

Vibrio vulnificus Disease Prevalence

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Abstract

Vibrio vulnificus is a deadly disease that has been increasing in prevalence. In this study, we review both primary and secondary data to discuss the factors that are contributing to the increase of vibrio disease, causing a 41% increase between 1996 and 2005. It has also been shown that public health campaigns to limit vibrio infections have focused on raw seafood consumption. However, an estimated 42% of infections are now being caused by wound infection, rather than through contaminated seafood. This shows the disparities in addressing vibrio contamination through contaminated seawater and open wounds. This is particularly stressing as global warming is causing an increase in risk of contaminated seawater. Reasons for this increase are discussed, and also possible solutions are presented for public health interventions to help mitigate this rise in vibrio infections.

Keywords

Vibrio, *Vibrio vulnificus*, Public Health Prevention, Global Warming, Oysters, Hurricanes, Rising Sea Temperatures, Surface Temperature, Open Wounds, Contaminated Water

1. Introduction

There are many health problems surrounding bacterial infections, but few articles address the bacterium that comes from our oceans. The *Vibrio* family of bacteria in particular contains several species that can contaminate humans. The one strain that we would like to address in this article is the bacterium that is commonly referred to as the “flesh-eating bacteria” [1]. This bacterium is *Vibrio vulnificus* and it is transmitted through oral consumption of marine life or through contaminated water coming into contact with an open wound.

Because this bacterium only grows in the world’s oceans, *Vibrio vulnificus* is rarely discussed in areas that are not near the coast. However, with our improved transportation systems, infected marine life can now be sold throughout

the world, no matter the distance to the coast line. This creates the issue that anyone within the United States can be at risk of contracting this deadly disease, and should thus be made aware of its spread and prevention measures.

In this project, we will use secondary research to discuss the spread of the *Vibrio* bacteria, as well as the implications that global warming has caused in the latest increase of this bacteria. Global warming has a unique effect on the transmission of this disease as it will affect the global trends of the growth of this bacterium within our waters. We will then discuss the prevention and safety options that surround the spread of this disease, specifically what medical actions are recommended for treatment and care, as well as what safety measures are in place to currently prevent the spread of this disease. And last, we will use this secondary research to develop a recommended prevention and awareness strategy to aid in limiting human infection from this bacterium. This may help to reduce the spread of *Vibrio vulnificus* in the human population in preparation for the increase in bacterial growth and an increase in marine contamination levels.

2. Problem Statement

The problem surrounding *Vibrio vulnificus* infections is that it is highly fatal and in many situations in which it spreads, there are limited prevention opportunities. This is because infection often occurs through the consumption of raw seafood, or through the combination of open wounds and infected ocean water [1]. Most cases of oral infection of *Vibrio* are through the consumption of oysters or shellfish. If foods are improperly prepared, either by being undercooked or by becoming cross contaminated with a food that contains this bacterium, it can lead to people becoming sick with the disease [2]. The next route of transmission is by the bacteria in ocean water entering the host via an open wound. This route is common for recreational swimmers, as well as following hurricanes and other natural disasters. Those who have the greatest risk of contraction of this disease are those with chronic liver disease or those with a weakened immune system [3].

These infections are a major problem due to the fact that people are often unaware of their exposure to this bacterium right away. The infection grows very fast and symptoms are often confused with other illnesses. The early symptoms of *Vibrio vulnificus* include diarrhea, vomiting and obvious wound infections. If left untreated, this disease can lead to the amputation of infected limbs or possible death.

The magnitude of the problem can be seen in the numbers. According To the Center of Disease Control and Prevention (CDC), one in five of those who contract the disease die within two to three days after becoming ill. And across the United States, there are approximately 80,000 illnesses contracted every year, resulting in up to 100 deaths annually [4]. It is unacceptable for any number of deaths to come from eating shellfish or wading through ocean waters. However, the most alarming part is that these numbers continue to increase each year.

This is in part because of global warming that has caused the bacteria to increase in numbers [5]. This is why *Vibrio vulnificus* has become a larger problem in the past several years.

3. Literature Review

Vibrio vulnificus Prevalence & Risk Factors:

Vibrio vulnificus is a bacterium that causes both septicemia and necrotizing wound infection, depending on whether it is an internal or external contamination of the patient. And, bacterial infection rates are on the rise. It was estimated that between the years of 1996 and 2005, there was a 41% increase in infections. This resulted in 92 infections within the United States in 2004, with 64 of them causing septicemia and 28 causing wound infections [1]. *Vibrio vulnificus* infection through wound exposure can also rapidly lead to necrotizing fasciitis, which has a mortality rate of approximately 11% and an amputation rate of 7% [3]. In this section, we will take a look at the data surrounding why this bacterium is becoming more prevalent, the different prevention methods that are currently in place, as well as the differences between risks of oral consumption and open wound infection.

First, we wanted to discuss the increase in prevalence of *Vibrio vulnificus* infections. *Vibrio vulnificus* can infect a person either through consumption of contaminated seafood, or through exposure of an open wound to contaminated seawater. However, if the vector is contaminated seafood, not all patients will develop septicemia. Instead, this effect occurs most regularly in those who already have immunocompromised conditions, such as hepatitis B or C, liver disease, or diabetes [6]. This makes it difficult to track the true amount of contaminated seafood that is being distributed. It has also been found that contamination only occurs in seafood that has not been thoroughly cooked, specifically in oysters that are undercooked [7]. This occurs through the cross-contamination of food with raw ingredients, or through insufficient cleaning or handling without the use of gloves. *Vibrio* diseases also spread in instances where there was inadequate refrigeration of the seafood [8]. In Florida, there was a study of *vibrio* diseases between the years of 1998 and 2007. The researchers began by looking at all of the cases of gastroenteritis caused by a *vibrio* bacterium. It was found that between the years of 1981 to 1993 that 45% of the patients had consumed raw oyster within the prior week. However, in the years from 1998 to 2007 these raw oyster cases dropped to represent only 26% of the cases of vibriosis. This decrease in raw oyster cases has been mainly due to the Florida Department of Health's efforts to raise awareness about the dangers of raw oysters and other raw seafood [9]. While this lowering of raw oyster contamination is great, it doesn't explain why the Centers for Disease Control and Prevention noted that there has been an increase in infection rates for all *Vibrio* species since 1996 [8]. This is in part due to the nature of the different *Vibrio* bacteria.

Oral Consumption vs. Wound Infection Incidence Rates:

It was discovered that the majority of *Vibrio vulnificus* bacteria is spread through raw oyster consumption and wound exposure and causes primary septicemia. And, while the incidence rates of *Vibrio vulnificus* are relatively low, the case-fatality rate is relatively high, at 3.6%. This is why *Vibrio vulnificus* is the leading cause of death when it comes to seafood consumption [8]. Another major cause of Vibrio contamination is the bacteria *Vibrio parahaemolyticus*, which commonly causes gastroenteritis and is spread more commonly solely through seafood consumption. This is most commonly spread in a restaurant setting, which accounts for 82% of overall cases [8]. Through public health campaigns, the cases of Vibrio associated with raw oyster consumption have decreased by almost 50%. However, this mainly focuses on *Vibrio parahaemolyticus* and only the 26.4% of *Vibrio vulnificus* cases that spread through raw oysters [8]. The other 73.6% of *Vibrio vulnificus* cases have been largely ignored due to the fact that they are spread through other means.

Of the types of Vibrio bacteria, it was found that the bacteria that was causing the most human contamination was the *Vibrio vulnificus* variant, making up for 33% of all infection cases. The second most abundant variant was *Vibrio parahaemolyticus* at 29%, followed by *Vibrio alginolyticus* at 16%. Through surveys, data was obtained to identify that 42% of all cases were due to wound infections and not from the consumption of shellfish [8]. This data is important as it shows that a large portion of Vibrio cases are not occurring through seafood consumption, even though this raw oyster consumption is what most public health campaigns are focused on.

In an article written in 2016 by Gabrielle M. Barbarite, she states that Vibrio bacteria are responsible for up to 80,000 illnesses and 100 deaths every year in the United States of America. She found that the state of Florida has the highest rates of infection and that 20% of the cases could be linked to recreational areas that had ocean water with a fresh water discharge location [10]. Vibrio also spreads after periods of warmer temperatures and heavy rainfall, which increases the area of lower salinity and water temperatures, causing the Vibrio's natural living environment to expand to new regions [11]. These occurrences often relate to tropical storm and hurricane environments, which also correlate with higher incidences of skin wounds. This combination causes higher rates of Vibrio infection immediately following hurricane and tropical storm events. For example, the Centers for Disease Control and Prevention found that after Hurricane Katrina, there were 22 new Vibrio cases with 18 of them being caused by wound infection and only 4 causing gastroenteritis. Then, of these 18 wound infection cases, 14 were found to be *Vibrio vulnificus* infections, while only 3 were from *Vibrio parahaemolyticus* and 1 was unknown [11]. This decline in *Vibrio parahaemolyticus* was confirmed through a study showing that temperatures above 17 C causes some antibacterial compounds to increase in activity and reduce the *Vibrio parahaemolyticus* bacteria [12]. This leads us to see how the primary bacteria causing gastroenteritis is actually declining, though the more deadly *Vibrio vulnificus* that spreads both through consumption and through

wound infection is increasing in prevalence, especially after these natural disaster effects due to the increase in temperature, increase in freshwater surface areas, and the increase in opportunity for getting hurt and causing open wounds.

Though the exact numbers of contaminated individuals can be difficult to measure, a research study was performed in 2016 to measure the amount of bacteria within the North Atlantic and North Seas. It has been previously noted that *Vibrio* bacteria thrive in sea water that is above 68 degrees Fahrenheit [1]. This study then noted that over the past 54 years, the surface temperature of sea water has risen by up to 2.7 degrees Fahrenheit [13]. This equates to more days with temperatures that promote bacterial growth. It has also been seen that the *Vibrio* bacterial growth has had a direct positive relationship with the sea surface temperature, which has been causing there to be even more *Vibrio* bacteria than in previous years, which is aligned with the steady increase in infections [13].

Public Health Campaigns:

There have been some public health campaigns that target *Vibrio* infections through raw oyster consumption. In 1993 there was a law passed in the state of Florida that requires all establishments that sell raw oysters to post visible warnings that tell consumers of the risks of consuming raw oysters. The Florida Department of Health has also been regularly distributing educational materials to a variety of target groups throughout the state that increases awareness of *Vibrio vulnificus* and its risk associated with raw oyster consumption [8]. While these campaigns have had some positive effect, there needs to be a transition to target *Vibrio* infection through open wound contamination. It has been seen that this new target group that is the most susceptible to wound infection through recreational activities are young children, those with underlying health conditions or compromised immune systems, and those over the age of 64. To limit the exposure in these groups, it is suggested to change health advisories to include *Vibrio vulnificus* levels, and to engage in safe sanitation practices such as covering any existing open wounds, showering before and after water and sand contact, and properly disinfecting all wounds that are sustained during recreational activities [14].

Those who are the most susceptible to open wound contamination through commercial activities include fishermen and those who sell or prepare raw seafood. Some suggestions for limiting the exposure to these groups are to raise awareness of proper handling techniques and to increase the usage of proper gear. This includes the use of landing gear, dehooking tools, and gloves for fishermen, and the use of gloves and proper refrigeration and cooking techniques for those selling and preparing seafood for consumption [9].

Summary:

This research has shown that the *Vibrio vulnificus* species has not only increased over the years, but with global warming trends, it will continue to increase in our environments [13]. Because of this, prevention measures need to be increased in order to decrease the number of *Vibrio* contaminations throughout the United States. These prevention measures need to continue to address the

risk of raw oyster and seafood consumption, but it also needs to begin to focus more on the possibilities of wound infection. By changing the focus and targeting highly-susceptible regions, such as populations visiting beaches or areas of freshwater marinas, this should help to decrease the number of individuals who are contaminated with this bacterium through open wounds.

4. Goal Statement

The Goal of this research is to uncover which prevention and treatment methods are the most effective to prevent the onset of *Vibrio vulnificus* disease.

5. Methodology

The methodology used in this article was a thorough review of existing scientific literature through the ProQuest Central Essentials database. Searches were conducted with combinations of the keywords “*Vibrio vulnificus*”, “global warming”, “raw oysters”, “Prevention” and “Hurricane” with emphasis given to peer-reviewed articles published in the past ten years. These peer-reviewed articles contained primary research that was conducted, as well as secondary research. Articles were then assessed based on their relevance to the topic and their age, with most recent studies being favored over older publications.

6. Discussion

From the literature we can see how measures have been implemented to raise awareness of *Vibrio* contamination through oral consumption of raw seafood. These campaigns have also been relatively successful in decreasing the number of people who are contaminated from eating raw seafood. Weis Hammond studied the public health approach of educating the public on the dangers of eating raw seafood, particularly eating raw oysters. It was seen that the intervention was geared towards educating those who prepare and sell seafood, as well as to the consumer to make them all aware of the need to cook the food thoroughly, as well as the dangers of cross-contamination of cooked seafood from raw seafood. These interventions used educational pamphlets, presentations, and posted signs to display information. I believe that these educational materials are an effective way to raise awareness. It is also detrimental to those who sell seafood as these warnings might dissuade customers from purchasing their products. But, by explaining to these same vendors the risk that they might face, in the form of lawsuits from customers who are harmed from consuming their food, then it would be easy to convince vendors that these warnings are in their best interest. I would also suggest that there be an increase in health inspections during the storage and cooking process of seafood, especially where they sell oysters. These inspectors will ensure proper cooking temperatures, wait times of food before it is served and occasional lab tests to screen for *Vibrio* bacteria. This method would cost a great deal more than educational material, but killing the bacteria and thus making the food harmless is much more effective than posting a notice

of risk.

Next, we see that while *Vibrio* contamination through oral consumption is declining, contamination through open wounds has actually been increasing. This is causing a higher percentage of *Vibrio* cases to come from open wound infection [13]. Now, while these cases are increasing, there was very little research indicating that this topic is being addressed sufficiently among public health districts.

It is very easy to prevent contamination from open wounds. But most educational material about beach safety does not include these recommendations. The easiest to implement are to cover existing wounds with waterproof bandages, have children and those over the age of 65 wear clothing that protects high-impact areas such as knees and arms, and to rinse off with clean water after coming into contact with sea water or the ground surrounding the ocean. Then, if any open wounds occur while in these situations, they need to be disinfected. These are proper health guidelines and would be simple to follow. However, educational materials are not sufficiently addressing the topic of bacterial infections during recreational or commercial usage of the oceans. If these proper health techniques were discussed, there would most likely be a drop in the cases of *Vibrio vulnificus* infections.

A few ways to reduce cases of infection at recreational swimming areas is to post signs in parking lots and trails leading to the water. These signs will simply caution swimmers about the dangers of swimming with open wounds and suggest disinfecting all wounds that are acquired. There could also be signs posted near showers that are generally located along popular beaches. These could also raise awareness of possible bacterial infection and could recommend rinsing off after contact with either water or sand.

Then, to limit the spread of infections during commercial use of seawater, there needs to be higher rates of education. For example, there is a great misconception that salt water promotes wound healing. Although this can be true, such salt water needs to be sterile. Ocean water is not sterile, and can harbor these harmful bacteria [15]. There also needs to be more education surrounding wound safety. By using proper equipment, fishermen can decrease the chances of being cut either by the marine life, or by improper use of equipment. By reducing the amount of open wounds, this can decrease the chances of *Vibrio* contamination.

Another factor to consider with *Vibrio vulnificus* is the increasing spread of this bacterium. It has been documented that *Vibrio vulnificus* cases have been increasing. It has also been seen that the amount of *Vibrio* bacteria in the oceans has been increasing [13]. This is said to be a direct result of global warming through the steady, but slow, rise of sea surface temperatures. These increases in water temperatures have been said to increase the prevalence of *Vibrio* bacteria. The study done by Thorstenson and Ullrich, however, did lab studies with *Vibrio vulnificus* bacteria growth at different temperatures within native sea waters. This study saw an increase of growth at the onset of the higher temperature,

but then a sharp decline after 48 hours. This decline shows that it is not solely the temperature that is dependent on bacterial growth, but there are also other limiting factors within the environment that will curb the growth of *Vibrio* bacteria. It was recommended that further studies would need to be conducted to measure the relationship between zooplankton levels, sea temperatures, and *Vibrio* bacteria to further determine the complex relationship between rising sea temperatures and an increase in this bacterium [12].

One thing that has been seen is that as global warming continues, there is a steady rise in sea levels. This equates to a steady increase in *Vibrio vulnificus*' living environment. This alone could be a cause for the increasing levels of this bacterium. Another effect that global warming has on the environment is an increase of extreme weather-related events. These include events such as drought, flooding, heavy rainfall, hurricanes, cyclones, etc. According to research conducted by K. F. Cann, episodes of flooding and heavy rainfall are the two events that cause the largest amount of waterborne disease outbreaks. This is due to the waterborne bacteria entering and contaminating the water supply, which then leads to contaminating the population [5]. Hurricanes have also been noted to cause large amounts of flooding and heavy rainfall, as well as can cause an increase of open wounds as people experience the hurricane, but also as people are active in cleaning up debris after the hurricane. Hurricanes can also cause a larger spread of waterborne diseases. For example, after Hurricane Katrina and Hurricane Rita, there was major flooding. Right after the flooding had ended, Lake Pontchartrain, a lake in Louisiana, was tested for *Vibrio* bacteria. It was found that *Vibrio cholerae*, *Vibrio vulnificus*, and *Vibrio parahaemolyticus* were all at very high levels within the lake waters. These levels then slowly receded in the months following [11].

In these various research studies, we have found that *Vibrio* infections are not only rising because of rising sea temperatures that are causing this bacterium to be more prevalent in the ocean. Instead, we are finding a much more indirect approach. Global warming is causing a rise in sea surface temperatures, which is causing a rise of sea levels. This increases the bacteria's habitat. Then, global warming is also causing an increase of extreme-weather events, such as heavy rainfall, flooding, and hurricanes. All of these particular extreme-weather events can spread this water that has higher rates of bacteria farther and farther inland.

This increased abundance and spread of water-borne pathogens is the main cause of concern for the spread of *Vibrio vulnificus*. With public health campaigns and more strict food preparation regulations, it can be seen that *Vibrio vulnificus* contamination through consumption of raw seafood (particularly raw oysters) has been declining. Now, the focus of public health campaigns should shift to the rising cause for contaminations, namely through open wound infection from contaminated sea water. Only through the reduction of either the bacterial spread, or of the rates of contamination can we ever hope to reduce the number of illnesses from the *Vibrio vulnificus* bacteria.

7. Limitations

One limitation to this study is that the factors for *Vibrio vulnificus* are still not fully known. This is how the two research articles that studied the effect of temperature on *Vibrio* growth had two different results, namely an increase of growth and an increase followed by a sharp decrease of growth. From the environmental study, it was seen that the *Vibrio* bacteria have been increasing as the sea surface temperatures have been rising [13]. However, when the lab research was conducted, the increased growth fell off sharply, which shows that there are other aspects and limiting factors within the environment that are also affecting the *Vibrio* growth [12]. These factors need to be further studied to determine the exact causes for increased *Vibrio* growth.

Without knowing the exact factors that are causing an increase in growth in *Vibrio vulnificus*, it is difficult to limit this growth. This makes it so all public health interventions can only focus on dealing with the symptoms, rather than focusing on the increasing numbers of bacteria that are increasing the chances of contamination.

Another limitation of this study is that no primary research was conducted. This leaves us to solely base our conclusions off of secondary data that was collected.

8. Implications

With global warming, *Vibrio* bacteria are both increasing in number, and increasing in spread. This bacterium is also increasing in spread through wound infection, which is the infection method that has been addressed the least in public health campaigns. This means that for the U.S. population as a whole, risks of contamination of *Vibrio vulnificus* continue to increase year to year, causing a need for a proportionate increase in public health funding and campaigning to lower the risks associated with this deadly disease.

9. Conclusions

Vibrio vulnificus is a serious disease that should be given more attention than it currently has been given within public health. It has been seen that with global warming, *Vibrio* bacteria have been increasing within the environment. Global warming has also started an increase in extreme weather events. This directly correlates with an increase in the opportunities for *Vibrio vulnificus* to spread through both consuming contaminated seafood, as well as through contaminated open wounds. This increasing prevalence within the environment and the increased risk for infection should be a cause for a proportionate increase in public health resources.

This public health initiative should shift its focus. There are currently many campaigns centered around decreasing the amount of *Vibrio* contamination through food-borne vectors. These campaigns have been highly effective at educating the public about the dangers of eating raw seafood, the risks of *Vibrio* and

other foodborne bacterial infections, and the ways to correctly prepare seafood to aid in killing this bacterium.

As we have seen, however, *Vibrio* infections through contaminated food have been decreasing. *Vibrio* infections through wound exposure have, in contrast, been increasing. Due to this shift in the method of contamination, there should be likewise a shift in a public health focus. More campaigns should be related to safety while being exposed to seawater that could potentially contain harmful bacteria. These could target communities such as those who live in coastal regions, as well as target individuals who are spending recreational time at the beach. These public health campaigns should also target those who are in frequent contact with seawater, such as commercial fishermen.

There should also be more research done to determine the exact factors that are contributing to this increased prevalence of *Vibrio vulnificus* within the environment. By identifying the exact mechanisms that aid the growth of this bacterium, then more will be able to be known in possibly limiting it within the environment, or at least can help to stop the increase of growth of this bacterium. This will ultimately be the most effective way to limit the spread of *Vibrio* illnesses.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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