

Increasing Rates of Vibriosis in the United States, 1996–2010: Review of Surveillance Data From 2 Systems

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Background. The Centers for Disease Control and Prevention monitors vibriosis through 2 surveillance systems: the nationwide Cholera and Other *Vibrio* Illness Surveillance (COVIS) system and the 10-state Foodborne Diseases Active Surveillance Network (FoodNet). COVIS conducts passive surveillance and FoodNet conducts active surveillance for laboratory-confirmed *Vibrio* infections.

Methods. We summarized *Vibrio* infections (excluding toxigenic *V. cholerae* O1 and O139) reported to COVIS and FoodNet from 1996 through 2010. For each system, we calculated incidence rates using US Census Bureau population estimates for the surveillance area.

Results. From 1996 to 2010, 7700 cases of vibriosis were reported to COVIS and 1519 to FoodNet. Annual incidence of reported vibriosis per 100 000 population increased from 1996 to 2010 in both systems, from 0.09 to 0.28 in COVIS and from 0.15 to 0.42 in FoodNet. The 3 commonly reported *Vibrio* species were *V. parahaemolyticus*, *V. vulnificus*, and *V. alginolyticus*; both surveillance systems showed that the incidence of each increased. In both systems, most hospitalizations and deaths were caused by *V. vulnificus* infection, and most patients were white men. The number of cases peaked in the summer months.

Conclusions. Surveillance data from both COVIS and FoodNet indicate that the incidence of vibriosis increased from 1996 to 2010 overall and for each of the 3 most commonly reported species. Epidemiologic patterns were similar in both systems. Current prevention efforts have failed to prevent increasing rates of vibriosis; more effective efforts will be needed to decrease rates.

Vibrios are gram-negative, rod-shaped bacteria that occur naturally in estuarine or marine environments. Roughly a dozen species are known to cause disease in humans [1], and infection is usually from exposure to seawater or consumption of raw or undercooked seafood [2, 3]. Vibriosis is characterized by diarrhea, primary septicemia, wound infections, or other extra-intestinal infections [2–6]. Cholera has been reportable in the United States for more than a century; however,

vibriosis did not become nationally notifiable until 2007. Laboratory criteria for diagnosis include isolation of a species of the family *Vibrionaceae* (other than toxigenic *Vibrio cholerae* O1 or O139, which is reportable as cholera) from a clinical specimen.

Vibrio infection results in an estimated 80 000 illnesses, 500 hospitalizations, and 100 deaths each year in the United States [7]. Two national surveillance systems monitor cases: the national Cholera and Other *Vibrio* Illness Surveillance (COVIS) system and the Foodborne Diseases Active Surveillance Network (FoodNet). COVIS is a passive surveillance system to which all states can report laboratory-confirmed *Vibrio* infections. FoodNet conducts active, population-based surveillance in 10 states for all laboratory-confirmed *Vibrio* infections, as well as other enteric infections transmitted commonly through food.

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We reviewed all cases of vibriosis reported to the Centers for Disease Control and Prevention (CDC) through COVIS and FoodNet from 1996 to 2010 to compare patterns in reports to the 2 surveillance systems.

METHODS

Surveillance

COVIS (http://www.cdc.gov/nationalsurveillance/cholera_vibrio_surveillance.html) was established in 1988 by the CDC; the Gulf Coast states of Alabama, Florida, Louisiana, and Texas (states with high incidences of vibriosis); and the US Food and Drug Administration (FDA) to conduct surveillance of illnesses caused by *Vibrio* species (Table 1). Other states began reporting to COVIS; by the late 1990s, about half of all states were reporting each year. Other reporting jurisdictions, such as Guam, Puerto Rico, and the District of Columbia, also report to COVIS and are counted as states for this analysis. Vibriosis became nationally notifiable in 2007 and was notifiable at the state level in all but 5 states by 2010; however, 3 of these 5 states reported at least 1 case to COVIS in 2010. State and local health officials submit COVIS report forms for laboratory-confirmed cases of human infection. The report form captures demographic and isolate information, as well as clinical and exposure-related information. Isolate information includes *Vibrio* species and the source of the specimen from which *Vibrio* was isolated. Although it occurs

rarely, >1 isolate can be reported from a single patient. Clinical information includes hospitalization and death.

FoodNet (<http://www.cdc.gov/foodnet/>) is a collaborative project that includes the CDC, 10 participating state health departments, the US Department of Agriculture's Food Safety and Inspection Service, and the FDA. Since 1996, FoodNet has conducted active surveillance for cases of laboratory-confirmed foodborne infections transmitted commonly through food (*Campylobacter*, *Listeria*, *Salmonella*, Shiga toxin-producing *Escherichia coli* [STEC] O157 and non-O157, *Shigella*, *Vibrio*, *Yersinia*, *Cryptosporidium*, and *Cyclospora*) by regularly contacting all clinical laboratories serving the surveillance area to ensure that all cases are reported. FoodNet initially included 2 states—Minnesota and Oregon—and selected counties in California, Connecticut, and Georgia. The FoodNet surveillance area has expanded and in 2010 included 7 states—Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, and Tennessee—and selected counties in California, Colorado, and New York. FoodNet sites also report *Vibrio* infections to COVIS. The FoodNet surveillance area includes 46.9 million people, or 15.3% of the US population. If a given pathogen is isolated from >1 specimen from a patient, only the most invasive isolate is reported. Hospitalizations occurring within 7 days of specimen collection date are recorded, as is the patient's vital status at hospital discharge or at 7 days after the specimen collection date, if not hospitalized. Deaths and hospitalizations meeting these criteria are attributed to the infection.

Table 1. Overview of COVIS and FoodNet

	COVIS	FoodNet
Year Started	1988	1996
Type of Surveillance	Passive	Active
Reporting states	1988: Gulf Coast states only (Alabama, Florida, Louisiana, Mississippi, Texas) 1988–2006: Gulf Coast states and voluntary reporting from other states 2007: Nationally notifiable and all 50 states reporting	California, Connecticut, Georgia, Minnesota, Oregon, then added Colorado (2001), Maryland (1998), New Mexico (2004), New York (1998), Tennessee (2000)
Variables captured		
Demographic	Age, sex, race, ethnicity, occupation	Age, sex, race, ethnicity
Isolate	Species, isolates (all), and specimen source	Species, isolate (most invasive only), and specimen source
Clinical	Symptoms, hospitalization, sequelae, death, antibiotic treatment, preexisting conditions, and medications	Hospitalization, patient outcome
Epidemiologic	Travel, seafood consumption, and recreational water exposure	Travel history, outbreak status
Seafood investigation	Seafood trace back	Not applicable

Abbreviations: COVIS, Cholera and Other *Vibrio* Illness Surveillance; FoodNet, Foodborne Diseases Active Surveillance Network.

Analysis

We examined *Vibrio* infections (excluding toxigenic *V. cholerae* O1 and O139) reported to COVIS and FoodNet from 1996 through 2010. We compared patient demographics (age, sex, race, and ethnicity) and clinical information (species, specimen source, hospitalization, and death). We categorized ages into 10-year age groups, with the oldest group consisting of persons aged ≥ 80 years. We defined the month of infection as the month of illness onset or, if onset date was not available, the specimen collection date. For each system, we calculated incidence rates by dividing the annual number of laboratory-confirmed infections by US Census Bureau population estimates for the surveillance area. For COVIS, we considered the surveillance area to include all states that reported at least 1 case in a given year. To assess changes in incidence, we compared the average annual incidence for 1996–2000 with 2006–2010 in each system. Based on COVIS data for 1996–2010 and for each state including only years in which at least 1 case was reported, we classified states as higher (≥ 0.30 cases per 100 000) or lower (< 0.30) incidence. Analyses were conducted using SAS version 9.2 (SAS Institute, Cary, North Carolina).

RESULTS

From 1996 through 2010, 7700 cases of vibriosis were reported through COVIS and 1519 through FoodNet; since 1996, an average of 19% of COVIS cases have also been reported to FoodNet. Seven states, all coastal (Connecticut, Delaware, Maryland, Florida, Washington, Louisiana, and Hawaii), were categorized as higher incidence. Reported incidence varied

greatly between states; for example, in 2010, state-specific incidence ranged > 50 -fold, from 0.03 per 100 000 population in Oklahoma to 1.7 per 100 000 population in Hawaii.

Demographic characteristics of patients reported to the 2 systems were similar. In both, 68% of illnesses were in men, the age group with the largest percentage of cases was 40–49 years (19% in COVIS, 21% in FoodNet), and most patients with reported race were white (74% in COVIS, 64% in FoodNet). Of patients with reported ethnicity, 18% were Hispanic in COVIS and 6% in FoodNet. Data on race and ethnicity were missing less often in COVIS than in FoodNet (race: 8% missing in COVIS, 19% in FoodNet; ethnicity: 14% missing in COVIS, 28% in FoodNet). In both systems, cases peaked in the summer months, with the highest proportion in July (20% COVIS, 21% FoodNet) and August (20% COVIS, 26% FoodNet). However, the summer peak occurred slightly earlier in COVIS than in FoodNet.

The 3 most commonly reported *Vibrio* species causing infection in both COVIS and FoodNet were *V. parahaemolyticus*, *V. vulnificus*, and *V. alginolyticus* (Table 2), which accounted for 75% of reports to both systems. *Vibrio parahaemolyticus* infection was reported most commonly but was rarely fatal, with a case-fatality ratio (CFR) $< 1\%$ in both systems. *Vibrio vulnificus* infection, by contrast, had the highest CFR, $> 30\%$ in both systems, with $> 80\%$ of patients hospitalized. Hospitalization and death rates for infection with *V. alginolyticus* were similar to those of *V. parahaemolyticus*. Because *V. vulnificus* infection accounted for a higher proportion of COVIS reports than FoodNet reports, the overall proportion hospitalized in COVIS (41% of 2925 patients) was higher than in FoodNet

Table 2. Number of Vibriosis Infections and Selected Outcomes, by Species, Reported to COVIS and FoodNet, 1996–2010

Vibrio Species	COVIS			FoodNet		
	Infections, No. (%)	Hospitalized, No. (%)	Died, No. (%)	Infections, No. (%)	Hospitalized, No. (%)	Died, No. (%)
<i>V. parahaemolyticus</i>	3460 (44.9)	714 (20.6)	24 (0.7)	820 (54.0)	131 (16.0)	4 (0.5)
<i>V. vulnificus</i>	1446 (18.8)	1250 (86.4)	462 (31.9)	193 (12.7)	157 (81.3)	58 (30.1)
<i>V. alginolyticus</i>	884 (11.5)	168 (19.0)	11 (1.2)	132 (8.7)	17 (12.9)	1 (0.8)
<i>V. cholerae</i> non-O1, non-O139	697 (9.1)	278 (39.9)	35 (5.0)	78 (5.1)	23 (29.5)	2 (2.6)
<i>V. fluvialis</i>	394 (5.1)	156 (34.2)	11 (2.8)	104 (6.2)	41 (39.4)	1 (1.0)
<i>V. mimicus</i>	173 (2.3)	73 (42.2)	3 (1.7)	30 (2.0)	14 (46.7)	2 (6.7)
<i>Grimontia hollisae</i> (formerly known as <i>V. hollisae</i>)	121 (1.6)	67 (53.1)	1 (0.8)	18 (1.2)	10 (55.6)	0 (0)
<i>V. cholerae</i> O1	40 (0.5)	22 (55.0)	2 (0.5)	10 (0.7)	4 (40.0)	0 (0)
<i>Vibrio</i> species not identified	284 (3.7)	97 (34.2)	9 (3.2)	90 (5.9)	19 (21.1)	2 (2.2)
Multiple	98 (1.3)	52 (53.1)	8 (8.2)
Other ^a	103 (1.3)	48 (46.6)	4 (3.9)	44 (2.9)	16 (36.4)	2 (0.2)
Total	7700	2925 (40.5)	570 (8.2)	1519	432 (28.4)	72 (4.7)

Abbreviations: COVIS, Cholera and Other *Vibrio* Illness Surveillance; FoodNet, Foodborne Diseases Active Surveillance Network.

^a Includes *Photobacterium damsela* subsp *damsela* (formerly known as *V. damsela*), *V. furnissii*, *V. metschnikovii*, *V. cincinnatiensis*, *V. cholerae* O139, *V. cholerae* non-O1, *V. cholerae* unspecified, and *V. Harveyi*.

(28% of 432) and the overall CFR was 8.2% in COVIS and 4.7% in FoodNet, although species-specific hospitalization rates and CFRs were similar.

The annual incidence of vibriosis per 100 000 population increased from 1996 to 2010 (Figure 1). In COVIS, it increased from 0.09 to 0.28, peaking in 2010 at 0.28. In FoodNet, it increased from 0.15 to 0.42, peaking in 2006 at 0.42. The incidence of *V. parahaemolyticus* infection increased from 1996 to 2010, in COVIS from 0.01 to 0.13 and in FoodNet from 0.06 to 0.23. The incidence of *V. vulnificus* infection increased slightly from 1996 to 2010, in COVIS from 0.03 to 0.04, but more in FoodNet, from 0.01 to 0.05 (Figure 1). The incidence of *V. alginolyticus* infection increased from 1996 to 2010, in COVIS from 0.001 to 0.04 and in FoodNet from 0.01 to 0.04. These patterns were consistent when the COVIS analysis was limited to states not in FoodNet, the contiguous United States (ie, excluding Hawaii, Alaska, and Guam), and states in which *Vibrio* infection is notifiable at the state level (data not shown).

DISCUSSION

Our analysis of surveillance data from the 2 US national systems that monitor *Vibrio* infection indicate that the incidence of vibriosis increased during the 15 years from 1996 through 2010. This increase has been driven primarily by increases in *V. parahaemolyticus*, the species most commonly reported, but is also seen for *V. vulnificus* and *V. alginolyticus*,

the second and third most commonly reported species. Increases of *V. vulnificus* are particularly concerning, given the high mortality rate associated with this pathogen. The causes of this increase are not known, but warming of coastal waters, which contributes to growth and persistence of *Vibrio*, has been posited as a factor that could contribute to increases in human illness [8]. If *Vibrio* contamination rates did not change, increased exposure to seafood or seawater could lead to increased risk of exposure to *Vibrio*, but we are not aware of evidence for such changes. Changes in surveillance for *Vibrio* infection could also affect reported rates, although, as discussed below, they are unlikely to account entirely for the observed increases.

Before vibriosis became nationally notifiable in 2007, FoodNet provided the most complete picture of vibriosis in the United States. However, FoodNet includes none of the Gulf Coast states that were founders of COVIS and, given the wide variation in rates between states, might not provide an accurate view of the nation as a whole. Also, FoodNet surveillance for isolates from specimen sources other than stool may have been incomplete in the early years of the program (P. M. Griffin, CDC, oral communication, December 2011), which may explain, at least in part, the larger increase in reported *V. vulnificus* incidence in FoodNet when compared with COVIS.

COVIS, on the other hand, expanded substantially over the study period and 96% of states have reported since 2007. Most of the few states where vibriosis reporting is not mandated have reported cases to COVIS. COVIS data show

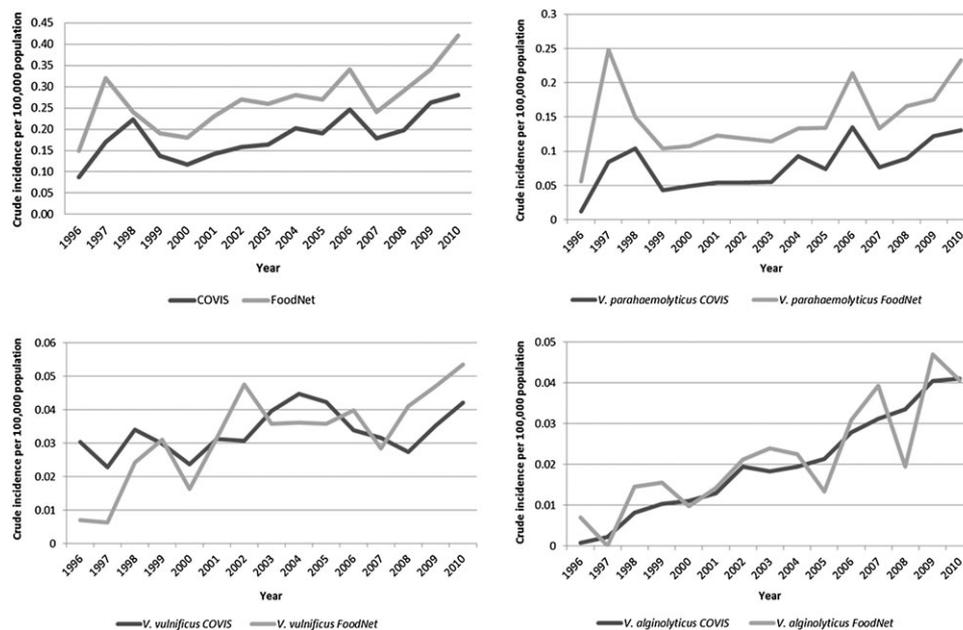


Figure 1. Crude vibriosis incidence per 100 000 population, Cholera and Other *Vibrio* Illness Surveillance system and Foodborne Diseases Active Surveillance Network, 1996–2010. Abbreviations: COVIS, Cholera and Other Vibrio Illness Surveillance; FoodNet, Foodborne Diseases Active Surveillance Network.

that all of the higher-incidence states are in coastal areas where consumption of shellfish and exposure to seawater would be expected to be most common. Because COVIS is a passive system, it is not known whether states not reporting cases each year actually had no cases. However, in recent years, this has applied to only a few states and would not likely change overall patterns of incidence.

Thus, the completeness of FoodNet data for the sites under active surveillance gives credence to trends seen in COVIS, and the national coverage of COVIS validates the representativeness of FoodNet. Taken as a whole, data from the 2 systems credibly demonstrates increasing incidence of vibriosis. The 2 systems also show similarities in demographic and seasonal patterns of laboratory-confirmed *Vibrio* infections in the United States, extending observation of previous reports [3, 6, 9, 10] to more recent years.

To facilitate public health action to prevent and control vibriosis, COVIS collects information about seafood and seawater exposures of patients. In an era of increasing incidence, this information can help to improve education and control measures. Raw shellfish, especially oysters, are the most common foodborne source of vibriosis [2, 6, 11]. Our data indicate that efforts to control vibriosis by educating the public about the hazards of raw oyster and other shellfish consumption have not been effective [12, 13] and that measures to decrease contamination of oysters, such as postharvest decontamination by freezing, heat treatment, or high hydrostatic pressure [14], may need to be implemented routinely to decrease rates of illness. It will also be important to understand the complex and dynamic factors affecting *Vibrio* persistence and growth in marine and estuarine environments in order to develop targeted strategies for decreasing *Vibrio* exposure through other routes. For example, potential strategies could include educational outreach to persons at higher risk for severe *Vibrio* disease, such as those with liver disease, and to avoid exposure of skin wounds to seawater.

Notes

Disclaimer. The contents of this work are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention.

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