

# Foods Associated with Food-borne Illness Outbreaks from 1990 through 2003

CAROLINE SMITH DEWAAL,\* GISELLE HICKS, KRISTINA BARLOW, LUCY ALDERTON, and LEORA VEGOSEN  
Center for Science in the Public Interest, 1875 Connecticut Ave. NW #300, Washington, D.C. 20009, USA

## SUMMARY

Critical to the understanding of foodborne illness outbreaks is the identification of both the contaminated food item and the responsible pathogen, allowing traceback to the original source of contamination and subsequent intervention. The Center for Science in the Public Interest (CSPI) maintains a database of foodborne illness outbreaks categorized by food vehicle, compiled from sources including the Centers for Disease Control and Prevention, state health departments, and scientific journals. Between 1990 and 2003, the foods most commonly linked to outbreaks with identified vehicles were seafood ( $n = 899$ ), produce ( $n = 554$ ), poultry ( $n = 476$ ), beef ( $n = 438$ ), and eggs ( $n = 329$ ). Multi-ingredient foods, including pizza and sandwiches, were linked to 812 outbreaks. Overall, 27% (1229/4486) of the outbreaks were attributed to meats, including beef, poultry, pork, and luncheon meats, while 66% (2954/4486) of outbreaks were linked to other food items. Seven percent (303/4486) were linked to multiple food vehicles. Our findings demonstrate the value of routinely linking outbreaks to specific foods and illustrate the importance of using a consistent, common-sense food categorization scheme for all food safety stakeholders. Food attribution and categorization allow consumers to more readily assess food safety hazards and provide better information on which to base policy decisions.

## INTRODUCTION

The US Centers for Disease Control and Prevention (CDC) estimates that foodborne disease causes 76 million illnesses and 5,000 deaths per year in the United States (19), and the US Department of Agriculture (USDA) has calculated that the annual economic burden of foodborne illnesses likely exceeds \$7 billion (14). While most foodborne illnesses occur as isolated cases, some are clustered together as a result of individuals ingesting a common contaminated food. These clustered illnesses, which can involve from two up to thousands of people, constitute an outbreak. Foodborne outbreaks occurring in the last few years have been linked to the consumption of such food items as tomatoes, unpasteurized milk/cheese, snow peas, basil, ground beef, and turkey (6–7, 10, 12–13, 23).

Outbreak reporting is one of the most critical components of foodborne disease surveillance. These reports are essential in determining food/hazard combinations, which is a crucial step toward preventing outbreaks from reoccurring. However, previous research has documented that underreporting of foodborne illness outbreaks is a major issue. Many outbreaks are never recognized because of their small size, long incubation period, or geographic dispersion. Other factors include an inability to identify the pathogen involved or the occurrence of mild cases of illness, with no medical care (4, 19–20).

The division of investigation and reporting responsibilities is another obstacle to outbreak reporting. Although CDC has established the FoodNet program to monitor laboratory isolations of

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\*Author for correspondence: Phone: 202.332.9110; Fax: 202.265.4954  
E-mail: csmithdewaal@cspinet.org

**TABLE I. CSPI Food Categories and Subdivisions  
Summary of Outbreaks and Cases, 1990–2003**

FDA-Regulated Foods			
Category	Subdivision	Outbreaks	Cases
<b>Beverages</b>	Juices	21	1,302
	Other Beverages	45	1,341
	<b>Beverages Total</b>	<b>66</b>	<b>2,643</b>
<b>Breads &amp; Bakery</b>	Bakery	89	2,642
	Breads	27	851
	<b>Breads &amp; Bakery Total</b>	<b>116</b>	<b>3,493</b>
<b>Dairy</b>	Cheese	44	1,680
	Ice Cream	38	1,632
	Milk	53	1,319
	Other Dairy	18	525
	<b>Dairy Total</b>	<b>153</b>	<b>5,156</b>
<b>Eggs</b>	Eggs	69	2,085
	Egg Dishes	260	8,764
	<b>Eggs Total</b>	<b>329</b>	<b>10,849</b>
<b>Game</b>	<b>Game Total</b>	<b>25</b>	<b>182</b>
<b>Multi-Ingredient Foods</b>	Prepared Foods	180	3,289
	Rice/Beans/Stuffing/Pasta Dishes	168	4,301
	Salads	181	7,841
	Sandwiches	104	2,565
	Sauces/Dressings/Oils	55	1,875
	Other Foods	124	3,255
	<b>Multi-Ingredient Foods Total</b>	<b>812</b>	<b>23,126</b>
	<b>Produce</b>	Fruits	93
Vegetables		205	10,358
Produce Dishes		256	10,158
<b>Produce Total</b>		<b>554</b>	<b>28,315</b>
<b>Seafood</b>	Finfish	571	2,991
	Molluscan Shellfish	135	3,156
	Seafood Dishes	129	2,400
	Other Seafood	64	765
	<b>Seafood Total</b>	<b>899</b>	<b>9,312</b>
<b>FDA Total</b>	<b>FDA Total</b>	<b>2,954</b>	<b>83,076</b>

common foodborne pathogens, this system tracks sporadic cases of illness and does not identify the food vehicle involved in the identified cases (25). Foodborne illness outbreaks are more likely to have an identified food source, but outbreaks are investigated by state and local health departments. The quality of these investigations varies depending on state and local funding (3, 16) and subsequent reporting to the CDC is mostly voluntary (15). While the CDC is charged with nationwide surveillance of outbreaks and the tracking of new and emerging pathogens, it does not have the authority to mandate uniform state reporting of foodborne illness outbreaks. Consequently, each state independently determines which diseases to track and sets out its own reporting requirements for health providers (15). Finally, responsibility for recalling unsafe food at the national level is divided among several federal agencies. Overall, twelve federal agencies share responsibility for monitoring, surveillance, inspection, enforcement, outbreak management, research and education (14). Such a highly fragmented system contains significant gaps that increase the risks to consumers (17, 22, 24).

Critical to the understanding and prevention of foodborne illness outbreaks is the identification of both the responsible pathogen and the contaminated food item, allowing traceback to the original source of contamination and subsequent intervention (15). In order to design and prioritize food safety interventions, food attribution and categorization need to be performed to identify the specific food-pathogen combinations causing illness (4). However, the majority of reported foodborne illness outbreaks do not have an identified etiology (20) and food vehicle (18). In addition, there exists no consistent food categorization scheme for outbreak data (4).

To address these gaps, the Center for Science in the Public Interest (CSPI) has organized existing outbreak data by food source. Such data alert consumers to food safety hazards, allow consumers to make informed handling decisions about the foods they eat, and provide better information to the government as a basis of setting priorities for food safety resource allocation. This article presents the results of CSPI's food categorization efforts and highlights the importance of food attribution.

## METHODS

### Data collection

CSPI maintains a database of foodborne illness outbreaks, compiled largely from CDC and state health department

**TABLE 1. (continued) USDA-Regulated Foods**

Category	Subdivision	Outbreaks	Cases
<b>Beef</b>			
	Ground Beef	164	3,280
	Beef Dishes	111	3,311
	Other Beef	163	6,111
	<b>Beef Total</b>	<b>438</b>	<b>12,702</b>
<b>Luncheon &amp; Other Meats</b>			
	Luncheon	48	981
	Meat Dishes	62	2,115
	Other Meats	35	2,191
	<b>Luncheon &amp; Other Meat Total</b>	<b>145</b>	<b>5,287</b>
<b>Pork</b>			
	Ham	45	2,105
	Pork Dishes	27	763
	Other Pork	98	2,991
	<b>Pork Total</b>	<b>170</b>	<b>5,859</b>
<b>Poultry</b>			
	Chicken	179	3,363
	Turkey	88	5,146
	Poultry Dishes	203	6,114
	Other Poultry	6	106
	<b>Poultry Total</b>	<b>476</b>	<b>14,729</b>
<b>USDA Total</b>	<b>USDA Total</b>	<b>1,229</b>	<b>38,577</b>
<b>Multiple Foods</b>			
Category	Subdivision	Outbreaks	Cases
<b>Both</b>	<b>Both Total</b>	<b>303</b>	<b>16,969</b>
<b>All Categories</b>			
All Foods	Total Outbreaks	Total Cases	
<b>Grand Total</b>	<b>4,486</b>	<b>138,622</b>	

annual outbreak line listings. Since 2001, the CDC outbreak data have been available as annual line listings on the Internet (5). Data on additional outbreaks were obtained from scientific articles, federal government publications, state health department postings, and newspaper reports verified by public health officials.

CSPI's outbreak data, maintained in Microsoft Access, is entered and managed by professional level staff who are familiar with Microsoft Access and trained on how to enter the data. Data selection is based on several factors. Data is carefully observed to determine listed food vehicle, etiology, and location of outbreak. Out-

breaks are excluded if the food vehicle is unknown or if a source other than food, e.g., ice, is the listed vehicle. Once the data has been entered, each entry is evaluated for accuracy by another staff person.

Incidents of foodborne illness were included in the CSPI database only if they met the CDC's definition of an outbreak: when two or more people have consumed the same contaminated food and come down with the same illness (9). In addition, each outbreak must have an identified etiology and food vehicle, must have occurred in the US or its territories between 1990 and 2003, and must have been reported by a reliable source. Outbreak reports that meet CSPI's inclusion criteria were further evaluated to determine whether they were already listed in the database or whether they represented new outbreaks. Outbreak reports from different sources may contain slightly different information about the same outbreak. When such discrepancies were discovered, a public health official at the state, local or federal level was contacted to determine which information was most accurate.

Excluded from the CSPI database were sporadic cases of foodborne illness (individual cases not linked to an outbreak), outbreaks that had no identifiable etiology or food vehicle, and waterborne outbreaks.

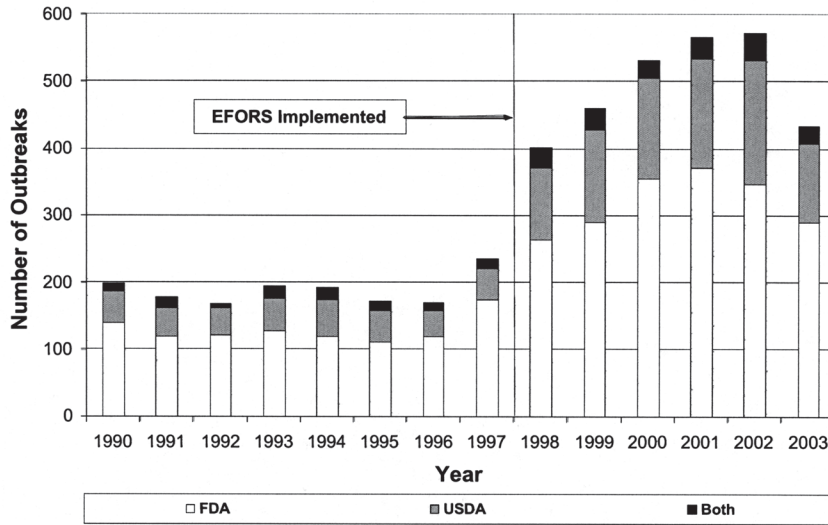
#### Food categorization scheme

Each outbreak in the CSPI database was categorized both as to the implicated food and the regulatory agency with primary responsibility for that particular food item. In general, meat, poultry, and processed egg products are regulated by the USDA, while seafood, shell eggs, produce and processed foods are subject to oversight by the US Food and Drug Administration (FDA) (15). In addition, restaurant foods are inspected by state, county or local public health officials.

The CSPI categorization scheme contains thirteen food categories in the majority of which were further divided into food subdivisions, presented in Table 1. Many outbreak reports involve mixed food ingredients, and sometimes multiple food vehicles. To simplify, we have put multi-ingredient foods without meat under FDA jurisdiction, and those containing meat under USDA jurisdiction. Where the suspected food source includes both FDA- and USDA-regulated foods, we use the category "Both."

Multi-ingredient foods were categorized under "Multi-ingredient" only if another more specific food category could not be identified. For example, "Chicken salad" was categorized under "Poultry

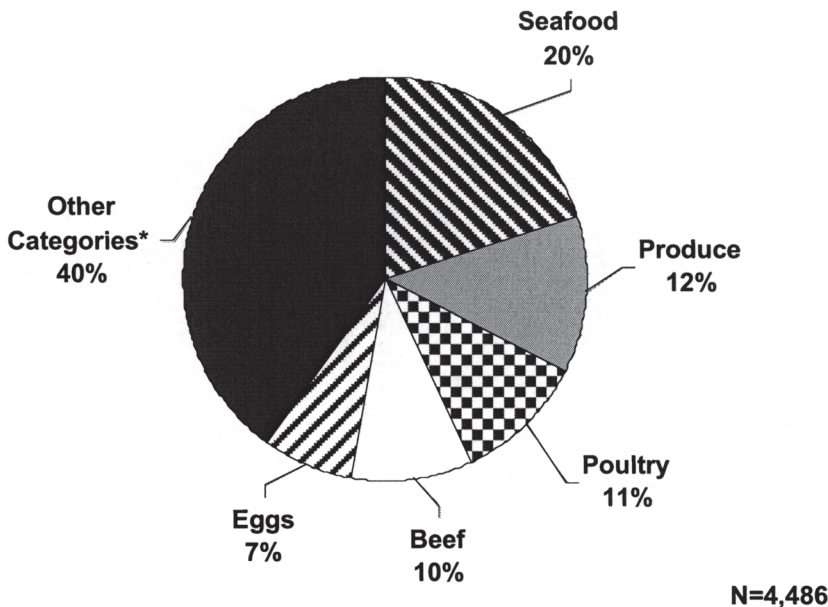
**FIGURE 1.** Number of Foodborne Illness Outbreaks by Year and Regulating Agency,\* 1990–2003



\* Agency with primary responsibility for regulating the implicated food. “Both” indicates that multiple foods were linked to an outbreak, some regulated by FDA and some by USDA.

The CDC Electronic Foodborne Outbreak Reporting System (EFORS) enabled state health departments to report foodborne illness outbreaks via the Internet, resulting in increased outbreak reporting.

**FIGURE 2.** Foodborne Illness Outbreaks By Food Category, 1990–2003



Percentages have all been rounded to the nearest whole number.

\* Includes multi-ingredient salads such as coleslaw, potato salad, or salad bar. Salads reported as green, or lettuce-based were categorized under Produce.

Dishes” and “Meat pizza” was categorized under “Meat Dishes,” but vehicles reported as “Soup” and “Pizza” were both categorized under “Multi-ingredient.” Similarly, outbreaks were included in the “Eggs” category only if the identified food vehicle specifically implicated contaminated eggs. For example, an outbreak linked to “Cake (eggs)” would be categorized under “Egg Dishes,” while an outbreak linked to “Cake” would be categorized under “Bakery.”

## RESULTS

A total of 4,486 outbreaks, involving 138,622 cases of illness occurring between 1990 and 2003, were included in the CSPI database (Fig. 1). Seven percent of these outbreaks were from sources other than the CDC. The five food categories, excluding multi-ingredient foods, linked to the largest numbers of foodborne illness outbreaks were seafood, produce, poultry, beef and eggs (Fig. 2 and 3). These five food categories were responsible for 60% (2696/4486) of all outbreaks in CSPI’s database and to 55% (75,907/138,622) of the cases. The produce category alone was linked to the largest number of foodborne illnesses associated with outbreaks, constituting 20% (28,315/138,622) of all cases in CSPI’s database.

Outbreaks linked to non-meat (FDA-regulated) multi-ingredient foods comprised 18% (812/4486) of the database, and outbreaks due to multiple foods, including both meat (USDA-regulated) and non-meat (FDA-regulated) items, comprised 7% (303/4486) of the database.

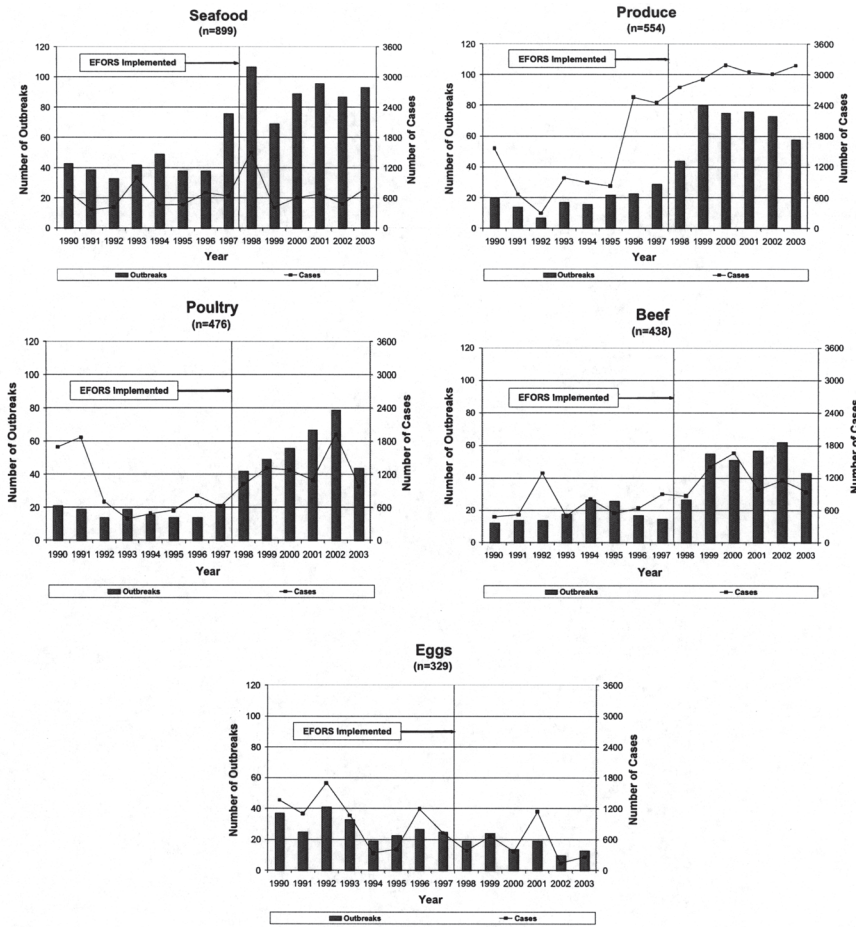
FDA-regulated foods were linked to 2,954 outbreaks with 83,076 cases, while USDA-regulated foods were linked to 1,229 outbreaks with 38,577 cases. Foods such as seafood, non-meat multi-ingredient foods, produce, eggs, dairy, breads, and beverages were linked to more than twice as many outbreaks and cases as meats (Fig. 4).

### Seafood and seafood dishes

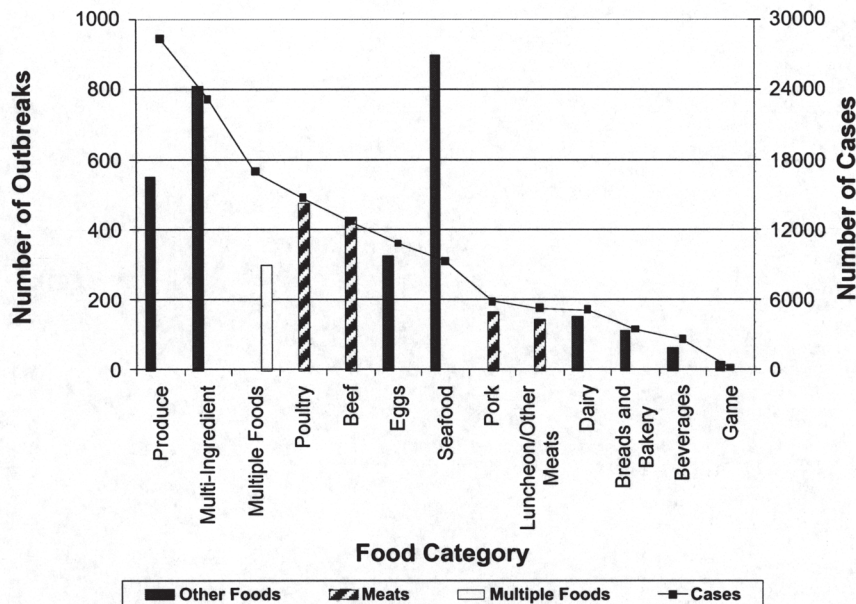
A total of 899 foodborne illness outbreaks and 9,312 cases were linked to seafood and seafood dishes. Outbreaks linked to seafood and seafood dishes comprised 20% of the outbreaks listed in the CSPI database, and 7% of the cases. The median number of cases per seafood-linked outbreak was three.

Of the seafood-linked outbreaks, 571 outbreaks and 2,991 cases were linked to finfish such as tuna and grouper; 135 outbreaks and 3,156 cases were linked to

**FIGURE 3.** Trends in Foodborne Illness Outbreak Reporting, 1990–2003



**FIGURE 4.** Cases Linked to Foodborne Illness Outbreaks, 1990–2003



molluscan shellfish, including oysters and clams; 129 outbreaks and 2,400 cases were linked to seafood dishes such as crab cakes and sushi; and 64 outbreaks and 765 cases were linked to other seafood, such as shrimp and lobster. The most common seafood items linked to outbreaks were tuna, raw oysters, and mahi mahi. Thirty-eight percent (341/899) of the seafood-associated outbreaks were caused by scombrototoxin and histamine, while another 24% (215/899) were caused by ciguatoxin. Although *Vibrio* species cause only 9% (78/899) of the overall seafood-linked outbreaks, they accounted for 33% (44/135) of the molluscan shellfish outbreaks and 36% (23/64) of the other seafood outbreaks.

**Produce and produce dishes**

A total of 554 outbreaks and 28,315 cases were linked to produce and produce dishes. Outbreaks linked to produce and produce dishes comprised 12% of the outbreaks listed in the CSPI database, and involved 20% of the cases. The median number of cases per produce-linked outbreak was 20.

Ninety-three produce-linked outbreaks and 7,799 cases were linked to fruits such as cantaloupe and various berries; 205 outbreaks and 10,358 cases were linked to vegetables, including alfalfa sprouts and mushrooms; and 256 outbreaks and 10,158 cases were linked to produce dishes such as lettuce-based salads, fruit salads and mashed potatoes. The most common produce food items linked to outbreaks were various produce-based salads and alfalfa sprouts. Almost 40% (215/554) of the produce-associated outbreaks were caused by either Norovirus or Hepatitis A. Another 30% (168/554) were caused by bacteria commonly found in meat and poultry, such as *E. coli* O157:H7, *Salmonella* spp. and *Campylobacter* spp., and twelve percent (67/554) were caused by *Bacillus cereus*, *Clostridium botulinum*, *Clostridium perfringens*, and *Staphylococcus aureus*. Although *Cyclospora* spp. outbreaks comprised only 3% (16/554) of the produce-associated outbreaks, they constituted 11% (3,233/28,315) of the cases due to two large outbreaks, each linked to raspberries, affecting more than 1,000 individuals each.

**Poultry**

A total of 476 outbreaks and 14,729 cases were linked to poultry. Poultry-linked outbreaks comprised 11% of both the outbreaks and the cases listed in the CSPI database. The median number of cases per poultry-associated outbreak was 13.

Chicken was linked to 179 outbreaks and 3,363 cases, turkey to 88 outbreaks and 5,146 cases, and poultry dishes such as chicken salad and chicken enchiladas to 203 outbreaks and 6,114 cases. Six outbreaks with 106 cases to other poultry including duck and Cornish hen. The most common poultry food items linked to outbreaks were chicken, turkey, and chicken salad. Forty-one percent (195/476) of the poultry-linked outbreaks were caused by *Campylobacter* spp., *E. coli*, and *Salmonella* spp. and another 36% (172/476) were caused by *Bacillus cereus*, *Clostridium perfringens* and *Staphylococcus aureus*. Norovirus was linked to an additional 13% (61/476) of the poultry-associated outbreaks. There were no poultry-linked outbreaks due to Hepatitis A.

## Beef

A total of 438 outbreaks and 12,702 cases were linked to beef. Outbreaks linked to beef comprised 10% of the outbreaks and 9% of the cases in the CSPI database. The median number of cases per beef-linked outbreak was 12.

Of the outbreaks associated with beef, 164 outbreaks with 3,280 cases were linked to ground beef, 111 outbreaks and 3,311 cases were linked to beef dishes such as beef stew and beef tacos, and 163 outbreaks and 6,111 cases were linked to other beef, including roast beef and prime rib. The most common beef food items linked to outbreaks were ground beef, hamburger and roast beef. *E. coli* O157:H7, *Campylobacter* spp. and *Salmonella* spp. caused 45% (199/438) of the beef outbreaks. *Bacillus cereus*, *Clostridium perfringens*, and *Staphylococcus aureus* caused 38% (168/438) and Norovirus and Hepatitis A together caused another 8% (35/438) of the beef-associated outbreaks.

## Eggs and egg dishes

A total of 329 outbreaks and 10,849 cases were linked to eggs and egg dishes. Outbreaks linked to eggs and egg dishes comprised 7% of the outbreaks and 8% of the cases listed in the CSPI database. The median number of cases per egg-linked outbreak was 16.

Eggs were linked to 69 outbreaks and 2,085 cases, and egg dishes such as eggs benedict and omelettes were linked to 260 outbreaks with 8,764 cases. The most common food items linked to egg outbreaks were eggs, while the most common egg dishes associated with outbreaks were ice cream and lasagna for which contaminated eggs have been implicated. Ninety-six percent (316/329) of the egg-associ-

ated outbreaks were caused by *Salmonella* spp., of which eighty-six percent (273/316) were *Salmonella* Enterica serovar Enteritidis.

## Multi-ingredient foods

A total of 812 outbreaks and 23,126 cases were linked to multi-ingredient foods. Outbreaks linked to multi-ingredient foods comprised 18% of the outbreaks listed in the CSPI database, and 17% of the cases. The median number of cases per outbreak associated with multi-ingredient foods was 12.

Of the outbreaks linked to multi-ingredient foods, 180 outbreaks with 3,289 cases were linked to prepared foods such as lasagna, pizza, and tacos. Multi-ingredient salads, including coleslaw and potato salad, were linked to 181 outbreaks and 7,841 cases, while multi-ingredient sandwiches such as submarine sandwiches were associated with 104 outbreaks and 2,565 cases. Foods including rice, beans, stuffing and pasta dishes were linked to 168 outbreaks and 4,301 cases. Fifty-five outbreaks and 1,875 cases were linked to sauces, dressings, and oils. Other foods, including nuts and unspecified soups, were linked to 124 outbreaks and 3,255 cases. Thirty-one percent (251/812) of the outbreaks linked to multi-ingredient foods were caused by bacteria such as *Bacillus cereus*, *Clostridium perfringens*, and *Staphylococcus aureus*. Thirty-two percent (262/812) of the outbreaks associated with multi-ingredient foods were caused by Norovirus or Hepatitis A. Another twenty-four percent (198/812) of these outbreaks were caused by *Campylobacter* spp., *E. coli*, and *Salmonella* spp.

## DISCUSSION

Historically, meats such as beef, pork, and poultry have been thought to pose greater hazards than other foods, but CSPI's data show that only 27% of foodborne illness outbreaks were attributed to meats. An additional seven percent of outbreaks were linked to multiple foods, including both meat and non-meat items; this may be a reflection of an inability to confirm a specific common food vehicle during the outbreak investigation, due to cross contamination. The majority (66%) of outbreaks were linked to other non-meat foods, including seafood, multi-ingredient foods, eggs, produce, and dairy, although some of these likely represent a transfer of pathogens from meat sources. For example, thirty percent of the produce-associated outbreaks identified by CSPI were caused by pathogens

that live inside animals' intestines and frequently contaminate meat and poultry, such as *Campylobacter* spp., *E. coli* O157:H7, *Salmonella* spp., and *Yersinia* spp. Therefore, targeting food safety interventions toward on-farm handling practices of animals and their waste products and the prevention of cross contamination along the entire spectrum of food production might prove more effective than a focus solely on meat products. In addition, although FDA-regulated foods are directly linked to more outbreaks than USDA-regulated foods, the original source of contamination might be similar for both categories of foods.

The five single-food categories most commonly implicated in outbreaks were seafood, produce, poultry, beef, and eggs. Interventions directed at these specific food categories would help to reduce the frequency of foodborne illness outbreaks. Although these food categories have been recognized in previous research as common sources of foodborne illness (1, 20), it is difficult to compare these results with results of previous outbreak research, since most foodborne illness data has been organized by pathogen and includes some non-foodborne illness data (5, 8).

Our research indicates that it is important to know which foods are most frequently linked to outbreaks, because identifying specific food/hazards combinations allows for better targeting of food safety interventions. For example, the vast majority of egg outbreaks are linked to one pathogen, *Salmonella* Enteritidis, so that interventions either on the farm or in the kitchen must be tailored to that pathogen. Food/hazard identification also provides critically important information to conduct the "hazard analysis" that is essential to developing effective Hazard Analysis Critical Control Point (HACCP) systems. A HACCP system is a systematic, science-based approach to the identification, evaluation, and control of food safety hazards.

The linking of foodborne illness outbreaks to specific foods necessitates food categorization, allowing identification and analysis of outbreak trends. Consistent food categorization enables researchers to assess which types of pathogens are causing outbreaks within a specific food type. Such evaluations can also indicate whether particular food categories are more prone to contamination on the farm, mishandling, inadequate preparation, cross contamination or personal hygiene factors. For instance, almost 40% of the seafood-associated outbreaks were caused by scombrototoxin or histamine, which typi-

cally results from inadequate refrigeration. Forty percent of the produce-linked outbreaks were caused by Norovirus and Hepatitis A, indicating the food was contaminated by infected humans, either through improper exposure to sewage in growing or processing or because of poor personal hygiene practices among food handlers (11). Another 30% of the produce-linked outbreaks were due to pathogens of animal origin, likely indicating cross contamination somewhere between the farm and the fork. Among the beef-associated outbreaks, the 43% caused by *E. coli* O157:H7 and *Salmonella* spp. were likely a result of undercooking, while the 37% due to *Clostridium perfringens* or *Staphylococcus aureus* likely indicate post-cooking handling abuses, including inadequate holding temperatures. Over thirty percent of the multi-ingredient food outbreaks were also linked to pathogens associated with inadequate holding temperatures, with another thirty percent due to Norovirus, potentially indicating poor personal hygiene practices among ill food workers.

Despite the value of food categorization, there are many difficulties inherent in categorizing the food vehicles associated with outbreaks because category decisions must be made for each individual outbreak. A challenge to consistent categorization of outbreaks is cross contamination. Cross contamination has the potential to occur at multiple points in the food production chain and it is often not possible to identify whether contamination occurred on-farm, during processing, at the retail level, or in the kitchen. When cross contamination has been identified, questions regarding which food category the outbreak belongs to and the consequences for the original source need to be addressed and consistently resolved. For example, outbreaks are categorized by the food consumed, unless investigators clearly identified another food as the cause of the outbreak. Such clear identification is rare, but when it occurs, we have categorized the outbreak according to the responsible food; e.g., an outbreak due to *E. coli* O157:H7 and associated with watermelon consumption but linked to raw beef cross contamination of the produce was categorized under "Beef" and not "Produce." Clearly, cross contamination poses challenges in any categorization scheme.

Multi-ingredient foods pose a second challenge to categorization efforts. It is almost impossible to know all of the components of a particular dish, and even when they are known, it is difficult to accurately attribute illness to any one of the ingredients. However, most foods consumed are multi-ingredient. CSPI ap-

proached this problem by incorporating food subdivisions called "Dishes" into its scheme to categorize vehicles with a primary ingredient. For example, outbreaks linked to "chicken salad" were categorized under "Poultry Dishes." While foods with highly varying primary ingredients, such as pizza or lasagna, remain a challenge, they were to be categorized consistently throughout the database under "Multi-ingredient Foods."

A third important challenge in creating a strong food categorization scheme is to ensure that it is based on common sense and that is intuitive for the average consumer. CSPI's categorization scheme is accessible to consumers because it uses easily recognizable categories, is useful to producers and scientists because it groups similar foods together, and is valuable to policy makers because it categorizes foods by regulatory agency.

Several food categorization schemes have addressed these difficulties differently. While studies in the United States have generally focused on pathogens, Adak et al. identified the foods most often linked to indigenous foodborne illness in England and Wales and analyzed food-specific risks by use of a food categorization scheme different from that used by CSPI (1). For example, the scheme used by Adak et al. included categories such as "infected food handler" and "cooked vegetables." Classifying foods along varying characteristics can enable different analyses that might be useful for different purposes. However, categories such as "infected food handler" represent the source of contamination, and thus indicate another level of outbreak categorization that is distinct from food attribution. Once outbreaks have been classified by food vehicle, they can be further broken down by cause, such as infected food handler, manure contamination on the farm, contamination in the processing plant, or cross contamination in the kitchen. Such cause identification, or determination of how contamination occurred, will frequently be more difficult to confirm than a food vehicle identification, but should be an important goal of foodborne illness surveillance because of the application to appropriate interventions and improved prevention.

Another food categorization scheme, proposed by the CDC (21), includes categories such as "row crops" and "tree crops," neither of which is intuitive to a consumer shopping in the produce aisle. Although such categories may have their advantages, it is essential that any scheme be easily understandable and accessible to the average consumer as well as to researchers and policy makers. Adopting a universal categorization scheme across

studies would also aid in comparison of results and analysis of trends.

Although the outbreaks represented in the CSPI database have been thoroughly checked for accuracy, outbreak data in general have several limitations. The outbreaks included constitute only a small proportion of the true number of outbreaks. Many foodborne illness outbreaks go unreported, and of those that are reported by the CDC in fewer than 40% are both an etiology and food source identified (5, 18). The outbreaks analyzed by CSPI are the most representative sample available of foodborne illness outbreaks in the United States with identified etiology and food vehicle, but certain biases in the database may be unavoidable. Foodborne illnesses that are diagnosed relatively easily, such as scombrototoxin and ciguatera, are more likely to be reported, and this could lead to overrepresentation of food categories such as seafood. Foodborne pathogens more likely to cause sporadic infections rather than outbreaks (i.e. *Vibrio vulnificus*, *Campylobacter* spp., and *Listeria monocytogenes*) are more likely to be underrepresented.

The lack of consistent outbreak reporting practices across the different US states also impacted the nature of the outbreaks in the database, as each state health department has different criteria for reporting their identified outbreaks to CDC. In addition, outbreak reporting practices varied dramatically between the periods of 1990–1997 and 1998–2003 because of the implementation of the Electronic Foodborne Outbreak Reporting System (EFORS) in 1998. This makes comparisons of outbreak data from these two periods difficult (Fig. 1). Although the implementation of EFORS greatly increased the number of reported outbreaks and improved the timeliness of the reports, there is still a lack of real-time outbreak reporting. This means that information is often not released until months or years after the investigation. Because of this, CSPI monitors news releases, scientific journals, and state health departments for more recent and up-to-date outbreak information. Finally, although outbreak data are a critical component of food safety surveillance, they cannot be considered in isolation. Food attribution and categorization information for sporadic cases are also very important and should be systematically compiled and released in a timely manner (2, 8).

CSPI's database and food categorization efforts provide critical information to consumers, producers, and policy makers for risk-based decision-making. The database could be improved if foodborne illness outbreak reporting by each state

to the CDC were made mandatory and were based on consistent criteria. The CDC and state health departments should routinely perform food attribution for all outbreaks, and this information should be made available to the public in a timely manner. Food categorization should be consistent and adhere to a common sense scheme. Policy makers and the public would benefit if a uniform categorization scheme were used by researchers and government alike. Such measures could greatly improve the consistency of outbreak reporting and the usefulness of such data in protecting public health.

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