# Re-emergence of Cholera in the Americas: Risks, Susceptibility, and Ecology

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## ABSTRACT

**Background:** The re-emergence of cholera in Haiti has established a new reservoir for the seventh cholera pandemic which threatens to spread to other countries in the Americas. **Materials and Methods:** Statistics from this new epidemic are compared to the 1991 Peru epidemic, which demonstrated the speed and complexity with which this disease can spread from country to country. Environmental factors implicated in the spread of *Vibrio cholerae* such as ocean currents and temperatures, as well as biotic factors from zooplankton to waterfowl pose a risk for many countries in the Americas. **Results:** The movement of people and goods from Hispaniola are mostly destined for North America, but occur to some degree throughout the Americas. These modes of transmission, and the probability of uncontrolled community spread beyond Hispaniola, however, are completely dependent upon risk factors within these countries such as water quality and availability of sanitation. Although North America has excellent coverage of these deterrents to the spread of infectious gastrointestinal diseases, many countries throughout Latin America and the Caribbean lack these basic services and infrastructures. **Conclusions**: In order to curb the immediate spread of cholera in Hispaniola, treatment availability should be expanded to all parts of the island and phase II epidemic management initiatives must be developed.

**Key words:** Americas, Cholera, Ecology, Epidemic, Haiti

## INTRODUCTION

After an absence of more than 100 years, cholera has returned to the island of Hispaniola and the seventh pandemic now threatens the rest of the Americas.[1] Centuries of research on *Vibrio cholerae* has revealed it to be a constantly evolving bacterium with numerous reservoirs, routes of transmission, and variations in the manifestation of subsequent epidemics.[2] To evaluate this new epidemic, it is imperative that the 1991 Peru cholera epidemic that spread to most American countries be analyzed to give context to the epidemiology of the O1 El Tor Ogawa strain of cholera with other emerging strains. This background, along with recent research on cholera transmission and management, could possibly predict the potential risks of future spread of the current epidemic to implement a novel interdisciplinary cholera epidemic management strategy.

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The seventh cholera pandemic began in Sulawesi in 1961 and quickly spread through South Asia where it became endemic. This newest and longest-lasting pandemic caused by *V. cholerae* O1 El Tor has been differentiated from other strains by its greater ability to survive in the aquatic environment, a lower rate of severe manifestation of disease, and lower immunological protection against re-infection.[2-4]

## MATERIALS AND METHODS

Information regarding the epidemiology of the 1991 Peruvian and 2010 Haitian epidemics was gathered from academic literature and organizational releases from various public health entities. Epidemiology was then compared to environmental factors present around the island of Hispaniola which could affect the transmission of cholera within the island and possibly facilitate further spread. Finally, regional susceptibility to translocation was determined by examining water and sanitation coverage and human mediated factors implicated in the spread of the disease for all American countries.

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## DISCUSSION

### The Haitian epidemic in context

The specific origin of the 1991 epidemic has been hypothesized to be a point source introduction, but was most likely a result of a rapid growth of environmental bacteria due to an El Niño event following introduction from an endemic area to the coast of Peru.[5] This was further confirmed by the identification of seven patients in five different cities separated by over 1,000 km, presenting clinical symptoms of cholera several months before the official start of the epidemic.[6] Subsequently, a large-scale epidemic beginning in Peru spread to Ecuador within two months and to Colombia, Brazil, and Chile within five months.[7]

The complex patterns of transmission that cholera can exhibit were illustrated by the next reported outbreak, which occurred in Mexico. Before any Central American country was hit by the disease, a case was detected in the rural city of San Miguel Totolmaloya and the disease quickly spread to impoverished, rural areas in the southern states of Mexico.[8] Two hypotheses attempt to explain why an index case appeared in such a remote, distant area from the origin of the outbreak. One suggests that the disease was imported from South America by drug traffickers using illegal airstrips in the area.[9] The other suggests the Mexican outbreak was an independent event arising from environmental *V. cholerae* off the coast of Mexico. This is supported by serological evidence indicating that El Tor *V. cholerae*, classical *V. cholerae*, and hybrid strains were all present from 1991 to 1997 in Mexico. Since the classical and hybrid biotypes were never found in South America, the best explanation for the presence of these unique biovars was their origin from the Gulf of Mexico.[10] The Mexican experience highlights the importance of both human and environmental factors in the spread of cholera.

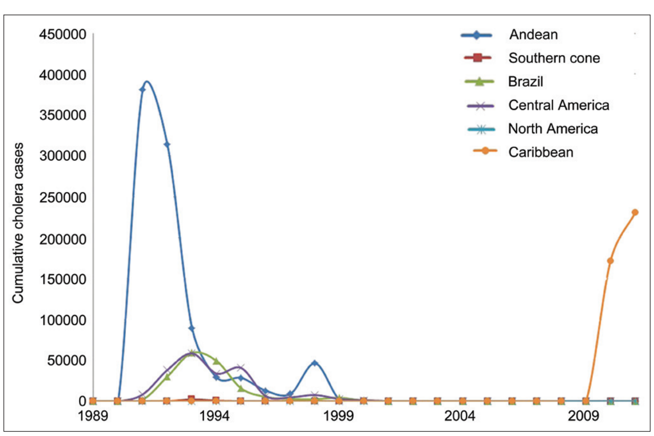


**Figure 1:** Annual cholera cases by region[11,67]

From Mexico, the disease spread through Central America eventually bringing the total countries reporting cholera to 21 with a total of more than 775,000 cases by the end of 1992.[11] The number of cases [Figure 1] gradually diminished through 1997, but rapidly increased in 1998 after an increase in ocean temperature off of the Pacific coast of South America due to an El Niño event.[5] Eventually, cases dwindled during the early 2000s when there were mostly small-scale outbreaks until cholera was eliminated from the South and Central America in 2005, except for five cases in Paraguay in 2009. It is striking that the Caribbean region was spared during these epidemics. One of the possible reasons, other than the geographical separation, could be the extremely limited trade relations between the Caribbean region and the Central and South American countries, which limited the exchange of people and materials.[12]

The Centers for Disease Control and Prevention (CDC) and the Ministère de la Santé Publique et de la Population (MSPP) of Haiti confirmed the first case of cholera in Haiti on October 21, 2010.[13] Despite initial suspicion that aquatic environmental *V. cholerae* was to blame for the epidemic, further epidemiological investigation and villagers' reports uncovered the likely source to be Nepalese soldiers serving as part of the United Nations Stabilization Mission in Haiti (MINUSTAH) who were exposed to the September 27, 2010 O1 El Tor Ogawa outbreak in Nepal. This investigation found that the first cases actually appeared on October 14 in Méyè and infected the Artibonite River, which fueled the spread of the bacteria through the rest of the country. The conclusion of translocation from Asia is supported by DNA fingerprinting and genotyping suggesting a geographically distant source of the bacterium and the elevated number of cases observed along the Artibonite River.[14]

After an initial peak in the number of cholera cases in Haiti, there was a lull in early November 2010 [Figure 2]. The subsequent peak of cases could possibly be due to the increased social gathering, contact, and feasting associated with the observance of the 'Day of the Dead' on November the 2$^{nd}$, one of the most important festivals of Haiti.[15,16] The peak attained a maxima in December 2010 and gradually decreased until another smaller rise in cases was seen beginning in May 2011 at the onset of the rainy season. This weather change greatly increased the number of cases seen in the Dominican Republic, which saw an increase from less than 200 cases per week in early May to over 1600 per week in early June.[17,18] In conjunction with these numbers, Andrews and Basu predicted approximately 779,000 new cases and 11,100 deaths between March and November 2011, with the greatest numbers for the Port-au-

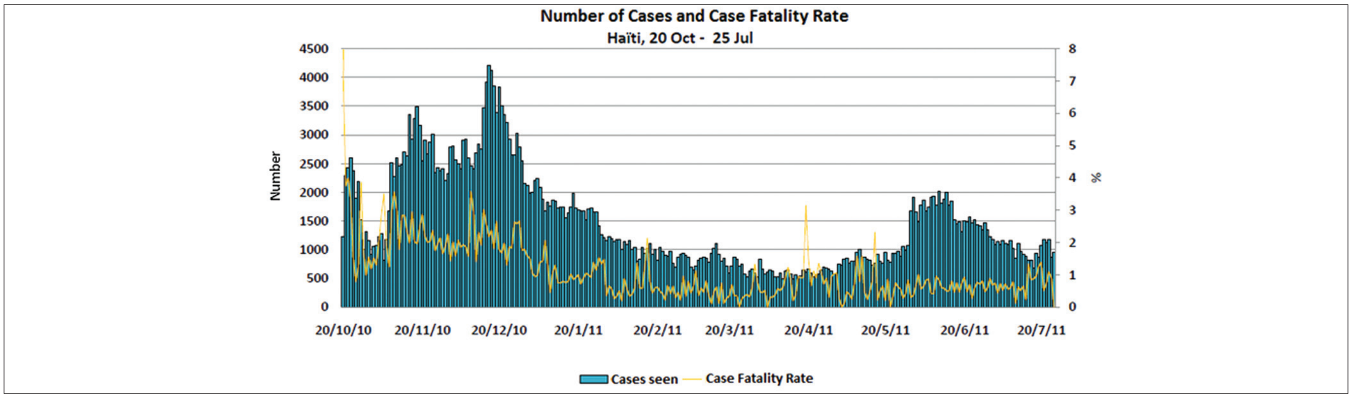


**Figure 2:** Suspected cholera cases and case fatality rate in Haiti[17]

Prince, Artibonite, and Nord Departments.[19] In October of 2011, a third cholera epidemic wave was emerging in Haiti and the Dominican Republic, with another increase in infections and deaths.[20]

The case fatality rate (CFR) of the cholera epidemic in Haiti had decreased since the beginning of the outbreak, from over 3% in the month after the beginning of the epidemic to 1.4% as of late July 2011 [Figure 2]. The CFR spike in April and May 2011 came at a time of reduced funding for Non-Governmental Organizations (NGOs) in Haiti, partially due to an underestimation of the severity of the epidemic by the World Health Organization (WHO) and other multilateral organizations.[21]

Significant deterioration in the quality of care resulted from the scaling down of operations around the country by these NGOs in response to financial difficulties. In fact, the number of operational cholera treatment centers in Haiti was cut in half from 96 in February 2011 to 48 in May 2011.[22,23] This reduction in cholera prevention efforts occurred in the face of widespread knowledge that the upcoming rainy season would increase cases around the country.[21]

The national averages, however, mask the disparity between the lowest CFR of 0.6% in Port-au-Prince and the highest CFR of 5.3% in the Departement Sud Est.[17] This disparity can be explained by health care delivery challenges comprising of difficulties in geographical and financial accessibility to health care, poor infrastructure, a paucity of trained health personnel, as well as the extent of community involvement.[24] For example, the continued improvement of water and sanitation services in the official NGO-run internally displaced persons (IDP) camps was in sharp contrast to the remote communities with no water or sanitation infrastructure. The difficulty of supplying remote areas was overcome in Ecuador during the 1991 epidemic by strategies such as sending out oral rehydration packets coupled with soft drinks.[25] Similar innovative practices may be considered for implementation in Hispaniola to reduce mortality.

This new epidemic of cholera engenders a human reservoir for toxigenic *V. cholerae* in the Americas and raises the specter of further spread of the disease to other countries. To evaluate this possibility; both human-dependent and ecologically-mediated transmission of the bacterium must be coupled with each country's potential for disease spread.

## Environmental reservoirs

The ability of *V. cholerae* to survive in aquatic environments is now well established. The bacterium attaches to chitin — the most abundant biopolymer in the marine, brackish water, and estuarine environments. This gives it an almost limitless habitat and contributes to its pathogenicity.[26] In addition, it enables *V. cholerae* to bind to the chitinous gut and carapace of zooplankton. There are numerous other reservoirs that include non-biting midges, phytoplankton, aquatic plants, and protozoa. These are responsible for the infection of higher organisms such as marine bivalves, fish, crustaceans, and possibly even marine mammals, which has led to suggestions that a decrease in copepods can have a measurable effect in the control of cholera. Illustratively, in an area of endemic cholera in rural Bangladesh, simple filtration of drinking water through sari cloth in order to remove copepods has been found to reduce cholera incidence by 48%.[27] Additionally, waterfowl can ingest and spread *V. cholerae* attached to its feathers and feet.[28,29] These environmental reservoirs and vectors for translocation have been found to have a significant impact on human disease and are affected by climatic factors. Although the bacterium is able to survive in salinities ranging from 0 to 45% and temperatures above 5°C, it has been found to thrive in certain conditions. These abiotic factors include high temperature near 35°C, salinity below 5% for optimal toxin expression, pH around 8.5, more sunlight, and increased rainfall. Increased rainfall causes a rise in the water table of the common sources of drinking water, which is then contaminated with human waste. Changes in these factors lead to varying degrees of cholera seasonality, which is lower in equatorial areas such as the Caribbean and Central America and higher in subtropical areas such as the Southern Cone and North America.[30–33] This means that while there may be periods of low environmental cholera transmission in the higher latitudes, environmental transmission rates are relatively even year-round near the equator, when considered independently from water table rises, infrastructure deficiencies, and social conditions.

The marine environment could significantly impact the spread of cholera from the island of Hispaniola. There is evidence of non-toxigenic *V. cholerae* thriving in the Caribbean Sea after intense rains create low salinity conditions.[34] Currently, the most affected areas are located along the largest river on Hispaniola — the Artibonite River. This river mostly flows at low altitude and high temperature directly into the largest mangrove forest in Haiti — all of which are conditions that are ideal for the growth of environmental *V. cholerae*.[8] This area of low salinity can be clearly seen in Figure 3 in the north of the Golfe de la Gonâve marked by dark blue coloration.

Although mangrove coverage is sparse in Haiti, there is greater coverage in the north of the neighboring Dominican Republic, and nearby Cuba has the second largest mangrove forests in North and Central America. The proximity of these mangroves to the epicenter of a cholera epidemic is cause for concern, because they offer low salinity and ideal conditions for *V. cholerae* hosts to thrive. Establishment of *V. cholerae* in these habitats could make cholera endemic here as it has been for decades in South Asia. Countries further away from Hispaniola have similar environments, but may be protected to some degree against translocation. Although there is significant mangrove coverage around the Gulf of Mexico, there is reason to believe that the Loop Current would prevent many organisms carrying the bacteria from reaching the Gulf Coast because of low nutrient availability and physical pressures due to fluid dynamics.[35] The same cannot be said for Cuba, which appears to be the destination of surface currents originating from Haiti [Figure 4].

Water temperature has been observed to be the single strongest predictor of cholera outbreaks, although some of this observed effect may be due to increased river flow occurring concurrently.[30,36] The water temperature around Hispaniola remains very stable year-round, so it is unlikely to be a significant contributor to the environmental propagation of *V. cholerae* on this island. This is in contrast to other locations around the Caribbean, which can be seen to have greater seasonal variation in water temperature [Figure 5]. Specifically, the Gulf Coast of the United States and Mexico appear to have the greatest variation in sea surface temperature, which could mean larger peaks and troughs of environmentally transmitted cases, were an epidemic to spread to the region.

One environmental factor that is not dependent upon oceanographic dynamics for the movement of *V. cholerae* is the migration of waterfowl. Many American bird species carry the bacteria long distances and most of these have been observed to spend time in the Caribbean.[37,38] For example, the blue winged teal is the most common winter resident duck in the Caribbean and has a range that includes Central America and northern South America. Other birds such as pelicans, coots, cormorants, heron, and killdeer migrate over a massive range from northern Canada to the

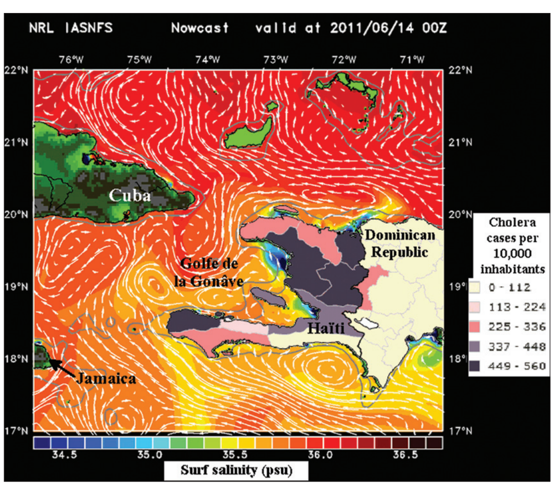


**Figure 3:** Surf salinity and cholera incidence rate[68,69]

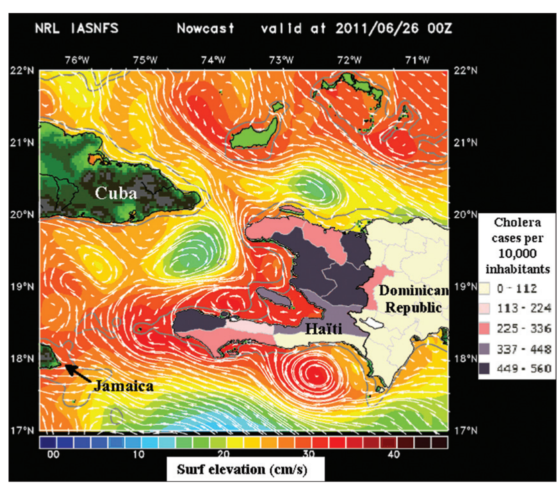


**Figure 4:** Surf elevation and cholera incidence rate [68,69]

Southern Cone. There is greater abundance of migratory birds in the surrounding Caribbean islands, southern United States, Central America, and northern South America with less species wandering far from the equator.[39]

In summary, it appears that the islands of Hispaniola, Cuba, Jamaica, and Puerto Rico are at risk of environmental *V. cholerae* being transported to their coasts by river flow and currents into their large mangrove forests with minimal effect from sea temperature. Conversely, continental North and South America seem to be protected by both the Loop Current and cooler sea surface temperatures for much of the year. Waterfowl, however, may carry the bacteria to almost any area in the Americas, as could human carriers.

## Human mediated transmission

In the past, Haitians have been discriminated against due to actual or perceived disease status by both governments and the general population of other countries.[40] This attitude still persists in spite of biological and epidemiological irrelevance. Persons who travel out of Hispaniola are just as likely to be foreigners returning to their original destination, or humanitarian workers or military traveling between vulnerable disaster or conflict zones. Also, almost all ships that can transfer infected ballast water sail under foreign flags.[41]

International shipping has historically been the main driving force behind the spread of epidemic cholera around the world.[42] Today, the shipping of goods remains an important factor to examine. The United States Food and Drug Administration emphasized this danger during the 1991 epidemic by advising that all ships traveling from affected countries exchange ballast water on the high seas before entering American ports.[43]

Although statistics on specific destinations of ships leaving Haitian ports is unavailable, the breakdown of Haiti's trade partners in Figure 6 approximates the destinations of these ships. The overwhelming majority of trade heads to the United States, followed by the neighboring Dominican Republic, and Canada. After these trading partners, Mexico, Colombia, Brazil, and El Salvador are the next largest

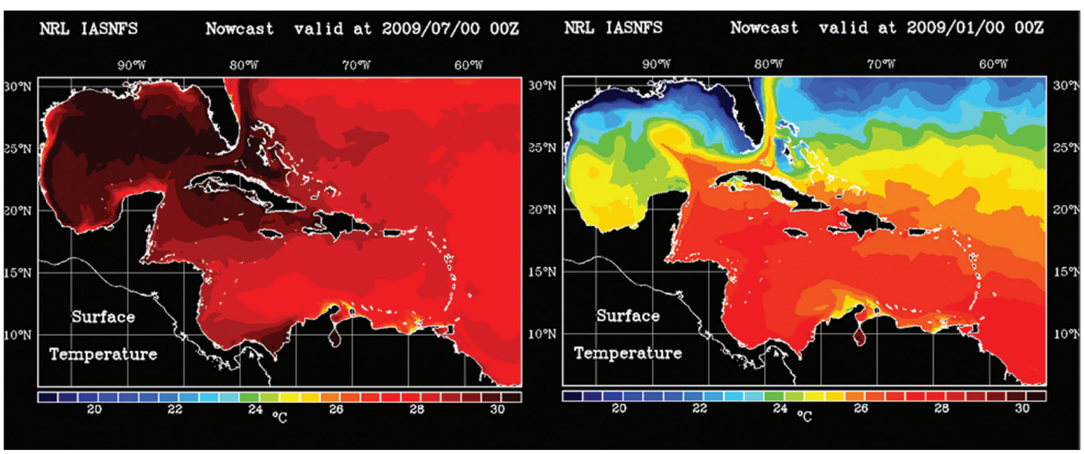


**Figure 5:** Average sea surface temperature in July (left) and January (right)[68]

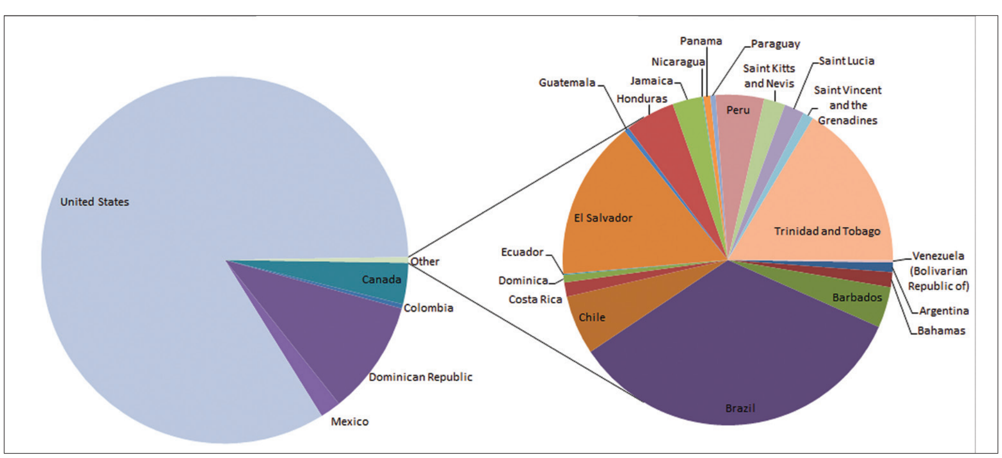


**Figure 6:** Percentage of Haitian exports by US$[12]

buyers of Haitian goods.[12] In total, there are 26 registered trade partners ranging from Nicaragua with only $2,385 of goods to the United States with over $419 million of exported goods. This disparity must be tempered with the fact that only one instance of infected ballast water is needed to infect an aquatic habitat. Also, the dollar value of goods being exported may not directly correlate with the amount of goods being shipped, and thereby the shipping traffic, if prices vary according to trade partner.

A specific category of goods that must be placed under increased scrutiny is that of fish, crustaceans, and mollusks, which have been proven to be the cause of cholera outbreaks in the past.[2] Only four countries report importing fish, crustaceans, or mollusks from Haiti. These are Canada (approximately $2.9 million), the United States ($1.7 million), Honduras ($38,000), and Mexico ($11 thousand).[12] There are suspicions that the trade of seafood from the waters surrounding Hispaniola is far more extensive than is represented in the statistics of the few countries reporting to know the true status of the export of these goods.

As the origin of the Haitian cholera epidemic has proven, the movement of infected persons by aircraft can be a source of cholera translocation and potential epidemics. Despite this, quarantine or the use of *cordon sanitaire* is not useful in preventing the spread of this disease and is not recommended by the WHO or the Pan American Health Organization (PAHO).[44] One reason for this is the fact that severe diarrhea only occurs in a small number of infected patients. It is estimated that 90% of cholera episodes are of mild or moderate severity, and there may be anywhere from three to a hundred asymptomatic carriers of the bacteria for every symptomatic carrier.[45,46] In addition, past efforts to halt the spread of cholera using quarantine have failed to do so and have diverted valuable resources away from treatment and prevention measures.[9,47,48]

The major destinations of aircraft departing from Haiti correlate closely with the trade partners in large part due to the presence of expatriate communities. As of November 2010, the United States accounted for 76% of passenger flights followed by the Dominican Republic and other Caribbean islands at 17%, France with 4%, Canada with 2%, and Panama with 2%.[49] These officially recorded statistics on the movement of persons do not include passengers using cruise liners and naval vessels to travel, which could also introduce the disease to a new area. It should also be noted that since the outbreak of cholera in Haiti in 2010, the number of cases in the United States has increased to four times the annual average from recent years, with 23 cases in eight states.[50] It also does not account for large movements of military or humanitarian personnel, who may be more likely to be operating, and exposed to *V. cholerae*, in areas of outbreaks. Overall, most of the movement of people from Hispaniola is destined for developed countries, with less travel to the Caribbean and Central America. That said, emergency response, medical, humanitarian, and military personnel may travel from Haiti and become carriers of cholera. These carriers could spread the disease to more impoverished areas in other Caribbean and Latin American nations while responding to challenges in areas at elevated risk for translocation, and subsequent uncontrollable community spread. The strong evidence of the O1 El Tor Ogawa strain of cholera in Hispaniola having come from U.N. troops originating from Nepal following their O1 El Tor Ogawa outbreak is a clear indicator of this danger.

## Susceptibility to disease

Cholera has spread in the western hemisphere through environmental reservoirs, the shipping of goods, and through movement of persons. However, these routes of transmission become irrelevant if the population has advanced water and sanitation measures, which prevent the disease from ever taking hold. For example, despite having several cases of endemic toxigenic serogroup O75 cholera and having imported at least 23 cases of serogroup El Tor O1 Ogawa cholera from Haiti, there have only been two recorded cases of secondary transmission within the borders of the United States since 1965.[49–51] By evaluating the risk factors of the disease, the true risk of epidemic cholera spread is evident.

One major risk factor in the spread of cholera is the lack of a clean water source as demonstrated by John Snow.[52] In addition, there is ample evidence of the importance of water quality from the 1991 epidemic. Contaminated water sources and the resultant water quality were found to be the most common cause for disease in separate studies in Peru, Mexico, and Ecuador.[8,25,53] Figure 7 presents a breakdown of the percentage of every country's population served by piped water, improved water source, or unimproved water source, except for the United States and Canada, which both report 100% piped water coverage. These categories do not present a perfect hierarchy, since decayed or clandestine water connections have been shown to be worse than high quality improved water sources.[25,54] Also, these averages obscure the significant disparities between high and low socioeconomic status groups within countries as well as between urban and rural communities.[55]

It is no surprise that there has been an explosion of cases in Haiti since it has the worst percentage of piped water coverage and water quality in the Americas. Countries at risk of marine spread such as Cuba, Jamaica, the Lesser Antilles nations, and Central America all have a significant percentage of their population drinking from an unimproved water source. Similarly, some of Haiti's top trading partners of Mexico, Colombia, Brazil, Trinidad and Tobago, and El Salvador exhibit potential for the spread of cholera due to poor water quality. Finally, the top destinations of flights are mostly covered by excellent water quality except for Panama and several Caribbean nations. However, cases of cholera in seafood workers and those ingesting seafood such as oysters from the Gulf of Mexico indicate that other vectors could lead to endemic cases, even where sanitation and water infrastructures are adequate, as witnessed during the spring of 2011 in Florida's Apalachicola Bay.[51]

Another crucial factor needed to break the cycle of fecal-oral transmission of cholera is the percentage of population covered by improved sanitation. Improving sanitation has been a cornerstone of cholera prevention and has also been shown to dramatically lessen the impact of epidemics.[56,57] As with water quality, these statistics need to be compared to other factors. For example, even though the residents of Santiago, Chile had very good sanitation coverage in 1991, the resulting sewage was used untreated in vegetable cultivation for human consumption. This resulted in an epidemic which was curbed to a great extent, once this practice was discontinued.[58]

Sanitation coverage statistics for the countries of the Americas are summarized in Figure 8. Tellingly, Haiti has the worst sanitation coverage of any country in the Americas, while the Dominican Republic has slightly better sanitation coverage compared to its water quality statistics. With the exception of Dominica and Central America, the countries at risk of marine spread have fairly good coverage of improved sanitation. The major trading partners of Mexico, Colombia, Brazil, and El Salvador, however, have significant segments of their population practicing open defecation. The major flight destinations

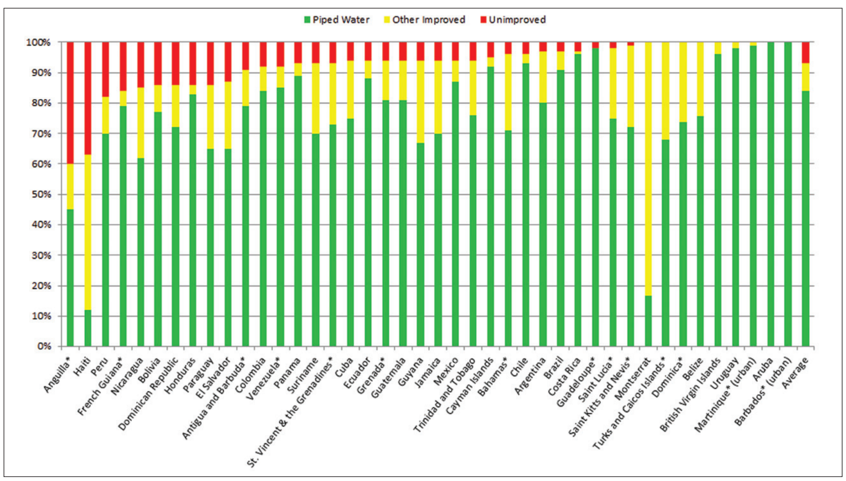


**Figure 7:** 2008 Water source statistics (asterisk denotes 2003 statistics)[55]

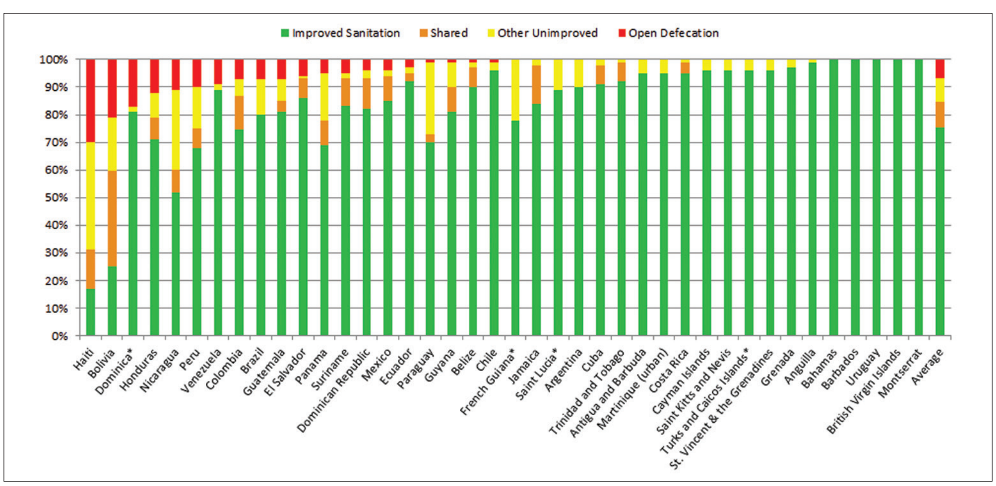


**Figure 8:** 2008 Sanitation statistics (asterisk denotes 2003 statistics)[55]

again have excellent sanitation coverage except for Panama and some Caribbean nations.

With most diseases, a protective factor in preventing the spread of disease is natural or artificially acquired immunity. The protective effects of naturally acquired immunity to El Tor O1 cholera after infection has been demonstrated to be less than that of the classical biotype, and the initial protective effect has been estimated to be anything from 90% protective to negligible protection.[2,3] Unfortunately, this effect seems to be short lived. The most important factor in the immune response appears to be the presence of vibriocidal antibodies, which reach effective levels between one to three weeks after infection. Although some claim the resulting protective immunity lasts for three to nine years, most estimate it to be as short as a couple months for mild infection and one to two years for severe infections.[45,59,60]

This means that for a population to have immunological protection against cholera, they must be repeatedly exposed to the bacterium at least once every couple years. This has been observed to happen in Bangladesh, where the population with detectable levels of vibriocidal antibodies reached 50% by age ten and 80% by age fifteen.[59,61] The Americas, however, have not had recorded cases of cholera in any significant number within the time span of plausible immunological protection. The only possible scenario for the presence of protective immunity is that there are remote endemic areas in the Americas which do not report cases of cholera because of the mildness of symptoms and the fact that endemic cholera overwhelmingly attacks children under the age of five.[62] Despite this possibility, it is safe to assume that the population of the Americas is immunologically naïve to *V. cholerae* because any immunity gained from the previous 1991 epidemic has been lost over time.

An active surveillance system for diarrheal diseases and easy accessibility of primary health care is critical to the early awareness of the public health system to the existence of suspicious cases of cholera in the community and thereby early implementation of remedial measures. Finally, public health education on cholera prevention practices such as hand washing, safe food handling, safe water storage, and safe disposal of cadavers also have significant impacts on preventing the transmission of cholera.[7,25,53] It is important to note, however, that education alone cannot succeed in preventing cholera without supplies and facilities to put knowledge into practice.[24]

Infrastructural, social, and behavioral interventions will be crucial to reducing deaths from the further spread of cholera in Haiti and the Dominican Republic, and reducing the probability of O1 El Tor Ogawa translocation and epidemic spread in the Americas from Hispaniola. Given that it is expected that there will be several more epidemic waves of the O1 Ogawa strain of cholera in both Haiti and the Dominican Republic over the next two years, it is imperative, according to testimonies in the U.S. Congressional Emergency Summit on the cholera epidemic in Haiti, that a Phase II epidemic management initiative should be implemented throughout the island of Hispaniola before and during the third and fourth waves of the epidemic.[63] This Phase II initiative proposes to assess mission critical gaps essential to controlling cholera in Health Capacity Zones throughout Haiti and the Dominican Republic. The use of intelligent social networks for improved operational bio-surveillance and rapid medical and public health response along with essential infrastructure development provides important opportunities for improving health capacities in high risk areas with favorable social and behavioral advances being made through new management and governance approaches against known modes of cholera transmission.

## CONCLUSION

After a brief reprieve from the menace of cholera, the seventh cholera pandemic has returned pathogenic *V. cholerae* to the Americas on the island of Hispaniola. Public health officials have the benefit of a broad body of work from the 1991 epidemic to predict the future path of this new wave. There are lessons to be learned from the weather-related factors, which influenced the beginning of the epidemic, the variety of factors which contributed to the spread, and the factors which put these countries at risk in the first place. There is a risk of cholera becoming endemic around the island of Hispaniola — especially in estuarine areas such as the mouth of the Artibonite. From these locations, there is a chance that organisms may be transported to other locations in the Caribbean. Haiti's major trade partners and flight destinations have also been analyzed and compared to their risk factors for epidemic cholera introduction. Almost every country outside of North America and the Southern Cone exhibit the risks of lack of safe water and sanitation in conjunction with the opportunity for the pandemic to spread to their borders. Translocation of cholera by medical, military and humanitarian personnel working directly in areas of high risk for cholera on the island of Hispaniola to other areas in the Caribbean and Latin America at heightened risk of community spread of gastrointestinal disease must also be considered to be a significant threat to health, human security, and economic activities in the Americas.

Finally, there appears to be an illusory dichotomy developing between debility before an increasingly intimidating bacterium as knowledge of the disease continues to grow, and continued inaction on fundamental public health necessities. There is cause for concern because not only has the seventh pandemic not been halted, it has expanded into Africa and re-emerged in the Americas. The O139 Bengal cholera serotype, which some describe as the eighth pandemic, has spread rapidly in South Asia by infecting even those who are immune to the O1 serotype.[64] A new strain of the El Tor O1 *V. cholerae* has been found to express the more dangerous classical cholera toxin, increasing the proportion of severely dehydrated cholera patients in the affected area from approximately 35% to over 70%.[65] Even more disconcerting may be the revelation that *V. cholerae* is so widespread through the earth's oceans that it will never be eradicated.[57]

Despite these alarming trends, cholera remains a disease which is completely controllable by simple interventions which have been known since the days of Koch. With universal access to safe water and sanitation, along with a robust public health preparedness system, there would only be sporadic cases acquired from environmental sources. It has been proposed that a Phase II Cholera Epidemic Management Initiative that significantly improves operational bio-surveillance, rapid medical response, and significantly enhanced infrastructural, social, and behavioral interventions in Health Capacity Zones throughout Hispaniola can and must be established now to reduce the risk of infections and deaths due to cholera in Haiti and the Dominican Republic.

Intelligent social networks, like the Haiti MPHISE (Medical and Public Health Information Sharing Environment) can now be engaged at modest cost to implement fifth generation management and governance approaches in defined geospatial areas — in which local communities are empowered to take essential actions to reduce their risks with the help of their governments and the support of international organizations. The degree to which these Phase II initiatives are implemented, at the cost of tens of millions of dollars, may be the deciding factor as to whether the current and emerging epidemic waves on the island of Hispaniola will lead to the deaths of tens of thousands more lives, potentially at the cost of billions of dollars in health interventions and trade losses in other nations around the Caribbean and Latin America in the near future.

Over fifty years ago it was clear that cholera epidemics 'do not create abnormal situations, rather they emphasize normal aspects of abnormal situations. An epidemic intensifies certain behavior patterns, but those patterns, instead of being aberrations, betray deeply rooted and continuing social imbalances'.[66] The 2010 cholera epidemic has brought to light the lack of clean water, sanitation, and public health protection for the people of the Americas. Until these social imbalances are corrected, cholera will continue to spread.

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