Available online at www.sciencedirect.com
SCIENCE DIRECT®
Food Control 15 (2004) 359–367
FOOD CONTROL
www.elsevier.com/locate/foodcont

Understanding the characteristics of US meat and poultry recalls: 1994–2002

Ratapol Teratanavat, Neal H. Hooker *

Department of Agricultural, Environmental, and Development Economics, The Ohio State University, 323 Agricultural Administration Building, 2120 Fyffe Road, Columbus, OH 43210-1067, USA

Received 27 March 2002; received in revised form 5 May 2003; accepted 6 May 2003

Abstract

The characteristics of US meat and poultry recalls between 1994 and 2002 are examined and the public health implications of these trends highlighted. Most recalls involve the most serious health consequences, including Class I and biological hazards. Numbers of recalls as well as the total amount in pounds have continually increased since 1997. This may be explained by improving inspection methods for detecting microbial pathogens, greater consumer awareness, and/or better surveillance of foodborne illnesses. To guarantee public health, it is important that problems are discovered as early as possible and all affected products are removed from the market.

Keywords: Food safety; Meat and poultry recalls; Policy effectiveness

1. Understanding the characteristics of US meat and poultry recalls: 1994–2002

Meat and poultry recalls have received heightened public awareness over recent years, following large incidents of recalls of more than 10 million pounds each year since 1997 (Table 1). Most recently in 2002 nearly 19 million pounds of ground beef possibly contaminated with *E. coli O157:H7* and 27.4 million pounds of chicken and turkey products that might be contaminated with *Listeria monocytogenes* were recalled. The Food Safety and Inspection Service (FSIS) of USDA is the main regulatory agency responsible for the safety of meat and poultry products and provides recall information to the public. In 1998, FSIS evaluated its' recall policy and developed recommendations to improve the process through reducing communication problems between the agency, firms, and related parties and maximizing product recovery (Axtell et al., 1998). Despite FSIS's efforts, whether the recall process has improved and foods have become safer for consumers over time continues to be debated. It is of interest to understand the characteristics of US meat and poultry recalls and to examine changes in recall events over the past several years.

A food recall, a good example of a joint risk management and communication tool, is an action taken voluntarily by food manufacturers or distributors after they determine independently or are informed by a government agency of the possibility of negative health concerns for consumers from eating their products (FSIS, 2002d). The purpose of the recall is to effectively remove meat, poultry, or egg products which are believed to be adulterated or misbranded from commerce. The US government has emphasized a risk analysis approach consisting of risk assessment, risk management and risk communication, in order to ensure the safety of the food supply (FDA, 2000). Risk assessment is the first step of the approach, and includes hazard identification, hazard characterization and exposure assessment. The other two tools are risk management and risk communication. Risk management includes the Pathogen Reduction (PR)/Hazard Analysis Critical Control Point (HACCP)-based program and risk communication is mainly involved with providing protection tools for consumers and other agents in supply chains (FDA, 2000; Woteki, 2000).

The voluntary nature of the process is the main difference between food recalls conducted by manufacturers

* Corresponding author. Tel.: +1-614-292-3549; fax: +1-614-247-7066.
E-mail address: hooker.27@osu.edu (N.H. Hooker).

0956-7135/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0956-7135(03)00098-7

Table 1
Recall incidents with more than 10 million pounds

Year	Recall sizes (pounds)	% of total pounds for the year	Company	Products	Problems
1997	25,000,000	88	Hudson Foods	Ground beef	*E. coli* O157:H7
1998	35,000,000	76	Bil Mar Foods	Hot dogs/packaged meats	*L. monocytogenes*
1999	35,000,000	88	Thorn Apple Valley	Frankfurters & lunch combinations	*L. monocytogenes*
2000	16,895,000	74	Cargill Turkey Products	Ready to eat turkey & chicken products	*L. monocytogenes*
2001	14,600,000	46	Bar-S Foods Company	Various meat products	*L. monocytogenes*
2002	19,000,000	32	ConAgra Beef Company	Fresh ground beef	*E. coli* O157:H7
2002	27,400,000	47	Pilgrim's Pride Corp. (Wampler Foods)	Fresh and frozen ready to eat turkey and chicken products	*L. monocytogenes*

and detention or product seizure enforced by FSIS (FSIS, 2000a). Food recalls also differ from market withdrawals and stock recovery, where these two actions do not involve products that are adulterated or misbranded; the main reasons that food products are recalled (Axtell et al., 1998; FSIS, 2000a). A market withdrawal is a voluntary removal of food products that do not violate the acts enforced by FSIS. A stock recovery is a voluntary removal of products that have not been distributed. FSIS and the Food and Drug Administration (FDA) are the two main federal agencies that are involved with food product recalls (FSIS, 2002d). FSIS emphasizes the safety of domestic and imported meat, poultry and related products, and processed egg products including liquid, frozen and dried pasteurized eggs. These products have a total annual retail value of $120 billion (FSIS, 2001). FDA regulates all other food products. This report focuses on meat and poultry recalls using FSIS data, in which these products primarily violate one or more provision of the Federal Meat Inspection Act (FMIA) or the Poultry Products Inspection Act (PPIA) [1] (Axtell et al., 1998; FSIS, 2000b).

Recall actions are mostly initiated either by food manufacturers or at the request of FSIS. Although firms are not required to inform FSIS of a problem, they are encouraged to do so. There are many ways that FSIS receives information about food safety problems, including consumer complaints, reports from food manufacturers, or sampling inspection results taken by firms, FSIS itself, or other state or federal agencies. After thoroughly assessing the hazards and identifying products and amounts to be recalled, FSIS will notify food companies to withdraw those products from the market (FSIS, 2000a). FSIS will also oversee the overall recall process to ensure that unsafe products are indeed being removed from the market. Upon determining that all firms involved have made all efforts FSIS will evaluate if the recall can be terminated (Axtell et al., 1998).

Related research evaluating meat and poultry recalls include Salin and Hooker (2001) and Thompson and McKenzie (2001) who studied the effect of meat and poultry recalls on firm's stock price, market return and societal reactions. Anderson, Murray, Teague, and Lindrooth (1998) and Muth, Karns, Wohlgenant, and Anderson (2002, 2003) discuss the impact of PR/HACCP based programs on the entry, exit, and survival rate of meat and poultry plants. The US General Accounting Office (GAO) (2000) also examined recalls and associated outbreaks of foodborne illnesses, as documented by USDA and FDA since 1984. The objective of this paper is to conduct exploratory research in an attempt to understand the key characteristics of US meat and poultry recalls. This study provides descriptive statistics of recall cases and information about recalled products, firms involved, how problems were discovered, and the depth of recalls. In addition, recall trends from 1994 through 2002 are analyzed and implications for public health and policy effectiveness forwarded.

2. Methods

Information about recalled products are contained in recall summaries, press releases, and Recall Notification Reports (RNR), maintained and updated by FSIS on their website http://www.fsis.usda.gov/oa/recalls/rec_intr.htm. The data from 1994 to 2000 used in this study are based on recall summaries, containing information about dates, identifying codes, company names, location where the report of incidents took place, products, reason and description, and size of recall and recovery in pounds. FSIS started to provide recall information in a single format—RNR—in 1998 and required all firms involved to issue a press release for all recall cases from 2000. The RNR and press release contain the same information provided in the report summary with the

[1] FSIS administers the Egg Products Inspection Act (EPIA) when inspecting egg products. FSIS's database does not include recalls of egg products.

addition of production date, how problems were discovered, distribution level, and depth of recall. Since recall summaries are available only until 2000, the data for 2001 and 2002 are based on the RNR and press releases. Information from these two sources was combined with the recall summary data for 1998–2000.

Recall data are grouped by year that recalls occurred, enabling the comparison of characteristics over time and the observation of changes in recall trends. This analysis includes recall class, hazard type, product type, shelf life, whether product is imported, reasons for recall, firm size, and total amount of recalled product. The analysis of recall trends describes changes over time in numbers of recall incidents, recovery rates, time until the problem was discovered, and how the problem was discovered.

Descriptions of recall class, hazard type, and plant sizes are shown in Appendix A. Recalled products are also grouped into four main categories including beef, poultry, pork, and others. Others include salami, pizza, sausage (no specific ingredient), salad, and soup. Product shelf life is divided into fresh/raw food and processed/cooked food. Whether recalled products are produced in the US or imported from other countries is also included. Reasons for the recall are grouped into five main categories; bacterial contamination, extraneous material, undeclared ingredients, under processed, and others including products illegally imported to the US or un-inspected products. Pathogens that led to the recalls are described.

Four main categories explore how problems are discovered leading to product recalls, including regular sampling tests by FSIS, microbiological testing results or product inspection by firms, consumer complaint reports, and others (GAO, 2000). Others include results from epidemiological tests by the Centers for Disease Control and Prevention (CDC), reports from state health departments, FDA, and reported foodborne illnesses. The notification level identifies the depth of recalls, including consumer, retail, user, and wholesale level (FSIS, 2000a). The FSIS data also includes the amount (in pounds) of meat and poultry products that have been recovered through the recall. The amount recalled is defined as the amount of affected product less the unshipped amount in the warehouse, which is still under the control of the company (Axtell et al., 1998). The recovery rate is defined as the percentage of recall volume retrieved by food manufacturers. Finally, the period between production date and problem discovery date is reported.

3. Results and discussion

The characteristics of meat and poultry recalls are relatively consistent during 1994–2002; thus this analysis is based on the average data over the 9 years. Any differences among the years will be noted. From Fig. 1 it can be seen that, almost three-quarters of all recall cases were Class I. Class II recalls account for 18%, whereas 8% of the incidents were Class III. Regarding foodborne hazards, biological or bacterial contamination have consistently been the major reason with an average of 69%; chemical and physical hazards have been less prevalent, accounting for 15% and 16% of all recall cases respectively. Most recalled products involve Class I and biological hazard implying that FSIS have emphasized its food safety policy on inspecting and regulating those risks with the most serious health consequences. This result is consistent with the risk analysis framework, which allows regulatory officials to focus their limited

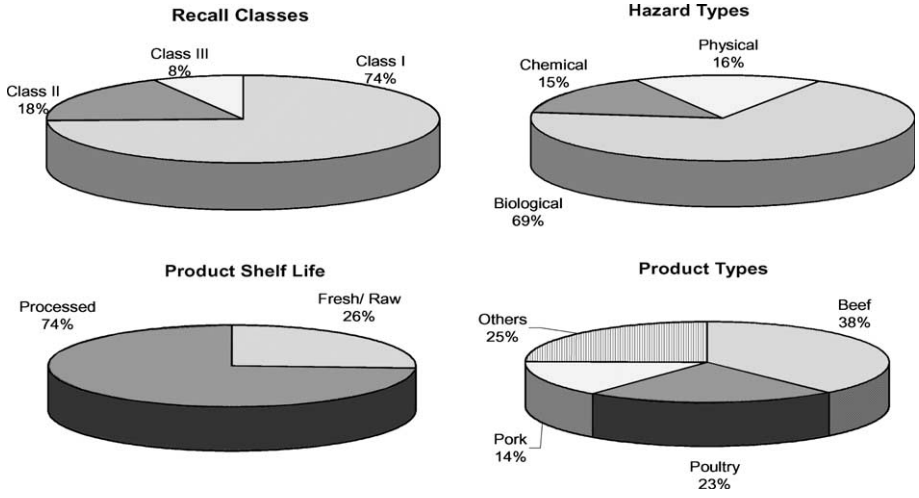

Fig. 1. Characteristics of recalls by product specific categories. Note: Other meat and poultry products include salami, pizza, sausage (no specific ingredients), and soup.

resources on those hazards that pose the greatest risk to public health (FSIS, 2003).

Many varieties of meat and poultry products are found in the recall data. Almost 40% are beef products, with poultry products including chicken, duck and turkey accounting for 23% and pork and ham products 14%. The remaining 25% are other products inspected by FSIS such as soup, pizza, ravioli, and mixed salads. Approximately 74% of all recalls are processed/cooked food, whereas 26% is fresh/raw product such as uncooked ground meat.

Considering the reasons meat and poultry products were removed from the market, the data from 1994 to 2002 (Table 2) shows that bacterial contamination is the main reason. The four most common pathogens associated with meat and poultry products are *Campylobacter jejuni/coli, E. coli* O157:H7, *Salmonella*, and *L. monocytogenes* (FSIS, 1998b). Of these cases, the most frequently cited pathogens are *L. monocytogenes* and *E. coli* O157:H7, whereas the other two pathogens that are commonly associated with meat and poultry products, *Campylobacter jejuni/coli* and *Salmonella*, are found infrequently in these recall cases. These incidents have prompted FSIS to take action adopting new measures to improve the detection of *E. coli* O157:H7 in ground beef and *L. monocytogenes* in ready-to-eat meat and poultry products with the goal of minimizing contamination from such pathogens (FSIS, 2002b; FSIS, 2002c). Other reasons for product recalls include extraneous materials (18%), undeclared ingredients and mislabeling (14%), and under-processed (10%).

In 1999, the US imported 3.38 billion pounds of raw and cooked meat and poultry products, accounting for less than 10% of the domestic meat supply (FSIS, 2000c). Over 90% of recalls are products that are produced and marketed within the US, with only a few cases each year where the recalled products are imported (Table 3). This percentage is proportional to the amount of imported goods relative to all meat and poultry consumption. The only exception is 2001, when there were 11 cases involving imported products; nonetheless, 10 of those imported products came from the same Brazilian producer over this period. Most of the imported products that are recalled originate in Canada, the largest trading partner for meat and poultry. Other countries that have had some of their products recalled include Israel, Brazil, Spain, Mexico, Croatia, the Netherlands, Denmark, the Dominican Republic and Puerto Rico. Imported products must come from slaughter or processing plants in countries which have *equivalent* food safety systems (FSIS, 1998a). In 2002, 35 countries were eligible to export meat and poultry products to the US (FSIS, 2002a).

The number of large plants recalling product has been relatively constant, less than 20 cases each year, although the relative proportion of overall cases has been declining since 1999 to 17% (Table 3). The number of recall cases arising from small and very small plants, however, has increased since 1997, when USDA started to implement PR/HACCP. Starting January 27, 1997, FSIS required all meat and poultry plants to have written Sanitation Standard Operation Procedures (SSOPs) and to test for generic *E. coli* O157:H7 (FSIS, 1998b). This result may indicate that once the PR/HACCP based system was in place, FSIS was able to strengthen its' food safety oversight in smaller sized plants.

The size of recalls ranges from few pounds to several millions of pounds. Focusing only on the average amount may result in misinterpretation; thus to further consider the size of the recalls, the data are divided into four groups, small (<10,000 pounds), medium (10,000–

Table 2
Reasons for meat and poultry recalls

Year	Bacterial contamination						Extraneous materials, chemical[a]		Undeclared ingredient, mislabeling		Under-processed		Others[b]	
	Listeria	*E. coli*	*Salmonella*	Others[c]	Total									
	No.	No.	No.	No.	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1994	17	3	0	3	23	(46)	16	(32)	1	(2)	7	(14)	3	(6)
1995	11	5	2	2	20	(48)	13	(31)	1	(2)	7	(17)	1	(2)
1996	6	2	1	1	10	(42)	5	(21)	3	(13)	6	(25)	0	(0)
1997	3	6	1	5	15	(56)	8	(30)	4	(15)	0	(0)	0	(0)
1998	7	13	2	2	24	(55)	11	(25)	4	(9)	5	(11)	0	(0)
1999	30	10	6	0	46	(74)	3	(5)	8	(13)	4	(6)	1	(2)
2000	36	20	4	0	60	(79)	5	(7)	9	(12)	2	(3)	0	(0)
2001	25	26	2	0	53	(56)	11	(12)	24	(26)	6	(6)	0	(0)
2002	40	24	4	0	68	(60)	4	(4)	36	(32)	4	(4)	1	(1)
Avg.						(57)		(18)		(14)		(10)		(1)

[a] Extraneous materials include glass, plastic, chemical compounds, metal, drugs, and bone fragments.
[b] Other recall reasons include illegally imported to the US and un-inspected products.
[c] Other bacterial contamination includes non-specified pathogens.

Table 3
Recall data by domestic plant sizes and origin

Year	Plant sizes								Origin			
	Large		Small		Very small		No information available		Domestic		Import	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1994	13	(28)	29	(62)	3	(6)	2	(4)	47	(94)	3	(6)
1995	8	(23)	15	(43)	7	(20)	5	(14)	35	(83)	7	(17)
1996	5	(24)	10	(48)	5	(24)	1	(5)	21	(88)	3	(13)
1997	11	(44)	9	(36)	2	(8)	3	(12)	25	(93)	2	(7)
1998	17	(43)	17	(43)	3	(8)	3	(8)	40	(91)	4	(9)
1999	10	(17)	29	(50)	17	(29)	2	(3)	58	(94)	4	(6)
2000	13	(18)	40	(56)	19	(26)	0	(0)	72	(95)	4	(5)
2001	15	(18)	38	(46)	21	(25)	9	(11)	83	(88)	11	(12)
2002	18	(17)	49	(45)	26	(24)	16	(15)	109	(96)	4	(4)
Avg.		(26)		(47)		(19)		(8)		(91)		(9)

Note: Lists of domestic federally inspected plants of different sizes taken from Field Automation and Information Management (FAIM), FSIS.

100,000 pounds), large (100,000–1,000,000 pounds), and very large (>1,000,000 pounds). As shown in Fig. 2, approximately 55% of all cases recall less than 10,000 pounds, whereas 24% and 17% of cases are medium and large. Even though only few cases (<4%) each year involved more than 1 million pounds of meat and poultry products, these cases account for more than two-thirds of total amount of product recalls (Table 1). Considering the depth of recall, cases include those which notify consumers directly (37%) and users including restaurants, hotels, and other food service firms (33%). Approximately 25% of recall cases notify retail stores, whereas 5% only notify wholesalers.

Numbers of recall incidents and the total amount of product recalled have been increasing since 1997, as shown in Fig. 3. The significant increase in the number and volume of recalls since 1997 is likely due in part to the improvement of FSIS's monitoring system, enhanced communication among all parties, better capabilities for detection, and PR/HACCP implementation (Shiptsova, Thomsen, & Goodwin, 2002). This can be shown from the increasing trends in problems detected by FSIS and firms and decreasing trends in consumer complaints or incidences from foodborne illness or reports from health departments (Table 4). In 2002, 63% of recall cases were discovered by FSIS through regular sampling, whereas 27% was detected by firms then reported to FSIS and 5% was initiated from customer complaints. A few cases were linked to epidemiological testing by CDC, reports about hazards, and outbreaks determined by state and local health departments. Products are occasionally held by plants for inspection prior to shipment to market. If the tests are found to be positive, these products will be discarded voluntarily by firms. If these products are to be included as recall cases, the total amount of food recalls reported herein may only provide a lower bound.

The total volume withdrawn from the market was approximately 4–5 million pounds in 1994 and 1995, before falling to about 1 million pounds in 1996. Since 1997, the volume of meat and poultry recalls has increased significantly to more than 20 million pounds a year. The highest amount to date was recorded in 2002 with approximately 58 million pounds. National Agricultural Statistical Services (NASS) data reports that annual meat and poultry production is over 40 billion

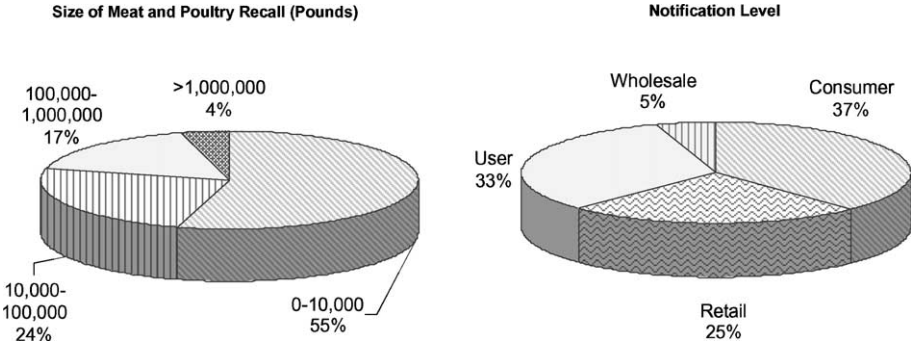

Fig. 2. Size of recalls (pounds) and notification level.

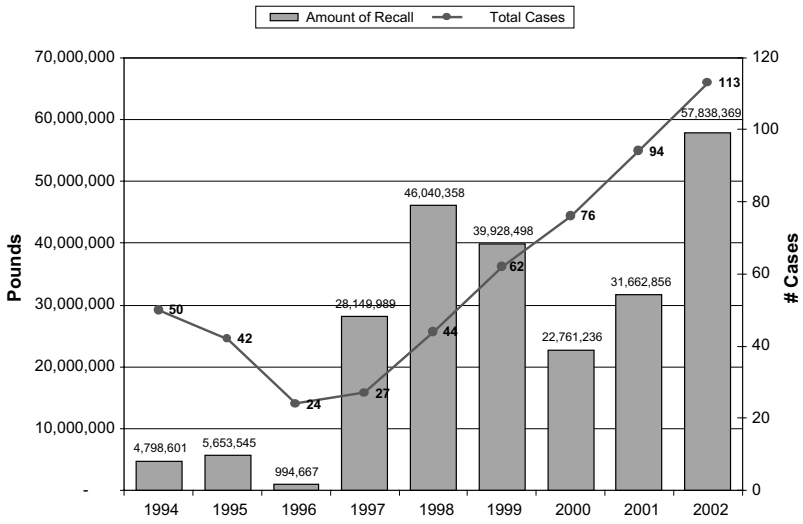

Fig. 3. Recall cases and total amount in pounds: 1994–2002.

Table 4
Recall cases grouped by how problems were discovered

Year	Detected by FSIS		Detected by firm		Customer complaint		Others[a]	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1998	15	(34)	3	(7)	9	(20)	17	(39)
1999	41	(66)	8	(13)	7	(11)	6	(10)
2000	53	(70)	9	(12)	5	(7)	9	(12)
2001	60	(64)	26	(28)	4	(4)	4	(4)
2002	71	(63)	30	(27)	6	(5)	6	(5)

[a] Others include results from epidemiological tests by CDC, reports from state health departments, FDA, and reported foodborne illnesses.

pounds (NASS, 1995–2002), which implies that the recall amount is generally less than 0.1% of the total meat and poultry production each year in the US. This small percentage however cannot be overlooked. Instances of foodborne illnesses and related deaths still occur every year. According to CDC, contaminated foods cause an estimated 76 million illnesses in the US each year, including 325,000 hospitalizations and 5,000 deaths (CDC, 2000).

During a meat and poultry recall, FSIS attempts to protect the public health by ensuring that potentially hazardous foods are removed from commerce as quickly as possible. The agency closely monitors the effectiveness of the firm's recall procedures and provides scientific and technical advice (FSIS, 2002d). This process is dramatically enhanced when the problem is discovered as early as possible ensuring all potentially unsafe products are removed from the market.

The examination of time until the problem was discovered is shown in Table 5. There is a relatively consistent pattern over the time period 1998–2002. On the average 62% of all recall cases were discovered

Table 5
Descriptive statistics for time until problems were discovered (days)

Year	Average	Standard deviation	Numbers of recall cases (%) when problems were discovered				
			Less than 1 month	Between 1 and 3 months	Between 3 and 12 months	More than 1 year	N/A
1998	59.83	78.24	20 (45%)	8 (18%)	8 (18%)	0 (0%)	8 (18%)
1999	45.38	50.64	38 (61%)	11 (18%)	11 (18%)	0 (0%)	2 (3%)
2000	34.88	57.59	54 (71%)	12 (16%)	6 (8%)	0 (0%)	4 (5%)
2001	76.95	120.52	51 (54%)	19 (20%)	15 (16%)	2 (2%)	7 (7%)
2002	66.17	128.39	64 (57%)	25 (22%)	17 (15%)	4 (4%)	3 (3%)

Note: N/A refers to cases where production dates are not available.

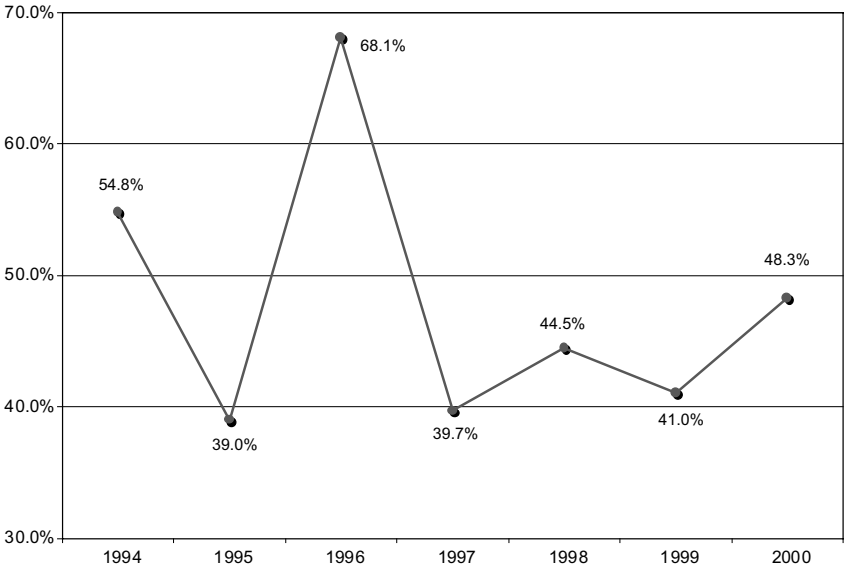

Fig. 4. Average recovery rates: 1994–2000. Note: Average recovery rates in 1996, 1997, and 1998 do not include those cases where recovery rates are greater than 100%. The information on recovery (in pounds) is not yet available for 2001 and 2002.

during the first month after products were manufactured or packed. In addition 20% were found within the first 3 months, whereas only a few cases reported problems that were discovered one year after the production date. Although it is shown that most problems are discovered within a short period, an improvement in problem discovery may still be necessary because there are many cases where it takes more than a month to one year to find the problem. The longer it takes to discover the problem, the less likely that the affected products will be recovered from the market.

The recovery rate plot indicates that only half of affected products are recovered on average (Fig. 4). There are a few cases during this period where the actual amount recalled or total recovery size outnumbers the initial amount FSIS listed in recall announcements. Without these extreme cases the average recovery rate varied from 39% to 68%. There is no clear pattern whether the recovery rate is increasing or decreasing during this period.

According to the Recall Policy Working Group, four factors affect the amount of product recovered from the recall: time before discovery of the problem, shelf life, identification of consignees and sub-consignees, and communication difficulties (Axtell et al., 1998). In order to increase the recovery rate, FSIS has determined that it is unlikely to accelerate the discovery of the problems or to change product shelf life. FSIS, as a result, has focused on facilitating identification, tracking of recalled products, and minimizing any risk communication difficulties. However, despite the heightened efforts of FSIS (e.g., PR/HACCP), this study shows no clear result as to whether the agency has been successful in increasing the amount of product recovered by plant size and recall class. Plants operating in a PR/HACCP environment may be more likely to discover food safety problems; nevertheless, there is no sign that this food safety program facilitates the recall process or sufficiently resolves risk communication problems to achieve a 100% recovery rate.

On its own, the current recall data, with the total number of cases, volumes, recovery rates, and time until problems were discovered is not sufficient to evaluate the effectiveness of recent food safety policy such as PR/HACCP. Further study is needed to incorporate the impact of all costs and benefits of having products recalled and recovered. The recall data from FDA and other nations, in particular the Canadian Food Inspection Agency must be included to study the effectiveness of food safety policy for all food products and to compare policy between the US and Canada, our major trading partner for meat and poultry products. In addition, the FSIS recall data needs to be updated regularly to track the impact of PR/HACCP. Detailed analysis of how the recovery rate varies among plants, recall classes, sizes, and date of PR/HACCP implementation should be included. The recall cases after full implementation are of most value because the current data primarily explains events before (1994–1996) and during (1997–2000) the policy implementation period. By having a similar period after implementation (2001–2003), better conclusions can be drawn whether product recalls, as one indicator within a larger ex post evaluation, can be used to assess the effectiveness of the PR/HACCP program.

4. Conclusion

Product recall is considered a tool (of last resort) to prevent unsafe product from reaching consumers. FSIS has orientated its' food safety policy towards inspecting and regulating those risks with the most serious health consequences, Class I and biological hazards. Numbers of US meat and poultry recalls as well as the total amount in pounds have increased since 1997. Such increases can be explained by more sensitive and rapid methods adopted by firms for detecting microbial pathogens, greater consumer and media awareness, and/or better surveillance and epidemiological studies of foodborne illnesses. During the recall process, to guarantee the safety of public health, FSIS must ensure that the problem is discovered as early as possible and all affected products are removed from the market.

Appendix A. Descriptions of recall characteristics: recall class, hazard type, and plant size

Category	Description
Recall class	FSIS groups food recalls into three classes including Class I, II, and III depending on the potential adverse health consequences (FSIS, 2002d).
Class I	The most serious case involving a health hazard situation with a high possibility of severe disease or death if people consume these food products.
Class II	Involves a potential health hazard that may occur to consumers when they consume these food products.
Class III	Does not cause adverse health outcomes to consumers, but involves the use of improper labels with items required by Federal regulations being omitted.
Hazard type	Different hazards are assigned to each recall, following the Food Code foodborne hazard specification (FDA, 1997).
Biological hazard	Includes bacterial, viral and parasitic organisms. Cross contamination and improper food processing and handling are the main reasons that these pathogens are found in food products.
Chemical hazard	Involves naturally occurring or artificial chemical contaminants arising in the production or processing of foods.
Physical hazard	Includes cases when hard foreign objects are found in food products.
Plant size	For the purposes of discussing the impact of PR/HACCP, USDA classifies meat and poultry plant sizes into three categories; large, small, and very small (FSIS, 2001).
Large plants	More than 500 employees. Required to have PR/HACCP systems in place by January 26, 1998. Total of 300 federally inspected plants.
Small plants	Between 10 and 500 employees. Required to have PR/HACCP systems in place by January 25, 1999. Total of 2,300 federally inspected plants.
Very small plants	Less than 10 employees or less than $2.5 million in sales. Required to have PR/HACCP systems in place by January 25, 2000. Total of 3,400 federally inspected plants.

References

Anderson, D., Murray, B. C., Teague, J. L., & Lindrooth, R. C. (1998). Exit from the meatpacking industry: a microdata analysis. *American Journal of Agricultural Economics, 80*, 96–106.

Axtell, J., Bailey, P., Behney, J., Derfler, P., Gioglio, M., Knight, J., Lange, L., Lombardi, S., Majkowski, J., McCaskey, P., Mondschein, J., & Blargan R. V. (1998). Improving recalls at the food safety and inspection services. Report of the Recall Policy Working Group. FSIS/USDA.

Center for Disease Control and Prevention (CDC) (2000). *CDC fact book 2000/2001*. Department of Health and Human Services. Available: http://www.cdc.gov/maso.factbook.main.htm.

Food and Drug Administration (FDA) (1997). Food Code—Annex 5: HACCP Guidelines. US Department of Health and Human Services. Available: http://vm.cfsan.fda.gov/~dms/fcannex5.html.

Food and Drug Administration (FDA) (2000). A description of the US food safety system. US Codex Office. Available: http://www.fsis.usda.gov/oa/codex/system.htm.

Food Safety and Inspection Service (FSIS) (1998a). Importing meat and poultry to the United States. A guide for importers and brokers. FSIS Mission & Activities. Available: http://www.fsis.usda.gov/oa/programs/import.htm.

Food Safety and Inspection Service (FSIS) (1998b). Pathogen reduction and HACCP systems and beyond. The new regulatory approach for meat and poultry safety. Backgrounders. USDA. Available: http://www.fsis.usda.gov/oa/background/bkbeyond.htm.

Food Safety and Inspection Service (FSIS) (2000a). Recall of meat and poultry products. FSIS Directive 8080.1 Rev.3. Available: http://www.fsis.usda.gov/foia/dir/8080.pdf.

Food Safety and Inspection Service (FSIS) (2000b). Report on meat and poultry recalls to the United States House and Senate Appropriations Committees: Executive Summary. Communication to Congress. USDA. Available: http://www.fsis.usda.gov/oa/congress/recallsumm.htm.

Food Safety and Inspection Service (FSIS) (2000c). FSIS import procedures for meat, poultry, and egg products. Available: http://www.fsis.usda.gov/oa/background/import.htm.

Food Safety and Inspection Service (FSIS) (2001). Protecting the public from foodborne illness: the food safety and inspection service. Backgrounder. USDA. Available: http://www.fsis.usda.gov/oa/background/fsisgeneral.htm.

Food Safety and Inspection Service (FSIS) (2002a). Importing to the United States. International Policy Staff. Office of Policy, Program Development and Evaluation. USDA. Available: http://www.fsis.usda.gov/oppde/ips/importing.htm.

Food Safety and Inspection Service (FSIS) (2002b). New measure to address *E. coli* O157:H7 contamination. Backgrounders. Available: http://www.fsis.usda.gov/oa/background/ec0902.htm.

Food Safety and Inspection Service (FSIS) (2002c). FSIS's directive to reduce *Listeria monocytogenes* in ready-to-eat meat and poultry products. Backgrounders/Key Facts. USDA. Available: http://www.fsis.usda.gov/oa/background/lmdirect.htm.

Food Safety and Inspection Service (FSIS) (2002d). FSIS food recalls. Backgrounder. Available: http://www.fsis.usda.gov/oa/background/bkrecalls.htm.

Food Safety and Inspection Service (FSIS) (2003). Risk analysis. Backgrounders/Key Facts. USDA. Available: http://www.fsis.usda.gov/oa/background/riskanak.htm.

Muth, M., Karns, S. A., Wohlgenant, M. K., & Anderson, D. W. (2002). Exit of meat slaughter plants during implementation of the PR/HACCP regulations. *Journal of Agricultural and Resource Economics., 27*(1), 187–203.

Muth, M., Karns, S. A., Wohlgenant, M. K., & Anderson, D. W. (2003). Explaining plant exit in the US meat and poultry industries. *Journal of Agricultural & Food Industrial Organization, 1*(1).

National Agricultural Statistical Services (NASS) (1995–2002). Meat slaughter and poultry slaughter. United State Department of Agriculture (USDA).

Salin, V., & Hooker, N. (2001). Stock market reactions to food recalls. *Review of Agricultural Economics, 23*(1), 33–46.

Shiptsova, R., Thomsen, M. R., & Goodwin, H. L. (2002). Producer welfare changes from meat and poultry recalls. *Journal of Food Distribution Research* (July), 25–33.

Thompson, M. R., & McKenzie, A. M. (2001). Market incentives for safe foods: an examination of shareholder losses from meat and poultry recalls. *American Journal of Agricultural Economics, 83*(3), 526–538.

US General Accounting Office (GAO) (2000). Food safety. Actions needed by USDA and FDA to ensure that companies promptly carry out recalls. GAO/RCED-00-195.

Woteki, C. (2000). USDA research needs in food safety. In L. J. Unnevehr (Ed.), *The economics of HACCP costs and benefits* (pp. 3–14). St. Paul, MN: Eagan Press.