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Animal and Plant Health Inspection Service

Veterinary Services

National Animal Health Monitoring System

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Layers 2013

Part II: Control and Prevention of *Salmonella* Enteritidis on Table-Egg Farms in the United States, 2013

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Items of Note

Salmonella serotype Enteritidis is a foodborne pathogen. In humans, illness with *Salmonella* Enteritidis is frequently attributed to eating improperly prepared and/or undercooked eggs. In 2010, the Food and Drug Administration (FDA) implemented the egg safety rule to control *Salmonella* Enteritidis on farms that produce eggs for human consumption.[1] The FDA used information from the National Animal Health Monitoring Systems' (NAHMS) Layers '99 study to assess the need for and economic impact of the egg safety rule. Since management practices on egg farms have changed substantially since the Layers '99 study, it was determined that updated information on these practices would be useful to industry stakeholders and various government agencies. As a result, NAHMS conducted the Layers 2013 study in summer 2013 to describe management practices relevant to *Salmonella* Enteritidis control and prevention, estimate the prevalence of *Salmonella* Enteritidis, and evaluate risk factors for *Salmonella* Enteritidis on commercial layer farms.

In 2013, layers on 89.9 percent of farms had been vaccinated against *Salmonella* as pullets, and birds on 9.1 percent of farms had been vaccinated against *Salmonella* as pullets and as layers. Only 1.0 percent of farms had birds that had not been vaccinated as pullets or as layers. Many different vaccination protocols were used, but the highest percentage of farms that vaccinated birds against *Salmonella*, (39.0 percent) gave two live *S. typhimurium* vaccines via spray, followed by a bacterin injection. Birds received the first vaccination at the hatchery. On about half of farms in which birds had been vaccinated as pullets, layers were vaccinated at 60 to 79 weeks of age on the majority of farms that vaccinated layers.

All farms in the Northeast, Southeast, and Central regions obtained pullets from breeding flocks certified as National Poultry Improvement Plan (NPIP) *Salmonella* Enteritidis clean flocks, compared with 92.0 percent of farms in the West region. All small farms (fewer than 30,000 birds) and medium farms (30,000 to 99,999 birds) obtained pullets from NPIP *Salmonella* Enteritidis monitored flocks.

The percentage of farms that had been producing eggs for human consumption for at least 5 years before the Layers 2013 study (2008) ranged from 70.8 percent of farms in the Central region to 97.1 percent in the West region. Nearly all medium and large farms (100,000 or more birds) had been producing eggs for human consumption at least since 2008, compared with just 34.6 percent of small farms. Overall, 84.9 percent of farms had been producing eggs for human consumption at least since 2008.

[1]Code of Federal Regulations, Title 21, Volume 2, Part 118 Production, storage, and transportation of shell eggs.

The percentage of farms that routinely tested layer houses for *Salmonella* Enteritidis increased from 67.0 percent in 2008 to 99.2 percent in 2013. This increase was particularly notable in the Central region, where only 19.9 percent of farms tested for *Salmonella* Enteritidis in 2008 compared with 97.3 percent of farms in 2013. Farms that only produce eggs for the breaker market are not required to test for *Salmonella* Enteritidis, and many breaker farms are in the Central region.

In 2013, over 90 percent of farms routinely conducted environmental testing when layers were 40 to 45 weeks of age and 4 to 6 weeks postmolt (for farms that molted); less than half of farms tested during these time frames in 2008. This change is most likely because of the FDA egg safety rule, which requires layers be tested from 40 to 45 weeks of age and 4 to 6 weeks postmolt (excluding farms that exclusively produce eggs for breaking).

Overall, 69.0 percent of farms had been inspected by the FDA. About one of five farms that had been inspected by the FDA (21.3 percent) had environmental samples collected during the inspection.

Over 60 percent of farms in the Northeast and West regions participated in a State egg (*Salmonella* Enteritidis) quality assurance program, compared with less than 10 percent of farms in the Southeast and Central regions. In the Southeast and Central regions, the majority of farms participated in company-sponsored *Salmonella* Enteritidis programs. A higher percentage of farms in the Southeast and West regions participated in a commodity group quality assurance program compared with farms in the Northeast and Central regions. About three-fourths of farms that participated in a *Salmonella* Enteritidis quality assurance program were inspected by someone not associated with the farm to verify compliance with the program.

Overall, 96.3 percent of farms conducted environmental tests and 5.8 percent of farms tested eggs from June 2012 through May 2013. Overall, 1.0 percent of flocks tested positive for *Salmonella* Enteritidis by environmental sampling from June 2012 through May 2013. The percentage of flocks that tested positive ranged from 0.3 percent in the Northeast region to 2.0 percent in the Central region. The Central region was the only region with any positive tests during summer (June–August). There were no environmentally positive flocks on farms with fewer than 30,000 hens.

Risk factor analysis was performed at the farm level and at the flock level. The purpose of the analysis was to identify characteristics associated with farms/flocks environmentally positive for *Salmonella* Enteritidis compared with environmentally negative farms/flocks.

A positive farm was a farm that had at least one positive environmental test result from June 1, 2012, through May 31, 2013. A negative farm was a farm in which all environmental tests were negative from June 1, 2012, through May 31, 2013. Four variables were associated with increased odds of a farm being environmentally positive

for *Salmonella* Enteritidis: location in the Central region (OR=5.9), a rodent index of 11 or higher (OR=4.3), routinely molting birds (OR=3.9), and down times of 10 days or less (OR=3.8).

For the flock-level analysis, the most recent environmentally positive flock was compared to the most recent environmentally negative flock. Flocks in the Central region and flocks that were tested postmolt had higher odds of testing positive for *Salmonella* Enteritidis compared with flocks in the other regions or flocks that were tested at other stages of production (OR=8.1 and 3.7, respectively). Flocks that had been vaccinated for *Salmonella* as pullets were less likely to test positive for *Salmonella* Enteritidis compared with unvaccinated flocks (OR=0.09).

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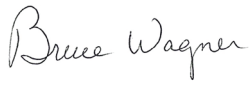
Acknowledgments

The Layers 2013 study was a cooperative effort among animal- and human-health officials, university researchers, poultry industry leaders, and producers. We would like to thank our reviewers for providing valuable expertise and guidance through their comments. All participants are to be commended, particularly the poultry producers whose voluntary efforts made the Layers 2013 study possible.



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Feedback
Feedback, comments, and suggestions regarding Layers 2013 study reports are welcomed. You may submit feedback via online survey at: http://www.aphis.usda.gov/nahms (Click on “FEEDBACK on NAHMS reports.”)

Introduction

The National Animal Health Monitoring System (NAHMS) is a nonregulatory program of the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service. NAHMS is designed to help meet the Nation's animal-health information needs.

Layers '99 was NAHMS' first national study on poultry and provided baseline health and management information for the table egg industry. Layers '99 estimated the prevalence and associated risk factors of *Salmonella* Enteritidis in U.S. layer flocks.

Poultry 2004 was NAHMS' second study of the U.S. poultry industry. Poultry 2004 provided information regarding bird health, bird movement, and biosecurity practices of backyard flocks, gamefowl breeder flocks, and live poultry markets.

The 2007 Small Enterprise Chicken study was NAHMS' third study of the poultry industry, focusing on biosecurity and bird movement on operations with 1,000 to 19,999 chickens.

Poultry 2010 was NAHMS' fourth study of the U.S. poultry industry, addressing four topics: 1) describe the structure of commercial poultry industries, 2) describe farm-level practices for chicken primary breeder and multiplier flocks, 3) estimate the prevalence and investigate risk factors associated with clostridial dermatitis on turkey grower farms, and 4) describe urban chicken flocks in four U.S. cities—Miami, Denver, Los Angeles, and New York City.

Layers 2013 is NAHMS' fifth study of the U.S. poultry industry. This study updates baseline health and management information for the table-egg industry, estimates the prevalence of *Salmonella* Enteritidis in U.S. layer flocks, and describes management practices to prevent and control *Salmonella* Enteritidis.

In 2010, the Food and Drug Administration (FDA) implemented an egg safety rule to control *Salmonella* Enteritidis on farms producing eggs for the table-egg market.[2] The FDA used information from the NAHMS Layers '99 study in their assessment of the need for and economic impact of the egg safety rule. As practices have changed substantially since 1999, it was determined that updated information on practices would be useful to the industry and government agencies. Therefore, NAHMS conducted a study in summer 2013 to estimate the prevalence and evaluate risk factors for *Salmonella* Enteritidis on commercial layer farms, as well as to assess changes in management practices since 1999 relevant to control and prevention of *Salmonella* Enteritidis . A sample of farms was selected from the FDA list of registered premises (including table-egg farms and farms that produce eggs for breaking).

[2]Code of Federal Regulations, Title 21, Volume 2, Part 118 Production, storage, and transportation of shell eggs.

Layers 2013 “Part II: Control and Prevention of *Salmonella* Enteritidis on Table-Egg Farms in the United States, 2013” is the second in a series of reports containing information from Layers 2013 study. Part II focuses on *Salmonella* Enteritidis control practices, prevalence, and risk factors. This report contains information provided by producers from 328 table-egg layer farms in 19 States.[3] These States accounted for 76.4 percent of egg farms with 3,200 or more layers in the United States,[4] 87.1 percent of hens on farms with 30,000 or more hens,[5] and 77.8 percent of table eggs produced in the United States.[5]

Information on the methods used and the number of respondents in the study can be found at the end of this report.

Further information on NAHMS studies and reports is available online at:

http://www.aphis.usda.gov/nahms

[3]Alabama, Arkansas, California, Florida, Georgia, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, New England (Connecticut, Maine, Massachusetts, New Hampshire, Vermont), North Carolina, Ohio, Pennsylvania, Texas, Washington, Wisconsin.

[4]2007 Census of Agriculture (includes table eggs and eggs for hatching).

[5]NASS “Chickens and Eggs” report, January 2009.

Terms Used in This Report

Autogenous vaccine: A vaccine individually tailored to a farm and made from organisms isolated on the farm.

Bacterin: A killed bacterial product administered to immunize the host against a specific bacterial disease.

Breaker egg market: Eggs taken to a processing plant where they are broken and their contents used for liquid, frozen, or dried egg products, after pasteurization.

Farm size: Size groupings based on the number of layers 20 weeks of age or older when at maximum capacity. For this report, farm sizes were categorized as small (fewer than 30,000 birds); medium (30,000 to 99,999 birds), and large (100,000 birds or more).

Flock: A group of birds of similar age (may vary several weeks from the median age of the flock) considered as a production unit. A flock usually fills only one layer house, but it may take up more or less than one house.

Last completed flock: The most recent flock in which the production cycle was completed and flock was removed from the farm.

Layer: A female chicken that produces eggs.

Molt: The period when birds are taken out of production (usually around 65 weeks of age) until they return to their approximate 18-week weight. After a rest period, birds are returned to production for another laying cycle.

National Poultry Improvement Plan (NPIP): A cooperative Federal/State/industry program intended to prevent and control certain poultry diseases. The NPIP identified States, flocks, hatcheries, and slaughter plants that meet certain control standards specified in the NPIP's various programs.

Odds ratio: The likelihood or odds of a farm/flock with a certain characteristic being positive for *Salmonella* Enteritidis, compared with farms/flocks lacking that characteristic.

Population estimates: Data from the operations responding to the survey are weighted to reflect their probability of selection during sampling and to account for survey nonresponse. Estimates in this report are provided with a measure of precision called the standard error. A 95-percent confidence interval can be created with bounds equal to the estimate plus or minus two standard errors. If the only error is sampling error, the confidence intervals created in this manner will contain the true population mean 95 out of 100 times. An estimate of 7.5 with a standard error of 1.0 results in limits of 5.5 to 9.5 (1.96 times the standard error above and below the estimate). An estimate of 3.4 gives a standard error of 0.3 and results in limits of 2.8 and 4.0. Alternatively, the 90-percent confidence interval would be created by multiplying the standard error by 1.65 instead

of 2. Most estimates in this report are rounded to the nearest tenth. If rounded to 0, the standard error was reported (0.0). If there were no reports of the event, no standard error was reported (—).

Pullet: A female chicken less than 20 weeks of age. A pullet placed in the laying house is called a layer.

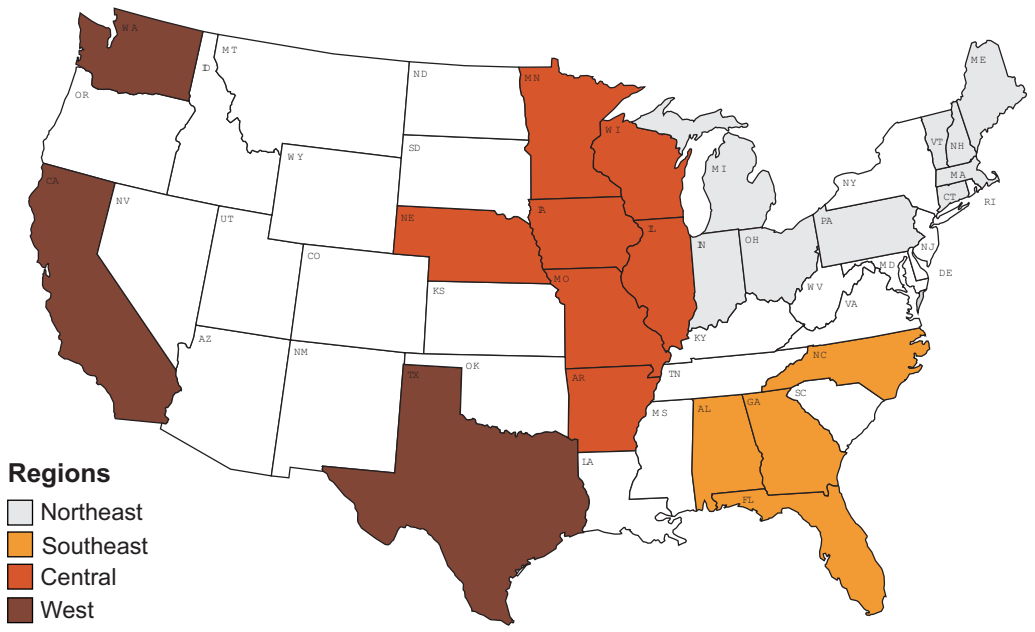
P-value: The probability that an association between a farm/flock characteristic and being positive for *Salmonella* Enteritidis is due to chance.

Regions:

Northeast: Indiana, Michigan, Ohio, Pennsylvania, New England (Connecticut, Maine, Massachusetts, New Hampshire, Vermont)
Southeast: Alabama, Florida, Georgia, North Carolina
Central: Arkansas, Illinois, Iowa, Minnesota, Missouri, Nebraska, Wisconsin
West: California, Texas, Washington

Rodent index: A measurement standardized to the number of mice caught per 12 traps per 7 days.

Layers 2013 study States*



*New England States (CT, MA, ME, NH, VT) were considered one State for study analyses.

Section I: Populaton Estimates

A. *Salmonella* Vaccination

1. Birds vaccinated

On about 9 of 10 farms (89.9 percent), birds had been vaccinated against *Salmonella* as pullets only, whereas on 9.1 percent of farms, birds had been vaccinated as pullets and layers. Only 1.0 percent of farms had birds that had not been vaccinated against *Salmonella* as either pullets or layers.

A.1.a. Percentage of farms in which birds had been vaccinated against *Salmonella* as pullets[1] and/or layers,[2] by region:

Percent Farms

	Region									
	Northeast		Southeast		Central		West		All	
Birds vaccinated as	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
Pullets only	87.6	(1.8)	97.0	(2.2)	94.7	(1.3)	83.2	(3.5)	89.9	(1.1)
Layers only	0.0	(—)	0.0	(—)	0.0	(—)	0.0	(—)	0.0	(—)
Both	12.4	(1.8)	0.0	(—)	3.4	(0.4)	15.5	(3.4)	9.1	(1.0)
Neither	0.0	(—)	3.0	(2.2)	1.9	(1.2)	1.3	(0.8)	1.0	(0.4)
Total	100.0		100.0		100.0		100.0		100.0	

[1]Pullets making up the most recently placed layer flock and vaccinated at pullet facility.
[2]Layers making up the last completed layer flock and vaccinated as layers.

The percentage of farms in which birds had been vaccinated against *Salmonella* as both pullets and layers increased as farm size increased.

A.1.b. Percentage of farms in which birds had been vaccinated against *Salmonella* as pullets[1] and/or layers,[2] by farm size:

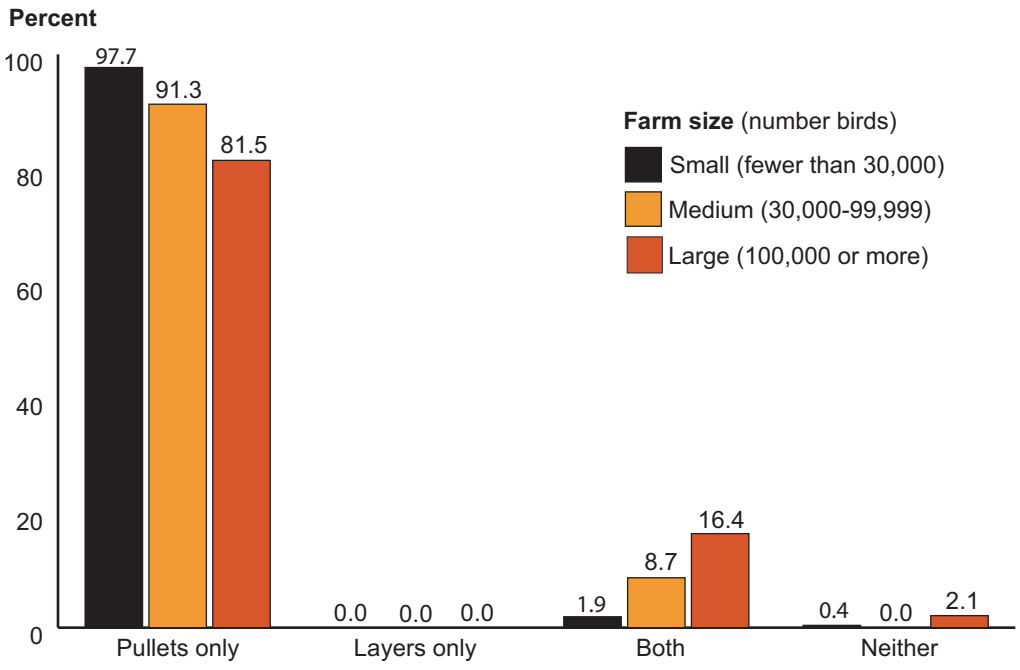
Percent Farms

Farm Size (number birds)

	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Birds vaccinated as	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
Pullets only	97.7	(1.1)	91.3	(2.7)	81.5	(2.0)
Layers only	0.0	(—)	0.0	(—)	0.0	(—)
Both	1.9	(1.0)	8.7	(2.7)	16.4	(1.7)
Neither	0.4	(0.3)	0.0	(—)	2.1	(1.0)
Total	100.0		100.0		100.0	

[1]Pullets making up the most recently placed layer flock and vaccinated at pullet facility.
[2]Layers making up the last completed layer flock and vaccinated as layers.

Percentage of farms in which birds had been vaccinated against *Salmonella* as pullets[1] and/or layers,[2] by farm size



[1]Pullets making up the most recently placed layer flock and vaccinated at pullet facility.
[2]Layers making up the last completed layer flock and vaccinated as layers.

2. Number of vaccinations

For farms in which birds had been vaccinated against *Salmonella* as pullets, 64.8 percent had birds that were vaccinated three times as pullets. For farms in which birds had been vaccinated against *Salmonella* as layers, 81.5 percent vaccinated layers just once.

A.2. For farms in which birds had been vaccinated against *Salmonella* as pullets or layers, percentage of farms by number of times birds had been vaccinated as pullets and number of times birds had been vaccinated as layers:

	Percent Farms Vaccinated as			
	Pullets[1]		Layers[2]	
Number of vaccinations	Percent	Std. error	Percent	Std. error
1	12.0	(2.9)	81.5	(5.3)
2	10.4	(1.6)	7.1	(4.1)
3	64.8	(2.8)	11.4	(3.8)
4	10.4	(1.3)	0.0	(—)
5	2.4	(0.6)	0.0	(—)
Total	100.0		100.0	

[1]Pullets making up the most recently placed layer flock and vaccinated at pullet facility.
[2]Layers making up the last completed layer flock and vaccinated as layers.

3. Type of vaccine and route of administration

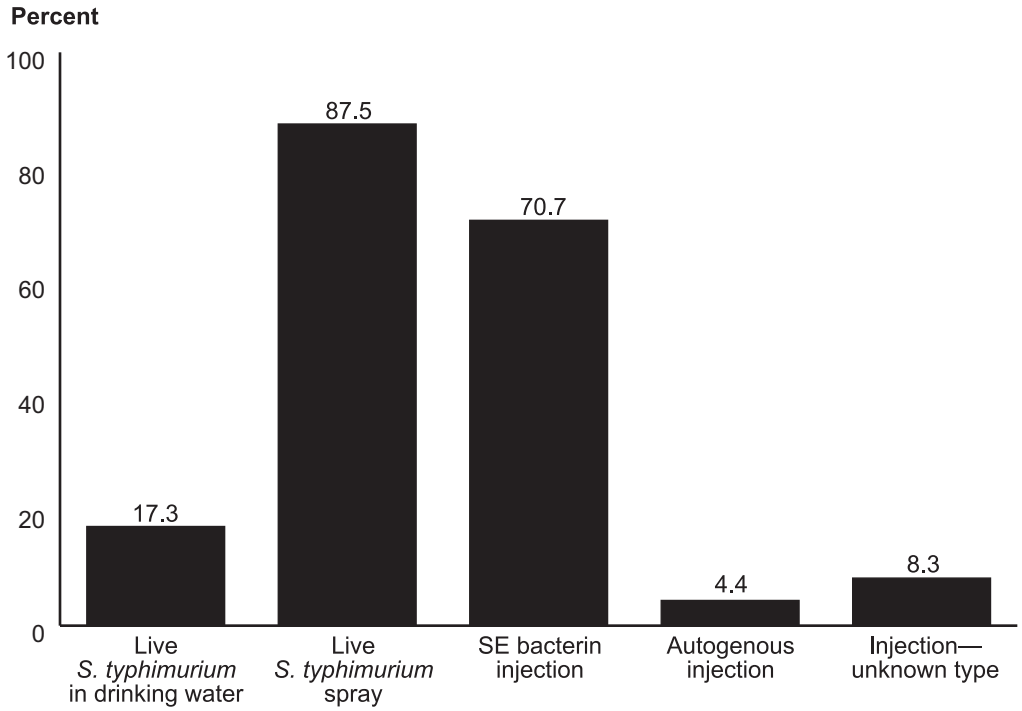
On about 9 of 10 farms in which birds had been vaccinated against *Salmonella,* birds had been given a live *S. typhimurium* vaccine. When administering live vaccine, a higher percentage of farms used spray rather than drinking water. For farms in which pullets had been vaccinated against *Salmonella,* 70.7 percent had birds that were given a *Salmonella* Enteritidis bacterin as pullets. *Salmonella* Enteritidis bacterin was not given to layers.

A.3.a. For farms in which birds had been vaccinated against *Salmonella* as pullets or layers, percentage of farms by type and route of vaccine given to birds as pullets[1] and percentage of farms by type and route of vaccine given to birds as layers[2]:

	Percent Farms Vaccinated as			
	Pullets[1]		Layers[2]	
Type and route	**Percent**	**Std. error**	**Percent**	**Std. error**
Live *S. typhimurium* in drinking water	17.3	(2.0)	22.5	(4.8)
Live *S. typhimurium* spray	87.5	(2.6)	66.1	(5.2)
Any live *S. typhimurium* vaccine	93.9	(2.1)	88.6	(3.8)
Salmonella Enteritidis bacterin injection	70.7	(3.4)	0.0	(—)
Autogenous injection	4.4	(1.2)	0.0	(—)
Injection—unknown type	8.3	(2.0)	11.4	(3.8)

[1]Pullets making up the most recently placed layer flock and vaccinated at pullet facility.
[2]Layers making up the last completed layer flock and vaccinated as layers.

For farms in which birds were vaccinated against *Salmonella* as pullets, percentage of farms by type and route of vaccine given to pullets*



*Pullets making up the most recently placed layer flock and vaccinated at pullet facility.

For farms in which birds (as pullets) had been vaccinated against *Salmonella* via injection, the highest percentage of farms administered *Salmonella* vaccinations in the thigh and/or breast.

A.3.b. For farms in which birds had been vaccinated against *Salmonella* as pullets via injection, percentage of farms by injection site:

Injection site	Percent farms	Std. error
Thigh	47.4	(2.7)
Breast	41.9	(2.3)
Neck	6.1	(0.8)
Other	6.5	(1.7)

*Pullets making up the most recently placed layer flock and vaccinated at pullet facility.

4. Pullet vaccination protocols

For farms in which birds had been vaccinated against *Salmonella* as pullets, the highest percentage of farms gave a series of two live *S. typhimurium* vaccines via spray, followed by a *Salmonella* Enteritidis bacterin injection (39.0 percent of farms that vaccinated pullets used this protocol).

A.4. For farms in which birds had been vaccinated against *Salmonella* as pullets,* percentage of farms by vaccination protocol (type, route, number of vaccinations):

Vaccine Number					
1st vaccine	2nd vaccine	3rd vaccine	4th vaccine	Percent farms	Std. error
Live spray	Live spray	Bacterin injection	—	39.0	(3.5)
Live spray	Live water	Bacterin injection	—	9.7	(1.4)
Live spray	Live spray	Live spray	Bacterin injection	8.4	(1.0)
Live spray	Live spray	Live spray		7.8	(2.2)
Bacterin injection	—	—	—	3.9	(1.7)
Live spray	—	—	—	3.0	(2.2)
Live spray	Bacterin injection	—	—	2.7	(1.2)
Live water	Live water	Type unknown injection	—	2.4	(1.3)
Live spray	Live spray	Autogenous injection	—	2.1	(0.4)
Any other combination				20.9	(2.7)
Total				100.0	

*Pullets making up the most recently placed layer flock and vaccinated at pullet facility.

5. Age vaccinated

On about half of farms in which birds had been vaccinated against *Salmonella* as pullets, birds had received their first vaccination at the hatchery. On 61.9 percent of farms that gave a second vaccination, birds had been given the second vaccination as pullets aged 3 to 5 weeks.

A.5.a. For farms in which birds had been vaccinated against *Salmonella* as pullets,* percentage of farms by age of birds when vaccinated and by vaccination number given:

Percent Farms

Vaccination

	1st		2nd		3rd		4th		5th	
Age (weeks)	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
At hatchery	53.1	(2.8)	NA		NA		NA		NA	
Less than 1	8.9	(1.4)	0.6	(0.3)	0.0	(—)	0.0	(—)	Too few respondents to estimate.	
1–2	27.7	(3.2)	15.7	(2.1)	0.0	(—)	0.0	(—)		
3–5	2.7	(1.3)	61.9	(3.3)	2.2	(1.3)	0.0	(—)		
6–8	4.9	(2.0)	13.0	(2.5)	6.8	(0.9)	0.0	(—)		
9–12	0.5	(0.4)	8.8	(1.8)	56.1	(3.1)	70.8	(4.9)		
13–16	2.3	(1.2)	0.0	(—)	34.9	(2.9)	29.2	(4.9)		
Total	100.0		100.0		100.0		100.0			

*Pullets making up the most recently placed layer flock and vaccinated at pullet facility.

For farms that vaccinated birds against *Salmonella* as layers, the highest percentage of farms (74.9 percent) vaccinated layers when they were from 60 to 79 weeks of age.

A.5.b. For farms that vaccinated layers* against *Salmonella*, percentage of farms by age of layers when vaccinated and by vaccination number given:

	Percent Farms					
	Vaccination					
	1st		2nd		3rd	
Age (weeks)	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
17–19	1.8	(1.1)	Too few respondents to estimate.			
20–59	23.3	(6.0)				
60–79	74.9	(6.0)				
80 or more	0.0	(—)				
Total	100.0					

*Layers making up the last completed layer flock and vaccinated as layers.

B. *Salmonella* Enteritidis Testing and Control Practices for Pullets

Note: This section describes practices used by each layer farm's pullet supplier while birds were still at the pullet farm.

1. NPIP *Salmonella* Enteritidis clean breeding flock

With the exception of the West region, all layer farms in every region obtained their pullets from breeding flocks considered *Salmonella* Enteritidis clean by the NPIP.

B.1.a. Percentage of farms in which pullets* originated from breeding flocks monitored for *Salmonella* Enteritidis by the NPIP, by region:

Percent Farms

Region

Northeast		Southeast		Central		West		All	
Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
100.0	(—)	100.0	(—)	100.0	(—)	92.0	(2.8)	99.0	(0.4)

*Pullets making up the most recently placed layer flock.

All small and medium farms, and nearly all large farms, obtained their pullets from breeding flocks considered *Salmonella* Enteritidis clean by the NPIP.

B.1.b. Percentage of farms in which pullets* originated from a breeding flock monitored for *Salmonella* Enteritidis by the NPIP, by farm size:

Percent Farms

Farm Size (number birds)

Small (fewer than 30,000)		Medium (30,000–99,999)		Large (100,000 or more)	
Percent	Std. error	Percent	Std. error	Percent	Std. error
100.0	(—)	100.0	(—)	97.4	(0.9)

*Pullets making up the most recently placed layer flock.

2. Monitoring methods

The highest percentage of farms (81.0 percent) cultured the environment or manure to monitor *Salmonella* Enteritidis in pullets still at the pullet farm. The percentage of farms in which pullets had been monitored by testing dead-on-arrival chicks or chick-box paper ranged from 30.6 percent of farms in the Central region to 68.7 percent of farms in the Southeast region. Some layer farms did not know if specific monitoring methods were used .

B.2.a. Percentage of farms by method used to monitor *Salmonella* Enteritidis in pullets,* and by region:

	Percent Farms											
	Region											
	Northeast		Southeast		Central		West		All		Don't know	
Method	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
Test dead-on-arrival chicks or chick-box paper	47.7	(5.6)	68.7	(4.1)	30.6	(4.7)	67.3	(4.8)	46.9	(3.2)	10.7	(1.6)
Culture environment or manure	84.9	(2.9)	97.6	(0.9)	70.4	(5.0)	79.0	(4.6)	81.0	(2.1)	4.2	(1.0)
PCR (Taqman, BAX) or other rapid test (SDIX, Neogen) of environment/ manure	31.7	(4.1)	35.4	(3.1)	31.8	(5.1)	47.0	(5.2)	34.0	(2.6)	13.7	(1.9)
Test live birds	8.4	(4.4)	1.2	(0.1)	11.2	(4.4)	21.3	(4.4)	10.3	(2.6)	12.1	(2.2)

*Pullets making up the most recently placed layer flock.

Pullet monitoring methods did not vary substantially by farm size.

B.2.b. Percentage of farms by methods used to monitor *Salmonella* Enteritidis in pullets,* and by farm size:

	Percent Farms					
	Farm Size (number birds)					
	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Method	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
Test dead-on-arrival chicks or chick-box paper	42.5	(5.5)	62.5	(6.4)	42.8	(4.6)
Culture environment or manure	75.7	(4.2)	80.9	(4.5)	86.2	(2.5)
PCR (Taqman, BAX) or other rapid test (SDIX, Neogen) of environment/ manure	32.9	(4.0)	30.1	(5.2)	37.4	(4.7)
Test live birds	8.5	(3.9)	14.0	(8.9)	10.0	(2.2)

*Pullets making up the most recently placed layer flock.

About two-thirds of farms that obtained pullets from a supplier and tested chick-box paper or chicks dead-on-arrival from the hatchery would most likely destroy their flock if *Salmonella* Enteritidis was found. The highest percentage of farms in the “Other” category indicated that they would consult with company headquarters.

B.2.c. For farms in which pullets had been monitored by testing chick-box paper or chicks dead on arrival from the hatchery, percentage of farms by what was usually done or would be done if *Salmonella* Enteritidis was found:

Response	**Percent farms**	**Std. error**
Treat with antibiotics	2.6	(2.5)
Destroy flock	62.0	(5.5)
Increase monitoring during growing period	23.2	(5.5)
Other	12.1	(4.1)
No changes in production practices	0.0	(—)
Total	100.0	

C. *Salmonella* Enteritidis Testing and Control Practices for Layers

1. Routine testing in 2008 and 2013

To examine changes in testing and control practices used for *Salmonella* Enteritidis since 2008 (5 years prior to the study), producers were asked about their practices in 2008 and 2013. Tables C.1.a and C.1.b show the percentage of farms that had produced eggs for human consumption in 2008.

Overall, 84.9 percent of farms in 2013 were producing eggs for human consumption in 2008, ranging from 70.8 percent of farms in the Central region to 97.1 percent of farms in the West region.

C.1.a. Percentage of farms in 2013 that were producing eggs for human consumption (shell eggs or eggs for breaking) in 2008, by region:

Percent Farms

Region

Northeast		Southeast		Central		West		All	
Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
90.4	(2.9)	80.7	(2.8)	70.8	(5.3)	97.1	(1.4)	84.9	(2.1)

Although nearly all medium and large farms in 2013 were producing eggs for human consumption in 2008, about one-third of small farms (34.6 percent) were not.

C.1.b. Percentage of farms in 2013 that were producing eggs for human consumption (shell eggs or eggs for breaking) in 2008, by farm size:

Percent Farms

Farm Size (number birds)

Small (fewer than 30,000)		Medium (30,000–99,999)		Large (100,000 or more)	
Percent	Std. error	Percent	Std. error	Percent	Std. error
65.4	(5.3)	96.5	(1.0)	98.0	(1.0)

The percentage of farms that routinely tested layer houses for *Salmonella* Enteritidis increased from 67.0 percent in 2008 to 99.2 percent in 2013. This increase was particularly notable in the Central region, where only 19.9 percent of farms tested for *Salmonella* Enteritidis in 2008 compared with 97.3 percent in 2013. Farms that only produce eggs for the breaker market are not required by the FDA to test for *Salmonella* Enteritidis, and many breaker farms are located in the Central region.

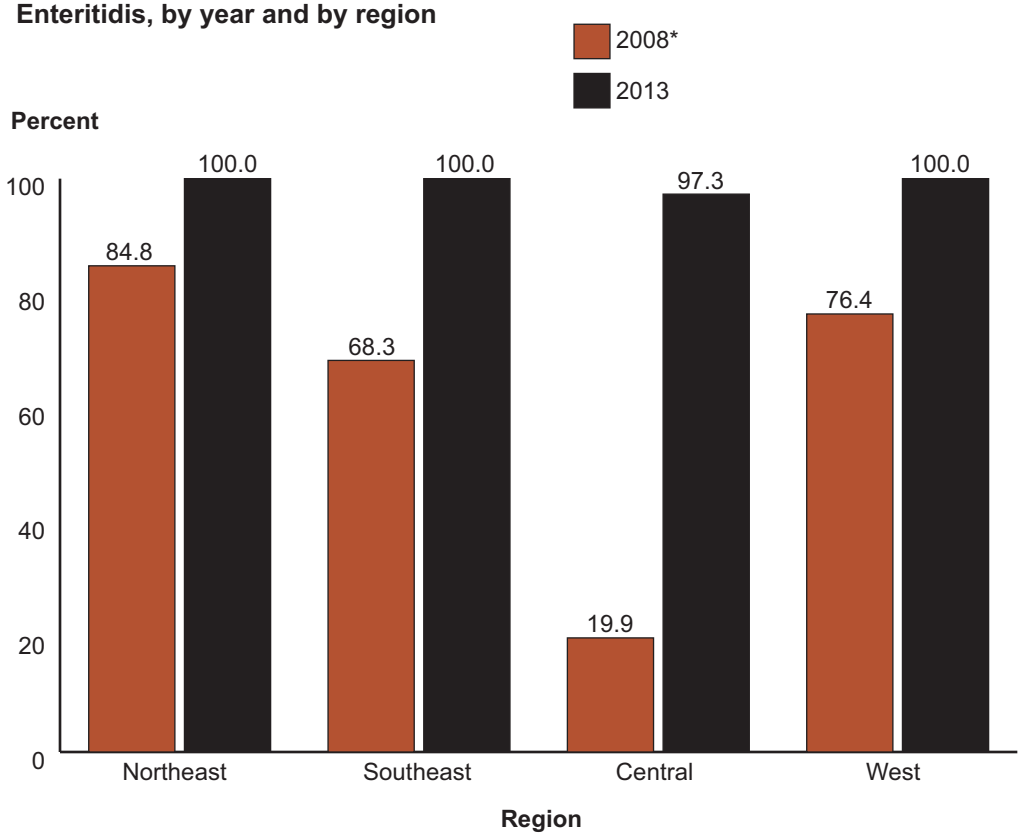
C.1.c. Percentage of farms that routinely tested layer houses for *Salmonella* Enteritidis, by year and by region:

Percent Farms

	Region									
	Northeast		Southeast		Central		West		All	
Year	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
2008*	84.8	(2.8)	68.3	(5.1)	19.9	(3.2)	76.4	(4.6)	67.0	(2.4)
2013	100.0	(—)	100.0	(—)	97.3	(1.6)	100.0	(—)	99.2	(0.5)

*For farms that produced eggs for human consumption in 2008.

Percentage of farms that routinely tested layer houses for *Salmonella* Enteritidis, by year and by region



*For farms that produced eggs for human consumption in 2008.

A higher percentage of medium farms tested layer houses for *Salmonella* Enteritidis in 2008 compared with small and large farms. All small and medium farms and 98.0 percent of large farms tested for *Salmonella* Enteritidis in 2013.

C.1.d. Percentage of farms that routinely tested layer houses for *Salmonella* Enteritidis, by year and by farm size:

Percent Farms

Farm Size (number birds)

	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Year	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
2008*	61.5	(6.3)	81.1	(3.6)	63.6	(3.4)
2013	100.0	(—)	100.0	(—)	98.0	(1.1)

*For farms that produced eggs for human consumption in 2008.

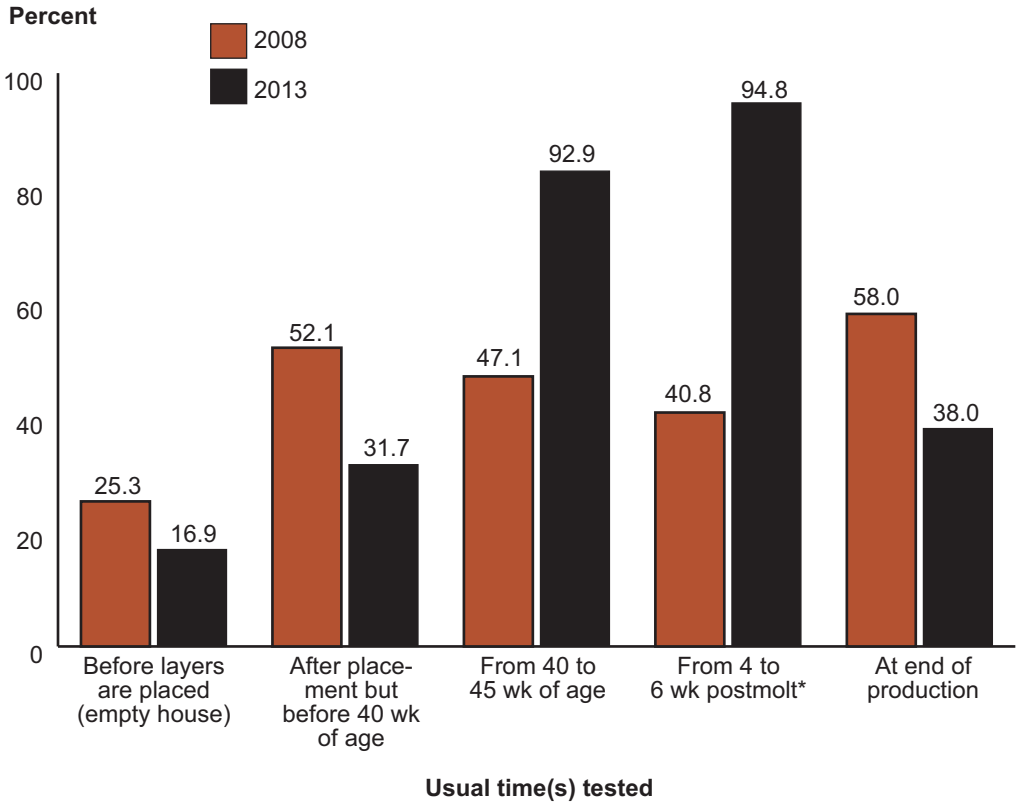
In 2008 and 2013, nearly all farms that tested layer houses for *Salmonella* Enteritidis tested manure. In 2008, less than half of farms tested when layers were 40 to 45 weeks of age and 4 to 6 weeks postmolt (for farms that molted) compared with 92.9 percent of farms in 2013. This change is most likely in response to the FDA egg safety rule, which requires birds be tested between 40 and 45 weeks of age and 4 to 6 weeks postmolt (excluding farms that exclusively produce eggs for breaking).

C.1.e. For farms that routinely tested layer houses for *Salmonella* Enteritidis, percentage of farms by testing practices and by year:

	Percent Farms			
	2008[1]		2013	
Testing practices	**Percent**	**Std. error**	**Percent**	**Std. error**
Samples tested				
Manure	97.5	(0.7)	96.6	(1.2)
Egg belts[2]	17.4	(1.7)	13.1	(1.7)
Elevator equipment[2]	10.9	(1.5)	9.6	(1.9)
Nests[2]	3.2	(0.9)	7.0	(2.3)
Other	2.4	(1.9)	12.2	(1.8)
Primary person who collected the samples				
Company or farm personnel	79.6	(5.3)	84.2	(3.3)
State or Federal personnel	0.2	(0.0)	0.4	(0.0)
Independent third party	13.0	(4.6)	10.9	(2.9)
Other	7.3	(2.8)	4.5	(1.6)
Total	100.0		100.0	
Usual time(s) for testing				
Before layers are placed (empty house)	25.3	(4.5)	16.9	(2.5)
After placement but before 40 weeks of age	52.1	(2.8)	31.7	(2.6)
From 40 to 45 weeks of age	47.1	(5.4)	92.9	(2.5)
From 4 to 6 weeks postmolt[3]	40.8	(7.4)	94.8	(2.7)
At end of production	58.0	(4.9)	38.0	(3.0)
Any other age during production	8.3	(2.7)	1.9	(0.6)
Any time after placement but before end of production	68.8	(2.4)	99.5	(0.1)

[1]For farms that produced eggs for human consumption in 2008.
[2]For farms that had such equipment.
[3]For farms that molted.

For farms that routinely tested layer houses for *Salmonella* Enteritidis, percentage of farms by usual time(s) tested and by year



*For farms that molted.

In 2013, a higher percentage of farms would culture and divert eggs if *Salmonella* Enteritidis were to be found in the layer house environment early in production than if it were found late in production. Conversely, a higher percentage of farms would take hens out of production if *Salmonella* Enteritidis were found late in production than if it were found early in production.

C.1.f. For farms that tested for *Salmonella* Enteritidis after birds were placed but before the end of the production cycle, percentage of farms by how farms would likely respond if *Salmonella* Enteritidis were to be found in the layer house environment early and late in the production cycle, and by year:

	Percent Farms			
	2008*		2013	
Response	**Percent**	**Std. error**	**Percent**	**Std. error**
Early in production cycle				
Collect and culture eggs for *Salmonella* Enteritidis	84.6	(2.3)	90.8	(1.5)
Divert eggs until culture is negative	88.8	(2.1)	92.1	(1.5)
Take hens out of production	30.2	(4.6)	30.9	(2.6)
Other	1.3	(0.7)	3.5	(0.8)
Late in production cycle				
Collect and culture eggs for *Salmonella* Enteritidis	80.1	(3.7)	77.4	(2.2)
Divert eggs until culture is negative	81.2	(4.2)	81.9	(2.3)
Take hens out of production	48.3	(4.8)	53.2	(2.5)
Other	1.3	(0.7)	3.9	(0.9)

*For farms that produced eggs for human consumption in 2008.

2. Testing practices in 2013

Farms in the Northeast region rarely tested any samples for *Salmonella* Enteritidis other than manure, whereas more than 4 of 10 farms in the West region tested egg belts and elevator equipment, if they had such equipment. A higher percentage of farms in the West region than in the other regions tested at the end of production.

C.2.a. For farms that routinely tested layer houses for *Salmonella* Enteritidis, percentage of farms by testing practices and by region:

Percent Farms

	Region									
	Northeast		Southeast		Central		West		All	
Testing practice	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
Sample(s) tested										
Manure	97.7	(2.2)	98.8	(0.1)	95.5	(1.4)	93.5	(3.0)	96.6	(1.2)
Egg belts[1]	0.6	(0.2)	30.6	(4.6)	18.0	(5.1)	45.1	(5.8)	13.1	(1.7)
Elevator equipment[1]	0.0	(—)	4.3	(0.4)	12.4	(6.2)	41.5	(6.5)	9.6	(1.9)
Nests[1]	0.4	(0.0)	0.0	(—)	14.6	(6.5)	16.6	(5.1)	7.0	(2.3)
Other	7.4	(2.4)	2.4	(0.1)	26.8	(4.6)	3.3	(2.8)	12.2	(1.8)
Primary person who collected the samples										
Company or farm personnel	79.6	(6.2)	95.1	(0.3)	88.4	(3.4)	84.8	(4.0)	84.2	(3.3)
State or Federal personnel	0.0	(—)	4.9	(0.3)	0.0	(—)	0.0	(—)	0.4	(0.0)
Independent third party	13.3	(5.4)	0.0	(—)	11.0	(3.4)	9.0	(3.2)	10.9	(2.9)
Other	7.1	(3.1)	0.0	(—)	0.6	(0.3)	6.2	(2.5)	4.5	(1.6)
Total	100.0		100.0		100.0		100.0		100.0	

Table continued.

C.2.a. continued:

	Percent Farms									
	Region									
	Northeast		Southeast		Central		West		All	
Testing practice	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
Usual time(s) for testing										
Before layers are placed (empty house)	15.8	(4.6)	36.7	(3.2)	8.6	(3.0)	26.9	(5.1)	16.9	(2.5)
After placement but before 40 weeks of age	47.1	(4.4)	1.2	(0.9)	15.0	(4.3)	30.8	(5.3)	31.7	(2.6)
From 40 to 45 weeks of age	92.3	(4.6)	98.8	(0.9)	89.1	(4.0)	100.0		92.9	(2.5)
From 4 to 6 weeks post molt[2]	93.9	(5.4)	88.3	(5.7)	94.2	(4.9)	100.0	(—)	94.8	(2.7)
At end of production	36.3	(5.4)	39.0	(2.9)	26.7	(4.3)	69.6	(5.3)	38.0	(3.0)
Any other age during production	0.0	(—)	0.0	(—)	5.5	(1.7)	2.1	(1.6)	1.9	(0.6)
Any time after placement but before end of production	100.0	(—)	100.0	(—)	98.3	(0.5)	100.0	(—)	99.5	(0.1)

[1]For farms that had such equipment.

[2]For farms that molted.

For farms that routinely tested layer houses for *Salmonella* Enteritidis, a higher percentage of large farms than small farms (20.2 and 4.5 percent of farms that had egg belts, respectively) tested egg belts for *Salmonella* Enteritidis, whereas a higher percentage of small farms than large farms (26.6 and 1.0 percent, respectively) tested "Other" samples (mostly floor slats).

C.2.b. For farms that routinely tested layer houses for *Salmonella* Enteritidis, percentage of farms by testing practices and by farm size:

	Percent Farms					
	Farm Size (number birds)					
	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Practice	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
Samples tested						
Manure	95.0	(2.7)	96.9	(1.9)	98.1	(0.9)
Egg belts[1]	4.5	(2.9)	14.1	(3.3)	20.2	(2.9)
Elevator equipment[1]	Too few to estimate.		6.2	(3.5)	11.2	(2.5)
Nests[1]	7.2	(3.0)	6.3	(2.5)	6.8	(4.7)
Other	26.6	(4.3)	6.0	(3.1)	1.0	(0.4)
Primary person who collected the samples						
Company or farm personnel	89.5	(3.9)	81.1	(10.2)	80.4	(4.6)
State or Federal personnel	0.0	(—)	0.0	(—)	1.1	(0.1)
Independent third party	9.0	(3.8)	18.9	(10.2)	8.8	(2.6)
Other	1.5	(1.0)	0.0	(—)	9.8	(3.9)
Total	100.0		100.0		100.0	

Table continued.

C.2.b. continued:

	Percent Farms					
	Farm Size (number birds)					
	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Practice	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
Usual time(s) for testing						
Before layers are placed (empty house)	6.0	(1.1)	26.2	(10.2)	22.9	(4.7)
After placement but before 40 weeks of age	38.6	(4.6)	41.6	(7.2)	19.7	(5.9)
From 40 to 45 weeks of age	93.2	(3.0)	84.9	(10.3)	96.7	(1.0)
From 4 to 6 weeks post molt[2]	100.0	(—)	88.2	(10.5)	96.3	(1.7)
At end of production	39.4	(4.7)	52.3	(10.3)	28.7	(2.4)
Any other age during production	1.6	(0.4)	0.0	(—)	3.3	(1.4)
Any time after placement but before end of production	100.0	(—)	100.0	(—)	98.8	(0.4)

[1]For farms that had such equipment.
[2]For farms that molted.

A higher percentage of farms in the West region than in the other regions would likely take hens out of production if *Salmonella* Enteritidis were to be found in the layer house environment. Farms in the Northeast and Southeast regions were more likely to culture and divert eggs if *Salmonella* Enteritidis were to be found compared with farms in the Central and West regions.

C.2.c. For farms that tested for *Salmonella* Enteritidis after birds were placed but before the end of the production cycle, percentage of farms by how farms would likely respond if *Salmonella* Enteritidis were to be found in the layer house environment early and late in the production cycle, and by region:

Percent Farms

	Region									
	Northeast		Southeast		Central		West		All	
Response	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
Early in production cycle										
Collect and culture eggs for *Salmonella* Enteritidis	98.3	(0.6)	100.0	(—)	79.8	(4.7)	80.4	(4.4)	90.8	(1.5)
Divert eggs until culture is negative	98.2	(0.6)	97.4	(0.2)	84.6	(4.6)	82.1	(4.3)	92.1	(1.5)
Take hens out of production	32.4	(4.2)	17.2	(1.5)	14.8	(4.5)	69.5	(5.9)	30.9	(2.6)
Other	0.4	(0.2)	12.9	(3.5)	5.2	(2.4)	5.8	(2.4)	3.5	(0.8)
Late in production cycle										
Collect and culture eggs for *Salmonella* Enteritidis	87.6	(2.7)	92.2	(0.8)	59.0	(5.1)	69.9	(4.9)	77.4	(2.2)
Divert eggs until culture is negative	91.3	(3.1)	89.8	(0.9)	68.9	(5.3)	70.3	(4.9)	81.9	(2.3)
Take hens out of production	52.6	(4.3)	30.0	(3.2)	50.8	(4.2)	76.0	(5.1)	53.2	(2.5)
Other	0.6	(0.2)	15.2	(3.9)	5.3	(2.4)	5.9	(2.4)	3.9	(0.9)

A higher percentage of small farms than large farms (39.7 and 19.6 percent, respectively) would likely remove hens from production if *Salmonella* Enteritidis were to be found in the layer house environment.

C.2.d. For farms that tested for Salmonella *Enteritidis* after birds were placed but before the end of the production cycle, percentage of farms by how farms would likely respond if Salmonella Enteritidis were to be found in the layer house environment early and late in the production cycle, and by farm size:

Percent Farms

Farm Size (number birds)

	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Response	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
Early in production cycle						
Collect and culture eggs for *Salmonella* Enteritidis	92.5	(2.9)	87.4	(2.8)	90.7	(2.3)
Divert eggs until culture is negative	93.8	(2.8)	90.9	(3.5)	91.2	(2.5)
Take hens out of production	39.7	(5.8)	35.3	(5.7)	19.6	(2.4)
Other	2.0	(0.7)	0.0	(—)	6.9	(2.0)
Late in production cycle						
Collect and culture eggs for *Salmonella* Enteritidis	72.7	(4.5)	80.8	(3.8)	80.2	(2.9)
Divert eggs until culture is negative	74.9	(4.5)	81.0	(5.8)	89.2	(2.3)
Take hens out of production	72.0	(4.6)	45.7	(7.2)	38.3	(3.6)
Other	2.0	(0.7)	0.0	(—)	7.9	(2.1)

3. Feed

About one-third of farms tested finished feed or feed ingredients for *Salmonella* Enteritidis.

C.3.a. Percentage of farms that routinely tested finished feed or feed ingredients for *Salmonella* Enteritidis, by farm size:

	Percent Farms							
	Farm Size (number birds)							
	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)		**All**	
Testing	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
Finished feed	35.0	(5.7)	17.5	(4.6)	23.4	(3.2)	26.8	(2.9)
Any feed ingredients	35.5	(5.9)	21.1	(5.0)	30.5	(3.2)	30.5	(2.9)
Either	35.9	(5.9)	24.1	(5.2)	36.9	(3.6)	33.9	(3.0)

About half of farms received feed for laying hens from a feed mill certified by the American Feed Industry Association (AFIA); the West region had the highest percentage of farms that used AFIA-certified feed.

C.3.b. Percentage of farms in which feed for laying hens came from a feed mill certified by the AFIA, by region:

	Percent Farms									
	Region									
Northeast		**Southeast**		**Central**		**West**		**All**	
Pct.	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
42.3	(5.1)	48.2	(3.7)	36.9	(5.6)	75.2	(4.6)	45.4	(3.1)

The percentage of farms that received feed from a feed mill certified by the AFIA did not vary substantially by farm size, when considering the standard errors.

C.3.c. Percentage of farms in which feed for laying hens came from a feed mill certified by the AFIA, by farm size:

Percent Farms					
Farm Size (number birds)					
Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Percent	**Std. error**	**Percent**	**Std. error**	**Percent**	**Std. error**
53.5	(6.1)	45.2	(7.1)	38.2	(4.8)

4. FDA inspection

The percentage of farms that had ever been inspected by the FDA ranged from 59.2 percent in the Central region to 90.4 percent in the West region.

C.4.a. Percentage of farms that had ever been inspected by the FDA, by region:

Percent Farms									
Region									
Northeast		**Southeast**		**Central**		**West**		**All**	
Pct.	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
68.2	(3.4)	77.5	(3.0)	59.2	(3.6)	90.4	(3.2)	69.0	(2.0)

The percentage of farms that had ever been inspected by the FDA increased as farm size increased, probably because farms with 50,000 or more laying hens were required to comply with the egg safety rule in 2010, whereas farms with 3,000 to 49,999 hens had until 2012 to come into compliance.

C.4.b. Percentage of farms that had ever been inspected by the FDA, by farm size:

Percent Farms					
Farm Size (number birds)					
Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Percent	**Std. error**	**Percent**	**Std. error**	**Percent**	**Std. error**
30.6	(4.6)	81.8	(5.2)	99.3	(0.3)

About one of five farms that had ever been inspected by the FDA had environmental samples collected during the inspection.

C.4.c. For farms that had ever been inspected by the FDA, percentage of farms in which environmental samples were collected during the inspection:

Percent farms	Std. error
21.3	(3.9)

5. Quality assurance programs

Over 60 percent of farms in the Northeast and West regions participated in a State egg (*Salmonella* Enteritidis) quality assurance program, compared with less than 10 percent of farms in the Southeast and Central regions; the majority of farms in the Southeast and Central regions participated in company sponsored programs. A higher percentage of farms in the Southeast and West regions participated in a commodity-group quality assurance program compared with farms in the Northeast and Central regions.

C.5.a. Percentage of farms that participated in a *Salmonella* Enteritidis quality assurance program, by program type and by region:

	Percent Farms									
	Region									
	Northeast		Southeast		Central		West		All	
Program type	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error	Pct.	Std. error
State	69.4	(3.4)	8.4	(3.0)	2.2	(0.7)	60.4	(4.5)	44.2	(1.9)
Company sponsored	50.9	(6.4)	77.1	(3.7)	60.4	(5.5)	43.3	(4.9)	54.8	(3.6)
Commodity group (e.g., United Egg Producers)	29.7	(5.5)	60.3	(3.3)	8.1	(2.1)	61.5	(5.8)	30.1	(3.0)
Other (excluding FDA)	0.0	(—)	11.4	(3.3)	3.2	(1.5)	1.9	(1.3)	2.1	(0.6)
Any	88.6	(2.8)	93.5	(2.1)	63.1	(5.4)	89.3	(2.9)	81.9	(2.2)

Compared with small farms, a higher percentage of medium farms participated in a State *Salmonella* Enteritidis quality assurance program and a lower percentage participated in a company program.

C.5.b. Percentage of farms that participated in a *Salmonella* Enteritidis quality assurance program, by program type and by farm size:

Percent Farms

Farm Size (number birds)

	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Program type	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
State	37.0	(4.0)	70.7	(4.5)	38.3	(3.5)
Company sponsored	64.5	(5.6)	40.5	(5.8)	52.5	(5.2)
Commodity group (e.g., United Egg Producers)	22.9	(3.1)	27.1	(4.7)	38.5	(5.2)
Other (excluding FDA)	3.4	(1.2)	1.5	(0.7)	1.2	(0.6)
Any	82.5	(4.5)	95.1	(2.7)	74.9	(3.0)

About three-fourths of farms that participated in a *Salmonella* Enteritidis quality assurance program had an inspection by someone not associated with the farm or company to verify program compliance.

C.5.c. For farms that participated in a *Salmonella* Enteritidis quality assurance program (other than the FDA), percentage of farms in which someone not associated with the farm or company inspected the farm to verify program compliance, by farm size:

Percent Farms

Farm Size (number birds)

Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)		**All**	
Pct.	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
61.4	(5.0)	87.2	(2.1)	77.5	(3.2)	73.4	(2.3)

D. *Salmonella* Enteritidis Testing June 1, 2012, through May 31, 2013

1. Environmental and egg testing

From June 2012 through May 2013, 96.3 percent of farms conducted environmental tests for *Salmonella* Enteritidis, and 5.8 percent tested eggs. The percentages of farms that tested for *Salmonella* Enteritidis were similar by time period.

D.1.a. Percentage of farms by type of testing done for *Salmonella* Enteritidis, and percentage of these farms that had at least one test-positive flock, and by time period:

Percent Farms

Type of Testing

	Environment				Egg			
Time period	**Pct. testing**	**Std. error**	**Pct. pos.**	**Std. error**	**Pct. testing**	**Std. error**	**Pct. pos.**	**Std. error**
June–August 2012	53.1	(3.4)	2.4	(1.1)	2.7	(0.8)	0.0	(—)
September–November 2012	51.7	(3.2)	2.1	(0.9)	2.7	(0.7)	0.0	(—)
December 2012–February 2013	58.5	(3.8)	2.4	(0.9)	3.6	(0.8)	0.0	(—)
March–May 2013	62.8	(3.5)	1.0	(0.6)	2.8	(0.7)	0.0	(—)
Any (June 2012–May 2013)	96.3	(1.4)	3.3	(0.8)	5.8	(1.0)	0.0	(—)

The percentage of farms with at least one positive test for *Salmonella* Enteritidis ranged from 1.2 percent in the Northeast region to 6.4 percent in the Central region.

D.1.b. For farms that performed environmental testing for *Salmonella* Enteritidis from June 2012 through May 2013, percentage of **farms** that had a least one positive test result, by region:

Percent Farms

Region

Northeast		Southeast		Central		West		All	
Pct.	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
1.2	(0.4)	2.7	(1.4)	6.4	(2.2)	4.6	(2.4)	3.3	(0.8)

Small farms had no environmental tests that were positive for *Salmonella* Enteritidis from June 2012 through May 2013.

D.1.c. For farms that performed environmental testing for *Salmonella* Enteritidis from June 2012 through May 2013, percentage of **farms** that had a least one positive test result, by farm size:

Percent Farms

Farm Size (number birds)

Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Percent	**Std. error**	**Percent**	**Std. error**	**Percent**	**Std. error**
0.0	(—)	1.2	(0.6)	7.3	(1.9)

Overall, 1.0 percent of flocks tested positive for *Salmonella* Enteritidis by environmental sampling from June 2012 through May 2013. The percentage of flocks that tested positive ranged from 0.3 percent in the Northeast region to 2.0 percent in the Central region. The Central region was the only region with any positive tests during the summer months (June to August).

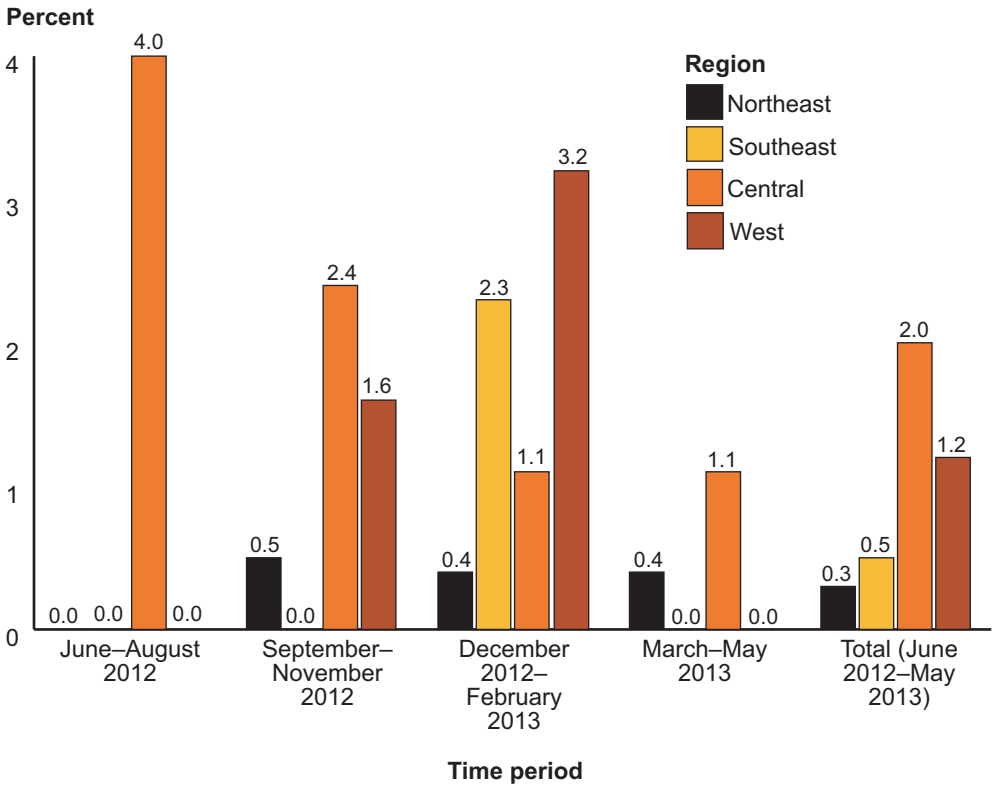
D.1.d. For flocks that were tested for *Salmonella* Enteritidis by environmental testing, percentage of **flocks** that tested positive, by time period and by region:

Percent Flocks

Region

	Northeast		**Southeast**		**Central**		**West**		**All**	
Time period	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
June–August 2012	0.0	(—)	0.0	(—)	4.0	(1.8)	0.0	(—)	1.2	(0.6)
September–November 2012	0.5	(0.3)	0.0	(—)	2.4	(1.3)	1.6	(1.2)	1.2	(0.5)
December 2012–February 2013	0.4	(0.2)	2.3	(1.2)	1.1	(0.9)	3.2	(1.6)	1.2	(0.4)
March–May 2013	0.4	(0.2)	0.0	(—)	1.1	(1.0)	0.0	(—)	0.5	(0.3)
Any (June 2012–May 2013)	0.3	(0.1)	0.5	(0.3)	2.0	(0.9)	1.2	(0.7)	1.0	(0.3)

For flocks that were tested for *Salmonella* Enteritidis by environmental testing, percentage of flocks that tested positive, by time period and by region



On small farms, no flocks were positive for *Salmonella* Enteritidis by environmental testing.

D.1.e. For flocks that were tested for *Salmonella* Enteritidis by environmental testing, percentage of **flocks** that tested positive, by time period and by farm size:

Percent Flocks

Farm Size (number birds)

	Small (fewer than 30,000)		**Medium** (30,000–99,999)		**Large** (100,000 or more)	
Time period	**Pct.**	**Std. error**	**Pct.**	**Std. error**	**Pct.**	**Std. error**
June–August 2012	0.0	(—)	0.0	(—)	1.6	(0.7)
September–November 2012	0.0	(—)	0.0	(—)	1.7	(0.7)
December 2012–February 2013	0.0	(—)	1.8	(1.2)	1.5	(0.6)
March–May 2013	0.0	(—)	0.0	(—)	0.8	(0.5)
Any (June 2012–May 2013)	0.0	(—)	0.4	(0.3)	1.4	(0.4)

2. Most recent positive and negative flocks

Because no flocks on small farms tested positive for *Salmonella* Enteritidis, only medium and large farms were included for the comparison of the most recent flocks that tested positive and negative for *Salmonella* Enteritidis. A higher percentage of positive flocks than negative flocks had sampled manure pits, and a lower percentage of positive flocks than negative flocks had performed testing from March through May. About 9 of 10 positive tests were confirmed via additional testing.

D.2.a. For medium and large farms, percentage of the most recent test-positive flocks and most recent test-negative flocks,[1] by test characteristics:

	Percent Flocks			
	Most Recent			
	Positive flock		Negative flock[2]	
Test characteristic	Percent	Std. error	Percent	Std. error
Time period				
June–August 2012	26.7	(13.2)	14.3	(3.5)
September–November 2012	10.8	(4.9)	9.0	(1.3)
December 2012–February 2013	43.3	(12.6)	13.0	(2.7)
March–May 2013	19.1	(11.0)	63.7	(4.3)
Total	100.0		100.0	
Type of sample(s) tested initially				
Manure pit	93.7	(3.5)	76.4	(2.9)
Egg belt	0.0	(—)	10.8	(1.7)
Walkway	0.0	(—)	4.8	(0.9)
Manure scraper	6.3	(3.5)	11.4	(1.7)
Manure belt	0.0	(—)	22.1	(4.1)
Floor of house (hens not caged)	0.0	(—)	12.7	(2.3)
Fans or ventilation equipment	0.0	(—)	4.9	(0.9)
Other	0.0	(—)	3.7	(1.5)

Table continued.
See footnotes at end of table.

D.2.a. continued:

	Percent Flocks			
	Most Recent			
	Positive flock		Negative flock[2]	
Test characteristic	Percent	Std. error	Percent	Std. error
Type of test(s) used for initial testing				
Culture	54.9	(14.2)	64.6	(3.1)
PCR (Taqman, BAX)	6.3	(4.1)	12.3	(2.1)
Other rapid test (SDIX, Neogen)	38.8	(14.3)	25.6	(2.6)
Other	0.0	(—)	1.6	(0.6)
Confirmatory or follow-up testing performed				
Yes	90.5	(7.0)	0.2	(0.0)
No	9.5	(7.0)	99.8	(0.0)
Total	100.0		100.0	
For farms that did follow-up testing, type of sample(s) tested for confirmation or follow-up				
Manure pit	39.4	(15.2)	Too few respondents to estimate.	
Egg belt	7.0	(4.6)		
Walkway	7.0	(4.6)		
Manure scraper	7.0	(3.9)		
Manure belt	0.0	(—)		
Floor of house (hens not caged)	0.0	(—)		
Fans or ventilation equipment	0.0	(—)		
Other layer house environment	0.0	(—)		
Hens	0.0	(—)		
Eggs	60.7	(15.1)		
Other	0.0	(—)		

Table continued.
See footnotes at end of table.

D.2.a. continued:

	Percent Flocks			
	Most Recent			
	Positive flock		Negative flock	
Test characteristic	Percent	Std. error	Percent	Std. error
For farms that did follow-up testing, type of test(s) used for confirmation or follow-up				
Culture	40.6	(15.1)	Too few respondents to estimate.	
PCR (Taqman, BAX)	36.3	(13.7)		
Other rapid test (SDIX, Neogen)	7.0	(4.6)		
Other	23.1	(13.0)		

[1]Positive or negative via environmental testing.
[2]Most recent negative flock from both positive and negative farms.

E. Risk Factor Analysis

A risk factor analysis was performed at the farm level and at the flock level. The purpose of the analysis was to identify characteristics associated with farms/flocks environmentally positive for *Salmonella* Enteritidis and farms/flocks environmentally negative for *Salmonella* Enteritidis.

Note: The risk factor analyses were limited to medium and large farms because no small farms reported positive results.

1. Farm level

A case farm was defined as a farm with at least one positive environmental test result from June 1, 2012, through May 31, 2013. A control farm was defined as a farm in which all environmental tests from June 1, 2012, through May 31, 2013, were negative. The following farm-level characteristics were included for evaluation:

- Region[6]
- Farm size[6]
- Layers caged versus cage-free
- Pullets caged versus cage-free
- Prebiotics/probiotics fed to layers
- Routinely molt[6]
- Dispose of daily mortality via renderer
- Hand-gather eggs
- Process eggs on-farm
- All eggs go to breaker
- Clean and disinfect egg racks
- Manure stored within 100 feet of layer house
- Down time (≤10 days versus >10 days)[6]
- Wash walls, cages, etc., after every flock[6]
- Vaccinate pullets for *Salmonella* three or more times
- Vaccinate layers for *Salmonella*
- Rodent index[6]
- Chlorinate drinking water

The percentages of farms with these farm-level characteristics are available in Parts I and II of this study.

[6]Variable met the criteria for multivariable modeling (p ≤0.25).

In the multivariable farm-level analysis, four variables were associated with increased odds of a farm being environmentally positive for *Salmonella* Enteritidis: located in the Central region, a rodent index of 11 or higher, farm routinely molts, and down time of 10 days or less.

E.1. For medium and large farms, percentage of case farms and percentage of control farms with the following characteristics, and results of backward elimination logistic regression:

Farm characteristic	Percent case farms[1]	Percent control farms[1]	Odds ratio	p-value
Central region	58.5	24.4	5.9	0.005
Rodent index of 11 or higher[2]	35.6	15.6	4.3	0.05
Routinely molts	71.2	55.6	3.9	0.10
Down time (10 days or less)	73.3	40.1	3.8	0.10

[1]Farms positive or negative for *Salmonella* Enteritidis.
[2]Rodent index=number of mice caught per 12 traps in 7 days.

2. Flock level

For the flock-level analysis, the most recent environmentally positive flock was compared with the most recent environmentally negative flock. Case farms contributed data regarding their most recent positive flock. Control farms contributed data regarding their most recent negative flock.

The following flock-level characteristics were included for evaluation:

- Region[7]
- Stage of production (postmolt test versus other)[7]
- Flock size[7]
- Bird density (sq. in. per bird)
- Flock vaccinated for *Salmonella* as pullets[7]
- Flock vaccinated for *Salmonella* as layers
- Layers caged versus cage free
- Floor-reared versus cage-reared as pullets
- Strain (white versus brown egg)

[7]See footnote 6.

Flocks in the Central region and flocks that were tested postmolt had higher odds of testing positive for *Salmonella* Enteritidis, compared with flocks in other regions or flocks tested at other stages of production. Flocks that had been vaccinated for *Salmonella* as pullets were less likely to test positive for *Salmonella* Enteritidis than unvaccinated flocks.

E.2. For medium and large farms, percentage of case flocks and percentage of control flocks with the following characteristics, and results of backward elimination logistic regression:

Flock characteristic	Percent case flocks*	Percent control flocks*	Odds ratio	p-value
Central region	58.5	24.3	8.1	0.002
Flock vaccinated for *Salmonella* as pullets	85.4	97.6	0.09	0.09
Postmolt test	27.3	15.7	3.7	0.09

*Flocks positive or negative for *Salmonella* Enteritidis.

Section II: Methodology

A. Needs Assessment

APHIS-VS formed a *Salmonella* Enteritidis working group formed to identify areas in which APHIS–VS should have a role in the prevention and control of *Salmonella* Enteritidis on table-egg farms. This working group identified a need to update the information from the NAHMS Layers '99 study as well as a need for a current estimate of the prevalence of *Salmonella* Enteritidis on table-egg farms.

B. Sampling and Estimation

1. State selection

The goal for NAHMS national studies is to include States that account for at least 70 percent of the animal and farm population in the United States. A total of 19 States were selected for inclusion in the study based upon each State's contribution to the total number of U.S. table-egg operations and the number of laying hens. For the purpose of sampling, Connecticut, Maine, Massachusetts, New Hampshire, and Vermont were considered as one State ("New England"). These 19 States accounted for 76.4 percent of egg farms with 3,200 or more layers,[8] 87.1 percent of hens on farms with 30,000 or more hens, and 77.8 percent of table eggs produced.[9]

2. Farm selection

The Food and Drug Administration (FDA) maintains a list of egg-producing operations with 3,000 or more laying hens that produce eggs for human consumption. A random sample of farms was selected from this list within four size strata (3,000 to 29,999, 30,000 to 49,999, 50,000 to 99,999, 100,000 or more laying hens[9]) in each of the 19 selected States. All organic farms on the list were selected.

3. Population inferences

Estimates infer to the population of farms with 3,000 or more layers registered with the FDA in 19 States. Data were weighted to reflect the population from which they were selected. The inverse of the probability of selection for each farm was the initial selection weight. This weight was adjusted for nonresponse within State and size stratum. All organic farms on the list were selected.

[8]2007 Census of Agriculture (includes table eggs and eggs for hatching).

[9]NASS "Chickens and Eggs" report, January 2009.

C. Data Collection

Veterinary medical officers from USDA–Veterinary Services contacted producers from June 1 to September 30, 2013. Questionnaires were completed via in-person interviews. Questions regarding pullet rearing, *Salmonella* Enteritidis testing, and vaccination were primarily answered by a company representative, while questions relating to day-to-day layer management were primarily answered by farm personnel. Data were collected under the Confidential Information Protection and Statistical Efficiency Act, which assures respondent confidentiality.

D. Data Analysis

1. Editing and estimation

Data were entered into a SAS data set. Validation checks were performed to identify improperly entered data and relational checks. Summarization and estimation were performed using SUDAAN software.

2. Study response

Of the 804 farms selected, 112 (13.9 percent) were ineligible (breeder farms, pullet farms, duplicate farms, etc.). Of the 692 eligible farms, 317 refused participation, 47 were unable to be contacted, and 328 (47.4 percent) participated.

Response category	Number farms
Selected	804
Eligible	692
Not contacted	47
Refusal	317
Participant	328

3. Risk factor analysis

A risk factor analysis was performed at the farm and flock levels. The purpose of the analyses was to identify characteristics associated with farms/flocks environmentally positive for *Salmonella* Enteritidis and farms/flocks environmentally negative for *Salmonella* Enteritidis. Because no small farms tested positive for *Salmonella* Enteritidis, only medium and large farms were included in the analysis. A case farm was defined as a farm with at least one positive environmental test result from June 1, 2012, through May 31, 2013. A control farm was defined as a farm in which all environmental tests from June 1, 2012, through May 31, 2013, were negative.

For the flock-level analysis, the most recent environmentally positive flock was compared with the most recent environmentally negative flock. Case farms contributed data regarding their most recent positive flock. Control farms contributed data regarding their most recent negative flock. For farm-level and flock-level analyses, variables were screened individually via logistic regression, with region as a covariate. Variables with a p-value of 0.25 or less were offered into a backward elimination multivariable logistic regression model. Variables with a p-value of ≤0.10 were retained in the final model.

Appendix I: Sample Profile

A. Size

Number of layers	Responding farms
Fewer than 30,000	114
30,000–99,999	62
100,000 or more	152
Total	328

B. Region

Region	Responding farms
Northeast	129
Southeast	50
Central	98
West	51
Total	328

Appendix II: Number of Farms and Number of Layers

State	No. farms[1,2]	No. table egg layers on hand Jan. 2013 (x1,000)[3,4]
Arkansas	542	3,744
Georgia	506	8,993
North Carolina	435	5,796
Alabama	426	1,468
Pennsylvania	267	23,488
Texas	182	15,021
Ohio	126	27,784
Iowa	104	51,278
Indiana	87	25,549
California	73	18,990
Missouri	62	6,435
Wisconsin	62	4,728
Minnesota	57	9,379
New England[5]	25	5,761
Florida	23	8,070
Nebraska	21	9,221
Illinois	17	3,930
Washington	16	6,464
Michigan	14	12,022
19-State total	3,045	248,121
U.S. total	3,986	284,575

[1] Farms with 3,200 or more layers (including table-egg layers and breeders).
[2]NASS 2007 Census of Agriculture.
[3]On farms with 30,000 or more table egg layers.
[4]NASS Chickens and Eggs report, March 2013.
[5]Connecticut and Maine.

Appendix III: Study Objectives and Related Outputs

1. Update previously collected information on layer farm management practices relevant to *Salmonella* Enteritidis
   - "Part I: Reference of Health and Management Practices on Table-Egg Farms in the United States, 2013," June 2014
   - "Part III: Trends in Health and Management Practices on U.S. Table Egg Farms, 1999–2013," expected September 2014
   - "Part IV: Reference of Organic Egg Production in the United States, 2013," expected September 2014

2. Estimate the prevalence of *Salmonella* Enteritidis on layer farms and investigate risk factors for *Salmonella* Enteritidis
   - "Part II: Control and Prevention of *Salmonella* Enteritidis on Table-Egg Farms in the United States, 2013," August 2014

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