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The Economics of Regulation and Information Related to Foodborne Microbial Pathogens

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Introduction

Previous papers in this conference have examined the data available to track foodborne pathogens from their sources to resulting illness for consumers. In this session, Roberts, Ahl, and McDowell have shown us how such data might ideally be put to use in risk assessment. Beyond risk assessment, however, is the need for data to inform public policy decisions about managing the risks from foodborne pathogens and options for controlling the level of safety in the U.S. food supply. Good public policy decisions and consideration of regulatory options involve choices. Alternatives are weighed based on their costs and benefits, which in turn requires knowledge about producer and consumer behavior and their responses to incentives. While many alternatives may have positive benefits, it is important to identify those with the highest benefits relative to costs. Because economic costs and benefits matter in public policy, we focus on data needs that will support choosing cost-effective public policies and generate incentives that are appropriate to achieving improved food safety.

In our paper, we examine how data can be used to evaluate policy options for managing the risks from foodborne microbial pathogens. We begin by reviewing the current policy structure for managing food safety risks, then we discuss the nature of the failure in markets for food safety and the range of options for intervention. Next we discuss how evaluation might proceed for either a standards-based approach that is focused on the Hazard Analysis Critical Control Point (HACCP) system, or for incentive-based approaches that are focused on providing information. Finally, we provide an overview of the data that are needed for an economic cost-benefit analysis of policy options.

Policy Background

The current system for assuring a safe supply of meat in the United States has evolved over the years, largely in response to changes in the production, processing, and distribution of meat products. Federal meat inspection legislation for ensuring the wholesomeness of American beef and meat dates back to 1890 (USDA FSIS, 1995). The Federal Meat Inspection Act of 1906 established today's standards for slaughter and processing of meats, including postmortem inspection of carcasses. Poultry products were added under the Poultry Products Inspection Act of 1957. Both antemortem and postmortem inspection of animals and sanitary standards for slaughter and processing facilities come under the legislation.

Today, two different Federal agencies share primary responsibility for ensuring the safety and quality of meat and poultry products: the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS), through inspection of meat, poultry, and eggs; and the Food and Drug Administration (FDA), which is responsible for ensuring the safety of domestic and imported food products by establishing standards of identity and quality, and regulating food processing and food establishments (except for meat, poultry, and some egg products).[1] Seafood also comes under FDA jurisdiction.

In addition to establishing standards of identity and quality, FDA's primary responsibility is to protect human health from food hazards after food enters the market. FDA has limited jurisdiction over meat and poultry production processes, only acting when there are actual or potential contamination or unsanitary conditions in its distribution.

In contrast to FDA, FSIS focuses on inspection of the processing and safety of food before it enters the final marketing and distribution channels. FSIS administers meat and poultry inspection in slaughtering and processing plants. FSIS inspection relies primarily on the inspector's sight, smell, and touch to detect abnormalities in

[1]Food safety activities at USDA, including on-farm programs and egg inspection, have recently been consolidated under FSIS. In addition to FDA and FSIS, other agencies play a peripheral role in meat product food safety through their authority over particular issues. For example, the Environmental Protection Agency sets pesticide residue tolerances for all foods, including meats. In addition to Federal activities, State and local authorities have jurisdiction over food retail establishments.

animals or carcasses, with on-the-spot corrective action. Recently, FSIS has taken steps to develop an inspection system that is based on more formalized assessment of the risks that are present in slaughter and processing plants (USDA FSIS, 1995).

However, the food safety problems of greatest concern today can neither be consistently identified through the current FSIS inspection programs nor be controlled through the FDA's standards and procedures [USDA FSIS, 1993). The most serious foodborne threats to public health from meat, poultry, and seafood products are from microorganisms that are hard to detect and prevent with current inspection and control procedures. Producers, processors, government, and consumers all play a role in controlling microbial contamination.

The complex nature of foodborne microbial hazards means that there is no one approach that will assure complete safety from them. The analysis and assessment of risks involved in meat and poultry production, processing and distribution are essential to the development of public strategies for managing food safety risks, for appropriate regulatory response, and for creating incentives for producers and consumers to achieve improved food safety levels. The rest of this paper considers the economic aspects of the issue, and how economic analysis can help to choose among management strategies.

How Economists Define the Food Safety Problem

Safety is an attribute of food products associated with reduced risk or chance of foodborne illness. If consumers can ascertain the level of safety or risk associated with a food prior to its purchase and understand the true risks to health, then they could choose among products to obtain the preferred level of food safety. In doing so, consumers could express their willingness to pay for varying levels of safety. A market for safety attributes would exist, with the cost of safety (including the personal "costs" of taking precautions) balanced against its value to consumers. However, safety usually is not ascertainable directly. Consumers do not always have complete information about the safety of food when they buy it. Furthermore, if they become ill from foodborne pathogens, they may have difficulty recognizing the source. Producers or processors also do not always have information about the safety of their products, and it may be costly or impossible for them to respond to consumer demand for improved safety. This lack of information creates a "market failure." Producers have little incentive to provide greater levels of food safety, since consumers will not pay for an attribute that they cannot verify.

Another aspect of this market failure is that the transaction costs of reaching agreement on the level of safety and the price premium are high. Although the current legislative and legal systems determine who is responsible or "at fault" for failure to assure safe food, the costs of actually deciding who is at fault are often very high. Given the fact that food handling from "farm to table" contributes to the final product, there is a relatively high degree of integration required to protect the food supply. Hence, it is difficult to identify who is at fault when a failure occurs. High transaction costs associated with negotiating agreements and the difficulty of assigning liability mean that private markets may fail to achieve the preferred level of food safety.

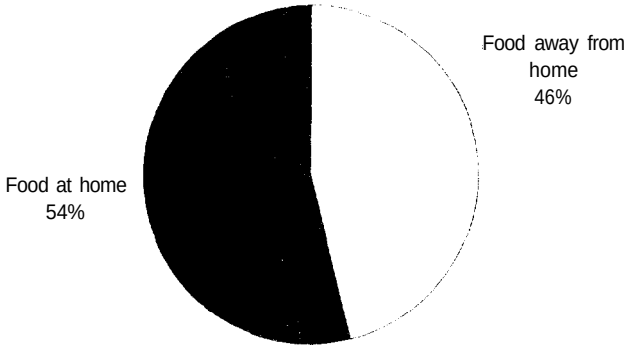
This market failure-the lack of information about safety and the high costs of achieving agreements privately-creates a public health problem. This problem is the fundamental justification for public intervention to improve food safety. Although Federal interventions in this area date from 1890, the Government's role has been the subject of renewed attention in recent years. Several structural changes may account for the growing attention to food safety issues.

More people are highly susceptible to microbial foodborne illness than before as the population ages, as medical technology keeps ill people alive longer, and as chronic illnesses that suppress people's immune systems (such as AIDS, diabetes, and cancer) spread. A recent Council for Agricultural Science and Technology report estimates more than 30 million individuals are at especially high risk today.

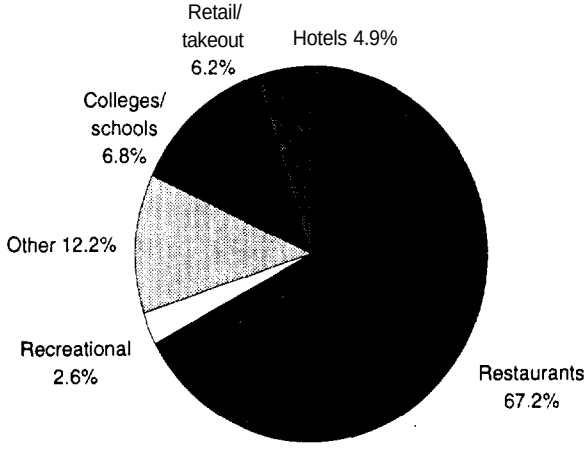
Another structural change is the growing popularity of convenience foods and food away from home. The proportion of food expenditures away from home has increased from 34 percent in 1970 to 46 percent in 1993 (USDA ERS, 1994). The food-away-from-home sector includes a wide variety of outlets in addition to restaurants (see figure 1), such as food prepared in grocery stores; food served in institutions like day care centers, college dormitories, or nursing homes; and food served at recreational establishments. The increased proportion of food consumption in the away-from-home sector reduces consumers' control over food preparation and may alter the nature of foodborne risks.

The value consumers place on food safety depends on their information about foodborne risks and their own susceptibility and ability to take precautions. News stories on recent outbreaks have heightened consumer awareness and have increased information about the nature of foodborne pathogen risks in the food supply. Thus, consumers may now place a higher value on reducing risks from microbial pathogens, even though such risks

Figure 1
Food expenditures, 1993



Food away from home by type of institution



are small. These structural changes, the increased population at risk, the changing structure of food markets, and growing consumer awareness lead to greater demand for food safety.

In addition to changes in demand, the improved ability to supply food safety through scientific advances is an impetus for increased attention to the regulation of food production and distribution. New pathogen tests and improved epidemiological methods link human diseases to their foodborne sources. Continued development of inexpensive, rapid tests will detect contaminants in foods and permit statistically based testing. The adaptation of HACCP systems to slaughter and processing for raw meat and poultry is another technological innovation that could lower the cost of providing a safer food supply. These advances create new opportunities for controlling foodborne pathogens. In other words, the cost of supplying food safety is lower.

Taken together, these changes in demand and supply suggest that a higher level of food safety should be observed, if interventions can be designed that allow these changes to be effective in the marketplace. Market interventions can take many forms, but all of them seek to address the fundamental information problem and the need for appropriate incentives for producers and consumers. We categorize market interventions into five types (adapted from Litan and Nordhaus, 1983, p. 38), distinguished by whether they are based on command and control or incentives (table 1).

Table 1-Possible interventions to correct market failure due to insufficient information

Type of intervention	Examples
Command-and-control type:	
Process standards	Specifying how products are produced
Outcome standards	Testing and inspection to ensure that products meet a particular safety standard
Mandatory disclosure	Requiring producers to reveal level of safety
Incentive-based type:	
Providing information to the public	Informing consumers about how to avoid risk; subsidizing food safety research to improve information technologies
Private bargaining	Providing voluntary certification of safety for certain producers, with possible public verification

Command and control approaches include setting standards for product content (outcome) or for processing techniques. Product control is achieved by setting standards for any product that enters the market or at various stages of the marketing channel. Visual inspection of products and setting appropriate microbiological limits at different points in production and distribution are methods of guaranteeing an end product of a specified quality. Such standards require the product's quality to be monitored (usually based on sampling and testing). In contrast, production or processing standards achieve an improved final product by directly specifying the processes or procedures to be followed in production. Examples include requiring specific product washing solutions or chill temperatures.

Mandatory disclosure of information is a command intervention that takes a different approach. For example, labeling is required for certain nutritional attributes of packaged foods, such as fat content, in order to give consumers information about product qualities that would be very costly to observe. However, it may be difficult to enforce disclosure of information about microbial pathogens, since producers do not always know the level of safety being produced or contained in the product at sale. Producers could be required to provide information on the production processes, such as irradiation, that they use.

Incentive-based approaches allow market participants to choose the use of inputs, technologies (in the case of producers), or among products or home production technologies (in the case of consumers). One way to facilitate such choices is by giving the public information. Additional product information allows consumers to more effectively weigh their willingness to pay for safer food against higher prices or to alter their own food handling instead of paying those costs. Labeling meat and poultry products with safe handling instructions is a way to give consumers information about how to reduce risks. Another example of information for the public is instruction about safe food handling for employees in food service establishments. Government can also affect the information available to industry or consumers by subsidizing food safety research that will reduce the cost of obtaining information. Incentive-based approaches are designed to induce either producers or consumers to identify and practice cost-effective methods that achieve desired (higher) levels of food safety.

Another way to motivate improved food safety is to foster opportunities for private bargaining in order to establish a market for reduced risk. This can be an effective strategy, especially where the number of "players" is relatively small or can be easily identified. One example is in organic or "natural foods" markets, where private organizations certify organic produce or certain production methods and a market for their products has developed. Another example is where food processors privately negotiate that certain standards of production (or nonuse of certain inputs) be met by farm-level producers. Finally, markets for products that meet higher standards of safety may develop to meet the needs of self-identified high-risk populations, such as nursing home residents or the immune-suppressed population.

Evaluating a Standards-Based Approach: HACCP

The National Research Council (1985) has suggested HACCP as a standard for achieving greater safety in meat and poultry production. HACCP is already widely recognized in the food industry as an effective approach to establishing good production, sanitation, and manufacturing practices that produce safe foods that are likely to withstand some variation in food handling and storage. This strategy for controlling food processing relies on identification and control points in the production process where problems can occur.

HACCP is designed to be a preventive system that focuses inspection and resources on areas critical to achieving product safety. Prevention is seen as more cost-effective than testing a product, and then destroying or reworking it. The system can be applied to control any stage in the food system, and involves sufficient traceability and feedback in the process to direct corrective activities.

There are seven principles involved in developing and operating a HACCP program (National Advisory Committee on Microbiological Criteria for Foods, 1992):

1. Assess the hazard, list the steps in the process where significant hazard can occur, and describe the prevention measures.
2. Determine critical control points (CCP's) in the process.
3. Establish critical limits for each CCP.
4. Establish procedures to monitor each CCP.
5. Establish corrective actions to be taken when monitoring indicates a deviation from the CCP limits.
6. Establish recordkeeping for the HACCP system.

7. Establish procedures to verify that the HACCP system is working.

The HACCP system has proved to be a very effective method to focus inspection and attention on CCP's, and improve the scientific basis for safety and control processes. A CCP is "any point in the chain of food production from raw materials to finished product where the loss of control could result in unacceptable food safety risk" (Pierson and Corlett, 1992, p. 3).

The concept of CCP is key to the control system and very demanding in terms of required resources and information. Monitoring of CCP's is done best by using indicators or characteristics that are easily measurable. This focus on measurable indicators can provide a more cost-effective approach to control than product sampling and testing, which is inherently expensive and often time-consuming.

HACCP was originally developed as a management tool by the private sector, and has only recently been proposed as a regulatory tool. It has been widely applied in food processing where product liability may create a greater need for industry to control processes, than in production of unprocessed products. A recent study by Karr showed that only 10 percent of meat and poultry plants in the Northeast currently use HACCP. Adoption of HACCP requires a firm to commit resources to achieving product quality. Over 60 percent of the companies in Karr's survey indicated they lacked adequate staff to implement HACCP.

Clearly there are costs to the firm for implementing a HACCP system. Without public intervention (regulation), firms will adopt HACCP as a means of ensuring a certain safety content in their products if there is some return in the marketplace for their efforts. The standards may be adopted as part of "good management practice," or to achieve a product standard that can be identified in the market and for which consumers will pay a higher price to compensate for the additional processing costs. If Karr's adoption rate is representative, then these incentives do not seem to exist currently for most firms in meat and poultry slaughter and processing.

In adapting HACCP as a regulatory tool to correct the failure in the market for food safety, it is important to recognize that there are limits to its use. HACCP is not designed to replace management decisionmaking relative to product design, choice of inputs, or product marketing. That is, weighing potential benefits from product design and qualities against costs, as well as weighing the value of improved safety versus the costs of achieving it are aspects of managerial decisions not addressed through HACCP processes. HACCP supports good production practices, but management (or the regulatory agency) has discretion to determine what the final product standard will be. To a large extent, these issues enter into the firm's deliberations in determining CCP's and tolerance limits at CCP's.

The explicit or implicit choice of a safety standard to be achieved through the use of HACCP has important implications for its use as a regulatory tool. Although HACCP is a process approach, in practice it may or may not be a process standard. The implementation of HACCP requires the choice of an outcome standard that the CCP's are selected to achieve.

Setting up a HACCP system involves verification (product testing) to ensure that the CCP's are working. Thus, requiring firms to adopt HACCP also implies requiring a particular standard for food safety, and the selection of the standard will have important implications for evaluating policy.

The dual nature of HACCP as both a process and a product standard is widely misunderstood. It is important because economists argue that process standards are inefficient; they specify how firms should achieve goals rather than specifying the product standard and allowing firms to choose the least expensive process for achieving it. From this perspective, setting product standards and allowing choice and, over time, innovation, to meet them should allow greater efficiency in meeting a particular public health goal.

However, food safety regulation is not as simple as this economic truism suggests. First, food safety outcomes are expensive to test and monitor. As mentioned previously, HACCP provides an efficient control approach because it relies on prevention and identification of measurable CCP's rather than ex post testing. Second, process standards can be rigid or very flexible in practice. HACCP is a general conceptual approach that can be adapted in many different ways to processes in individual plants and at all stages of production, processing, and distribution. Thus, its flexibility allows firms some choice in meeting the regulated standard. Third, inspection and verification by the regulatory agency can be more efficient when it is focused on prevention. Checking CCP's and verifying a HACCP program that is in place may be a more efficient way of regulatory monitoring than testing product. Thus, HACCP can have some attractive features as an efficient regulatory tool, in spite of its appearance as a process standard.

How could HACCP be evaluated as a potential policy option? The costs and benefits of any particular HACCP

regulation will depend on the accompanying implicit standard for safety improvement. The benefits would flow from that standard and the corresponding fewer cases of foodborne illness. The costs of these avoided illnesses would give a lower bound estimate of the benefits of a HACCP regulation. The costs of the regulation would be the firms' costs to set up and maintain a HACCP system. It may be important to recognize differences among firms in the costs of implementing HACCP. The challenging part of evaluating HACCP is likely to be directly linking its adoption to specific reductions in pathogens and in foodborne illnesses.

In the past, industry has applied HACCP to control hazards where a zero-risk standard is appropriate (e.g., broken glass in canned food). For microbial pathogens, particularly in unprocessed products, a zero-risk standard may or may not be appropriate. Establishing the critical limits that must be met at each CCP for microbial contamination is likely to involve many tradeoffs. Application of HACCP to these kinds of hazards will require marginal cost-benefit analyses, where the value of reducing risk to very low levels is weighed against the additional costs.

Evaluating Incentive-Based Approaches to Regulation

Consumers carry out food handling and storage. Well-informed consumers fully understand the characteristics, including the risks, of products they buy and consume, and are well-informed about (and adequately able to achieve) cooking and food handling methods that will ensure the food's safety. Thus, an alternative to regulating food safety is to shift some of the burden of choosing and maintaining product standards to consumers through practices such as food labeling. With labeling, consumers are informed about the product's characteristics but they also assume some responsibility for ensuring its safety.

Providing information is an incentive-based approach because it allows individual actors in the market to exercise choice. This has the advantage of leading to more efficient market outcomes. If a small but significant number of consumers desires greater safety, then providing information can allow that group to express their preferences through personal behavior or willingness to pay. If some firms can produce a safer product at a lower cost, then public or privately sponsored certification can allow those firms to exploit a market niche for safety, while other firms can produce at lower cost for the rest of the market. When such a market niche exists, it provides incentives over time for the development of less expensive production methods to ensure safety. It can also allow increased demand for safer products to be reflected in higher price premiums.

Providing information suffers from some general drawbacks that are related to consumers' ability to use it. The challenge in designing this kind of intervention is to structure the information so that it allows consumers to make better decisions (Magat and Viscusi, 1992). Consumers have limited time and ability to process information, particularly with respect to small risks. They can become overloaded with information, and the impact of this regulatory tool can easily be diluted by overuse.

In addition, consumers may be prevented from exercising their choice due to the structure of the market. An increasing proportion of food is consumed away from home. Consumers in nursing homes or day care centers have little choice or control over food safety, yet they are among those who are most vulnerable to foodborne disease.

The design of information interventions can be complex. First, a risk assessment is needed to identify where behavior can be modified to reduce risk. For example, in designing information about safe handling, first it would be useful to know the incidence of pathogens in products entering the home, the incidence of foodborne illness arising from food preparation in the home, and the current use of safe handling practices by consumers. If most foodborne illness arises in the away-from-home or prepared foods subsector, then safe handling labels will have little impact. Alternatively, if most consumers already follow safe handling practices, then identifying those who do not would be a way to target educational efforts. Answers to these kinds of questions can help to assess whether or not safe handling labels contribute to better consumer decisionmaking.

The second step would be to evaluate the costs and benefits of the information intervention. Magat and Viscusi argue that interventions to provide safe handling instructions to consumers should be evaluated with respect to whether better decisions are made, which is inherently difficult to measure. If decisions are improved, then how much will risks be reduced? Only with answers to these questions can the benefits of labeling be evaluated.

Another information approach would be voluntary certification of higher levels of safety for some products. This approach allows a market to develop for higher safety, with the equilibrium premium for safety determined by the value of safety to consumers and the costs to firms of improving safety. The higher level of safety may be of particular interest to certain high-risk groups.

In this case, the public role is to certify that products meet a particular safety standard or that the production process that is advertised as leading to a safer product does in fact produce one (e.g., egg pasteurization). Choosing the safety standard that improves welfare is the challenge. Safety is a continuous attribute, but certification generally distinguishes only between high and low quality. The high-quality product needs to have a safety difference great enough to elicit a price premium. However, if the safety level is too high, it may preclude the development of a market because costs are also high and the number of interested consumers is small. If it is too low, it will not reduce risks significantly or motivate industry to improve safety.

Evaluating the costs and benefits of a certification intervention requires assessing the extent of market demand for the certified product and the resulting risk reduction. Useful information would include the consumers' willingness to pay for increased safety levels, particularly by consumers in high-risk groups or by institutions serving those consumers. Such willingness-to-pay estimates would indicate the potential value of higher safety and the potential market for a certified product. The social value of the certification program could then be measured by the reduced costs of illness resulting from market behavior or the willingness to pay for reduced risks. These could be compared to the costs to industry for providing a particular level of safety and the costs to Government agencies for certifying that safety level. Answers to these questions would indicate whether a market could develop for certification of a particular level of safety, and how far that market would go towards achieving public health goals.

Providing information may or may not represent the best approach to food safety, and must be designed and evaluated carefully. As Magat and Viscusi note, providing information is often attractive as a stopgap measure when risky behavior is likely to continue and the risks are small. However, some food safety risks are large. It may make economic sense to combine information with standards that exclude the lowest levels of safety from the market. Evaluating such a mixed approach is more complex, but it could be the basis for designing interventions that achieve better public health at the least cost.

Food Safety Indicators for Policy Analysis

The previous sections have outlined the kind of information needed to evaluate potential policies to reduce risks from foodborne illness. This section discusses some ideal indicators that might be developed to facilitate policy analysis. Indicators are constructed from time series data in order to interpret trends easily. One familiar economic indicator is the consumer price index, which is constructed from price series data to provide an indicator of inflation. In the food safety area, many data series are in their infancy, so no indicators have been developed. A regular series of food safety indicators could provide information on the nature and extent of the food safety problem, and could be used to analyze the effects of food safety policies.

For example, a cost-of-illness index could be constructed from data on the incidence of illness and health care costs to indicate how the economic dimension of the food safety problem is changing over time. If broken down by pathogen, cost-of-illness indicators would show the relative economic importance of different pathogens. Other examples would be indicators showing the incidence of pathogens in farm animals, the adoption of management practices to control pathogens, and the costs of those practices. Such indicators could be used to analyze the costs of reducing pathogens at the farm level or the distribution of problems to be targeted for increased control or intervention. Data on the adoption of HACCP, the incidence of pathogens in products, and the costs associated with HACCP could be used to analyze the costs of reducing pathogens in meat products. Data on food intake and preparation methods for population subgroups could facilitate analysis of the distribution of benefits from reducing hazards.

As many food safety data series are in their infancy, it would be useful to outline potential indicators now in order to guide data collection efforts. There are four basic types of indicators: economic, proxy, physical, and distributional (Nelson and Miranowski, 1994). An economic indicator shows the severity of the food safety problem by measuring its cost to society. A proxy indicator shows the potential for a food safety problem; a physical indicator directly measures the existence of a food safety problem and its biological severity. Distributional indicators show how the risks and costs of risk reduction are distributed across different kinds of consumers and producers. Distribution is an additional dimension of any other indicator.

Table 2 shows some possible indicators and data sources. An example of a proxy indicator is the incidence of a pathogen in live animals or on slaughtered carcasses, which shows a potential food safety problem. The incidence of foodborne illness in the population from a particular pathogen would be a physical indicator that would show the existence of the problem. An economic indicator would be the costs of any illness caused by a particular pathogen. An example of a distributional indicator would be the incidence of illness in certain subpopulations. These examples demonstrate that proxy or physical indicators, and a scientific basis for linking

Table 2-Potential food safety indicators at various stages in the food chain

Type of indicator	Farm	Slaughter/ processing	Retailing	Consumer
Proxy	Nonadoption of control measures	Nonadoption of HACCP	Nonadoption of HACCP	Intake of risky foods; nonadoption of precautions
Physical	Pathogens in farm animals	Pathogens in meat products	Pathogens at point of sale	Incidence of illness
Economic	Cost of control measures	Cost of control measures	Cost of control measures	Benefits of reducing illness; willingness to pay for reduced risk; price premiums paid for safer products
Distributional	Geographic distribution of pathogens in farm animals	Incidence of pathogens by firm size	Incidence of pathogens by firm size	Incidence of illness by age
Potential data sources[1]	APHIS/FSIS	FSIS/industry	State and local agencies	ERS/ARS/ CDC/FDA

[1]APHIS = USDA Animal and Plant Health inspection Service; FSIS = USDA Food Safety and Inspection Service; ERS = USDA Economic Research Service; ARS = USDA Agricultural Research Service; CDC = US. Department of Health and Human Services Centers for Disease Control and Prevention; and FDA = Food and Drug Administration.

the two, are often a prerequisite for building an economic indicator. The quality of the economic indicator (e.g., cost of illness) will be directly dependent on the quality of the physical data (e.g., incidence of illness).

There are several reasons why constructing these indicators would be difficult. First, some of the possible data sources listed are only potential sources. Many surveys are not regular and ongoing, do not cover the entire population of interest, or are not widely available for analysis. The National Animal Health Monitoring System conducted by the Animal and Plant Health Inspection Service only covers particular animals and focuses on veterinary issues rather than food safety issues. FSIS might be in a position to collect and report data from the slaughter/processing level, but it has not made such data public in the past. The Centers for Disease Control and Prevention data rely on the willingness of States, doctors, and individuals to report illness and their ability to identify a foodborne source of the illness. Therefore, these data do not adequately represent the extent of foodborne illness. Second, economic information often is not available, even when proxy or physical indicators are available. Economists need to work with the agencies that are generating data to encompass the economic dimension of physical indicators.

Conclusions

We have focused on laying out the range of possible alternatives and the data needs for evaluating alternative policies for managing food safety risks. We have not presumed that either incentive- or standard-based approaches are preferable, but we have discussed their pros and cons for addressing the complex issue of microbial foodborne pathogens. A standards-based approach needs to recognize the dual nature of HACCP as a process and a product standard, and its preventive nature as a potential benefit for regulatory efficiency. Providing information is often a preferred textbook solution, but given the changing structure of food markets, it may or may not address the underlying risks. Information approaches must be carefully designed to actually improve decision-making in the marketplace. Finally, regulatory approaches must be flexible, recognizing that there is an incomplete scientific basis for assessing the risks, producing safer products, and evaluating product safety.

The size and complexity of food safety problems caused by foodborne pathogens require careful consideration of the alternative policy responses and possibilities for managing the risks in the food supply. The failure of private markets to provide adequate information to con-

sumers due, in part, to the inherent variability of food products and processing, indicates a role for regulation and some Government involvement. What is required is the ability to monitor problems and changes in food safety risks, to identify priorities and alternatives for policy interventions, and to evaluate those alternatives within an economic framework. A coordinated effort is needed to identify and link data that will indicate the extent of the problems, to monitor changes (and improvement), and to provide the feedback that policymakers need to set priorities for directing scarce public and private resources to reducing the risk of foodborne disease.

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