999, 70.6% in CY 2000, and 65.2% for the 2 years combined. The overall pass rate for code A sample sets from both

TABLE 1. Prevalence of *Salmonella* in the PR/HACCP verification testing program for calendar years (CY) 1998 through 2000 for code A sample sets^a

Product	Performance standard (%)	CY 1998						CY 1999					
		Large		Small		All sizes		Large		Small		All sizes	
		No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive
Broilers	20.0	5,645	10.8	14	7.1	5,659	10.8	4,530	9.3	2,238	15.6	6,768	11.4
Market hogs	8.7	1,390	5.8	0		1,390	5.8	973	1.8	950	18.0	1,923	9.8
Cows/bulls	2.7	58	0.0	121	1.7	179	1.1	116	0.9	1,405	2.3	1,521	2.2
Steers/heifers	1.0	214	0.0	0		214	0.0	272	0.4	510	0.2	782	0.3
Ground beef	7.5	1,125	4.9	171	16.4	1,296	6.4	765	6.7	15,610	4.2	16,375	4.3
Ground chicken	44.6	24	4.2	0		24	4.2	125	15.2	172	16.9	297	16.2
Ground turkey	49.9	591	36.5	0		591	36.5	759	33.1	291	27.8	1,050	31.6

^a Prevalence estimates include all samples collected during the indicated CY.

large and small market hog establishments for all 3 years combined was 80.8%.

Federal inspection personnel collected 1,057 code B market hog carcass sponge samples for *Salmonella* analysis from CY 1998 through CY 2000, including 383 samples from large establishments and 674 from small establishments (Table 3). The overall *Salmonella* prevalences in code B market hog carcass sponge samples for all years combined were 14.4% for large establishments and 14.1% for small establishments. Eighteen complete code B sample sets were collected from market hog establishments from CY 1998 through CY 2000, including 7 sets from large establishments and 11 sets from small establishments (Table 4). For all years combined, the percentages of code B sample sets that met the performance standard were 71.4% for large market hog establishments and 54.5% for small establishments. The overall pass rate for code B sample sets from both large and small market hog establishments for all 3 years combined was 61.1%.

Federal inspection personnel collected 193 code C market hog carcass sponge samples for *Salmonella* analysis from CY 1999 through CY 2000, including 110 samples from large establishments in CY 1999 and 83 from small

establishments in CY 2000 (Table 5). The *Salmonella* prevalences in code C market hog sponge samples were 2.7% for large establishments and 8.4% for small establishments. Two complete code C sample sets were collected from large market hog establishments during CY 1999 (Table 6), and both sets met the performance standard.

Cows and bulls. The performance standard for *Salmonella* in cows and bulls is 2.7%. From 26 January 1998 through 31 December 2000, federal inspectors collected 3,695 code A cow and bull carcass sponge samples for *Salmonella* analysis (Table 1). For large cow and bull establishments, *Salmonella* prevalences in code A carcass sponge samples were 0.0% in CY 1998, 0.9% in CY 1999, and 0.6% in CY 2000. The overall *Salmonella* prevalence in cow and bull carcass sponge samples from large establishments was 0.6% for all 3 years combined. For small cow and bull establishments, *Salmonella* prevalences in code A carcass sponge samples were 1.7% in CY 1998 (volunteer small establishments), 2.3% in CY 1999, and 2.1% in CY 2000. The overall *Salmonella* prevalence in cow and bull carcass sponge samples from small establishments was 2.2% for all 3 years combined. The prevalence

TABLE 2. Percentages of code A sample sets meeting the *Salmonella* performance standards for calendar years (CY) 1998 through 2000^a

Product	Performance standard (%)	CY 1998						CY 1999					
		Large		Small		All sizes		Large		Small		All sizes	
		No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing
Broilers	20.0	77	90.9	0		77	90.9	111	91.0	40	85.0	151	89.4
Market hogs	8.7	16	68.8	0		16	68.8	26	100.0	12	50.0	38	84.2
Cows/bulls	2.7	1	100.0	0		1	100.0	2	100.0	17	76.5	19	78.9
Steers/heifers	1.0	1	100.0	0		1	100.0	3	100.0	3	100.0	6	100.0
Ground beef	7.5	9	88.9	0		9	88.9	21	85.7	252	87.3	273	87.2
Ground chicken	44.6	0		0		0		2	100.0	3	100.0	5	100.0
Ground turkey	49.9	7	85.7	0		7	85.7	18	94.4	5	80.0	23	91.3

^a Sample sets were completed during the indicated calendar year, although they may have been started during an earlier year.

TABLE 1. *Extended*

CY 2000								All years (1998–2000)							
Large		Small		Very Small		All sizes		Large		Small		Very Small		All sizes	
No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive
7,175	7.5	2,821	13.0	61	18.0	10,057	9.1	17,350	9.1	5,073	14.1	61	18.0	22,484	10.2
1,919	4.1	2,144	7.7	1,107	7.2	5,170	6.2	4,282	4.1	3,094	10.9	1,107	7.2	8,483	7.0
173	0.6	1,593	2.1	229	3.5	1,995	2.2	347	0.6	3,119	2.2	229	3.5	3,695	2.1
222	0.0	693	0.6	177	0.0	1,092	0.4	708	0.1	1,203	0.4	177	0.0	2,088	0.3
1,373	5.4	21,065	3.4	10,406	2.7	32,844	3.3	3,263	5.5	36,846	3.8	10,406	2.7	50,515	3.7
169	12.4	233	15.0	12	8.3	414	13.8	318	12.9	405	15.8	12	8.3	735	14.4
1,173	26.5	377	23.3	1	0.0	1,551	25.7	2,523	30.8	668	25.3	1	0.0	3,192	29.7

of *Salmonella* in code A carcass sponge samples collected at very small cow and bull establishments in CY 2000 was 3.5%. The overall prevalence of *Salmonella* in code A carcass sponge samples from cow and bull establishments of all sizes for all 3 years combined was 2.1%.

From 26 January 1998 through 31 December 2000, federal inspectors collected 52 complete code A sample sets from cow and bull establishments for *Salmonella* analysis, including 5 sets from large establishments, 47 from small establishments, and none from very small establishments (Table 2). For large cow and bull establishments, the single code A sample set collected in CY 1998, both sets collected in CY 1999, and both sets collected in CY 2000 all met the performance standard. For small cow and bull establishments, the percentages of sample sets that met the performance standard were 76.5% in CY 1999, 83.3% in CY 2000, and 80.9% for the 2 years combined. The overall pass rate for code A sample sets from both large and small cow and bull establishments for all 3 years combined was 82.7%.

Federal inspection personnel collected 366 code B cow and bull carcass sponge samples for *Salmonella* analysis from small establishments from CY 1999 through CY 2000 (Table 3). The overall *Salmonella* prevalence in these sam-

ples for both years combined was 4.6%. Six complete code B sample sets were collected from small cow and bull establishments from CY 1999 through CY 2000 (Table 4). For both years combined, 50.0% of these six code B sample sets met the performance standard.

Federal inspection personnel collected 41 code C cow and bull carcass sponge samples from small establishments for *Salmonella* analysis during CY 1999 (Table 5). The average *Salmonella* prevalence in these 41 code C samples was 7.3%. The one complete code C sample set collected from a small cow and bull establishment during CY 1999 failed to meet the performance standard (Table 6).

Steers and heifers. The performance standard for *Salmonella* in steers and heifers is 1.0%. From 26 January 1998 through 31 December 2000, federal inspectors collected 2,088 code A steer and heifer carcass sponge samples for *Salmonella* analysis (Table 1). For large steer and heifer establishments, *Salmonella* prevalences in code A carcass sponge samples were 0.0% in CY 1998, 0.4% in CY 1999, and 0.0% in CY 2000. The overall *Salmonella* prevalence in steer and heifer carcass sponge samples from large establishments was 0.1% for all 3 years combined. For small steer and heifer establishments, *Salmonella* prevalences in

TABLE 2. *Extended*

CY 2000								All years (1998–2000)							
Large		Small		Very small		All sizes		Large		Small		Very small		All sizes	
No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing
137	96.4	53	79.2	0		190	91.6	325	93.2	93	81.7	0		418	90.7
32	93.8	34	70.6	0		66	81.8	74	90.5	46	65.2	0		120	80.8
2	100.0	30	83.3	0		32	84.4	5	100.0	47	80.9	0		52	82.7
3	100.0	8	87.5	0		11	90.9	7	100.0	11	90.9	0		18	94.4
27	81.5	344	91.9	75	90.7	446	91.0	57	84.2	596	89.9	75	90.7	728	89.6
3	100.0	2	100.0	0		5	100.0	5	100.0	5	100.0	0		10	100.0
15	93.3	2	50.0	0		17	88.2	40	92.5	7	71.4	0		47	89.4

TABLE 3. Prevalence of *Salmonella* in the PR/HACCP verification testing program for calendar years (CY) 1998 through 2000 for code B sample sets^a

Product	Performance standard (%)	CY 1998						CY 1999					
		Large		Small		All sizes		Large		Small		All sizes	
		No. of samples	% positive	No. of Samples	% positive	No. of samples	% positive	No. of Samples	% positive	No. of Samples	% positive	No. of Samples	% positive
Broilers	20.0	349	21.5	0		349	21.5	398	14.8	218	17.0	616	15.6
Market hogs	8.7	99	18.2	0		99	18.2	174	16.7	24	4.2	198	15.2
Cows/bulls	2.7	0		0		0		0		58	13.8	58	13.8
Steers/heifers	1.0	0		0		0		0		0		0	
Ground beef	7.5	19	5.3	0		19	5.3	98	11.2	875	9.1	973	9.4
Ground chicken	44.6	0		0		0		0		0		0	
Ground turkey	49.9	53	45.3	0		53	45.3	53	58.5	21	14.3	74	45.9

^a Prevalence estimates include all samples collected during the indicated CY.

code A carcass sponge samples were 0.2% in CY 1999 and 0.6% in CY 2000, with an overall prevalence of 0.4% for the 2 years combined. The prevalence of *Salmonella* in code A carcass sponge samples collected at very small steer and heifer establishments in CY 2000 was 0.0%. The overall prevalence of *Salmonella* in code A carcass sponge samples from steer and heifer establishments of all sizes for all 3 years combined was 0.3%.

From 26 January 1998 through 31 December 2000, federal inspectors collected 18 complete code A sample sets from steer and heifer establishments for *Salmonella* analysis, including 7 sets from large establishments, 11 from small establishments, and none from very small establishments (Table 2). For large steer and heifer establishments, the single code A sample set collected in CY 1998, the three sets collected in CY 1999, and the three sets collected in CY 2000 all met the performance standard. For small steer and heifer establishments, the percentages of sample sets that met the performance standard were 100.0% of three sets collected in CY 1999 and 87.5% of eight sets collected in CY 2000, with an overall pass rate of 90.9% for the 2 years combined. The overall pass rate for code A sample sets from both large and small steer and heifer establishments for all 3 years combined was 94.4%.

Federal inspection personnel collected 26 code B steer and heifer carcass sponge samples for *Salmonella* analysis from small establishments during CY 2000 (Table 3). The *Salmonella* prevalence in these 26 samples was 0.0%. No complete code B sample sets were collected from steer and heifer establishments from CY 1998 through CY 2000 (Table 4). No code C steer and heifer carcass sponge samples or sample sets were collected from CY 1998 through CY 2000 (Tables 5 and 6).

Ground beef. The performance standard for *Salmonella* in ground beef is 7.5%. From 26 January 1998 through 31 December 2000, federal inspectors collected 50,515 code A ground beef samples for *Salmonella* analysis (Table 1). For large establishments, *Salmonella* prevalences in code A ground beef samples were 4.9% in CY 1998, 6.7% in CY 1999, and 5.4% in CY 2000. The overall *Salmonella* prevalence in ground beef samples from large establishments was 5.5% for all 3 years combined. For small establishments, *Salmonella* prevalences in code A ground beef samples were 16.4% (of 171 samples from volunteer small establishments) in CY 1998, 4.2% in CY 1999, and 3.4% in CY 2000. The overall *Salmonella* prevalence in ground beef samples from small establishments was 3.8%

TABLE 4. Percentages of code B sample sets meeting the *Salmonella* performance standards for calendar years (CY) 1998 through 2000^a

Product	Performance standard (%)	CY 1998						CY 1999					
		Large		Small		All sizes		Large		Small		All sizes	
		No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing
Broilers	20.0	6	33.3	0		6	33.3	7	85.7	3	100.0	10	90.0
Market hogs	8.7	1	0.0	0		1	0.0	4	75.0	0		4	75.0
Cows/bulls	2.7	0		0		0		0		1	0.0	1	0.0
Steers/heifers	1.0	0		0		0		0		0		0	
Ground beef	7.5	0		0		0		1	100.0	10	40.0	11	45.5
Ground chicken	44.6	0		0		0		0		0		0	
Ground turkey	49.9	1	100.0	0		1	100.0	1	0.0	0		1	0.0

^a Sample sets were completed during the indicated calendar year, although they may have been started during an earlier year.

TABLE 3. *Extended*

CY 2000								All years (1998–2000)							
Large		Small		Very Small		All sizes		Large		Small		Very Small		All sizes	
No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive
357	16.2	391	13.3	0		748	14.7	1,104	17.4	609	14.6	0		1,713	16.4
110	7.3	650	14.5	0		760	13.4	383	14.4	674	14.1	0		1,057	14.2
0		308	2.9	0		308	2.9	0		366	4.6	0		366	4.6
0		26	0.0	0		26	0.0	0		26	0.0	0		26	0.0
211	18.0	1,546	7.6	84	0.0	1,841	8.4	328	15.2	2,421	8.1	84	0.0	2,833	8.7
0		0		0		0		0		0		0		0	
53	60.4	85	29.4	0		138	41.3	159	54.7	106	26.4	0		265	43.4

for all 3 years combined. The prevalence of *Salmonella* in code A ground beef samples collected at very small establishments in CY 2000 was 2.7%. The overall prevalence of *Salmonella* in code A ground beef samples from ground beef establishments of all sizes for all 3 years combined was 3.7%.

From 26 January 1998 through 31 December 2000, federal inspectors collected 728 complete code A sample sets from ground beef establishments for *Salmonella* analysis, including 57 sets from large establishments, 596 from small establishments, and 75 from very small establishments (Table 2). For large establishments, 88.9% of code A sample sets met the performance standard in CY 1998, 85.7% met the standard in CY 1999, and 81.5% met the standard in CY 2000. For all 3 years combined, 84.2% of code A sample sets from large ground beef establishments met the performance standard. For small establishments, the percentages of sample sets that met the performance standard were 87.3% in CY 1999, 91.9% in CY 2000, and 89.9% for the 2 years combined. Of the 75 code A sample sets collected at very small ground beef establishments in CY 2000, 90.7% met the performance standard. The overall pass rate for code A sample sets from ground beef establishments all of sizes for all 3 years combined was 89.6%.

Federal inspection personnel collected 2,833 code B ground beef samples for *Salmonella* analysis from CY 1998 through CY 2000, including 328 samples from large establishments, 2,421 from small establishments, and 84 from very small establishments (Table 3). The overall *Salmonella* prevalences in code B ground beef samples for all years combined were 15.2% for large establishments, 8.1% for small establishments, and 0.0% for very small establishments. Thirty-eight complete code B sample sets were collected from ground beef establishments from CY 1999 through CY 2000, including 4 sets from large establishments and 34 sets from small establishments (Table 4). For both years combined, the percentages of code B sample sets that met the performance standard were 75.0% for large ground beef establishments and 70.6% for small establishments. The overall pass rate for code B sample sets from both large and small ground beef establishments for both years combined was 71.1%.

Federal inspection personnel collected 239 code C ground beef samples from small establishments for *Salmonella* analysis from CY 1999 through CY 2000 (Table 5). The overall *Salmonella* prevalence in these code C ground beef samples for both years combined was 5.9%. Five complete code C sample sets were collected from

TABLE 4. *Extended*

CY 2000								All years (1998–2000)							
Large		Small		Very small		All sizes		Large		Small		Very small		All sizes	
No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing
8	100.0	5	80.0	0		13	92.3	21	76.2	8	87.5	0		29	79.3
2	100.0	11	54.5	0		13	61.5	7	71.4	11	54.5	0		18	61.1
0		5	60.0	0		5	60.0	0		6	50.0	0		6	50.0
0		0		0		0		0		0		0		0	
3	66.7	24	83.3	0		27	81.5	4	75.0	34	70.6	0		38	71.1
0		0		0		0		0		0		0		0	
1	0.0	2	100.0	0		3	66.7	3	33.3	2	100.0	0		5	60.0

TABLE 5. Prevalence of *Salmonella* in the PR/HACCP verification testing program for calendar years (CY) 1998 through 2000 for code C sample sets^a

Product	Performance standard (%)	CY 1998						CY 1999					
		Large		Small		All sizes		Large		Small		All sizes	
		No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive	No. of samples	% positive
Broilers	20.0	2	0.0	0		2	0.0	202	11.4	0		202	11.4
Market hogs	8.7	0		0		0		110	2.7	0		110	2.7
Cows/bulls	2.7	0		0		0		0		41	7.3	41	7.3
Steers/heifers	1.0	0		0		0		0		0		0	
Ground beef	7.5	0		0		0		0		82	14.6	82	14.6
Ground chicken	44.6	0		0		0		0		0		0	
Ground turkey	49.9	0		0		0		0		0		0	

^a Prevalence estimates include all samples collected during the indicated CY.

small ground beef establishments from CY 1999 through CY 2000 (Table 6). The two sets collected in CY 1999 both failed to meet the performance standard, and all three sets collected in CY 2000 met the performance standard. During CY 2000, one of the two subsequent code D sample sets from small ground beef establishments passed the performance standard, and the other failed to meet the performance standard (data not included in this report).

Ground chicken. The performance standard for *Salmonella* in ground chicken is 44.6%. From 26 January 1998 through 31 December 2000, federal inspectors collected 735 code A ground chicken samples for *Salmonella* analysis (Table 1). For large establishments, *Salmonella* prevalences in code A ground chicken samples were 4.2% in CY 1998, 15.2% in CY 1999, and 12.4% in CY 2000. The overall *Salmonella* prevalence in ground chicken samples from large establishments was 12.9% for all 3 years combined. For small establishments, *Salmonella* prevalences in code A ground chicken samples were 16.9% in CY 1999, 15.0% in CY 2000, and 15.8% for the 2 years combined. The prevalence of *Salmonella* in code A ground chicken samples collected at very small establishments in CY 2000 was 8.3%. The overall prevalence of *Salmonella* in code A

ground chicken samples from ground chicken establishments of all sizes for all 3 years combined was 14.4%.

From 25 January 1999 through 31 December 2000, federal inspectors collected 10 complete code A sample sets from ground chicken establishments for *Salmonella* analysis, including 5 sets from large establishments, 5 from small establishments, and none from very small establishments (Table 2). For large ground chicken establishments, no code A sample sets were collected in CY 1998, but both of the sample sets collected in CY 1999 and all three sample sets collected in CY 2000 met the performance standard. For small ground chicken establishments, all three code A sample sets collected in CY 1999 and both of the sample sets collected in CY 2000 met the performance standard. The overall pass rate for code A sample sets from both large and small ground chicken establishments for both years combined was 100.0%. No code B or code C ground chicken samples or sample sets were collected from CY 1998 through CY 2000 (Tables 3 through 6).

Ground turkey. The performance standard for *Salmonella* in ground turkey is 49.9%. From 26 January 1998 through 31 December 2000, federal inspectors collected 3,192 code A ground turkey samples for *Salmonella* anal-

TABLE 6. Percentages of code C sample sets meeting the *Salmonella* performance standards for calendar years (CY) 1998 through 2000^a

Product	Performance standard (%)	CY 1998						CY 1999					
		Large		Small		All sizes		Large		Small		All sizes	
		No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing	No. of sets	% passing
Broilers	20.0	0		0		0		4	100.0	0		4	100.0
Market hogs	8.7	0		0		0		2	100.0	0		2	100.0
Cows/bulls	2.7	0		0		0		0		1	0.0	1	0.0
Steers/heifers	1.0	0		0		0		0		0		0	
Ground beef	7.5	0		0		0		0		2	0.0	2	0.0
Ground chicken	44.6	0		0		0		0		0		0	
Ground turkey	49.9	0		0		0		0		0		0	

^a Sample sets were completed during the indicated calendar year, although they may have been started during an earlier year.

and small ground turkey establishments for all 3 years combined was 60.0%.

Federal inspection personnel collected 24 code C ground turkey samples from large establishments for *Salmonella* analysis during CY 2000 (Table 5). The overall *Salmonella* prevalence in these 24 code C ground turkey samples was 33.3%. No complete code C sample sets were collected from ground turkey establishments from CY 1998 through CY 2000 (Table 6).

DISCUSSION

The prevalence data reported here for *Salmonella* in raw meat and poultry products have certain limitations that restrict the range of valid statistical inferences. The HACCP verification program is strictly regulatory in nature and was designed to track establishment performance rather than to estimate national product *Salmonella* prevalence. During the first 3 years of the implementation of this regulatory program, the requirements for PR/HACCP systems and the *Salmonella* performance standards were phased in on the basis of establishment size (large, small, and very small). Because the program is not statistically designed, different establishments may be sampled from year to year, confounding rigorous trend analyses. Furthermore, it is important to note that the prevalence estimates computed from the FSIS's pre-HACCP baseline studies and surveys were nationally representative because they were weighted on the basis of the production volume of the sampled establishments. In contrast, the PR/HACCP *Salmonella* prevalences from the regulatory testing program reported here represent unweighted test results.

Nonetheless, *Salmonella* prevalences for most of the product categories appeared to be lower after PR/HACCP implementation than they were shown to be in FSIS baseline studies and surveys conducted before the implementation of PR/HACCP. The results of 3 years of testing in large establishments under HACCP show that the average *Salmonella* prevalence in enforcement sequence code A samples met the performance standard for all seven product categories. After 2 years of testing in small establishments under HACCP, the average *Salmonella* prevalence in code A samples was lower than the performance standard for all product categories except market hogs (a 10.9% average prevalence compared with the 8.7% performance standard). However, the *Salmonella* prevalence in code A market hog carcass sponge samples from small establishments decreased from 18.0% in CY 1999 to 7.7% in CY 2000. The limited data available from very small establishments after approximately 8 months of testing under HACCP show that the *Salmonella* prevalence met the performance standard for all product categories except cows and bulls (a 3.5% prevalence compared with the 2.7% performance standard). However, any speculation pertaining to the significance of the 3.5% *Salmonella* prevalence for very small cow and bull establishments would be premature, since this value is based on only 229 samples and no completed sample sets.

The results of 3 years of testing show that the majority of completed code A sample sets met the *Salmonella* performance standard. *Salmonella* compliance levels, based on

the number of sets meeting the performance standard, for all sizes of establishments and all years combined were 90.7% for broilers, 80.8% for market hogs, 82.7% for cows and bulls, 94.4% for steers and heifers, 89.6% for ground beef, 100.0% for ground chicken, and 89.4% for ground turkey. The majority of code B and C sample sets collected as a result of code A sample set failures also met the performance standard. From CY 1998 through CY 2000, only three code C sample sets failed to meet the performance standard, two from small ground beef production establishments and one from a small cow and bull establishment. Only one of the three subsequent code D sample sets, a set from a small ground beef production establishment, failed to meet the performance standard.

The decreased *Salmonella* prevalences may partly reflect changes due to HACCP implementation. Many establishments have incorporated antimicrobial treatments (e.g., trisodium phosphate, organic acid rinses, steam) or process adjustments (e.g., counterflow chillers or scalders, steam vacuum) in order to meet the PR/HACCP *Salmonella* performance standards. In addition, increased attention to quality control concepts and microbial-process control monitoring, such as generic *E. coli* testing, probably enabled establishments to decrease process fluctuations after the PR/HACCP rule was implemented.

The FSIS finds it encouraging that most establishments achieve the *Salmonella* performance standards. While establishments failing to meet the performance standards are few, they may benefit from targeted outreach and technical assistance to help them meet the performance standard in subsequent sample sets. The attainment of a reduction in pathogens reduces the risk of illness; however, all segments of the food chain as well as consumers should continue to properly handle, cook, and store all meat and poultry products in order to guard against foodborne illness.

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REFERENCES

1. Andrews, C. D., L. Dillard, M. Pratt, and J. Rivera. 2001. FSIS procedure for the use of *Salmonella* rapid screening immunoassay kits, p. 4A-1. In B. P. Dey and C. P. Lattuada (ed.), USDA/FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. U.S. Government Printing Office, Washington, D.C. (<http://www.fsis.usda.gov/OPHS/microlab/mlgchp4a.pdf>).
2. Rose, B. E. 1998. Isolation and identification of *Salmonella* from meat, poultry, and egg products, p. 4-1. In B. P. Dey and C. P. Lattuada (ed.), USDA/FSIS microbiology laboratory guidebook, 3rd ed., vol. 1. U.S. Government Printing Office, Washington, D.C. (<http://www.fsis.usda.gov/OPHS/microlab/mlgchp4.pdf>).
3. U.S. Department of Agriculture, Food Safety and Inspection Service, 1994, "Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers," U.S. Department of Agriculture, Food Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/steer1.pdf>.
4. U.S. Department of Agriculture, Food Safety and Inspection Service, 1996, "Nationwide Beef Microbiological Baseline Data Collection Program: Cows and Bulls," U.S. Department of Agriculture, Food

- Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/cows1.pdf>.
5. U.S. Department of Agriculture, Food Safety and Inspection Service, 1996, "Nationwide Broiler Chicken Microbiological Baseline Data Collection Program," U.S. Department of Agriculture, Food Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/broiler1.pdf>.
 6. U.S. Department of Agriculture, Food Safety and Inspection Service, 1996, "Nationwide Federal Plant Raw Ground Beef Microbiological Survey," U.S. Department of Agriculture, Food Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/rwgrbeef.pdf>.
 7. U.S. Department of Agriculture, Food Safety and Inspection Service, 1996, "Nationwide Pork Microbiological Baseline Data Collection Program: Market Hogs," U.S. Department of Agriculture, Food Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/markhog1.pdf>.
 8. U.S. Department of Agriculture, Food Safety and Inspection Service, 1996, "Nationwide Raw Ground Chicken Microbiological Survey," U.S. Department of Agriculture, Food Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/rwgrchck.pdf>.
 9. U.S. Department of Agriculture, Food Safety and Inspection Service, 1996, "Nationwide Raw Ground Turkey Microbiological Survey," U.S. Department of Agriculture, Food Safety and Inspection Service, Washington, D.C., [Internet, WWW], ADDRESS: <http://www.fsis.usda.gov/OPHS/baseline/rwgrturk.pdf>.
 10. U.S. Department of Agriculture, Food Safety and Inspection Service. 1996. Pathogen reduction; hazard analysis and critical control point (HACCP) systems; final rule. Fed. Regist. 61:38806-38989 (http://www.fsis.usda.gov/OA/fr/haccp_rule.htm).