

Salmonella Enteritidis on Table-Egg Farms in the United States

Salmonella Enteritidis is a foodborne pathogen frequently attributed to illness in humans due to eating improperly prepared and/or undercooked eggs. In 2010, the Food and Drug Administration (FDA) implemented the egg safety rule to control *S. Enteritidis* on farms with 3,000 or more birds that produce eggs for human consumption.¹

In 2013, the USDA's National Animal Health Monitoring System (NAHMS) conducted a study of U.S. farms that produce table eggs. A sample of farms with 3,000 or more laying hens was selected from the FDA list of registered egg producers. A total of 328 farms located in 19 States participated in the study (see map). Goals of the study included evaluating potential risk factors for *S. Enteritidis* and identifying management practices used to control the pathogen on-farm.

Layers 2013 study States*



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

Prevention and control

Layers on 89.9 percent of farms had been vaccinated against *Salmonella* as pullets only, and birds on 9.1 percent of farms had been vaccinated against *Salmonella* as pullets and again as layers. Only 1.0 percent of farms had birds that had not been vaccinated as either pullets or 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 (table 1). For about half of farms in which birds had been

¹ CFR, Title 21, Volume 2, Part 118, Production, Storage, and transportation of shell eggs.

vaccinated as pullets, birds had received the first vaccination at the hatchery.

All farms in the Northeast, Southeast, and Central regions and 92.0 percent in the West region (see map) obtained pullets from flocks certified as *S. Enteritidis* clean by the National Poultry Improvement Plan (NPIP). All small farms and medium farms, and 97.4 percent of large farms,² obtained pullets from NPIP *S. Enteritidis* clean flocks.

Overall, 81.9 percent of farms participated in an egg (*S. Enteritidis*) quality assurance program, ranging from 63.1 percent of farms in the Central region to 89.3 percent in the West region (table 2). The majority of farms in the Northeast and West regions participated in a State quality assurance program, while the majority of farms in the Southeast and Central regions participated in a company-sponsored program.

Table 1. 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				Percent farms
1 st vaccine	2 nd vaccine	3 rd vaccine	4 th vaccine	
Live spray	Live spray	Bacterin injection	—	39.0
Live spray	Live water	Bacterin injection	—	9.7
Live spray	Live spray	Live spray	Bacterin injection	8.4
Live spray	Live spray	Live spray	—	7.8
Bacterin injection	—	—	—	3.9
Live spray	—	—	—	3.0
Live spray	Bacterin injection	—	—	2.7
Live water	Live water	Type unknown injection	—	2.4
Live spray	Live spray	Autogenous injection	—	2.1
Any other combination				20.9
Total				100.0

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

² Farm size:
Small (fewer than 30,000 birds)
Medium (30,000-99,999 birds)
Large (100,000 or more birds)

Table 2. Percentage of farms that participated in an egg (*Salmonella* Enteritidis) quality assurance program, by program type and by region

Program type	Percent Farms				
	Region				
	North-east	South-east	Central	West	All
	Pct.	Pct.	Pct.	Pct.	Pct.
State	69.4	8.4	2.2	60.4	44.2
Company sponsored	50.9	77.1	60.4	43.3	54.8
Commodity group (e.g., United Egg Producers)	29.7	60.3	8.1	61.5	30.1
Other (excluding FDA)	0.0	11.4	3.2	1.9	2.1
Any	88.6	93.5	63.1	89.3	81.9

Testing for *S. Enteritidis*

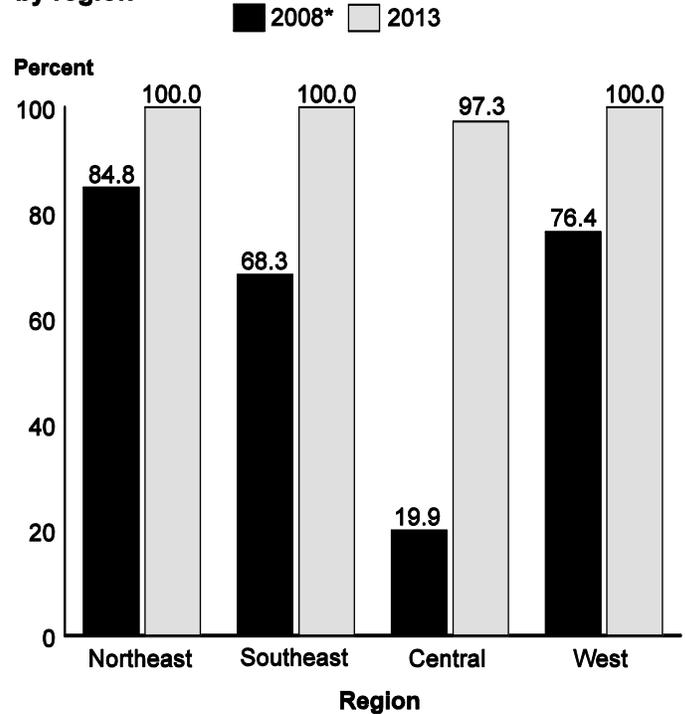
Producers were asked about the routine environmental and egg testing done for *S. Enteritidis* on samples from layer houses at the time of the study and 5 years previously (2008).

The percentage of farms that routinely tested layer houses for *S. Enteritidis* increased from 67.0 percent in 2008 to 99.2 percent in 2013. This increase was particularly notable in the Central region, where in 2008 only 19.9 percent of farms routinely tested for *S. Enteritidis* compared with 97.3 percent in 2013 (figure 1). The FDA egg safety rule requires testing of layer house environments for *S. Enteritidis*; however, farms that only produce eggs for the breaker market are exempt from this testing requirement. Over 9 of 10 farms (92.9 percent) routinely tested layer houses for *S. Enteritidis* when layers were 40 to 45 weeks of age, and 94.8 percent tested the houses 4 to 6 weeks postmolt (for farms that molted). About one-third of farms (31.7 percent) tested after placement but before birds were 40 weeks of age, and 38.0 percent tested at the end of production. Nearly all farms (96.6 percent) tested manure for *S. Enteritidis*; less than 20 percent of farms routinely tested egg belts, elevator equipment, nests, or other samples.

From June 2012 through May 2013, 96.3 percent of farms conducted environmental tests for *S. Enteritidis*, while only 5.8 percent tested eggs. Overall, 1.0 percent of flocks tested were positive for *S. Enteritidis* by environmental sampling, ranging from 0.3 percent in the Northeast region to 2.0 percent in the Central region (figure 2). The Central region was the only region with any positive flocks during summer (June through August). No farms (n=114) with fewer than 30,000 laying hens had any flocks that tested positive for *S. Enteritidis* by environmental testing. Only 1.2 percent of flocks on farms with more than 30,000 laying hens tested positive.

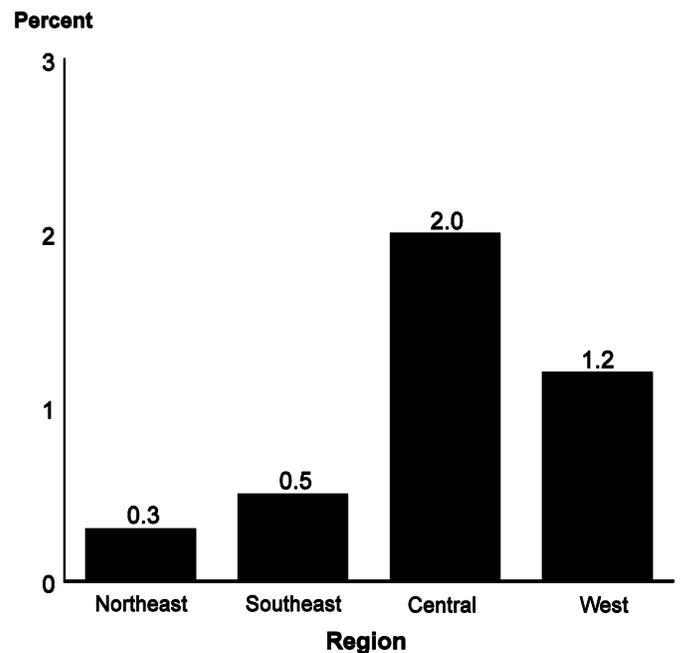
This prevalence estimate is lower than that found in a similar study conducted by NAHMS in 1999. In the 1999 study, 7.1 percent of houses on farms with 30,000 or more laying hens tested positive for *S. Enteritidis*, based on a one-time sampling.

Figure 1. 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.

Figure 2. For flocks that were tested for *Salmonella* Enteritidis by environmental testing, percentage of flocks that tested positive, by region



Risk factors associated with *S. Enteritidis*

Risk factor analysis was performed at the farm level and at the flock level. Results are presented as odds ratios. An odds ratio is the odds that farms or flocks testing positive for *S. Enteritidis* have a certain characteristic compared with farms or flocks testing negative. A case farm was defined as a farm with at least one positive environmental test result from June 1, 2012, to May 31, 2013. A control farm was defined as a farm in which all environmental tests from June 1, 2012, to 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. Because no small farms tested positive, only medium and large farms were included in the risk factor analysis.

Figure 3 and table 3 show characteristics associated with farms that tested positive for *S. Enteritidis*. Compared with negative farms, a higher percentage of positive farms were located in the Central region, had a moderate or high rodent index, routinely molted birds, and had a down-time of 10 days or less.

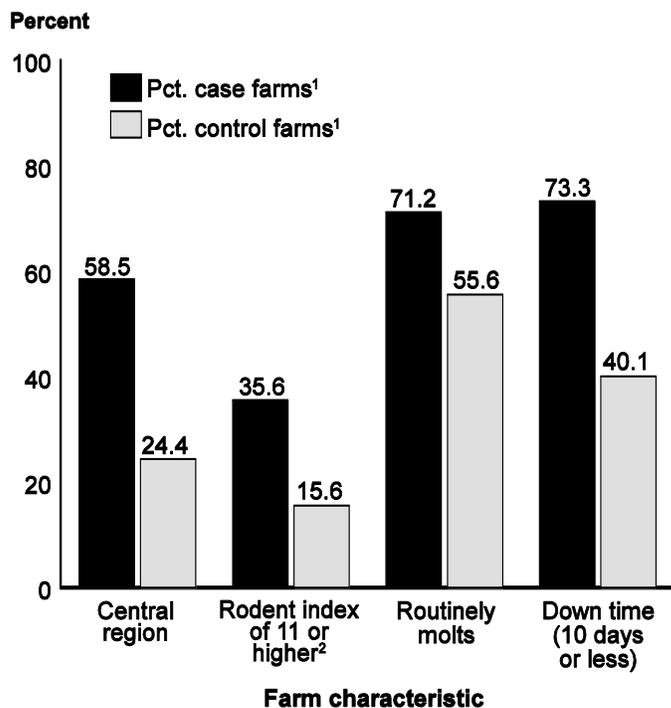
Table 3. For medium and large farms, percentage of case farms and percentage of control farms with the following characteristics

Farm characteristic	Pct. case farms ¹	Pct. 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

¹Farms positive or negative for *S. Enteritidis*.

²Rodent index=number of mice caught per 12 traps in 7 days. 1-10=low; 11-25=moderate, 26+ =high.

Figure 3. For medium and large farms, percentage of case farms and percentage of control farms with the following characteristics



¹Farms positive or negative for *Salmonella* Enteritidis.

²Rodent index=number of mice caught per 12 traps in 7 days: 1-10=low; 11-25=moderate; 26+=high.

Figure 4 and table 4 show characteristics associated with flocks that tested positive for *S. Enteritidis*.

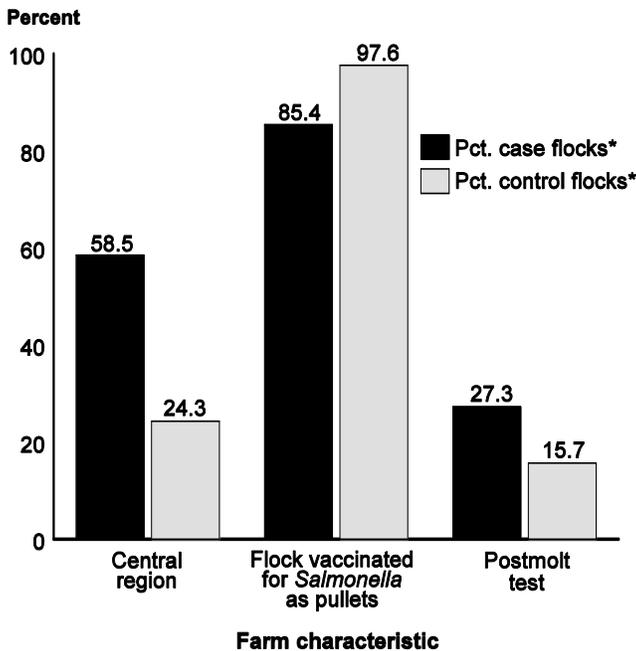
Compared with negative flocks, a higher percentage of positive flocks were located in the Central region and were tested during the postmolt period. In addition, a lower percentage of positive flocks had been vaccinated against *Salmonella* as pullets.

Table 4. For medium and large farms, percentage of case flocks and percentage of control flocks with the following characteristics

Flock characteristic	Pct. case flocks*	Pct. control flocks*	Odds ratio	p-value
Central region	58.5	24.3	8.1	0.002
Flock vaccinated for <i>Salmonella</i> 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 *S. Enteritidis*.

Figure 4. For medium and large farms, percentage of case flocks and percentage of control flocks with the following characteristics



*Flocks positive or negative for *Salmonella* Enteritidis.

Summary

The prevalence of *S. Enteritidis* on table-egg farms has apparently decreased since 1999. The postmolt period presents a higher risk for presence of *S. Enteritidis* compared with other stages of production. Controlling rodents, having a down-time greater than 10 days, and vaccinating pullets against *Salmonella* can reduce the risk of *S. Enteritidis* occurrence on table-egg farms.

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