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Steaming Oysters Does Not Prevent Norwalk-like Gastroenteritis

SYNOPSIS

Objectives. To determine whether steaming oysters prevents gastroenteritis caused by small round structured (Norwalk-like) viruses and to identify risk factors for illness.

Methods. The authors interviewed all 48 people who ate oysters at two church suppers that were followed by outbreaks of gastroenteritis from a Norwalk-like virus. Data were collected on demographics, clinical illness, number of oysters eaten, and the extent to which they were cooked.

Results. Among the 48 persons, the attack rate was 56%. The risk of illness increased with the number of oysters eaten (chi-square for trend = 5.7, $P = 0.02$). There was no decrease in attack rates among persons who ate oysters that were better done (chi-square for trend = 1.1, $P = 0.29$).

Conclusions. In these outbreaks, the risk of illness increased with the number of oysters eaten. Steaming oysters did not appear to prevent illness, suggesting that steaming may not be adequate to inactivate small round structured viruses. Public health messages that have emphasized the role of raw shellfish in the transmission of enteric viruses should be altered to increase the public's awareness that eating steamed oysters may also pose health risks.

Norwalk-like viruses (NLV) have been implicated in several large outbreaks of gastroenteritis associated with the consumption of shellfish.¹⁻⁵ It is likely that many sporadic cases of shellfish-associated NLV gastroenteritis occur but are simply not recognized. Although steamed and baked clams have been associated with illness in some reported outbreaks,^{4,5} most shellfish-associated NLV gastroenteritis is thought to result from eating raw shellfish.

In November 1993, outbreaks of NLV gastroenteritis occurred in Louisiana, Maryland, Mississippi, and North Carolina. Epidemiologic investigations of the outbreaks implicated oysters harvested from a specific Louisiana oyster bed that had been contaminated with fecal material thrown overboard by oyster harvesters who had a gastrointestinal illness.⁶⁻⁸

In North Carolina, two outbreaks of gastrointestinal illness occurred in November 1993 following church suppers where oysters were served. Unlike oysters associated with outbreaks in other states, most of those served at the

North Carolina church suppers had been steamed. In the Louisiana outbreaks, most ill people had eaten raw oysters. Two people, however, became ill after eating oyster stew.⁷ We investigated the North Carolina outbreaks to determine whether steaming protected against NLV gastroenteritis and to identify the risk factors for illness among those who ate oysters.

Methods

Using a standard questionnaire, we obtained food histories and clinical information (symptoms, incubation period, duration of symptoms) by telephone from all of the people who had attended the two church suppers. For people who had eaten oysters, we conducted follow-up telephone interviews, asking questions about demographics, clinical illness, the number of oysters eaten, the extent to which the oysters were cooked, consumption of alcohol within two hours before or after eating oysters, gastrointestinal illnesses within the preceding year, knowledge of the potential for infectious gastrointestinal illness following oyster consumption, and future plans to eat oysters.

Each attendee was asked to quantify the number of oysters eaten in each of five categories defined by the oysters' moisture content and texture: (a) raw, (b) steamed—wet and slippery, (c) steamed—moist and juicy, (d) steamed—firm and dry, and (e) steamed—tough and dried out. To determine the effect of how well the oysters were cooked on risk of illness, each person was assigned to the category of the least-cooked oyster he or she had eaten. The criterion for gastrointestinal illness was either vomiting or diarrhea occurring within 72 hours after attending one of the two church suppers.

From three ill people who had attended the first church supper we collected stool samples and acute serum samples within 72 hours, and convalescent serum samples 19 to 21 days later. Seven people who had attended the second church supper gave single serum specimens approximately 14 days after the onset of illness. Swabs of the three fresh stool specimens were transported in enteric transport media to the North Carolina State Laboratory of Public Health, where they were cultured for *Salmonella*, *Shigella*, *Yersinia*, *Campylobacter*, and *Vibrio* species using standard methods. Samples were then refrigerated at 4°C and subsequently examined by direct electron microscopy for the presence of NLV at the viral gastroenteritis laboratory at the Centers for Disease Control and Prevention in Atlanta. Reverse transcription-polymerase chain reaction (RT-PCR) was used to identify Norwalk-like viruses in stool specimens, and the amplified genetic material was

sequenced.⁹⁻¹⁰ Paired acute and convalescent serum specimens were tested for IgG antibodies to Norwalk virus, and single convalescent sera were tested for IgA antibodies by an enzyme immunoassay using baculovirus expressed antigen.¹¹

The person who prepared the oysters for each church supper was interviewed to collect information about the cleaning, steaming, and serving of the oysters.

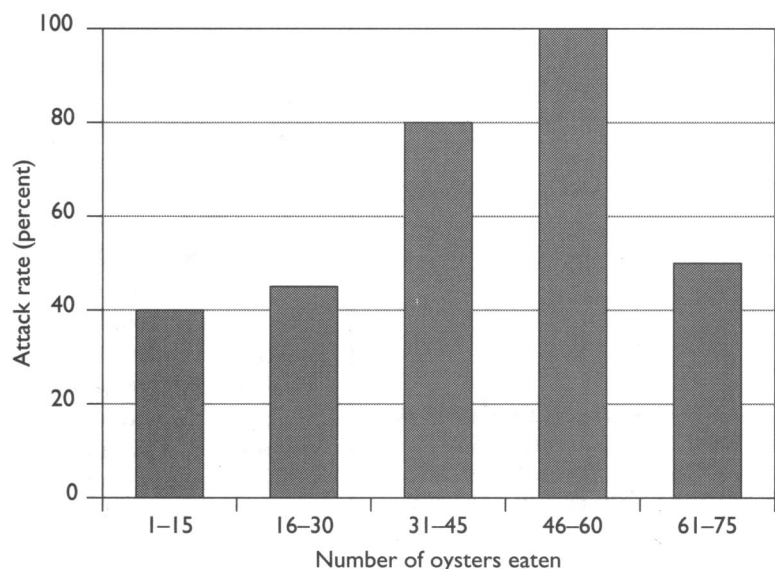
Data from the two outbreaks were analyzed separately and together, with similar results. Unless otherwise noted, results presented here are from analyses of the two outbreaks taken together. A multivariable logistic regression model that included the number of oysters eaten and the extent they were cooked was constructed to look simultaneously for an effect of these variables.

Results

Among the total of 72 people attending the two church suppers, 27 (38%) met the case definition of vomiting or diarrhea occurring within 72 hours; none of the 24 persons who did not eat oysters met the case definition. For those who were ill, the median incubation period was 37 hours (range 9–62 hours) and the median duration of illness was 24 hours (range 3–120 hours). Twenty-three people (85%) had diarrhea, 15 (56%) vomiting, and 14 (52%) fever. Fourteen people (52%) had more than one symptom.

Bacteriologic cultures of the three stool samples from the first church supper were negative for *Salmonella*, *Shigella*, *Yersinia*, *Campylobacter*, and *Vibrio* species. Small round structured viruses were seen by electron microscopy in all three specimens from the first supper using RT-PCR, confirming the presence of NLV in all of the specimens.

Figure 1. Attack rate of gastrointestinal illness associated with Norwalk-like virus infection following two church suppers, by number of oysters eaten



PCR products from two of these specimens were sequenced and were identical to each other and to the strain of NLV implicated in outbreaks in Louisiana and Maryland. Serologic testing demonstrated a four-fold rise in IgG to Norwalk virus in two of three paired samples from the first church supper. Blood serum samples from four of seven ill persons from the second church supper demonstrated IgA levels to Norwalk virus of more than 200 units, consistent with recent infection.

The 27 people who became ill represented 56% of the 48 people who ate oysters at one or the other of the two church suppers. The median number of oysters eaten per person was 30 (range 1–75 oysters). Twenty-nine people (60%) ate oysters in more than one category. Nine people (19%) ate raw oysters, and 40 people (83%) reported eating at least one oyster that was moist and juicy. None of the 48 people who ate oysters reported drinking an alcoholic beverage within two hours before or after attending the church supper.

The total number of oysters eaten was a significant predictor of illness. The attack rate increased significantly as the number of oysters eaten increased (chi square for trend = 5.6, $P < 0.02$) (Figure 1). Attack rates for all categories were high, ranging from 45% to 75% (Figure 2). No relationship was found between attack rate and the extent to which oysters were cooked (chi-square for trend = 1.1, $P = 0.29$). Multivariable logistic regression models controlling for number of oysters eaten in each category of doneness showed no effect for degree of doneness on attack rate. In other words, the extent to which oysters were cooked had no effect on an individual's likelihood of becoming ill.

Of the 48 people who ate oysters, 13 (27%) reported having had a gastrointestinal illness in the 12 months before the

church supper; none of these illnesses had occurred during the two most recent months and none was thought by the person being interviewed to have been shellfish-associated. A history of gastrointestinal illness in the preceding 12 months did not protect against becoming ill after eating oysters.

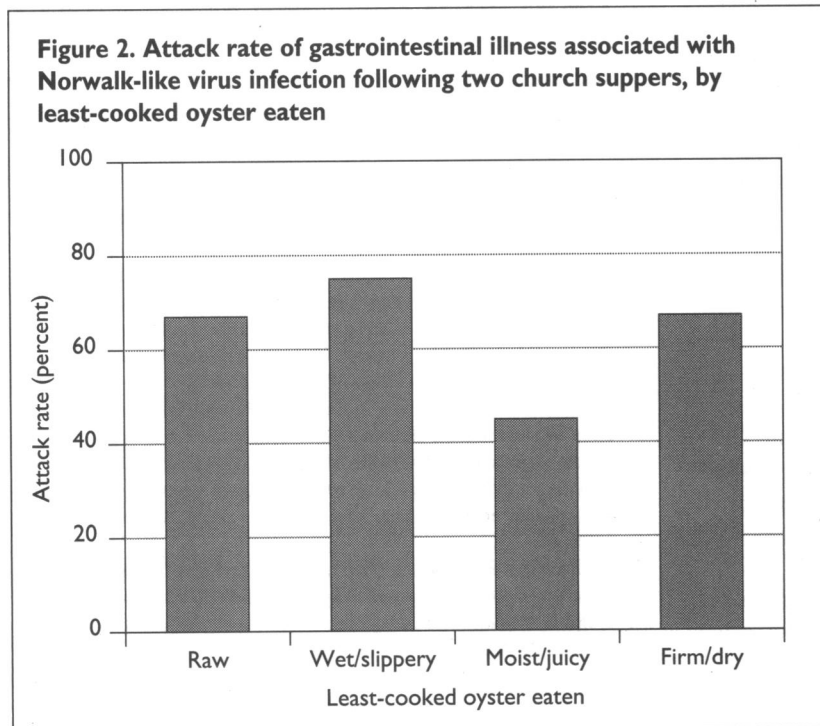
Twenty-five people (52%) were aware that raw oysters could be associated with gastrointestinal illness, but only 10 people (21%) were aware that cooked oysters could be associated with such an illness. Forty-two (87%) of the 48 people who had eaten steamed oysters planned to eat them again. Those who had become ill were as likely to plan to eat steamed oysters again as those who had not become ill.

Oysters used at both church suppers were purchased in their shells on the day of the event. Before cooking, the oysters were sprayed with water to clean the shells. The oysters were steamed over boiling water in large pots on top of the stove. At the first church supper, batches of 25 to 30 oysters were steamed for an estimated 12 to 15 minutes, until some shells started to open. At the second church supper, batches of approximately 50 oysters were steamed for 15 to 45 minutes until the shells of the oysters on top had opened. At both events, the steamed oysters were dumped onto large tables covered with newspapers. Participants then shucked their own oysters.

Discussion

We found the total number of oysters eaten to be the major predictor of illness. Steaming oysters did not prevent illness. The infectious dose of NLV is thought to be low,¹² which may explain the fact that one person became ill after eating only three steamed oysters. The apparent dose-response relationship we found suggests that only some of the oysters served at either church supper were contaminated with NLV and that eating more oysters raised the likelihood of eating a contaminated oyster. It is likely that those who ate more than 50 oysters ate at least one contaminated oyster; immunity to NLV is a possible explanation for why some of these people did not become ill.

A "done" oyster by culinary standards may not be a "done" oyster in virologic terms. Studies of the survival of poliovirus during cooking demonstrate a remarkable ability of that virus to persist in oysters: after 30 minutes of steaming, when the internal temperature of the oyster measured 94°C, 7% of the experimentally inoculated poliovirus was still viable.¹³ NLV is known to be an even more heat-resistant virus in vitro than poliovirus.¹⁴ Given its low infectious dose, even a small amount of virus remaining after cooking could be clinically significant.



Few attendees were aware that steamed oysters can be associated with gastrointestinal illness. Many shellfish eaters consider steamed oysters or clams to be "done" at the point during the steaming when their shells open. However, in one study, when clams were steamed individually under laboratory conditions, their shells opened after an average of 51 seconds of steaming, at an internal temperature of less than 70°C.¹⁵ In the two North Carolina church kitchens, oysters steamed for at least 12 minutes until some shells were open did not reach adequate internal temperatures for a sufficient time to inactivate NLV.

Our original hypothesis was that oysters that appeared better done correlated with increasing protection from illness due to NLV. Because of the lack of consensus on what defines a "done" oyster, we created categories based on an oyster's texture and moisture content that we thought would correlate with the extent to which it had been steamed but did not require measuring the internal temperature of each steamed oyster. Our study suggests, however, that there is no point at which an oyster is steamed sufficiently to prevent NLV infection; therefore, it is of no practical use to categorize oysters by degree of doneness.

Our study suggests that although most people who attend functions where oysters are served are aware that eating raw oysters can result in gastrointestinal illness, few are aware that cooked oysters can cause illness, despite published evidence from both epidemiologic and laboratory studies suggesting that cooking shellfish may not inactivate NLV.^{4,5,14,15}

Potential limitations of our study include recall and misclassification bias. Although it is unlikely that they misremembered or misreported acute illness, people who ate oysters may have incorrectly recalled the total number of oysters eaten or the number of oysters eaten in each category of doneness. However, it is unlikely that people who ate a large number of oysters reported that they ate only a few or that those who ate a few reported having eaten a large number. Consequently, it is unlikely that selective recall biased our finding that the risk of illness increased with numbers of oysters eaten.

In this study, there were two potential sources of misclassification error. First, people with gastrointestinal symptoms unrelated to this outbreak could have met our case definition. Second, the descriptive scale we used to classify the extent to which oysters were cooked was subjective and different subjective perceptions of the degree of doneness of oysters may have led different people to classify similarly cooked oysters into different categories. Given the small sample size, such misclassification errors could have limited our ability to identify a protective effect of longer steaming on the risk of illness.

In the past, public health messages have emphasized that shellfish should be thoroughly cooked and not eaten raw to prevent shellfish-related illness. In the case of NLV, our study suggests that steaming is not adequate to inactivate the virus in oysters and cannot be relied on as a preven-

tive measure. Further studies are needed to determine the degree and type of cooking required to inactivate NLV and to prevent illness. In the meantime, efforts should be directed at avoiding the contamination of oyster beds and educating shellfish eaters about the risks of illness associated with eating both raw and steamed oysters.

Sarah Evans of the Craven County Health Department and Helen Morris of the Beaufort County Health Department assisted in the epidemiological investigation. Charles Humphrey, PhD, Tamie Ando, PhD, Stephan Monroe, PhD, and Sara Stine, PhD, of the Centers for Disease Control and Prevention (CDC) performed laboratory work, and Roger Glass, MD PhD, of CDC provided comments and suggestions.

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