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7. Farm-Level Costs for Control of *Salmonella enteritidis* in Laying Flocks

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Farm-Level Costs for Control of *Salmonella enteritidis* in Laying Flocks

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Rising incidence of *Salmonella enteritidis* (S.e.)-related foodborne illnesses has been noted not only in the U.S. (Centers for Disease Control and Prevention 1992) but also worldwide (World Health Organization 1989, Rodrique et al. 1990). In the U.S., reported S.e. infections have increased more than threefold since 1975 with a six-fold increase in the Northeastern and mid-Atlantic states (Altekruse 1990, St. Louis et al. 1988). Consequently, Objective 12 of Healthy People 2000 (U.S. Department of Health and Human Services 1991) states as its goal "the reduction of outbreaks to no more than 25 by the Year 2000, using the 77 outbreaks of human S.e. recorded in 1989 as a starting point" (see Table 7.1).

Furthermore, epidemiological evidence has linked a high proportion of S.e.-related foodborne outbreaks to the consumption of Grade A shell eggs (St. Louis et al. 1988, Centers for Disease Control and Prevention 1988, 1990). During 1983 through 1992, 193 (83 percent) of 233 outbreaks with identified food vehicles were associated with shell eggs (Centers for Disease Control and Prevention 1994).

TABLE 7.1 Reported Outbreaks of S.e. Foodborne Illness in the U.S., 1985-1993

Year	Outbreaks	Cases	Number Hospitalized	Deaths
1985	26	1,166	144	1
1986	48	1,539	131	6
1987	53	2,498	523	15
1988	40	1,010	121	8
1989	77	2,394	175	14
1990	70	2,273	288	4
1991	68	2,346	151	4
1992	59	2,748	229	4
1993	63	2,221	216	6
Total	504	18,195	1,978	62

Source: *Morbidity and Mortality Weekly Reports*. 43(No. 36, September 16, 1994):669-671.

As the number of human outbreaks due to *Salmonella enteritidis* increased, increasing pressure was placed by the public and by members of Congress on the U.S. Department of Agriculture to address the issues surrounding the S.e. controversy (Committee on Agriculture 1987). The sharply rising incidence of S.e. resulted in the current USDA S.e. Control ("Traceback") Program initiated in February 1990 in response to the Secretary of Agriculture's declaration of an S.e. emergency situation. Under this program, eggs implicated in reported human S.e. outbreaks are traced back to their flock of origin, and the layers and environment are then tested for S.e. If the flock of origin tests positive for S.e., eggs from that flock are restricted for sale as shell eggs. The producer with an S.e. test-positive flock can either depopulate the flock prematurely and restock with S.e.-negative pullets, or retain the positive flock through completion of its production cycle but divert eggs to the breaking egg market where they are cracked open and pasteurized. Over the first two years of the program, 19 out of 25 laying flocks involved in a traceback were restricted resulting in the voluntary depopulation of 3.1 million birds and the diversion of 1.2 billion eggs (1 percent of total egg production per year of the traceback program).

As discussion of the merits of various control strategies intensified, it became obvious that there was a lack of data and a need for field research on the economic factors influencing farm-level control of S.e. in layers. Subsequently, a field study was undertaken for the purpose of describing: 1) institutional and market factors affecting farm management decisions regarding S.e. control in layer flocks, and 2) producers' costs of control or compliance such as market discounts, labor, materials, and restocking and cleanup costs.

This chapter discusses the farm-level costs associated with the control of S.e. in laying flocks. In particular, producer costs for compliance with the S.e. traceback program are presented. Potential market effects and the ensuing welfare implications of a nationwide S.e. control program are evaluated, applying the farm-level data on additional input costs for controlling S.e.

Farm-Level Costs of S.e. Traceback Program

There are potentially high short-run producer costs associated with either early depopulation of S.e.-positive flocks or diversion of eggs from positive flocks to the breaking egg market. If the producer depopulates, no indemnities are paid and, in addition, the income stream from that flock is lost. Further, there is a good chance that replacement pullets may not be immediately available, adding opportunity costs of idle capital associated with restocking. If the producer opts for diversion, then the premium from selling in the shell egg market is lost. Moreover, eggs from an identified S.e.-positive source are further discounted at the breakers (average 6 cents per dozen discount for known positive eggs) in addition to the standard discount from shell egg prices. The loss in revenue will be inversely related to the age of the flock at restriction. In either case, the producer may further be required to purchase shell eggs in the open market to fulfill existing contracts.

Additionally, affected producers incur the costs of the cleaning and disinfection (C&D) requirements of the regulation with either depopulation or diversion. After compliance with C&D requirements, houses must test negative for S.e. prior to restocking with S.e.-negative pullets. This usually results in additional downtime between flocks over the standard two-week period, so costs due to idle capital increase even more.[2] There are other less obvious costs, such as those associated with liability claims, higher insurance premiums or canceled coverage, loss of consumer confidence, and in unusual circumstances, recalls and bans.

In order to obtain information on the farm-level costs of S.e. control and compliance with the S.e. traceback program, a questionnaire was developed using traditional survey research methods (Rossi et al. 1983). The cost-of-compliance survey was designed to collect data on production and management practices, operating costs, and direct and indirect producer costs associated with S.e. (such as monitoring, prevention, and control; egg marketing and contracting changes; restocking delays; insurance changes; and market discounts).

The reference population was limited to operations of known S.e.-positive status and a particular state with involvement in several tracebacks was selected for questionnaire administration through on-site interview. The final listframe consisted of 7 operations with a total of 12 test-positive flocks. Three of the 7 producers (42.9 percent) agreed to participate, and point estimates before and after traceback were obtained for 5 of the 12 traceback flocks (41.7 percent).

Two of the respondents sold both shell and breaker eggs, while the third sold only in the shell egg market. One firm sold only nest-run eggs while the other two sold both graded and nest-run eggs. Eggs were marketed both directly and through brokers. Replacement practices varied with one producer using a strictly one-molt two-cycle[3] program while the other two ran primarily single-cycle operations. Pullets were housed between 18 to 20 weeks and the typical downtime between flocks was 2 weeks.

Table 7.2 describes several management practices that were notably affected by S.e.-positive status and lists the additional costs associated with S.e. control or compliance with the traceback program. Compliance costs were much affected by the age of the flock at traceback, the number of houses involved in a traceback, the occurrence of multiple tracebacks to the same operation, time lapse between consecutive tracebacks, and the proportion of total egg production sold as shell eggs.

All S.e.-positive laying flocks were in the first production cycle, with the youngest flocks testing positive at 35 weeks of age and the oldest at 70 weeks. The older flocks were depopulated shortly after testing positive. Eggs from the younger S.e.-positive flocks were diverted until the flock was sold nearing the end of the first production cycle (between 68 to 70 weeks of age for all layers from test-positive houses, including those from the one-molt two-cycle operation).

Losses related to diversion and breaker egg discounting varied greatly depending on the number of infected houses, the age of the flock at regulation, the layer replacement program, and the proportion of eggs sold as shell or breaker eggs. For instance, the youngest test-positive flocks (35 weeks of age) were in production for only 13 to 16 weeks and eggs were diverted from these flocks for 33 to 35 weeks. Additionally, the two-cycle operation opted for early replacement of hens, thus losing the 25 to 30 additional weeks of egg production from the recycled hens.[4] The biggest problem facing the producer that depopulated ahead of schedule was replacement pullet availability since as a general practice, scheduling of pullet placements is done 6 months in advance. The three respondents indicated that egg production declined by 5.5 to 15 percent of normal quarterly levels due to empty houses.

Aside from pullet placement constraints, depopulated S.e.-positive houses sat empty for extended periods of time due to increases in downtime of up to 8 weeks. Regulatory protocol requires that environmental test results on the house are S.e.-negative before restocking with pullets, necessitating rigorous cleaning and disinfecting of S.e.-positive houses. If the house tests positive for S.e. after the usual 2-week downtime, it sits empty until retested. When the house tests negative for S.e. and the producer restocks with certified S.e.-negative pullets, then regulatory restrictions on the house are lifted. In 60 percent of S.e.-positive houses in the survey, the average downtime between laying flocks was longer than the standard two-week period because of persistent positive environmental test results. In 30 percent of the houses, downtime extended to an 8-week period before the houses tested S.e.-negative.

All eggs diverted under seal (eggs from known S.e.-positive flocks) incurred an additional discount of 5 to 8 cents per dozen eggs on top of the standard breaker egg discount. For flocks that tested positive at 35 weeks and were depopulated at 70 weeks, a producer could potentially lose between $59,600 to $95,400 per house from the S.e.-positive egg discount alone for a 35-week diversion period.[5] If we assume that the shell egg premium averages 2½ cents per dozen shell eggs, then a producer who sold eggs only to the shell egg market would incur an additional loss of $29,900 in the lost shell egg premiums. Total losses for the 100 percent shell egg producer from breaker egg standard plus S.e.-positive egg discounts are highest ranging from $89,500 to $125,300 per house of 80,000 layers. These

TABLE 7.2 Management Practice Changes and Additional Costs for S.e. Control

Cost-of-Compliance Survey Question	Range of Responses
Number of houses with S.e. (+) status during any one traceback period	1-10 houses
Age of layers at traceback	35-70 weeks
Percent production of the flock at restriction	65-92%
Age of S.e. (+) flock when sold	68-70 weeks
Number of weeks S.e. (+) flock was in production	48-51 weeks
Downtime in S.e. (+) houses	2-8 weeks
Total number of eggs diverted to breakers	1,246.5-487,500 cases
Additional breaker discount for S.e. (+) eggs	< \$0.05-\$0.08 per dozen
Changes in quarterly egg production during the traceback period	< 5.5-15% of normal production
Percent of eggs typically sold to breakers prior to traceback	0-60%
Percent of eggs sold to breakers during the year after regaining S.e. (-) status	60-75%
Additional labor hours during S.e. (+) status:	
Management/field servicemen	0-29 hours/month
Hired labor	0-40 hours/month
Paid consultants	3-20 hours/month
Additional labor costs during S.e. (+) status	\$660-\$1,000 per month
Additional expenses during S.e. (+) status:	
Repairs and maintenance	\$0-\$300 per month
Animal health supplies	\$10-\$400 per month
Miscellaneous supplies	\$0-\$100 per month
Average feed costs per layer prior to S.e. (+) status	\$5.63-\$5.96 per layer (52 weeks)
Average feed costs per layer during S.e. (+) status	\$5.65-\$6.14 per layer (52 weeks)

(continues)

TABLE 7.2 Management Practice Changes and Additional Costs for S.e. Control (continued)

Cost-of-Compliance Survey Question	Range of Responses
Cleaning and disinfecting (C&D) costs:	(per house basis)
Dry cleaning costs	$600-$1,508
Average pressure washing costs	$2,500-$4,000
Fumigation costs	$280-$500
Heat treatment costs[a]	$1,000
Disinfection costs	$225-$800
Cost of S.e. testing in pullets	$0.003-$0.02 per pullet
Cost of environmental testing in layer houses	$200-$250 per house
S.e. vaccine costs	$0-$0.16 per bird
Rodent control costs[a]	$60 per month
Fly control[a]	$210 per month
Feed additive costs for S.e. control[a]	$0.005 per lb. feed

[a]Only one respondent reported using this method and/or incurring this cost.

calculations are not discounted over time. The total number of eggs diverted under seal to the breakers ranged from 1,246.5 cases (30-dozen eggs) for an operation in a single traceback involving one house to 487,500 cases in a multihouse/multiple traceback situation. Thus, in order to minimize their losses, producers have the incentive of voluntary diversion of eggs from non-regulated test-positive flocks. They then incur the standard discount for breaker eggs, but do not bear the added loss of discounting for known S.e.-positive eggs.

There is another cost related to diversion that is not included in these calculations for lack of data. Producers need to keep up with their contracts with brokers or retailers for the delivery of shell eggs. Potential sources for shell eggs to make up the deficit are usually either from within the operation or from the open market. All the respondents reported having to purchase shell eggs in the open market in order to fulfill existing contracts while diverting S.e.-positive eggs to the breakers.

Labor requirements also changed with S.e.-positive status. Increases in labor hours were common to all three firms, mainly in the form of increased management hours and technical services (primarily veterinarian and nutritionist) and additional costs ranged from $660 to $1,000 per month during periods of regulatory involvement. Feed costs increased substantially if feed additives were used as part of the farm's S.e. control program. Feed costs have been known to increase by $5 to $10 per ton of feed with the addition of probiotics, propionic acid, lactobacillus, or a number of other feed additives that have been documented in the biological literature as effective adjuncts in S.e. control. For one producer, feed costs increased by a half-cent per pound of feed ($10 per ton) for augmented feed. Assuming an average feed consumption of 23 pounds of feed per 100 hens per day over a 52-week production cycle, a half-cent per pound increase would raise feed costs by $33,500 per 80,000-layer house.

The cost of a replacement pullet also increased with S.e. testing and certification by an average of 2 cents per pullet. This translates to an increase in replacement costs of $1,600 per 80,000-layer house placement for certified S.e.-negative pullets. If newly placed pullets test positive for S.e., producers can return the birds to the source at no cost. However, if pullets have been placed for a week or more before testing positive, the producer must keep the flock.

Several costs for S.e. cleanup and control were common to all three firms, including dry cleaning, pressure washing, disinfecting, and fumigating costs (referred to as cleaning and disinfecting or C&D costs). On a per house basis, these C&D costs ranged from a total of $3,605 to $6,808. Among the 4 most commonly applied C&D methods, pressure washing constituted the highest and most variable cost share. While the average cost for pressure washing was between $2,500 and $4,000, the actual range of pressure washing costs fluctuated from $2,000 to as high as $10,000 because of repairs and maintenance costs resulting from electrical problems or physical damage to houses from the high water pressure. Heat treatment of houses was only used by one of the three producers.

Although USDA bore the cost of testing under the traceback program, producers reported additional labor requirements during USDA environmental testing of houses ranging from $200 to $250 per house tested. Moreover, pullet testing for S.e. was done by all three operations at a cost of 0.3 to 2.0 cents per pullet.

Other S.e. control measures included the use of S.e. vaccine. The manufacturer's recommendation is to apply the vaccine twice to ensure maximum efficacy, although producers reported between 1 and 2 vaccine applications. Vaccination costs inclusive of labor were $0.12 to $0.16 per bird per application. If vaccination was to be used as recommended (2 vaccine applications per bird), the cost for a typical layer house would range from $19,200 to $25,600 for 80,000 layers.

It was interesting to note that, at the time, only one producer specified rodent control as part of their on-farm S.e. control program, at a cost of $60 per month. Current recommendations consistently emphasize rodent control programs (along with rigorous C&D practices and placement of chicks/pullets of known negative S.e. status) as crucial to any layer S.e. control program at the farm level. Likewise, one producer indicated that fly control was important to their S.e. control program at a cost of $210 per month.

There were other costs associated with S.e. traceback status that varied from one producer to the next. One operation experienced a contracting change after being involved in a traceback and testing S.e.-positive. Although one respondent stated that a breaker had refused to purchase S.e.-positive eggs at one point, producers generally did not have problems getting a breaking egg plant to purchase eggs from known S.e.-positive flocks. However, prices paid for eggs from such flocks were consistently discounted at the breakers.

Two out of three producers changed their insurance coverage as a result of regulatory involvement. Anecdotal evidence indicates that product liability is the most common insurance coverage change since the inception of the S.e. traceback program. One producer was dropped by the insurance company as a direct result of extensive traceback involvement. Two of the three producers were involved in litigation related to S.e.-positive status. None of the producers had bans or recalls imposed on their eggs.

Industry-Level Costs for S.e. Control

The U.S. Food and Drug Administration (FDA) has advocated a nationwide mandatory S.e. control program that would require the testing of all laying flocks, not just those implicated in S.e. food poisoning outbreaks (U.S. Animal Health Association 1989). Under such a mandatory testing and control program as proposed by the FDA, a likely producer response would be to increase S.e. control in order to lower the probability of testing S.e.-positive and thus avoid the potentially high short-run costs of restriction/diversion or depopulation. The imposition of a higher standard of S.e. control could be accomplished by the adoption of some combination of inputs applied to improving S.e. control. In effect, a mandatory S.e. testing and control program will raise sanitary and phytosanitary standards above what the market would otherwise require, and increase the costs of selling eggs in the shell market.

Given the farm-level information on the additional input requirements and costs for S.e. control, a conceptual framework was developed that would allow utilizing the information on farm-level costs to evaluate the effects of an industry-wide policy to control S.e. in shell eggs (Morales 1995). Several assumptions for the multioutput model of shell and breaker egg production are made: 1) a representative agent model is used; 2) shell and breaker eggs are substitutes in demand and supply, thus the respective demand and supply curves are conditioned on the other market's price; 3) given the nature of the survey data, the control program effect is incorporated via an S.e. regulatory input price per unit of shell egg output, enabling a taxlike representation of the S.e. program effect; 4) a nationwide testing and control program for S.e. would increase the marginal costs of selling in the shell egg market, shifting shell egg supply back in the aggregate; and 5) policy effects would spill over into the breaker egg market, since shell and breaker eggs are highly substitutable in supply.

Simultaneous equations systems for the supply and demand equations of shell and breaker eggs were estimated using time series data and correcting for autocorrelation. Estimated supply and demand elasticities were used to simulate the welfare effects of the control program (Morales 1995).[6] Note that this model accommodates diversion in its cost accounting of the effects of a nationwide control program through the cross-price supply elasticity and spillover effects into the breaker market.

In order to arrive at a cost estimate of additional input requirements for S.e. control per unit output (dozen eggs), the survey information was used to determine certain control methods and practices that might be instituted by the industry as a whole should a nationwide mandatory S.e. control program be set in place. Table 7.3 presents a list of potential control methods that producers might adopt if an industry S.e. control program was instituted with their corresponding costs based on the survey data.

TABLE 7.3 Cost Estimate of Selected Input Requirements for S.e. Control and Prevention

Control Method	Cost of Control
Environmental testing	0.25-0.31 cents per layer/year
Fumigation	0.4-0.5 cents per layer/year
Pressure wash	3.5-4 cents per layer/year
Clean & disinfect	0.5-1.8 cents per layer/year
Labor/supplies	1.7-2.0 cents per layer/year
Pullet testing	0.3-2.0 cents per layer/year
Rodent control	9.0 cents per layer/year
Total cost per layer	15.65-19.61 cents
Total cost per dozen eggs	0.745-0.981 cents (assumes 20-21 dozen eggs per layer/year)

TABLE 7.4 Distributional Effects of an Industry-Wide S.e. Control Program Assuming Additional S.e. Input Requirement Costs of 1 Cent Per Dozen Eggs (Million Dollars Per Year)

	Consumer Surplus			Producer Surplus			Net Change in Surplus
	Shell	Breaker	Total	Shell	Breaker	Total	
Short Run	-6.678	4.241	-2.437	-40.629	-4.251	-44.879	-47.317
Medium Run	-17.912	2.243	-15.669	-21.498	-2.248	-23.747	-39.416

Some practices and methods that were common to the producers surveyed or that seemed to be reasonable input requirements for the control of S.e. at the farm included several C&D methods, additional labor and supplies associated with S.e. cleanup, pullet and environmental testing, and rodent control. The range of costs of these practices and control methods were converted to a per layer cost, on the basis of a typical house of 80,000 layers. While forced molting can be used to induce up to three production cycles, the single cycle (52 weeks) is the most common production method practiced by the industry, followed by the one-molt two-cycle method. The three-cycle two-molt practice is extremely limited. For this reason, the S.e. control costs were then framed within the single-cycle time span.

Based on the selected subset of control methods, total cost of the additional input requirements for S.e. control is in the range of 15.65 to 19.61 cents per layer.[7] Assuming that hens lay between 20 to 21 dozen eggs in a 52-week production cycle, then the additional cost of S.e. control per dozen eggs will lie between 0.745 to 0.981 cents per dozen eggs.

Using a representative figure for the additional cost of S.e. control of 1 cent per dozen eggs, the distributional welfare effects on the shell and breaker egg markets can be broken down as shown in Table 7.4. Notice that, in the short run, the producer and the shell egg market bear most of the program costs. Consumers gain in the breaker egg market because of the price decline as consumers shift from shell to breaker eggs. However, the gain in the breaker market is offset by the consumer loss in the shell egg market where prices increase. As length of run increases, there is a redistribution of welfare effects with the burden being shared more evenly between consumers and producers in the shell egg market. One would expect that, in the long run, the burden of the program costs will be borne entirely by consumers.

Summary

Costs associated with S.e. regulatory activity varied considerably among producers, depending on whether the facility was involved in single versus multiple tracebacks, on the number of houses involved and the corresponding proportion of layers affected, on the age of the layers, and on the ratio of shell to breaker eggs sold. Not only were producer costs substantial, but government costs were likewise incurred.

Certain control methods and costs appeared to be commonly incurred by producers who were involved in regulatory activity. Using this information, a regulatory input cost per unit of output was calculated and applied to simulate the equilibrium effects of an S.e. control program on the egg industry.

As regulatory programs evolve that are more suitable to current industry situations, the cost estimate of the additional input requirements for S.e. control and prevention can be recalculated and reapplied to the simulation model (Morales 1995).

As with any food safety regulation, the primary goal of an S.e. control program is the reduction of the number of S.e. illnesses in humans. The benefit that would result from the reduction of illness would range from the abatement of productivity loss, medical expenses, pain and suffering, and death. Therefore, it is necessary to put such control program costs into perspective.

The average number of cases of foodborne illness due to S.e. from 1990 through 1993 was 2,511. If we assume that 83 percent of those cases involved shell eggs (Centers for Disease Control and Prevention 1994), then 2,008 of those S.e. foodborne illnesses could be linked to shell egg consumption. An average cost of a case of salmonellosis (accounting for medical costs and productivity losses) is $850 (USDA Food Safety and Inspection Service 1995). Assuming that the average cost of a case of S.e. food poisoning is equal to that of a case of salmonellosis, then the cost associated with 2,008 cases of S.e. food poisoning due to shell eggs would be in the range of $1.7 million. The Centers for Disease Control and Prevention estimate that one in 50 cases of salmonellosis is reported (Morris Potter 1994, Personal Communication). This implies that the cost of S.e. illness could be close to $85 million. This compares to a cost of $40 to $50 million for an S.e. control program that increases input costs by 1 cent per dozen eggs, exclusive of government program costs.

Finally, there are also potential benefits of a control program to producers. Those producers who are not under regulation could stand to profit in the short-run, not only because they incur no regulatory costs, but also because prices for their output would rise. Further, unaffected producers share in reputational benefits from being part of a quality controlled industry. The benefits to the industry of providing consumers with the perception that the regulation is effective could translate into stable or even increasing demand for shell eggs.

Notes

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[2]Downtime is a term used to refer to the period of time when a house is empty prior to restocking with new birds, typically a 2-week interval. During this 2-week period, layer houses and equipment are cleaned, disinfected, and aired out according to standard sanitation practices.

[3]The first production cycle begins when pullets are 20 to 21 weeks of age and continues through 72 to 78 weeks of age. One-molt two-cycle programs extend the productive life of a flock by an additional 25 weeks or so beyond the first production cycle.

[4]The lost income stream from eliminating the second production cycle by early replacement is offset to some extent since variable costs for that flock (particularly feed) have been truncated. Further, the income stream from the new flock moves up in time, assuming minimal restocking delays.

[5]These cost estimates assume that an average hen will lay 0.71 to 0.75 eggs per day and that a typical laying house holds 80,000 layers.

[6]Estimated own-price demand elasticities for shell and breaker eggs are -0.140 and -0.107, respectively. Short-run estimated own-price supply elasticities for shell and breaker eggs are 0.137 and 0.657, respectively. The cross-price supply elasticity (which determines the spillover effect in the breaker market) is -0.517 in the short-run and -0.478 in the medium-run.

[7]The cost estimate can be modified as data on more effective control methods becomes available or as regulatory activity evolves. For instance, several states are now developing so-called quality assurance programs coordinating the activities of federal and state regulatory agencies and local egg producers. These programs generally recommend pullet testing and placement of certified S.e.-negative chicks/pullets, environmental testing, bio-security (which includes C&D methods), rodent and pest control, and refrigeration of eggs.

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