Risk factors for cholera in Pohnpei during an outbreak in 2000: lessons for Pacific Countries and Territories

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Abstract

In April 2000, a large outbreak of cholera due to Vibrio cholerae serotype Ogawa biotype El Tor affected the Island of Pohnpei in the Federated States of Micronesia. A Pacific Public Health Surveillance Network team conducted a case control study in the middle of the epidemic. The aims of the study were to identify individual and household level risk factors for cholera, and to evaluate public health interventions aimed at controlling the outbreak. A case was a person admitted to the Pohnpei hospital with acute watery diarrhoea in the months of June and July 2000. We used a pre-tested questionnaire to interview cases about exposures in the five days prior to illness and visited their house to collect water samples, observe hygiene, and assess uptake of health education. 100 mL water samples were filtered and cultured for V. cholerae. We randomly selected neighbouring houses to identify a control that was similar age and sex for each case. Identical observations were made for eligible controls where their household members had not had diarrhoea since the beginning of the epidemic. We stored and analysed data using an Epi Info version 6.04. 53 case control pairs were enrolled into the study. The study identified that storing food outside uncovered, and having a pit latrine as the main toilet were risk factors for cholera infection. There were also several factors that protected against cholera infection, including washing hands after using the toilet and before eating, having a container to store safe water, the presence of soap in kitchen and bathroom, the presence of chlorine bleach and two or more hand washing buckets, a working refrigerator/ice box, and toilet inside or near the house and having a flush toilet. In multivariate analysis, having a working refrigerator/ice box (OR 0.19, 95%CI 0.05–0.70) and Clorox present in the house (OR 0.17, 95%CI 0.04–0.81) were strongly protective against illness. Only 13% (14/106) of case households reported disinfecting household water with chlorine. V. cholerae was isolated from the household water supplies of two controls and one case. During outbreaks of diarrhoeal disease, public health agencies need to aggressively advise affected communities to: disinfect drinking water with clorox bleach, store water in narrow-necked containers, and prepare and store food safely. Health authorities should use multiple strategies inform people about preventive hygiene measures, and implement vaccine campaigns early in outbreaks of cholera. Improvements in sanitation and hygiene are needed to prevent further cholera epidemics in the Pacific. (PHD, 2005 Vol 12 No 2 Pages 17 -22)

Introduction

Cholera is an acute watery diarrhoea caused by intestinal infection with *Vibrio cholerae*.[1] The infectious dose for cholera is quite high, although many people show little or no symptoms. Fatalities from cholera due to severe dehydration predominantly occur where access to treatment is limited or unavailable.[2] Transmission of *V. cholerae* is faecal-oral, with water, food and infected persons playing an important role in the spread of disease during outbreaks.[1,3] Contaminated seafood and plankton can act as reservoirs for *V. cholerae*.[3,4] Cholera can result in massive epidemics, particularly in environments where sanitation is poor.[1]

Despite global efforts to improve hygiene, epidemic cholera remains a major cause of morbidity and mortality throughout the world.[1] The current, or seventh pandemic due to *Vibrio cholerae* serotype O1 biotype El Tor originated in Indonesia in 1905. Since then *V. cholerae* El Tor has spread to the whole world, including Pacific Island Countries and Territories (PICTs).[5] PICTs have reported periodic outbreaks and sporadic cases of El Tor cholera since the early 1970's.[6–10] The majority of these outbreaks have been associated with consumption of raw seafood, contaminated water supplies, and inadequate disposal of human waste.

Recognition of the outbreak

On 17 April 2000, patients began presenting to the Pohnpei State Hospital with symptoms of acute watery diarrhoea, vomiting and dehydration. The Pohnpei State hospital laboratory isolated *Vibrio cholerae* from faecal swabs, which was subsequently confirmed as serotype Ogawa at the Guam Public Health Laboratory, and biotype El Tor at the Noumea Pasteur Institute. The

number of people presenting to Pohnpei health services increased rapidly, particularly people resident in rural areas.

In response to the outbreak, the State of Pohnpei declared a state of emergency and established a 'Cholera Task Force' and a 'Hospital Task Force'. The Federated States of Micronesia (FSM) requested assistance from the Secretariat of the Pacific Community (SPC) and the World Health Organization (WHO). The SPC and WHO under the Pacific Public Health Surveillance Network (PPHSN) formed a field response team to identify risk factors for infection and review control measures. Following this investigation, the Government implemented a vaccination campaign with an oral live attenuated vaccine that achieved 47% coverage of the 32,178 people living on the island of Pohnpei.[5]

In total, the Pohnpei outbreak resulted in 3,452 cases of cholera and 20 deaths giving a case fatality rate of 0.6%.[11] In this report, we present findings from a case control study conducted during the epidemic to identify factors conferring higher and lower risks for infection prior to the vaccination campaign.

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Methods

Case definition

In outbreak settings, the World Health Organization defines a case of suspected cholera as a person who is five years old or greater with acute watery diarrhoea.[12] For the case control study, we defined a case as someone meeting this definition that was admitted to Pohnpei hospital with acute watery diarrhoea in the months of June or July 2000.

Control selection

To select a control, interviewers visited randomly-selected neighbouring houses to a case residence, until a suitable control was found. A control was someone who was resident in a house where all household members were free of diarrhoeal illness since the beginning of the outbreak, and who had not had diarrhoea. Controls were required to be the same sex and in the same 5 year age group as the matching case.

Exposure assessment

A health professional and an interpreter interviewed cases and controls using a pre-tested questionnaire about exposures in the five days prior to illness or interview. The investigators then visited the house of the study subject, where they interviewed the head of the household, collected water samples, and made observations about hygiene and uptake of health education.

Environmental testing

During house visits, investigators collected samples of the main drinking water source for each household. Two 500 mL water sample were collected in a sterile bottle for testing for *V. cholerae.* The EPA filtered these water samples and the Pohnpei hospital laboratory cultured them using classical isolation techniques for *V. cholera.*

Data management and analysis

Data were entered into an Epi Info 6.04 database (Centers for Disease Control and Prevention, Atlanta, USA). Epi Info 6.04 was used to calculate descriptive and exact maximum likelihood estimates of odds ratios and 95% Confidence Intervals (CI) for matched case control pairs. To explore the relationship between risk factors identified in the univariate analysis and illness we conducted conditional logistic regression using a backward elimination approach with the variables with a statistically significant association with the outcome variable (level of statistical significance p <0.1).

Results

We enrolled 53 case control pairs into the study, of which 43% were female. The median age of cases was 31 years old (range: 5–79 years old) compared to a median age of 33 years old (range: 6–75 years old) for the controls. The median sizes of cases' and controls' households were 9 (range: 2–26) and 8 (range: 3–15) persons respectively, which was similar to the household size found during the previous census (8 persons per household). Case and control households were recruited from all municipalities of Pohnpei, with 25% of houses being from Sokehs, 23% from Nett, 20% from Uh, 19% from Kitty, 8% from Kolonia and 7% from Madolenihmw.

Amongst cases, 70% (37/53) reported that one or more people in their household had experienced watery diarrhoea since the beginning of the outbreak. The median time interval between the date symptoms began and the date the patient was admitted to hospital was 1 day (range: 0–5 day).

Exposure assessment

During the outbreak, both case and control households commonly engaged in practices potentially at high risk for cholera transmission (Table 1).

13% (14/106) of households reported chlorinating their drinking water and only 10 of these were doing it according to guidelines. In 84% (89/106) of the households the water was piped from a water source, and only 17% (18/106) was from the town water supply.[(a)]

(a) The only water supply with water storage and treatment.

In 37% (33/89) of the households the pipe was on the ground and 33% (11/33) of these were leaking. Of the 13% (14/106) houses using water from a shallow well, 20% (3/14) were susceptible to drain surface water.

18% (18/102) of the households most commonly used toilet was inside the house, while 25% (25/102) were 0–25 feet from the house, and in 56% were more than 25 feet from the house. In 35% (35/102) of the households the toilet was less than 25 feet from the water supply.

In 60% (64/106) of households someone regularly prepared sakau, a local kava drink prepared with roots of Piper methysticum and water. Of these households, 84% (54/64) indicated that they had made preparation of sakau safer using boiled water and cleaning preparation surfaces.

Overall 86% (91/106) of households reported that they received health advice from one or more sources, including school teachers, public health teams, Red Cross workers, the media and the hospital. No households reported receiving advice from churches or community chiefs. 53% (56/108) of households received a brochure with instructions for chlorinating drinking water. In 84% (76/91) of households, the health advice was understood. In 16% where advice was not understood, the information was in relation to the disease and the mode of transmission, and using bleach ("clorox") for water disinfection.

Risk factors for infection

The case control study identified several factors that were positively and negatively associated with infection (Table 2). The majority of these risk factors were indicative of poor hygiene and may also relate to socio-economic status.

In multivariate analysis, the presence of a working fridge/ice box and the presence of bleach were found to best fit a model explaining the association between household hygiene and the illness (Table 3).

Environmental testing

3% (3/104) of water samples were positive for V. cholera. Two positive samples were collected from the water at control households, while one sample from a case household was positive.

Table 1: Prevalence of individual and household level exposures of 53 cases and 53 controls during an outbreak of cholera on Pohnpei, 2000

Exposure	Proportion of cases and controls with exposure (%)
Individual Level	
Eat raw reef fish	20
Eat raw deep water fish	28
Drink sakau	38
Attend funeral	21
Attend gathering	13
Do not always wash hands after toilet	42
Go to toilet in the bush	24
Household Level	
Container to store water safely	77
Drinking water in narrow-neck container	70
Soap present in kitchen	67
Soap present in bathroom	60
Clorox bleach present in house	51
≥2 handwashing buckets	16
A bucket with water and Clorox	21
Working refrigerator/ice box	58
Prepared food in the house	59
Prepared food covered or in refrigerator/ice box	70
Piped water	84
Pipe on the ground	37
Spring water primary drinking water source	31
Town supply primary drinking water source	17
Rainwater tank primary drinking water source	19
Shallow well primary drinking water source	13
Pit latrine	55
Waterseal toilet	19
Flush toilet	27

Table 2: Results of matched analysis of individual and household level exposure that were significantly associated with cholera infection, Pohnpei July 2000

Exposure	Number of pairs Case + Control -	Case – Control +	Odds ratio (95% CI)
Individual Level			
Wash hands before eating	2	9	0.2 (0.02–1.1)*
Store cooked food outside uncovered > ½ day	8	1	8.0 (1.1–355.0)
Household Level			
Soap present in kitchen	1	23	0.0 (0.0–0.3)
Soap present in bathroom	4	14	0.3 (0.1–0.9)
Clorox present in house	2	22	0.1 (0.0–0.4)
≥2 handwashing buckets	1	10	0.1 (0.0–0.7)
Bucket with water and Clorox	3	11	0.3 (0.1–1.0)
Working refrigerator/ice box	3	27	0.1 (0.0–0.4)
Container to store water safely	1	8	0.1 (0.0–0.9)
Narrow-neck water container	2	12	0.2 (0.0–0.8)
Untreated rain water main source	8	1	8.0 (1.1–355.0)
Pipe or tap leaking	12	3	4.0 (1.1–22.1)
Toilet inside house	4	15	0.3 (0.1–0.8)
Pit latrine	13	4	3.3 (1.0–13.7)
Holes around pit latrine	10	1	10.0 (1.4–434.0)
Flush toilet	2	12	0.2 (0.0–0.8)

** Exact 95% Mid-P limits for maximum likelihood estimate of odds ratio: 0.1-0.9*

Discussion

This case control study identified several risk factors that are important for controlling the spread of epidemic cholera. The study reinforces the importance of good personal hygiene, safe water, and appropriate sanitary measures in preventing cholera.[1,13,14]

Good personal hygiene is known to be a protective factor against faecal-oral transmission of diarrhoeal diseases.[1] The study showed that "always washing hands before eating" was protective against cholera, which is consistent with many other diarrhoeal diseases. As well, "always washing hands after going to the toilet" was also protective although not significantly. This could indicate protective practices more present amongst the controls, and may also relate to differences in educational levels between cases and controls.

The study identified that people in Pohnpei commonly prepare food and keep it for consumption at a later time. *Vibrio cholerae* can survive and multiply in many kinds of foods once they have become contaminated through poor hygiene.[15] In this study, uncovered storage of food increased a person's risk of cholera infection. Transmission via pre-prepared food is a well known source of cholera. During this epidemic, health authorities suspected that sharing food at gatherings was a major way the epidemic may have spread. Food for these gatherings are usually prepared some time before and stored inappropriately. At the time of the study, all social gatherings with food were banned, except for funerals, which were modified to ensure that cholera would not spread.

In houses there were several factors that protected residents from cholera, which included: having a container to store safe water, keeping drinking water in a narrow-neck container, having soap in the kitchen or in the bathroom, the presence of Clorox bleach in the house, using two or more buckets for hand washing, having a bucket with water and Clorox, and having a working refrigerator/ice box. All of these factors indicate households with a better standard of hygiene.

Table 3: Results of conditional logistic regression with the variables describing household hygiene, Pohnpei July 2000 (*n*=104)[*]

Variables	β coefficient	Se [β]	Odds ratio (95% CI)	p-value
Presence of a working fridge/ice box	-1.64	0.65	0.19 (0.05–0.70)	0.01
Clorox present in house	-1.77	0.79	0.17 (0.04–0.81)	0.03

[*] Likelihood Ratio chi square test: 27.5088 with 2 degrees of freedom ($p < 10^{-4}$)

During the epidemic, the Red Cross promoted and distributed narrow-neck containers for water storage, which were shown to be protective against illness. These containers have shown their efficacy for safe storage of household water during cholera epidemics in Africa and other countries.[13,14] During this outbreak, we identified that household water supplies were contaminated with *V. cholerae*, making protective measures very important. In our study, approximately 24% of people reported going to the toilet in the bush, which may have contributed to widespread contamination of the environment. To prevent outbreaks of diarrhoeal disease, people should be encouraged not to go to the toilet in the bush.

There was very low uptake of public health messages to chlorinate drinking water in Pohnpei households. This has also been noted in other cholera outbreaks, along with an outbreak in neighbouring Marshall Islands some months later.[16,17] It was interesting to see that no health advice reportedly came from the traditional chiefs and the church, both being good potential channels to get messages through to the communities.

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Sakau preparation and drinking is very common in Pohnpei. Most of the sakau bars were closed when this study was carried out, although someone prepared sakau in 60% of all household, and 38% of the cases and controls drank sakau in the 5 days prior to interview or illness. *V. cholera* contamination is possible during many steps of sakau preparation starting with the water used to make the beverage. It is reassuring to see that more than 80% of the people preparing sakau reported they received instructions and changed the way they prepared sakau in order to make it safer. Nevertheless this effort needs to be maintained, given the popularity of sakau consumption and its potential to transmit other waterborne diseases.

The study identified that households with a pit latrine as the main toilet were at higher risk of infection, particularly those that were poorly maintained. Households with flush toilets as their main toilets were at lower risk, which may indicate a better socio-economic status, and thus better hygiene. Having the most commonly used toilet inside the house was also a protecting factor because all these toilets were flush-based toilets and probably cleaner. Indirectly, this is also indicative of a better socio-economic status, and thus a better hygiene.

It is important to recognise that the risk factors identified in this study relate to causes of illness in the middle of the cholera epidemic in Pohnpei. The study was started after health agencies had instituted public health interventions implemented to address some of the suspected risk factors therefore likely affecting the mode of spread. The study therefore allowed us to evaluate the implementation of these interventions. But this also made the identification of risk or protective factors more difficult, and there was probably a shift towards risk factors that were more difficult to control. Epidemiological studies during epidemics may not provide information about the means of introduction of *V. cholerae*, but can provide useful information for health education and longer-term prevention measures.[18,19]

Another problem with the study, common to many case control studies of cholera, was the difficulty of finding true controls. Outbreaks of El Tor cholera may result in several asymptomatic infections for each symptomatic case, which is more than with the classical biotype.[1] The consequence of this is that the selection of the controls on the basis of clinical signs may have lacked specificity. The study overcame this problem by selecting control households where no one had been ill with diarrhoeal illness since the beginning of the epidemic in April 2000. In Pohnpei, the average size of the households was more than 8 people, making it less likely that controls were asymptomatically infected where the whole household was free of diarrhoea. In cholera epidemics, investigators have found that there is little difference in identified risk factors when comparing results of studies using clinically defined cases and controls using symptom presence or absence and those defined using serological definitions.[16,20]

In this study, the PPHSN team used a case definition that did not require laboratory confirmation of a diagnosis of cholera. The case definition was consistent with the WHO definition of suspected cholera and required that cases were admitted to the hospital. The fact that patients were admitted to the hospital made it much more likely that they were true cholera infections and not another diarrhoeal disease. In the midst of a cholera epidemic, the proportion of people admitted to hospital due to a diarrhoeal disease other than cholera is quite small. During the epidemic, microbiological confirmation of rectal swabs of patients with suspected cholera resulted in very high rates of confirmation (>90%) even late in the outbreak.[5] The decrease of specificity in the “case” status for this study was expected to be very low.

Conclusion

Poor hygiene and sanitation were the major contributing factors to the size of this large outbreak where approximately 10% of Pohnpei residents attended a medical facility for treatment.[5] Educating Island

populations about sanitation and hygiene remain a key, long-term public health measure to prevent future outbreaks. During outbreaks of diarrhoeal disease, public health agencies need to aggressively advise affected communities to: disinfect drinking water with clorox bleach, store water in narrow-necked containers, and prepare and store food safely. Health authorities should use multiple strategies inform people about preventive hygiene measures, and implement vaccine campaigns early in outbreaks of cholera.

Acknowledgements

We would like to thank the Federated States of Micronesia Department of Health and the Pohnpei Health Services for their assistance with the investigation. We would like to thank Pertina Saimon, Terri Malone and Justin Washington for conducting field work for the case-control study.

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