Vibrio parahaemolyticus Infections in the United States, 1973–1998

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***Vibrio parahaemolyticus* infections are associated with consumption of raw or undercooked shellfish, contaminated food, and exposure of wounds to warm seawater. Foodborne outbreaks and sporadic infections from *Vibrio* species in 4 Gulf Coast states are reported routinely to the Centers for Disease Control and Prevention (CDC). Between 1988 and 1997, 345 sporadic *V. parahaemolyticus* infections were reported: 59% were gastroenteritis, 34% were wound infections, 5% were septicemia, and 2% were from other exposures. Forty-five percent of patients suffering from these conditions were hospitalized for their infections, and 88% of persons with acute gastroenteritis reported having eaten raw oysters during the week before their illness occurred. Between 1973 and 1998, 40 outbreaks of *V. parahaemolyticus* infections were reported to the CDC, and these outbreaks included >1000 illnesses. Most of these outbreaks occurred during the warmer months and were attributed to seafood, particularly shellfish. The median attack rate among persons who consumed the implicated seafood was 56%. To prevent *V. parahaemolyticus* infections, persons should avoid consumption of raw or undercooked shellfish and exposure of wounds to seawater.**

Vibrio parahaemolyticus is a gram-negative, halophilic bacterium that naturally inhabits marine and estuarine environments and causes 3 major syndromes of clinical illness—gastroenteritis (the most common syndrome), wound infections, and septicemia [1]. *V. parahaemolyticus* was first identified as a cause of foodborne illness in Japan in 1950. At that time an outbreak investigation confirmed that infection was associated with eating sardines; 272 persons became ill, and 20 died [2]. Since then, *V. parahaemolyticus* has been recognized as a common cause of foodborne illness in Japan and throughout Asia. During the past 10 years in the United States, *V. parahaemolyticus* has been the most common *Vibrio* species isolated from humans, as well as the most frequent cause of *Vibrio*-associated gastroenteritis [3]. Recent *V. parahaemolyticus* outbreaks in the United States have been associated with consumption of raw or undercooked shellfish [4–6]. Despite an increasing number of *Vibrio* infections, *V. parahaemolyticus* and other noncholera *Vibrio* infections have not been reported in most states.

In this article, we describe the epidemiology of *V. parahaemolyticus* infections in the United States from 1973 to 1998, including data on sporadic infections and foodborne outbreaks reported to the US Centers for Disease Control and Prevention (CDC). These epidemiologic data, along with environmental factors that may have contributed to the occurrence of recent *V. parahaemolyticus* outbreaks, suggest potential control measures to reduce the burden of illness caused by this organism in the United States.

Methods

Since 1988, the CDC has collected epidemiologic and clinical information about sporadic *V. parahaemolyticus* infections in states that participate in the Gulf Coast *Vibrio* Surveillance System. These states include Florida, Alabama, Louisiana, and Texas. Sporadic infections are reported voluntarily to the CDC on a standard reporting form completed by state or local health departments after

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State epidemiologists can obtain copies of the Centers for Disease Control and Prevention's (CDC) "Cholera and other *Vibrio* Illness Surveillance Reporting Form" from the CDC, Foodborne and Diarrheal Diseases Branch, Mailstop A38, Atlanta, GA 30333.

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Table 1. Characteristics of 337 patients with *Vibrio parahaemolyticus* infections, by clinical syndrome, 1988–1997.

Characteristic	Gastroenteritis (n = 202)	Wound infections (n = 118)	Septicemia (n = 17)
Male	109 (56)	97 (84)	9 (53)
Fever	79 (52)	46 (49)	14 (93)
Diarrhea	180 (98)	6 (7)	11 (65)
Abdominal cramps	148 (89)	6 (8)	12 (71)
Nausea	133 (76)	16 (20)	12 (75)
Vomiting	97 (55)	5 (6)	10 (63)
Bloody diarrhea	43 (29)	1 (<1)	6 (40)
Localized cellulitis	1 (<1)	85 (83)	3 (20)
Bullous lesions	—	8 (11)	1 (8)
Hospitalized	72 (38)	68 (61)	14 (82)
Died	4 (2)	3 (3)	5 (29)
Median age, years (range)	36 (<1–93)	37 (4–83)	46 (3–77)
Duration of illness, days (range)	6 (1–30)	7 (1–215)	5 (1-30)
Underlying illness	58 (29)	48 (41)	12 (71)
Peptic ulcer disease	12	—	—
Diabetes	10	13	2
Alcoholism	6	7	2
Liver disease	5	5	8

NOTE. Data are no. (%), unless otherwise noted.

they have finished the investigation of a culture-confirmed illness. The surveillance report includes data on demographics (e.g., age, sex, race/ethnicity, and occupation of victims); data on the sites of *Vibrio* infection; clinical information (e.g., symptoms, preexisting medical conditions, duration of illness, sequelae of infection, and patient clinical outcomes); and epidemiologic information (e.g., recent travel experiences, seafood exposure, and contact with seawater).

To obtain clinical and epidemiological information (including food history) on *V. parahaemolyticus* infections, we extracted data for 1988–1997 from the *Vibrio* database that is maintained at the CDC. For analysis of data, wound infections were considered to be the source of infection when a patient incurred a wound before or during exposure to seawater or seafood drippings and when a culture of the wound, blood, or of a normally sterile site yielded *V. parahaemolyticus.* Primary septicemia was defined as a systemic illness characterized by fever or shock (<90 mm Hg systolic blood pressure), in which *V. parahaemolyticus* was isolated from either the blood or a normally sterile site (specifically when no wound infection preceded the illness). Gastroenteritis was defined as an illness with attendant diarrhea, vomiting, or abdominal cramps; no evidence of wound infection; and isolation of *V. parahaemolyticus* from stool samples alone.

Since 1973, the CDC has received reports of foodborne disease outbreaks, including those caused by *Vibrio* species, from state and local health departments. A *V. parahaemolyticus* outbreak was defined as an incident in which ⩾2 persons experienced a similar illness resulting from the ingestion of a common food and in which ⩾2 persons had laboratory-confirmed *V. parahaemolyticus* infection or as an incident in which $\geqslant 10^5$ Kanagawa-positive *V. parahaemolyticus* organisms per gram were isolated from epidemiologically implicated food. We reviewed *V. parahaemolyticus* outbreaks that occurred between 1 January 1973 and 31 December 1998 and that were reported on standard investigation forms through the foodborne disease–outbreak surveillance system.

Results

Sporadic disease. Between 1988 and 1997, a total of 345 cases of *V. parahaemolyticus* infection were reported to the CDC by the states participating in the Gulf Coast *Vibrio* Surveillance System. Cases were reported from Florida, Alabama, Louisiana, and Texas. Of the 345 patients whose cases were reported to the CDC, 202 (59%) had gastroenteritis, 118 (34%) had wound infections, and 17 (5%) had septicemia. Eight other infections were reported, including ear, eye, urinary tract, and peritoneal infections. Ear infections developed after swimming in the Gulf of Mexico, an eye infection occurred after a penetrating corneal injury and exposure to warm seawater, and the peritoneal infection was diagnosed after surgery for acute appendicitis. Two hundred twenty-one (64%) of the reported infections occurred in males. Patients' ages ranged from 1 month to 93 years (median, 36 years). Between 1988 and 1997 in the Gulf Coast states, a median of 34 infections occurred per year (range, 26–41). Among the 88 patients with *V. parahaemolyticus* gastroenteritis and known food history, 77 (88%) reported having eaten raw oysters in the week before their illness occurred. Among the 11 patients with septicemia and known food history, 10 (91%) had eaten raw oysters.

Overall, 119 (34%) persons reported having a preexisting illness, and 156 (45%) persons were hospitalized. Of the 301 patients for whom information on survival was available, 12 (4%) died as a result of their infections. Of the 12 patients who died, 5 (29%) had primary septicemia, 4 (2%) had gastroenteritis, and 3 (3%) had wound infection. Of the 9 patients who died as a result of severe gastroenteritis or septicemia, food histories existed for 5 of them; all of them had eaten raw oysters during the week before the onset of illness. Of the 12 patients who died, 10 (83%) had a known preexisting medical condition; these conditions included alcoholism, liver disease, renal disease, vas-

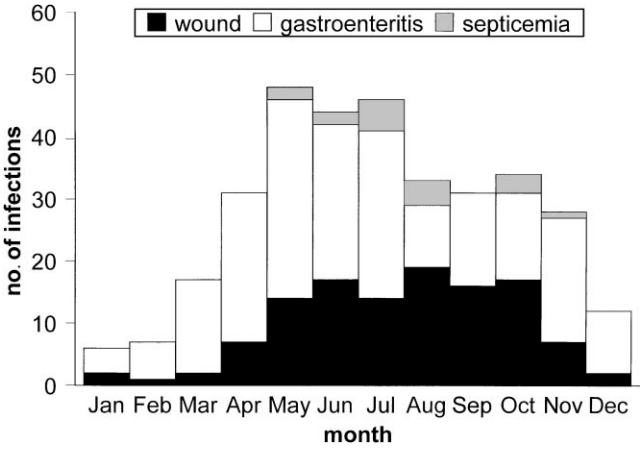

Figure 1. *Vibrio parahaemolyticus* infections in the United States, as reported to the Centers for Disease Control and Prevention, by month of culture date, 1988–1997.

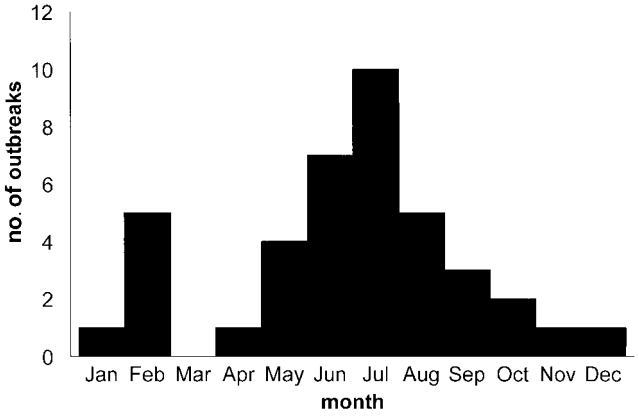

Figure 2. *Vibrio parahaemolyticus* outbreaks in the United States, by month of occurrence, 1973–1998.

cular disease, and diabetes. The clinical characteristics of patients with *V. parahaemolyticus* infection by clinical syndrome are summarized in table 1. Patients with primary septicemia (10 [83%] of 12 patients) were more likely than those with gastroenteritis (11 [19%] of 58 patients) to have a known history of alcoholism or liver disease. All syndromes of *V. parahaemolyticus* infection were more common in the warmer months (figure 1); 94% of cases occurred between April and October.

Foodborne outbreaks. Between 1973 and 1998, the CDC received reports of 40 outbreaks of *V. parahaemolyticus* infection in 15 states and the Guam Territories; these outbreaks resulted in 1064 illnesses (table 2). The majority of these outbreaks occurred during the warmer months (figure 2), with 80% occurring between April and October; the median month of occurrence was July. Outbreaks were reported along all coastal areas in the United States and the Guam Territories. The range for attack rates was 3%–100%, with a median of 56%. The median incubation period was 17 h (range, 4–90 h). The median number of ill persons involved in these outbreaks was 5 (range, 2–296 persons). Diarrhea was the most common symptom and often was associated with abdominal cramps, nausea, and vomiting. The median reported duration of illness was 2.4 days (range, 8 h to 12 days). One death was reported. The food vehicle in all the outbreaks was seafood or cross-contamination with seafood, particularly raw or undercooked shellfish. Seafood was eaten raw in 15 (38%) of the outbreaks.

Twelve (30%) of the 40 *V. parahaemolyticus* outbreaks were reported in 1997 and 1998, which may suggest a resurgence of this pathogen (figure 3). Three recent large multistate outbreaks occurred in 1997 and 1998. During July–August 1997, an outbreak linked to consumption of raw or undercooked shellfish harvested from waters off the coasts of California, Oregon, Washington, and British Columbia resulted in >200 illnesses in 7 states and Canada [4]. The most common *V. parahaemolyticus* serotypes isolated from patients involved in this outbreak were O4:K12 and O1:K56. During May–July 1998, 416 persons in 13 states reported having gastroenteritis after eating oysters harvested from Galveston Bay, Texas (these patients included those who reported 296 cases of *V. parahaemolyticus* infection in Texas and 120 cases of infection from other states). All patient isolates were *V. parahaemolyticus* serotype O3:K6, which commonly causes outbreaks in Asia but had not been identified previously in the United States. Later in 1998, another multistate outbreak of *V. parahaemolyticus* O3:K6 infection occurred; 23 culture-confirmed cases of infection were reported from New York, New Jersey, and Connecticut. Infection was linked to consumption of raw oysters and clams harvested from Oyster Bay, Long Island, New York [5].

Discussion

Our clinical and epidemiologic review of *V. parahaemolyticus* infections and foodborne outbreaks demonstrates that this infection causes significant morbidity in the United States and occasionally can be fatal. Nearly 30% of reported patients with gastroenteritis had bloody stools, which suggests that only the most severe cases came to the attention of medical personnel. The high case fatality rate (4%) of sporadic infections and the high attack rate (56%) during outbreaks may also suggest a reporting bias toward severe cases. Most sporadic infections and outbreaks were linked to consumption of contaminated, raw molluscan shellfish. During the past several years, the number of reported outbreaks has increased steadily; there was a sharp rise after 1997. A possible explanation for this observed increase may be that warmer sea temperatures affect the emergence of more-virulent serotypes in oyster-harvesting areas.

The occurrence of outbreaks that result from consumption of contaminated seafood, particularly shellfish harvested between February and December from the waters of all coastal regions of the United States and the Guam Territories, is consistent with the ecology of *V. parahaemolyticus.* The seasonality of infections, which occurred mainly during the warmer months, suggests that water temperature may be an important factor in the epidemiology of *Vibrio* infection. Water temperatures have been shown to influence the growth of *V. parahaemolyticus* [7–11]. Interestingly, 1997 and 1998 were El Niño years that resulted in warmer sea temperatures in coastal areas. These elevated temperatures have been shown to influence the incidence of *V. cholerae* [12] and may also explain the resurgence of *V. parahaemolyticus* during these years. Although we did not have information on the site of oyster harvest and on the water temperature at time of harvest, one recent CDC study showed that 89% of oysters that made persons ill with *V. vulnificus* were harvested in waters with a temperature >22°C [13]. The emergence of more-virulent serotypes in oyster-harvesting areas also could have contributed to an increase in *V. parahaemolyticus*

Table 2. Epidemiological characteristics of outbreaks of *Vibrio parahaemolyticus* infection reported to the Centers for Disease Control and Prevention, United States, 1973–1998.

Year	Month	State or territory	Vehicle	No. of persons exposed	No. of persons ill	Attack rate (%)
1973	February	California	Shellfish	4	2	50
1975	July	Louisiana	Boiled shrimp	700	100	14
1975	November	Guam	Octopus	590	122	21
1977	December	Virgin Islands	Seafood salad	1059	98	9
1977	October	Guam	Shrimp	400	20	5
1978	June	Louisiana	Boiled shrimp	122	82	67
1978	May	Guam	Shellfish	350	10	3
1978	June	Guam	Shellfish	8	8	100
1978	August	Guam	Shellfish	8	4	50
1979	February	Guam	Shrimp	40	3	8
1979	February	Guam	Shrimp	30	11	37
1980	October	Arizona	Shrimp	5	4	80
1980	April	Florida	Raw oysters	2	2	100
1980	July	Guam	Shrimp	5	3	60
1980	August	Guam	Shrimp	3	3	100
1981	February	Arizona	Seafood dinner	2	2	100
1981	February	Rhode Island	Shellfish	223	11	5
1982	August	Massachusetts	Raw clams	51	26	51
1982	July	New York	Steamed clams	300	10	3
1982	July	New York	Raw clams	3	3	100
1986	September	Washington	Shrimp	3	2	67
1987	July	Washington	Raw oysters	4	4	100
1987	September	Washington	Raw oysters	5	5	100
1990	August	Idaho	Oysters	Unknown	5	—
1990	July	Washington	Raw oysters	Unknown	5	—
1990	July	Washington	Raw oysters	12	9	75
1990	August	Washington	Raw oysters	9	2	22
1993	May	Washington	Unknown	Unknown	4	—
1997	May	Washington	Raw oysters	Unknown	56	—
1997	July	Oregon	Raw oysters	Unknown	13	—
1997	June	California	Raw oysters	Unknown	11	—
1997	September	California	Shark's fin/crabmeat	44	16	36
1998	January	Guam	Cross-contamination with seafood	150	47	31
1998	May	Florida	Steamed lobster/shrimp	8	6	75
1998	June	Texas	Raw oysters	Unknown	296	—
1998	June	North Carolina	Boiled shrimp	19	17	89
1998	June	Florida	Crabs	15	13	87
1998	June	California	Raw oysters/steamed shrimp	Unknown	4	—
1998	July	New York, New Jersey, Connecticut	Raw oysters and clams	Unknown	23	—
1998	July	Washington	Raw oysters	Unknown	2	—
Median	July					56
Total				4174	1064	

outbreaks in the United States from 1997 to 1998. Several strains of *V. parahaemolyticus* (e.g., O3:K6, O4:K12, and O1:K56) have been associated with this recent upsurge. Whether warmer seawater temperature influences strain selection is unknown.

More than 95% of *V. parahaemolyticus* strains isolated from stool cultures of symptomatic persons are virulent, as determined by a positive Kanagawa reaction [14]. In contrast, $\leqslant$1% of strains from the environment, including strains isolated from seafood implicated during outbreaks, have a positive Kanagawa reaction [14–16]. The reason for this discrepancy in virulence between human and environmental isolates is unknown. Nevertheless, it suggests that environmental sampling of oyster beds to detect the presence of *V. parahaemolyticus* may not be a useful public health measure. In a volunteer feeding study, the infective dose of *V. parahaemolyticus* was determined to be between 10^5 and 10^7 organisms [17]. Participants were healthy young adults who were given antacid tablets before being fed *V. parahaemolyticus.* Recent outbreaks in the United States indicate that the infective dose may be much lower [4, 5].

V. parahaemolyticus in stool specimens is readily identified on selective media such as thiosulfate-citrate-bile salts (TCBS) agar; it usually appears as a blue-green colony [18], and identification is accomplished by using biochemical tests. In 1997, a survey of US clinical laboratories in FoodNet sites in California, Connecticut, Georgia, Minnesota, and Oregon found that only 31% of laboratories routinely cultured stool specimens specifically for *Vibrio* by using TCBS agar [19]. In a random survey of Gulf Coast clinical laboratories, we found that only 20% of laboratories used TCBS routinely to culture stool spec-

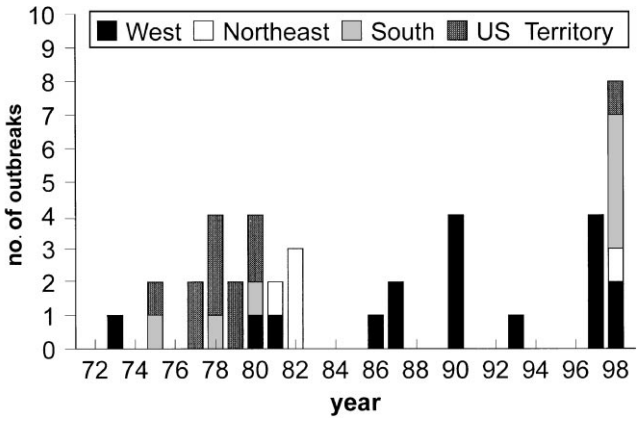

Figure 3. *Vibrio parahaemolyticus* outbreaks in the United States, by region, 1973–1998.

imens (CDC, unpublished data). Blood agar and other nonselective media may also support the growth of *Vibrio;* however, detection is more difficult than with TCBS. Many laboratories are now using automated biochemical machines, such as Vitek (Vitek Systems, Hazelwood, MO), to identify microorganisms. These automated machines have not been validated for identification of *Vibrio* species. Misclassification of *Vibrio* with other enteric pathogens may occur, particularly in the cases of *Aeromonas, Pleisiomonas,* and *Pseudomonas.* Therefore, all *Vibrio* isolations should be confirmed using TCBS and standard biochemical tests at state public health laboratories.

Recent outbreaks have highlighted the need to reevaluate regulations and policies concerning the safety of raw molluscan shellfish, and these outbreaks indicate that current policy and regulations for oyster harvesting do not protect the approximately 1 in 10 American adults who occasionally eat raw shellfish (CDC FoodNet, unpublished data). During recent outbreaks, the implicated oyster beds met current bacteriologic standards for fecal coliforms, which were established by the National Shellfish Sanitation Program [20], and the median enumerated *V. parahaemolyticus* counts were less than the regulatory threshold of 10,000 cfu/g [4, 5]. Molluscan shellfish harvesting is regulated by individual states. In most states, oyster beds are closed by state shellfish authorities when human illness is traced to harvest sites. Because surveillance for *V. parahaemolyticus* infections detects only a fraction of cases of human illness, many cases may occur before an outbreak is detected; 1 culture-confirmed case may represent a larger outbreak. Therefore, in addition to closing oyster beds after tracebacks from outbreaks of human illness, prevention strategies might include (1) monitoring oysters, to identify beds in which *Vibrio* counts are elevated; (2) identifying and implementing processing technologies to reduce *Vibrio* counts in oysters that are sold for raw consumption; (3) banning harvesting of oysters during the warmer months (e.g., months without the letter "R" in their names), when seawater temperatures and *Vibrio* counts are usually elevated; or (4) diverting oysters harvested during the warmer months for cooking, irradiation, or pasteurization. Development of environmental parameters (e.g., seawater temperatures and salinity levels) that could more precisely predict the risk of *V. parahaemolyticus* infection could be a useful additional way to enhance the safety of raw molluscan shellfish.

Prompt recognition of outbreaks by clinicians, clinical laboratories, and public health authorities is important for implementing control measures, such as closing implicated shellfish harvest sites to prevent further illness. During outbreaks, *V. parahaemolyticus* isolates should be referred to public health laboratories for confirmation and strain subtyping. Pulsed-field gel electrophoresis is more discriminatory than serotyping [21] and may be useful in linking common source outbreaks. Clinical laboratories in coastal areas are encouraged to use TCBS agar when culturing stool specimens, particularly during the summer months.

To prevent gastroenteritis attributable to *V. parahaemolyticus,* all consumers should avoid eating raw or undercooked molluscan shellfish. In particular, persons with liver disease should be counseled to avoid eating raw or undercooked molluscan shellfish, since they are at particularly high risk for *V. parahaemolyticus* and other severe *Vibrio* infections [22]. Cooking oysters and other shellfish could prevent illness by killing *Vibrio.* To prevent wound infections, people should avoid exposure of open wounds to seawater or raw shellfish products.

Clinicians should insist that a stool specimen be tested for *Vibrio* when patients seek medical attention for acute gastroenteritis within 48 h of ingesting raw or undercooked shellfish. Treatment of gastroenteritis with anything other than oral rehydration is seldom necessary, since gastroenteritis is usually mild and self-limited, although antimicrobial therapy may help those patients with severe diarrhea, wound infections, or septicemia. Antimicrobials effective against *Vibrio* infections include tetracycline, fluoroquinolones, third-generation cephalosporins, and aminoglycosides.

State shellfish programs should establish a protocol for closing and reopening oyster beds, and they should require regular monitoring of environmental factors, such as seawater temperature and salinity levels at oyster-harvest sites, particularly environmental monitoring during the warmer months and during periods when the number of cases of human illness increases. Data from improved monitoring should be linked to human-illness data, to help develop better criteria for the closing and reopening of oyster beds. Because of the recent increase in multistate outbreaks, all states should consider mandating that infections involving *V. parahaemolyticus* and other *Vibrio* species be reported, as they are in the 4 Gulf Coast states.

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