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Crayfish: A newly recognized vehicle for vibrio infections

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SUMMARY

We conducted a 1-year case-control study of sporadic vibrio infections to identify risk factors related to consumption of seafood products in two coastal areas of Louisiana and Texas. Twenty-six persons with sporadic vibrio infections and 77 matched controls were enrolled. Multivariate analysis revealed that crayfish ($P < 0{\cdot}025$) and raw oysters ($P < 0{\cdot}009$) were independently associated with illness. Species-specific analysis revealed an association between consumption of cooked crayfish and *Vibrio parahemolyticus* infection (OR 9·24, $P < 0{\cdot}05$). No crayfish consumption was reported by persons with *V. vulnificus* infection. Although crayfish had been suspected as a vehicle for foodborne disease, this is the first time to our knowledge that consumption of cooked crayfish has been demonstrated to be associated with vibrio infection.

INTRODUCTION

In the 30 years between 1964 and 1994, *per capita* consumption of seafood in the United States has followed a steady upward trend, from 10·5 pounds of edible meat consumed per capita in 1964 to 15·2 pounds in 1994. The highest *per capita* consumption occurred in 1987, at 16·2 pounds [1]. This trend toward increased consumption may be due to an enhanced health consciousness. Despite its nutritional qualities, however, seafood is not without health risks and may become contaminated by pathogenic microorganisms (e.g. vibrios). While public health measures have focused on the association between eating raw molluscan shellfish and subsequent vibrio infections [2], less emphasis has been placed on other potential vehicles.

Current data on seafoods that act as vehicles for vibrio infections are limited for a number of reasons: 1. vibrio infections most often occur sporadically, making it more difficult to identify a new vehicle associated with infection; 2. a primary source of information concerning foodborne disease in the United States captures only information concerning outbreaks and does not include information on sporadic illnesses; 3. although a regional Gulf State *Vibrio* Surveillance System provides information on sporadic vibrio infections [3], until recently there was no nationwide laboratory-based sporadic vibrio surveillance system that could alert health care workers to newly acquired sporadic vibrio infections.

We conducted a 1-year case-control study of sporadic vibrio infections in 2 coastal areas of the

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United States to identify specific high-risk seafood products and to evaluate the potential hazards of bringing raw seafood products into the kitchen.

METHODS

The surveillance areas chosen for the study were Harris County, Texas (population 2818199) and 19 parishes in southwest Louisiana (population 2109806). A case was defined as a person presenting with clinical illness due to a vibrio infection occurring from 1 April, 1992 through 31 March 1993 in a person who resided within either of the catchment areas. All sporadic cases identified by the clinical laboratories that served patients in the surveillance areas were included in the study. For outbreaks (defined as more than one vibrio infection in a household or institution), the patient with the earliest specimen date was selected for enrollment into the case-control study.

To identify persons with vibrio infections, each week clinical laboratories in the surveillance area were contacted to determine if a vibrio isolate had been identified. Vibrio isolates were sent to the state public health laboratory for species identification. Persons with a vibrio infection were contacted either by telephone or a home visit.

Three controls matched by age, gender and telephone exchange were enrolled for each patient. Controls were selected by $+1/-1$ digit dialing from the patient telephone number. Interviewers were required to make up to 200 phone calls to find 3 matches for each case. Persons reporting diarrhoea, bloody stools, nausea, vomiting, or stomach cramps in the 30 days before onset of the patient illness were not eligible to be controls.

The case and control interviews were conducted using a standardized questionnaire on food consumption during the 7 days before the date of onset of the patient's illness (controls were asked about the same 7-day period), food preparation practices in the home, clinical history, and epidemiologic information. Food consumption questions focused on the following food groups: poultry, beef, pork, crustacean shellfish, molluscan shellfish, fin fish, fruits, vegetables, and eggs. Additional questions were asked about inadequately cooked or raw foods; method of food preparation (e.g., grinding, freezing); bringing raw meat, seafood, and poultry ingredients into the home; and preparation of raw ingredients in the home.

Other questions regarding exposure asked about travel outside the United States in the 7 days before the onset of illness in the patient, hospitalization or antibiotic use in the 30 days before onset of illness, antacid use, immunosuppressive status, and underlying illnesses.

Conditional logistic regression was used to determine the relationship between illness and risk factors. Factors were included in the multivariate model if they were potential confounders, of theoretical interest, or statistically associated with illness. Interactions among the factors were examined in the logistic models.

RESULTS

From 1 April 1992 through 31 March 1993, a total of 29 vibrio infections were reported from the Louisiana catchment area (1·3/100000) and 11 from the Texas catchment area (0·4/100000). Fourteen persons were ineligible for enrollment. Of the 26 eligible persons *V. parahaemolyticus* was isolated from 10 patients, *V. vulnificus* from 6, *V. alginolyticus* from 3, *V. mimicus* from 2, *V. cholerae* nonO1 from 2, *V. cholerae* O1 from 2, *V. cholerae* unspecified from 2 (these 2 isolates were not available for further analysis by the lab), and *V. hollisae* from 1 (Table 1). We did not have O139 antiserum at the time this study was performed. Excluding the two isolates that were unavailable for analysis, each *V. cholerae* was tested for cholera toxin and would have identified any potential O139 isolates. No cholera toxin-positive vibrio isolates were identified that were not serogroup O1. It is highly unlikely that the two isolates that were unavailable for analysis were O139 since to date no O139 isolates have been reported in the United States. *V. parahaemolyticus* and *V. alginolyticus* were recovered from the same clinical specimen of one patient; *V. parahaemolyticus* and *V. vulnificus* from another patient. Organisms were isolated from stool in 20 patients, blood in 3 patients, wound in 2 patients, and blood and wound in 1 patient. Eighteen patients (69%) were male and 22 (85%) were white; median age was 40 years (range 19–83).

Two patients had taken an antibiotic in the 30 days before onset of illness (1 trimethoprim-sulfamethoxazole for a sinus infection and 1 ciprofloxacin for sore throat), none had been hospitalized in the 30 days preceding onset of illness but 9 reported underlying medical conditions; diabetes and a heart condition (1), diabetes and previous colon surgery (1), diabetes/pacemaker (1), immune deficiency (1),

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Table 1. *Clinical characteristics*

Species	Complications				Signs and symptoms		
	Number	Duration of illness, days (range)	Hospitalized	Median days hospitalized	Blood in stool	Fever	Diarrhoea
V. alginoyticus	2	2–3	1	2	1	1	2
V. cholerae O1	2	8	1	11	0	0	2
V. cholerae Non-O1	2	2–6	1	5	1	2	2
V. cholerae unspecified	2	17–37	1	10	0	0	1
V. hollisae	1	6	0	—	0	0	1
V. mimicus	2	5–18	0	—	1	1	2
V. parahaemolyticus	8	2–16	1	2	1	3	8
V. vulnificus	5	5–18	4	8	1	3	2
V. parahaemolyticus/ *V. alginoyticus*	1	7	0	—	1	0	1
V. parahaemolyticus/ *V. vulnificus*	1	10	1	10	0	0	0
All species	26	2–37	10	8	6	10	21

cancer/heart disease/hypothyroidism/lymphoma (1), epilepsy/asthma/arthritis (1), hypertension (1), gallbladder removal (1), renal insufficiency (1).

Twenty-one patients reported gastroenteritis and four septicemia. Median duration of illness was 7 days (range of 2–37 days). Ten were hospitalized (median 8 days, range 2–11), and 23 were treated with antibiotics for their vibrio infection. Complications resulting from the vibrio infection included cellulitis (1) and hypotension (1); none died.

Three controls per case were identified except for one case in which only two controls were identified. Univariate logistic regression analysis revealed statistically significant relationships between illness and eating raw oysters (odds ratio [OR] 16·12, $P < 0·01$, 95% confidence interval [CI] 1·92, 135·27) or crayfish (OR 6·04, $P < 0·03$, CI 1·20, 30·36), and a protective effect with eating processed fish (e.g., canned fish) (OR 0·30, $P < 0·04$, CI 0·09, 0·94). Infection was not statistically associated with eating cooked oysters, shrimp, or crabs; meals prepared in homes in which raw shellfish was handled; having an immunosuppressive disorder or underlying medical condition; taking immunosuppressive drugs or antacid; or alcohol consumption. Multivariate analysis revealed that crayfish ($P < 0·03$) and raw oysters ($P < 0·009$) were independently associated with illness while processed fish was not. All patients who ate processed fish also reported consumption of shellfish.

Consumption of crayfish was reported by 8 (30%) of 23 patients and 10 (13%) of 76 controls. Crayfish was reported by 5 of 10 persons with *V. parahemolyticus* infection, 1 of 2 with *V. alginolyticus*, 1 of 2 with *V. mimicus*, and in the person with both *V. parahaemolyticus* and *V. alginolyticus*. No crayfish was reported by the persons with *V. vulnificus* infection.

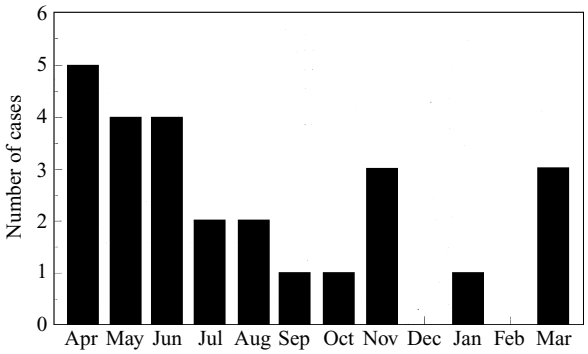

Fig. 1. Date of onset of vibrio illness by month, 1992–3.

Dates of onset of illness of patients were distributed from March to November and did not exhibit clustering (Fig. 1). Seven of 8 patients who are crayfish had onset dates in March, April and May. All patients and controls who consumed crayfish were from Louisiana.

Species-specific risk factors could be statistically examined only for *V. parahaemolyticus* (10 cases). Since 2 *Vibrio* species were isolated from the same patient in 2 cases, these 2 were excluded from this logistic regression analysis. For *V. parahaemolyticus*, only consumption of crayfish was statistically associated with infection (OR 9·24, $P < 0·05$, CI 1·03, 82·88).

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Two patients and no controls reported traveling outside the United States in the 7 days preceding illness; one patient (*V. cholerae*, unspecified) visited El Salvador, and one (*V. cholerae* O1) visited Venezuela. One of the patients reported eating shrimp; the food history of the other patient was not available.

DISCUSSION

Although crayfish had been suspected as a potential vehicle for foodborne disease [4], this is the first time that eating cooked crayfish was demonstrated to be associated with vibrio infection. Crayfish has been described as 'nouvelle cuisine' and is becoming an increasingly popular seafood item in many areas outside the Gulf Coast regions of the United States. Crayfish consumption may be a previously unrecognized vehicle for vibrio infection. Given that patterns of seafood consumption are changing in this country [5] and that public health messages have frequently focused on the hazards of eating raw shellfish products, this study suggests that greater public health education should be focused on the proper handling of cooked and steamed shellfish products. As demonstrated by Blake, traditional recipes for steaming and boiling crabs are insufficient to kill vibrios [4]. This study would suggest that, to prevent vibrio infection, crayfish, which are frequently steamed, may also require a longer cooking time than traditional recipes indicate. Recent outbreaks also show that traditional methods of steaming shellfish are inadequate to inactivate viral agents [6]. Time-temperature studies of artificially contaminated crayfish should be undertaken to determine the cooking times and temperatures necessary to kill vibrios in crayfish.

Consumption of crayfish was reported by patients infected with *V. parahaemolytic*, *V. alginolyticus*, and *V. mimicus* but not by those with *V. vulnificus*. This may suggest that the ecologic niches of these bacteria differ or that consumers at high risk for *V. vulnificus* infections are more likely to eat raw oysters than cooked seafood.

Although the hazards of raw oyster consumption have been repeatedly noted [4, 7] the risk remains and is re-emphasized by this study. *V. vulnificus* is not associated with human or animal fecal contamination but occurs naturally in the marine environment. Even if oysters are harvested from areas believed to be free from fecal contamination, the risk of *V. vulnificus* infections from oysters continues [7].

Control of vibrios is complicated by their role as normal inhabitants of estuarine waters. Their presence in seafood does not indicate unclean harvest sites or inappropriate handling after harvest. The seasonal distribution of human infections with vibrios mirrors their accelerated growth as coastal waters warm in the late spring.

Levine and colleagues [3] found that the majority of patients with vibrio gastroenteritis had eaten raw oysters. In contrast, our study found 60% of patients with gastroenteritis ate cooked shellfish products and only 29% ate raw oysters. Additional public health education measures are necessary to emphasize the importance of thorough cooking and proper handling to reduce the risk of vibrio infections from traditional 'cooked or steamed seafood products'. In the 1989 Vibrio Gulf State Surveillance System, Levine and Griffin reported rates of infection comparable to those found in this study [3].

Findings in this study, are consistent with earlier research: the most severe vibrio illnesses were typically found in *V. vulnificus* infections in persons with underlying chronic disease; death rates have been reported as high as 50% [8]. The increasing numbers of persons in this country with an immune disorder makes vibrio particularly life threatening [9]. Increased risk of vibrio infections has been demonstrated in persons with HIV infection, cancer, and diabetes mellitus.

With endemic *V. cholerae* now reported in Central and South America, increased caution should be exercised in selection of food and drinks in these areas since different food handling and cooking practices may be employed [10].

In conclusion, crayfish appear to be an important emerging vehicle for vibrio infections. Investigation into the attributes of crayfish should be undertaken to determine the appropriate cooking times and methods to kill the vibrio bacterium in this vehicle. Further, education programmes should stress the need for appropriate food handling techniques and hazards of shellfish.

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