

# The Role of Pork as a Vehicle for Confirmed Foodborne Disease Outbreaks in the United States, 1990-1997



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**Abstract:** Outbreaks of confirmed foodborne disease in the United States reported to CDC from 1990-1997 were reviewed to evaluate the role of pork in causing outbreaks and to identify strategies for prevention. Sixty-four (4%) of 1,692 outbreaks with a known etiology were due to pork or pork-containing foods. Raw or undercooked pork appeared to be the source for most outbreaks in which the pork product was implicated as a primary vehicle. However, in many outbreaks involving pork as an ingredient in the implicated food, the pork may not have been the source of contamination. Primary prevention of foodborne outbreaks due to pork will require further pathogen reduction on raw pork and improved foodhandling practices in commercial establishments and private homes.

**Introduction:** Monitoring the occurrence of foodborne diseases and investigating outbreaks is part of foodborne disease surveillance. Although no one likes to be part of a foodborne disease outbreak, investigating outbreaks gives public health officials a chance to learn more about how and why outbreaks happen. Foodborne disease surveillance is important to help answer the following questions:

- Where are the problems?
- What are the most important problems?
- How can we prevent them?

Foodborne outbreak investigations are usually conducted by State and Local Health Departments. Federal regulatory agencies, such as USDA and FDA assist in outbreak investigations when foods under their jurisdiction are identified as the source of the outbreak. The Centers for Disease Control and Prevention (CDC) helps co-ordinate multi-state outbreak investigations and assists at the request of individual states. Results of the investigations are reported to CDC, which maintains a national database of foodborne disease outbreaks.

During the past decade, several food safety problems have developed around specific foods:

- Salmonella* Enteritidis and shell eggs
- E. coli* O157:H7 and ground beef
- Salmonella* spp. and alfalfa sprouts
- Vibrio vulnificus* and molluscan shell fish

Public Health officials anticipate that new foodborne disease issues will continue to emerge. In order to stay in front of food safety issues and help producers identify opportunities to control existing foodborne disease threats, the National Pork Board sought to evaluate the role of pork as a vehicle for confirmed foodborne disease outbreaks reported to CDC.

**Objectives:** The overall objectives of the project are to evaluate pork's role in causing foodborne disease outbreaks and to identify strategies for preventing outbreaks due to pork. Specific objectives include:

1. Determine the relative proportion of pork vehicles among outbreaks by agent (i.e., % of *Salmonella* outbreaks in which a pork vehicle was implicated).
2. Determine the distribution of pathogens among outbreaks in which a pork vehicle was implicated.
3. Determine the distribution of pork-associated outbreaks by time and location to identify geographic patterns and trends over time.
4. Evaluate available contributing factor data to identify remediation and prevention strategies.

**Procedures:** Line lists of all confirmed foodborne outbreaks reported to CDC for the years 1990-1997 were obtained by the National Pork Board from CDC. Records were requested under the Freedom of Information Act.

Data from the line lists was entered into a database for analysis. The following information was available for reported outbreaks:

- The agent (the organism that caused the outbreak)
- The state in which the outbreak occurred
- The month and year in which the outbreak occurred
- The food item identified as the source of the outbreak (also called the vehicle)
- The setting in which the outbreak occurred

Data were entered for all outbreaks with a confirmed etiology, and for those outbreaks with an unknown etiology in which a pork or pork-containing product was identified as a source. Implicated food items were identified by a brief description (i.e., pork roast, sausage lasagna). For implicated food items that identified pork products as the source or as an ingredient, foods were classified as: pork, ham, or sausage.

Outbreaks were classified according to whether the pork product implicated was the primary vehicle or an ingredient in the implicated food item. Analyses were conducted using Epi-Info, statistical analysis software.

**Results:** From 1990-1997, 1,692 outbreaks with a confirmed etiology were reported to CDC. Of these, 64 (4%) were attributable to pork or pork-containing foods, 1,090 (64%) were attributable to food items that did not include pork, and for 538 (32%) the vehicle was unknown.

**Objective 1:** The most common cause of all confirmed outbreaks was *Salmonella* (789 outbreaks). Pork or pork containing foods were identified as the source for 23 (3%) of these outbreaks. The proportion of outbreaks involving pork, for all agents are shown in Table 1.

Table 1. Number of Outbreaks with a Known Etiology Involving Pork or Pork-Containing Foods, United States, 1990-1997

Agent	No. Pork (%)	No. Total
<i>Salmonella</i>	23 ( 3)	789
<i>Escherichia coli</i> O157:H7	1 ( 1)	98
<i>Clostridium perfringens</i>	6 ( 6)	95
<i>Staphylococcus aureus</i>	14 (19)	73
Norwalk-like virus	1 ( 1)	69
<i>Clostridium botulinum</i>	1 ( 2)	50
<i>Campylobacter</i>	1 ( 2)	41
<i>Bacillus cereus</i>	5 (17)	30
<i>Trichinella</i>	7 (50)	14
<i>Yersinia</i>	3 (100)	3

Although *Salmonella* was the most frequent cause of all reported foodborne outbreaks and of those involving pork, only 3% of *Salmonella* outbreaks were due to pork or pork-containing foods. Thus, although pork is a potential source for *Salmonella*, other sources appear to be more important for causing outbreaks. However, one limitation of this analysis is that if a contaminated pork product was a source for *Salmonella* in a kitchen that resulted in contamination of a salad, the salad and not the pork product may be identified as the source.

Although less common than *Salmonella*, outbreaks of *Yersinia* and *Trichinella* are much more frequently due to pork or pork-containing foods. The distribution of pathogens by type of pork product suggests differences in whether the pork was the source of the contamination, or was contaminated from other sources. For example, Norwalk-like virus is not known to infect animals. The outbreak involving Norwalk-like virus involved ham that was likely contaminated by an ill food worker.

**Objective 2:** Because outbreaks involving pork as the primary source seem to be different from outbreaks involving pork as an ingredient, these groups were analyzed separately. Table 2 shows the distribution of pathogens by type of pork that was identified as the primary source for the outbreak. Table 3 shows the distribution of pathogens when these pork products were ingredients in the implicated food item.

Six (33%) of 18 outbreaks with a known etiology, in which pork was implicated as a primary vehicle were caused by *Salmonella*. In contrast, 10 of 12 (83%) outbreaks with a known etiology in which ham was implicated as a primary vehicle were caused by *Staphylococcus aureus*. These data suggest that *Salmonella* from raw or undercooked pork is a source for foodborne outbreaks, but that most outbreaks involving ham likely occur because of improper food handling practices.

In contrast to the distribution of pathogens associated with outbreaks in which pork products were implicated as primary vehicles, 16(59%) of 27 outbreaks involving pork products as ingredients, were caused by *Salmonella*. Several outbreaks involved agents that are not typically associated with hogs and pigs. For example, Norwalk-like virus is not known to have an animal reservoir, and *E. coli* O157:H7 has been primarily associated with cattle.

A variety of *Salmonella* serotypes were associated with implicated pork vehicles. This is consistent with the variety of *Salmonella* serotypes isolated from hogs. During 1997, 56 serotypes of *Salmonella* were isolated from hogs and reported through USDA to CDC. *Salmonella* Typhimurium, the most common serotype, accounted for 27% of reported isolates. *Salmonella* Enteritidis caused only 1/12 (8%) of outbreaks involving pork as a primary vehicle or ingredient. In contrast, *Salmonella* Enteritidis caused the one *Salmonella* outbreak in which ham was implicated as a primary vehicle, and six (60%) of the 10 *Salmonella* outbreaks in which ham or sausage was an ingredient. Thus, pork was not the likely source of *Salmonella* Enteritidis in these outbreaks. This is also consistent with the strong association between *Salmonella* Enteritidis and egg-laying chickens. During 1997, 91% of *Salmonella* Enteritidis from animals reported to CDC were from chickens or eggs, only 5% came from hogs or pigs.

Fifty-four outbreaks with an unknown etiology were attributed to pork or pork-containing foods from 1990-1997. Of these, 19 (35%) involved pork as a primary vehicle, and 35 (65%) involved pork as an ingredient. More than half of these outbreaks involved ham (32 outbreaks, 59%). The occurrence of one confirmed Norwalk-like viral outbreak and the increased percentage of outbreaks with an unknown etiology, among outbreaks in which ham was an ingredient in the implicated food item, suggest that many of these were outbreaks of viral gastroenteritis. Most of these outbreaks occurred in commercial establishments or institutions. Outbreaks such as these are typically caused by ill food workers.

Table 2. Number of Outbreaks with a Known Etiology Involving Pork Products as a Primary Vehicle, United States, 1990-1997

<b>Agent</b>	<b>Pork</b>	<b>Ham</b>	<b>Sausage</b>	<b>Total</b>
<i>Staphylococcus aureus</i>	2	10	0	12
<i>Salmonella</i>	6	1	0	7
<i>Trichinella</i>	3	0	4	7
<i>Yersinia</i>	3	0	0	3
<i>Bacillus cereus</i>	2	0	0	2
<i>Clostridium perfringens</i>	1	1	0	2
<i>Clostridium botulinum</i>	0	0	1	1
<i>Campylobacter</i>	1	0	0	1
Total known agents	18	12	5	35

Table 3. Number of Outbreaks with a Known Etiology Involving Pork Products as an Ingredient, United States, 1990-1997

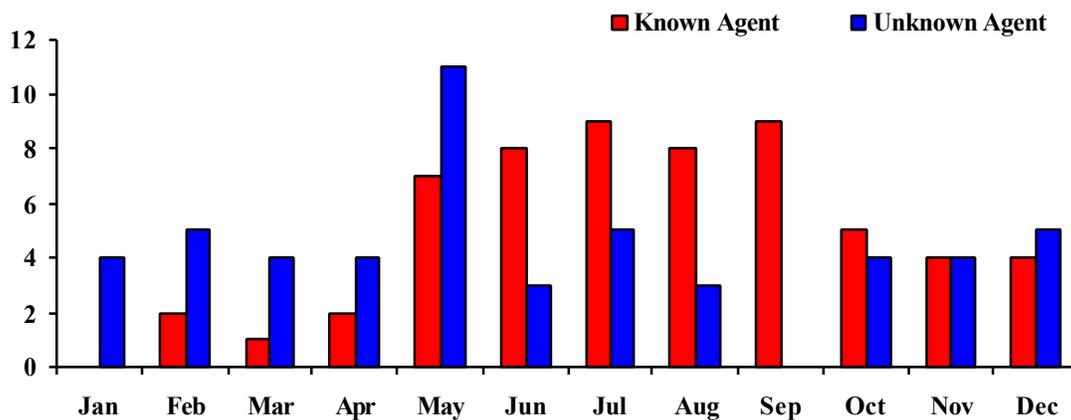
<b>Agent</b>	<b>Pork</b>	<b>Ham</b>	<b>Sausage</b>	<b>Total</b>
<i>Salmonella</i>	6	6	4	16
<i>Clostridium perfringens</i>	2	0	2	4
<i>Bacillus cereus</i>	3	0	0	3
<i>Staphylococcus aureus</i>	0	2	0	2
<i>Escherichia coli</i> O157:H7	1	0	0	1
Norwalk-like virus	0	1	0	1
Total known agents	12	9	6	27

Table 4. *Salmonella* serotype in Outbreaks Involving Pork Products as a Primary Vehicle or Ingredient, United States, 1990-1997

<b><i>Salmonella</i> serotype</b>	<b>Primary (%)</b>	<b>Ingredient (%)</b>	<b>Total</b>
Enteritidis	2 (<1)	6 ( 1)	484
Heidelberg	1 ( 2)	2 ( 4)	55
Typhimurium	1 ( 2)	3 ( 6)	54
Newport	0	2 (22)	11
Thompson	1 (13)	0	8
Agona	0	1 (17)	6
Reading	0	1 (20)	5
Berta	1 (50)	0	2
Litchfield	1 (100)	0	1
Spp.	0	1 ( 1)	71

**Objective 3:** The number of reported outbreaks involving pork ranged from four to 12 per year, with an average of seven to eight. There was no trend in the occurrence of outbreaks over time. The distribution of outbreaks by month of onset are shown in Figure 1. The distribution of outbreaks by month varied by whether the agent was known or unknown. Outbreaks due to known agents peaked during the summer months while the unknown agents were more likely to occur during winter and spring. This is consistent with other data suggesting that many of the outbreaks due to unknown agents are likely outbreaks of viral gastroenteritis.

*Figure 1. Outbreaks Involving Pork Products by Month of Onset, United States, 1990-1997*



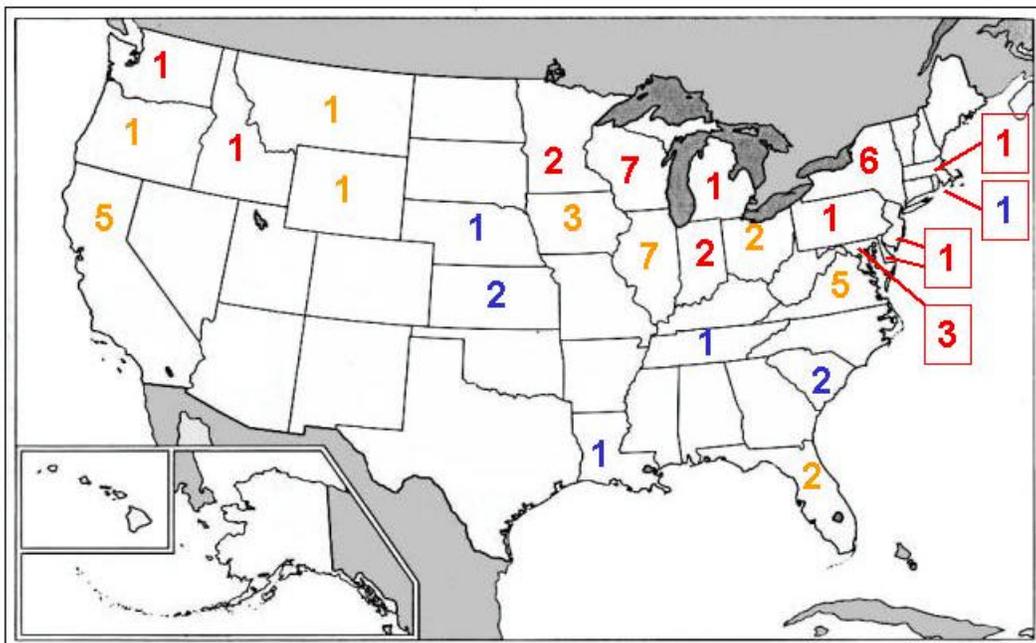
The distribution of outbreaks by setting is shown in Table 5. Eighteen (29%) outbreaks involving pork products occurred in private homes, 14 (23%) occurred at commercial establishments, 11 (18%) occurred at special events, and nine (15%) occurred in institutional settings. Many of the special events involved picnics and pig roasts.

*Table 5. Number of Outbreaks with a Known Etiology Involving Pork Products, by Outbreak Setting, United States, 1990-1997*

Setting	Pork	Ham	Sausage	Total
Private home	10	1	7	18
Commercial establishment	7	6	1	14
Special event	6	4	1	11
Institution	4	5	0	9
Workplace	1	4	0	5
Not reported	2	1	2	5
<b>Total known agents</b>	<b>30</b>	<b>21</b>	<b>11</b>	<b>62</b>

The distribution of outbreaks by state are shown in Figure 2. The distribution of outbreaks by state shows some clustering of outbreaks in hog producing states. Thus, a high proportion of outbreaks involving pork reported are reported from Midwestern states. However, many of these states also have relatively strong public health systems, and report more outbreaks of all types. Data on food consumption patterns reported by FoodNet, CDCs Active Surveillance System for Foodborne Diseases confirm that consumption of pork products across the country does not vary as markedly as does the occurrence of outbreaks. Thus, limitations in our public health surveillance system for foodborne disease may result in many outbreaks not being detected or investigated thoroughly to identify the source.

*Figure 2.* Number of Outbreaks with a Known Etiology Involving Pork Products, by State, 1990-1997. (Highlighting by state correlates to the number of all outbreaks with a known etiology per million population reported for the state. For example, Minnesota reported more than 1 outbreak per million population, Iowa reported between 0.5 –1 outbreak per million population, and Nebraska reported <0.5 outbreaks per million population).



**Objective 4:** Specific information on contributing factors identified during the outbreak investigations was not included in the available line lists. Because available data were taken from line lists rather than from original outbreak reports, it is not possible to

formally evaluate all of the factors leading to the occurrence of these outbreaks. Other limitations of this study include:

- The description of implicated vehicles may have led to misclassification of outbreaks.
- Outbreaks identified as having multiple vehicles may have included pork-containing foods that were not identified.
- The identification of implicated food vehicles does not account for a potential role for cross-contamination between pork and ready-to-eat foods, such as salads.
- Outbreaks account for only a small percentage of all foodborne illnesses. The role of pork as a cause of foodborne disease may not be limited to its role as a cause of outbreaks.
- The occurrence of foodborne outbreaks does not address potential environmental concerns regarding environmental contamination from manure.

Given the stated limitations of the study, there are some clear conclusions that can be drawn from the national surveillance system regarding the role of pork as a source of foodborne outbreaks:

- A relatively small number of outbreaks have been reported in which pork containing foods have been implicated. This almost certainly understates the absolute role of pork, due to limitations in state-based foodborne disease surveillance systems. However, pork-containing foods also appear to account for a small percentage of all foodborne outbreaks reported in the US. This is not likely due to limitations in surveillance.
- Differences in the distribution of pathogens between outbreaks in which pork is identified as a primary vehicle or as an ingredient suggest that pathogens associated with hogs cause outbreaks in which pork is identified as the primary vehicle, or source of the outbreak. However, in many of the outbreaks in which pork is an ingredient in the implicated food item, the pork may not be the actual source of contamination.
- The distribution of pathogens associated specifically with outbreaks involving ham suggest that handling of the product is the main factor contributing to the occurrence of the outbreak.

There are two primary implications of these conclusions for preventing future foodborne disease outbreaks involving pork and pork products:

- Primary prevention of foodborne outbreaks due to pork will require further reduction in the levels of pathogens on raw pork, either through interventions on the farm, during processing, or through irradiation of raw pork.
- Education of foodhandlers, in commercial establishments and homes is needed to prevent outbreaks due to inadequate foodhandling practices.

## **Craig W. Hedberg, Ph.D.**

Dr. Hedberg is an Associate Professor of Environmental and Occupational Health, School of Public Health, University of Minnesota, Minneapolis, MN. Dr. Hedberg received his B.S. in Biology from the University of Connecticut in 1976, an M.S. in Environmental Health from the University of Minnesota in 1984, and a Ph.D. in Epidemiology from the University of Minnesota in 1993. From 1985 to 1999, he conducted and supervised statewide surveillance for foodborne diseases at the Minnesota Department of Health. In April 1999, Dr. Hedberg took a faculty position in the Division of Environmental and Occupational Health, in the School of Public Health at the University of Minnesota. This was the first faculty position established within the School of Public Health to focus on food safety issues.

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