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Widespread dissemination of diarrhea due to rotavirus serotype G9P8 in the Solomon Islands after a focal flood-related outbreak

Short Title: Flood-associated rotavirus outbreak in Solomon Islands

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Abstract

Background

Extreme weather events can precipitate epidemic transmission of diarrhea. We describe a large nationwide epidemic in the Solomon Islands following a focal flash flood disaster on April 3-5, 2015 in the capital city of Honiara.

Methods

The Early Warning Alert and Response Network surveillance system (EWARN) detected an outbreak of diarrhea in Honiara. We identified cases from EWARN and retrospective review of outpatient registries in Honiara prior to and during the outbreak. We reviewed data from the public adverse event system to identify diarrhea-related deaths. Rapid diagnostic testing for rotavirus was performed on stool samples from cases. RT-PCR analysis was used to genotype rotavirus isolates.

Results

We identified 4,231 cases of diarrhea in the city of Honiara (pop. 64,609) during an epidemic which occurred following massive flooding. The mean weekly incidence of diarrhea increased from 21.6 to 43.7 cases per 10,000 population during the period before and after flooding. Although flooding was limited to Honiara and the province of Guadalcanal, hospital-based surveillance detected increase in weekly cases of diarrhea in 4 additional provinces situated on separate islands. Peak weekly incidences in these provinces occurred 4-10 weeks after the peak of the outbreak in Honiara. The highest attack rates for diarrhea in Honiara and nationwide were observed in children with age <5 years. In total, 27 children died due to diarrhea related causes, which exceeded the 22 deaths directly attributed to the flash flood emergency. Rotavirus was identified in 26 of 61 (43%) of the outbreak cases for which testing was performed. All four isolates that were genotyped were found to be serotype G9P8.

Conclusions

Our findings indicate that a disaster sparked a large nationwide epidemic of diarrhea which spread rapidly across islands unaffected by the flood event. Although laboratory testing was limited, rotavirus appears to be an important pathogen in this outbreak. Outbreaks caused by extreme weather events carry a significant burden and should be given large consideration when describing the health impacts of climate change.

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List of Abbreviations

EWARN	Early Warning and Response Network Surveillance System
EWE	Extreme Weather Event
GSH	Good Samaritan Hospital
MHMS	Ministry of Health and Medical Services
NRH	National Referral Hospital
RDT	Rapid Diagnostic Test
RR	Rate Ratio
SSS	National Syndromic Surveillance System
WHO	World Health Organization

Introduction

Extreme weather events (EWE), such as hurricanes, droughts, and floods, cause massive physical destruction, social upheaval, famine, and economic decline [1], [2]. Small Pacific island nations are particularly vulnerable to EWE due to frequent occurrence of events, fragile economies, and limited disaster mitigation and response capabilities [3]–[5]. As climate change is predicted to increase the severity of EWE [6]–[10], small Pacific island nations are expected to be increasingly affected by EWE [11]. In just the past the two years, EWE have had devastating impacts in the Pacific, including Typhoon Haiyan/Yolanda (Philippines, 2013)[12] and Cyclone Pam (Vanuatu, 2015) [13]. 2015 is also the first year ever recorded to have three Category 5 storms in the first three months of the year in the Pacific (Joint Typhoon Warning Center Database) [14].

EWE cause a range of direct and indirect health consequences, including drowning, trauma, exacerbation of chronic diseases, damage to health facilities, and interruption of essential services. Such events also create environments conducive to enhanced disease transmission, often due to disruption of hygiene and sanitation infrastructure, contamination of water sources, and overcrowding [15]. Though disease outbreaks following EWE have been reported in other regions [15]–[21], they have not been previously reported in the Pacific.

From April 3-5, 2014, heavy rain from a tropical depression caused severe flooding in the Solomon Islands, specifically in the capital city, Honiara, and other parts of Guadalcanal island. Multiple rivers flooded, washing away houses, bridges and key infrastructure. In total, there were 22 deaths and more than 9,000 persons were displaced in temporary and makeshift evacuation centers[22]. The Ministry of Health and Medical Services (MHMS) with the World Health Organization (WHO) assistance conducted a post-disaster risk assessment from April 8-12 to quantify the risk of increased disease transmission and outbreaks. Key findings included limited access to hygiene and sanitation facilities, insufficient clean

water, and overcrowding in evacuation centers. The risk of substantial water-borne enteric disease outbreak was concluded to be high [23].

The Early Warning Alert and Response Network surveillance system (EWARN) detected an outbreak of diarrhea on April 20, 2014 in the flood-affected regions of Honiara and Guadalcanal. In the following weeks, diarrhea outbreaks were observed in many parts of the country, including island provinces that were unaffected by the flood. The burden of the nationwide epidemic was significant in comparison to the initial disaster, having implications for emergency preparedness and response [24], [25]. We describe the large diarrhea outbreak in relation to the flashflood emergency and propose rotavirus to be an important contributing agent to the outbreak.

Methods

Setting and Surveillance

The Solomon Islands is an archipelago consisting of nine provinces and 992 islands located in the Western Pacific (Figure 1A). According to a 2009 census, the population is 515,870, 80.2% of which reside in rural areas. The capital city, Honiara, (pop. 64,609) is located on the northern coast of Guadalcanal island. The National Referral Hospital (NRH) is located in Honiara and is the largest hospital in the Solomon Islands (300 - 400 beds); each province has one provincial hospital (25-150 beds) [26].

The National Syndromic Surveillance System (SSS) performs surveillance since 2012 for six syndromes, including diarrhea, from 8 sentinel sites that include provincial hospitals (5) and outpatient clinics in Honiara (3). Early warning alerts for diarrhea outbreaks were detected in 7 out of 8 sites, four in Guadalcanal and three in the provinces of Malaita, Western and Choiseul during the post-flood period from March 31 to July 13. Following the flooding event, EWARN was implemented for 9 weeks (April 14 – June 15) to enhance surveillance and response in the flood-affected regions of Guadalcanal [27]. EWARN increased the number of sentinel sites in Guadalcanal (from 4 to 17), increased the number of syndromes reported (from 6 to 8), and classified cases as <5 or ≥5 years old. EWARN also established an event-based surveillance system, allowing both formal and informal reports to be channeled to the MHMS.

Outbreak Investigation

The Ministry of Health and Medical Services and health care facilities define diarrhea as three or more loose or watery stools within 24 hours and bloody diarrhea cases as an episode of diarrhea with visible blood. We identified cases that occurred during the post-flood period from March 31 to July 13, 2014 by reviewing SSS & EWARN databases and conducting a retrospective review of outpatient registers from

one hospital and 8 outpatient clinics in Honiara. We reviewed diagnoses in the outpatient registries for keywords relating to diarrhea, extracted information on age, and recorded cumulative weekly cases for age groups of <5 or ≥5 years. We also reviewed the national SSS database and outpatient registers from 1 hospital and 8 outpatient clinics in Honiara to obtain information on weekly case counts for the period prior to the flood event from June 17, 2013 to March 30, 2014. Lastly, we reviewed the national SSS & EWARN databases and outpatient registers from 6 provincial hospitals outside of Honiara during the post-flood period. No case data were collected during some weeks in Makira (June 9- July 13) and Isabel (July 7 – July 13) and during the entire outbreak for Central and Rennell and Bellona Provinces. Cases collected for Guadalcanal came from two hospitals (the NRH and Good Samaritan Hospital [GSH]). Data from GSH was only available from April 14 – June 1.

We identified diarrhea-related deaths by reviewing EWARN event-based reports and medical records with death cards from the NRH. Event reports concerning unexpected deaths were investigated through over-the-phone interviews to determine whether the cause of death was diarrhea-related. Information was extracted on the date of death, province, village, age, sex and recent visits to health centers.

Information for daily rainfall for the provinces of Guadalcanal, Western, Malaita and Choiseul were obtained for the period between January 1, 1991 to November 19, 2001 and April 9, 2005 to December 31, 2014 from the National Oceanic and Atmospheric Association [28].

Laboratory Investigation

In Honiara, the NRH collected stool samples from cases of diarrhea as part of routine procedure, which were evaluated for the presence of *Salmonella enterica* and *Shigella* by culture isolation and for the presence of *Vibrio cholerae* and rotavirus by rapid diagnostic testing (RDT). We reviewed laboratory records at NRH for test results from June 17, 2013 to June 20, 2014. Information were extracted from

these records on test date, demographics of patients tested, and laboratory results. In the provinces of Malaita, Isabel, Makira, and Choiseul, we performed additional testing on stool samples for rotavirus with an immunochromatographic RDT (SD Rota/Adeno Rapid; Standard Diagnostics, Inc., Korea) [29]. Isolation of rotavirus was performed for stool samples from RDT positive cases [30]. Genotyping of isolates was performed at Royal Children's Hospital (Melbourne, Australia) using RT-PCR methods which have been previously described [30].

Data Analysis and Mapping

Cumulative weekly cases are reported in weeks starting on Monday and ending on Sunday. As the flood event occurred mid-week (April 3 – 5), the pre- and post-flood periods were respectively defined as June 17, 2013 – March 30, 2014 and March 31 – July 13, 2014. By July 13, weekly case counts at all provincial hospitals dropped below their own respective threshold of two standard deviations above baseline. Statistical analyses were performed with the R software system (Version 3.1.0). Negative binomial regressions and Fisher exact χ^2 -test were used to evaluate for significant differences in rates and proportions of positive diagnoses, respectively, across period and age groups. Maps were created using ArcGIS 10.2 (ESRI, Redlands California). Shape files were acquired from the Solomon Islands Ministry of Lands (Honiara, Solomon Islands) and Natural Earth (naturalearthdata.com).

Ethical Considerations

This investigation was determined to be exempt from Institutional Review Board approval through institutional review at Yale University.

Results

Investigation of the Flood-Associated Outbreak in Honiara

During the week of March 31, 2014, a tropical depression caused rainfall of 663mm in Honiara, which was 21.2 times the historical average rainfall for this week between 1991-2014, and widespread inundation of the city. After this event, we identified a total of 4,231 diarrhea cases that presented to the outpatient clinics in Honiara (Figure 2 and Table 1). The mean weekly incidence of diarrhea increased from 21.6 to 43.7 cases per 10,000 persons per week (RR, 2.02 [95% CI: 1.56– 4.29]) from the pre-flood period (June 17, 2013 - March 30, 2014) to the post-flood period (March 31, 2014 – July 13, 2014) (Table 1). The peak number of weekly cases (596 cases) occurred on the week of April 28 to May 4. Weekly cases decreased significantly after June 1 2014 and subsided to pre-flood case counts after July 13 2014. An epidemic of diarrhea of this size with respect to case numbers had not been previously identified in Honiara. Pronounced seasonal increases in diarrhea case counts were not observed in the 26 month period preceding the epidemic (Supplementary Figure S1).

Among age-identified cases during the outbreak, 66% had age <5 years. Children <5 years old had 14.38 [95% CI: 9.40 – 22.01] times the risk of diarrhea of the population with age ≥5 years after the flood, which was twice the risk ratio [7.38, 95% CI: 6.36-8.56] between these age groups in the period prior to the flood. Among diarrhea cases, 90% were identified to have non-bloody diarrhea.

Nationwide Increase in Rates of Diarrhea Disease Following Honiara Outbreak

Although heavy rainfall and severe flooding was limited to Guadalcanal, 5 out of 8 provinces not affected by the flood also reported outbreaks of diarrhea (Figure 1B-1D). Nationwide, 4,494 cases were identified from 7 hospital-based surveillance sites experiencing increase rates, which included NRH. Significant increases in weekly case counts was first identified Guadalcanal, in which Honiaria is situated,

on the week ending on April 6 (Peak: 483 cases on May 4), followed by Malaita, Makira, and Western on the week ending on May 18 (Peaks: 114, 50 and 58 cases on June 1, June 1, and June 22), Isabel on the week ending on June 1 (Peak: 57 cases on June 15), and finally Choiseul on the week ending on June 15 (Peak: 14 cases on July 13) (Figure 3B-3E). The interval for peak weekly incidence of diarrhea between the flood-affected province of Guadalcanal and unaffected provinces ranged from 4 to 10 weeks (Mean: 6.2 weeks). The mean weekly incidence of diarrhea was lower in non-flooded provinces (4.0 per 10,000 persons per week) than in Guadalcanal (11.9 per 10,000 persons per week) during the outbreak period (Table 2). Among provinces unaffected by flooding, Isabel had the highest incidence (6.9 per 10,000 persons per week) while Choiseul had lowest incidence (1.2 per 10,000 persons per week). An outbreak of diarrhea was not detected at the SSS site in Temotu province.

Among provinces of Guadalcanal, Malaita, Makira and Isabel for which information on the case age was available, 63% of the cases were children with age <5 years, similar to observed during the Honiara outbreak. Children with age <5 years had 11.17 [95% CI: 6.33 – 19.73] times the risk of diarrhea than the population ≥5 years of age.

Diarrhea-related Mortality Associated with the Nationwide Epidemic

The 27 diarrhea-associated deaths occurred during the period of the outbreak from April 23 to June 8, 2014, which was higher than the number of deaths (22) directly attributed to the flash flood emergency. Nineteen deaths occurred among children <5 years old, of which ten were <1 year old and six had an undetermined age. There were fewer deaths in Guadalcanal (10) than in provinces not affected by the flood (17). Overall mortality rate attributable to diarrhea was 0.5 deaths per 10,000 population during the epidemic in the Solomon Islands. Highest diarrhea-associated mortality was observed in Western province which had an overall mortality rate of 1.4 deaths per 10,000 population and mortality rate among children <5 years of age of 8.1 deaths per 10,000 population.

Identification of Rotavirus G9P8 as the Agent for the Nationwide Epidemic

Rotavirus was identified as the agent in 26 (43%) of the 61 cases of diarrhea for whom testing was performed during the epidemic (Table 3). The proportion of rotavirus test positive cases after the flood was significantly increased in comparison the proportion (0% of 34, $p < 0.001$) during the pre-flood period. Shigella was isolated from 5% of the 60 cases for which isolation was performed during the epidemic, yet this proportion was not significantly different from that observed (1.4% of 70) in the pre-epidemic period. Children aged <1 year had the highest percentage of positive tests (56%), while adults aged ≥ 15 years had the lowest (20%). Rotavirus was isolated from four of five cases with rotavirus rapid diagnostic test positive results, all of which were children with age <6 years from provinces unaffected by the flood. Genotyping identified the agent to be the rotavirus G9P8 serotype.

Discussion

Our findings indicate that a flashflood emergency precipitated a large nationwide epidemic of diarrhea and included islands unaffected by the initial flash flood event. A predominant risk group during the outbreak were children with age <5 years. The mortality of the outbreak was severe, leading to more deaths than the actual flooding event. Although several etiologic agents contributed to transmission, our findings indicate that rotavirus was a primary cause of diarrhea during the epidemic.

Flooding and flood-related disasters are well-recognized cause of diarrhea outbreaks. Cann et al. conducted a systematic review showing that of all reported waterborne disease outbreaks caused by extreme weather events, most were related to heavy rainfall and/or flooding [17]. On the week of the flood, the Solomon Islands Meteorological Service Honiara site recorded its largest daily rainfall in recorded history on April 3, 2014 (298.6mm). A total of 732.6 mm occurred over the four day period from April 1-4 [31]. The resulting flood destroyed pipelines and inundated sewage systems [32] and interrupted access to potable secure water sources and proper waste disposal, which in turn promoted the spread of enteric pathogens [23].

However, relatively few extreme weather event related outbreaks spread across an entire country to areas unaffected by the disaster. Our findings suggest that the initial outbreak in the city of Honiara in the province of Guadalcanal likely precipitated outbreaks in the isolated island provinces not affected by the flood. Rainfall does not appear to have contributed to the outbreaks in unaffected provinces (Figure 3). Introduction of pathogens from other another country also is unlikely since the Pacific Syndromic Surveillance System did not detect such outbreaks in nearby regions during the period. Instead, we speculate that movement or migration of people from Guadacanal may have transmitted agents associated with the outbreak in Honiara to other provinces. Outbreaks in these provinces appeared soon after the peak of the outbreak (May 4) in Guadalcanal. The provinces without flooding first to experience outbreaks (Malaita and Western) contain the three largest cities outside of

Guadalcanal and had regular boat traffic with Honiara. The sentinel site in the province furthest removed in terms of distance (Temotu) did not experience an outbreak.

The highest disease incidence and mortality associated with the epidemic occurred in children with age <5 years. In endemic settings, the population <5 years old is generally at higher risk for diarrhea and death [33], but during outbreaks, children are not necessarily at higher risk, depending on the pathogen. The 27 diarrhea related deaths exceeded those caused directly by the flood (22) and were predominantly among children <5 years of age. This difference was likely dependent on several factors including the severity of the flood, pathogens involved, level of emergency response and the population's ability to adapt. Generally, deaths from outbreaks after extreme weather events have large variations in magnitude (Range: 1 – 71,687) [17]. However, it is uncertain how often the number of deaths from the outbreak has exceeded the number of deaths from the immediate disaster.

Our findings suggest that rotavirus was the primary agent for the epidemic in Honiara as well as the cause of widespread nationwide dissemination of the outbreak. Rotavirus causes a non-bloody diarrhea and predominantly affects the age group of children which had highest observed disease incidence during the epidemic. In Honiara, risk for non-bloody diarrhea increased much more for children than adults after the flood, but risk for bloody diarrhea had similar increases overall. From hospital surveillance, both flood and non-flood affected provinces appear to have more similar rates of non-bloody (9.9 vs. 3.7 cases per 10,000 persons per week) than bloody diarrhea (2.0 vs. 0.2 cases per 10,000 persons per week). These findings may suggest that multiple pathogens caused increased diarrhea in Honiara's post-flood environment while a pathogen that primarily causes watery diarrhea in children (e.g. rotavirus) spread across the entire country. Additionally, this outbreak was explosive, spreading nationwide in 15 weeks. Though several diarrheal pathogens (such as cholera and norovirus)[19], [34], [35] have been observed to have rapid outbreaks through person-to-person transmission, rotavirus is the only one known to afflict mostly children. Lastly, similar nationwide diarrhea outbreaks which were

caused by rotavirus have been observed in the Pacific, in Truk District (1980) and in Kiribati (2008) [36], [37].

The finding of G9P8 in all samples genotyped substantiates our claim that this was a national epidemic caused by the same strain of rotavirus. Though G9P8 is not considered a rare genotype, samples from distinct provinces all collected during the peak of the outbreak all have the same genotype lends additional credence to our interpretation. This genotype has also been associated with nationwide outbreaks in the Pacific as well [38].

Our epidemiological investigation was subject to limitations. The case finding in Honiara included more health facilities and longer baseline periods than other parts of the country. Thus, we used the data collected from Honiara only to describe the local outbreak in relation to the flood, while hospital surveillance data were analyzed to compare relative timing and magnitude of outbreaks between provinces. Some clinics and hospitals were missing data for particular weeks. Notably, the flood destroyed nearly all records of and temporarily closed a pediatric clinic (Pikinini Clinic) in Honiara, potentially introducing an age bias into our sample (Table 1). However, we believe the impact of missing records to be small given the large sample collected. Case characteristics collected were broad in terms of time scale (weekly), age (<5 vs ≥5 years), and clinical features (bloody vs. non-bloody). The Solomon Islands were estimated to have had 21 diarrhea-attributed deaths over the year of 2008 in children <5 years old, indicating that that 27 deaths over a 15-week period was out of the ordinary [39]. Additionally, determining if death were diarrhea-related was challenging often due to the presence co-existing conditions (e.g. pneumonia, malnutrition). Lastly, the level of detail on individual deaths reported through the event-based system varied greatly based on who and where the reports came from.

The laboratory data also have limits to their interpretation for reasons besides small sample size and lack of testing for other pathogens. Before the flood, testing for diarrheal pathogens at the NRH

Laboratory was sometimes inconsistent. After the flood, the MHMS and WHO provided support to improve laboratory testing capacity and protocols, potentially leading to more frequent and accurate testing. However, the increase in percentage positive between periods is highly significant, making these biases likely negligible. Unfortunately, no rotavirus sample from Guadalcanal was able to be genotyped to determine if the local outbreak could have been caused by G9P8. Lastly, we cannot definitively conclude whether all genotyped samples were from the same outbreak strain without further genetic analysis and a larger sample size.

Our study highlights a potential health consequence of climate change in the Pacific that is not well understood [40]. Through rising sea levels, changing temperatures, and increased severity of EWE, the population health of small pacific islands is particularly vulnerable [1]–[8]. Outbreaks sparked by meteorological events carry significant burden [17], yet are poorly described phenomena in the Pacific. If climate change increases severity of EWE in the Pacific, the patterns of infectious disease transmission in the Pacific are likely to change, and outbreaks may become more frequent [11], [41].

We recommend that outbreaks are taken into consideration in emergency preparedness for natural disasters. Development of national protocols for post-disaster risk assessments and implementation of early warning systems are effective at tracking and mitigating morbidity [42]. Strengthening and expanding existing syndromic and laboratory surveillance can ease transition to emergency response systems during a disaster. Standardized and timely clinical management should also be given high priority during an outbreak response to limit severe disease and death. Lastly, outbreaks caused by EWE carry a significant burden, require better understanding, and should be given large consideration when describing the health impacts of climate change.

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Table 1: Outpatient clinic and hospital surveillance for diarrhea in the city of Honiara before and after the flood.

Age Group	Population	Cases (Mean Weekly Incidence ^a)		Rate Ratio
		Pre-Flood Period ^b	Post-Flood Period ^b	(95% Confidence Interval) ^c
<5 years	7570	2738 (83.2) [◊]	2539 (211.4) [◊]	3.46 (2.63 – 4.61)
≥ 5 years	57039	2795 (12.0) [◊]	1330 (15.5) [◊]	1.77 (1.42 – 2.23)
ND		187	362	
Total	64609	5720 (22.6)	4231 (43.7)	2.02 (1.57 – 2.63)

^aCases of diarrhea per 10,000 persons per week.

^bJune 17, 2013 – March 30, 2014 (41 weeks)

^cMarch 31 – July 13, 2014 (15 weeks)

^eThe rate risk was calculated by comparing rates from the post and pre-flood periods.

[◊]Data was not collected for all fifteen weeks. Mean weekly incidence was calculated by dividing by the number of weeks observed.

Cases were collected from outpatient registers of the National Referral Hospital (NRH) and 9 local clinics.

Table 2: National hospital-based surveillance for diarrhea and mean weekly incidence according to province during the epidemic period of March 31 to July 13, 2014

Region	Population	Cases (Mean Weekly Incidence ^a)		
		<5 years	≥5 years	Total
<i>Flood-Affected</i>				
Guadalcanal	158222	1908 (84.0) [◊]	745 (4.0) [◊]	2826 (11.9)
<i>Not Flood-Affected</i>				
Malaita	137596	353 (16.8) [◊]	141 (1.2) [◊]	739 (3.6)
Western	76649	*	*	435 (3.8)
Makira	40419	123 (16.3) [◊]	71 (1.9) [◊]	194 (4.4) [◊]
Isabel	26158	155 (29.5) [◊]	96 (3.1) [◊]	251 (6.9) [◊]
Choiseul	26372	*	*	49 (1.2)
Total	307194	*	*	1668 (4.0)

^a Cases of diarrhea per 10,000 persons per week.

*No data available.

[◊]Data was not collected for all fifteen weeks. Mean weekly incidence was calculated by dividing by the number of weeks observed.

All cases were collected from hospital outpatient departments.

Table 3: Identification of Agent for Diarrhea among Cases before and after the Flood, June 17, 2013 – July 13, 2014

Pathogen	% Positive (# Positive/ # Tested)		p ^c
	Pre-Flood ^a	Post-Flood ^b	
Shigella	1.4% (1/70)	5.0% (3/60)	0.335
Salmonella enterica	0.0% (0/70)	0.0% (0/60)	1.000
Cholera	0.0% (0/34)	0.0% (0/32)	1.000
Rotavirus	0.0% (0/34)	42.6% (26/61) ^c	<0.001

^a The pre- and post-flood periods were 41 (June 17, 2013 – March 30, 2014) and 15 (March 31 – July 13, 2014) weeks in duration, respectively.

^b P-value according to the Fisher Exact χ^2 test

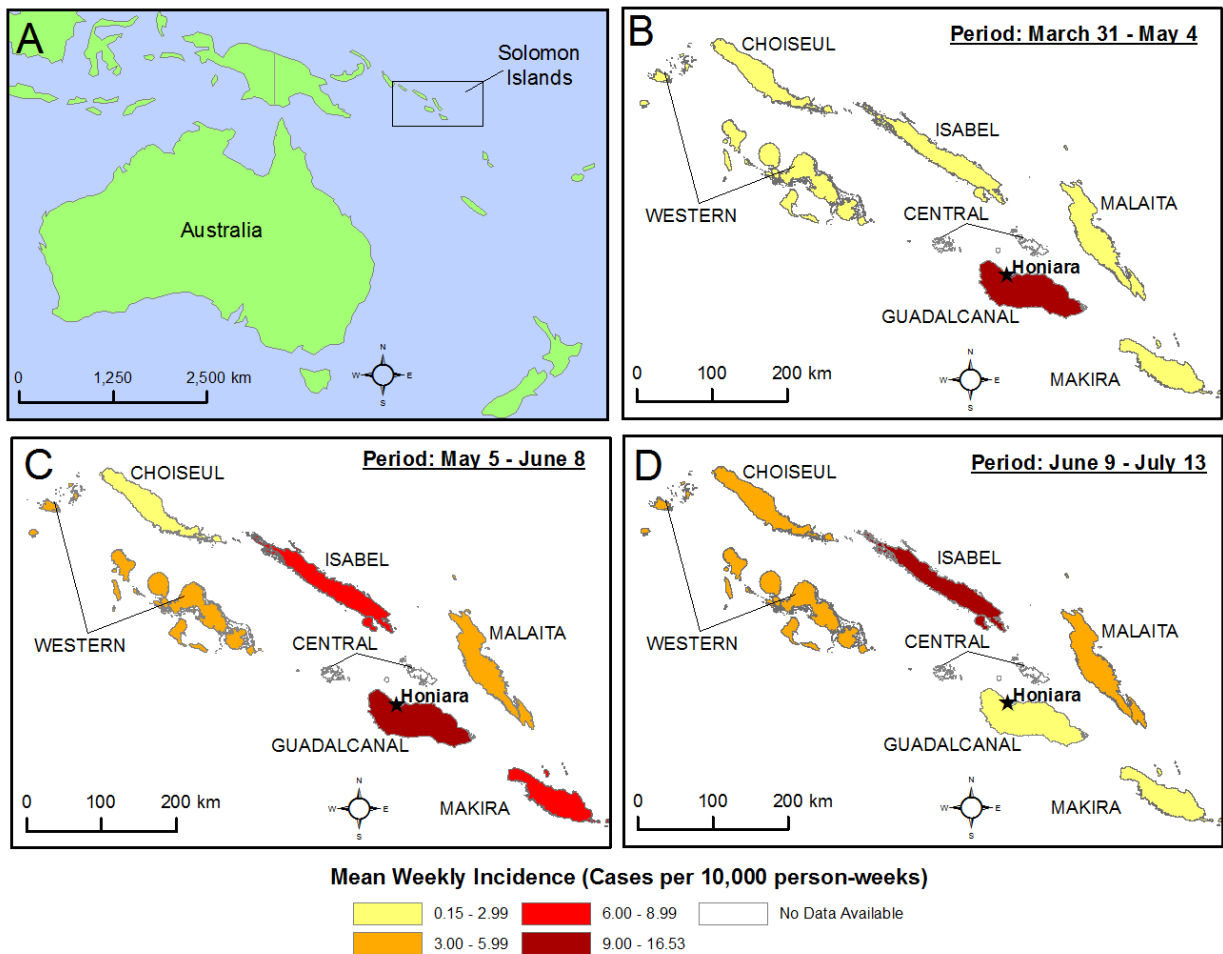


Figure 1: Location of Solomon Islands and geographical distribution of mean weekly incidence during the nationwide epidemic of diarrhea from March 31 to July 13, 2014 A map of the Western Pacific is shown (Figure 1A). Mean weekly incidence rate are reported for each province over five week periods from B) March 31 – May 4, C) May 5 – June 8, and D) June 9- July 13. Cumulative cases presenting to hospital outpatient departments are divided by provincial population and five weeks. Data from Honiara and Guadalcanal Province were combined to calculate the incidence rate for Guadalcanal. The provinces of Temotu and Rennell & Bellona are not shown.

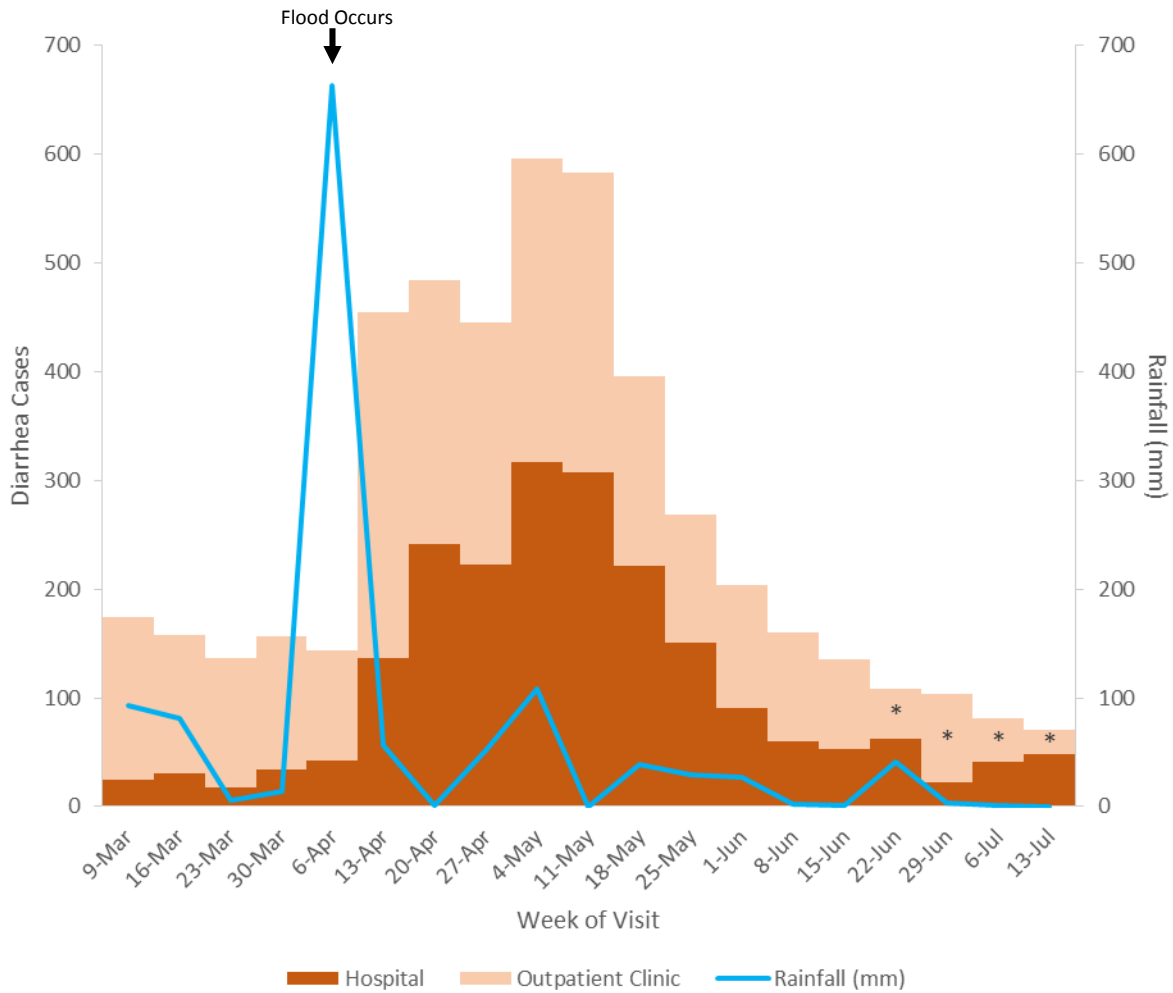


Figure 2: Weekly diarrheal cases ascertained by outpatient clinic and hospital-based surveillance and weekly rainfall after massive flooding in the city of Honiara, March 3 – July 13, 2014 Cumulative weekly mm of rainfall and counts of cases found in clinic and hospital outpatient registers. Last day of week is shown on x-axis. The flood occurred from April 3-5.

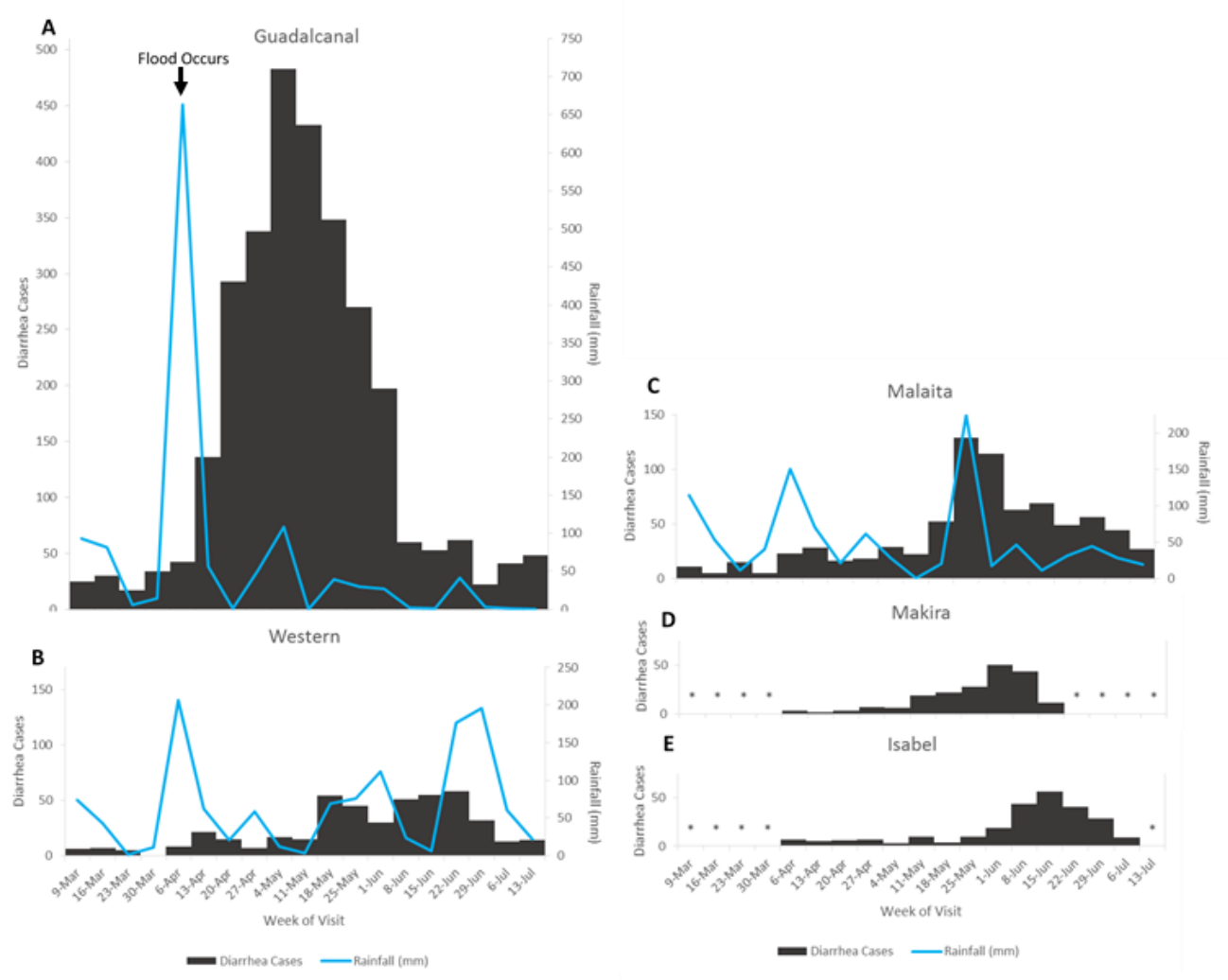


Figure 3: Weekly cases ascertained by hospital-based surveillance and weekly rainfall during the nationwide epidemic of diarrhea, according to province, from March 3 to July 13, 2014 Cumulative weekly mm of rainfall and counts of cases found in hospital outpatient registers. Last day of week is shown on x-axis. The flood occurred from April 3-5 in Guadalcanal; case data from Honiara and Guadalcanal Province were combined to form Figure 3A. Rainfall data from one site from each province was available except for Makira and Isabel Provinces (Figure 2D & 2E). Choiseul Province also had an outbreak, but had insufficient cases to show effectively in this graphic.
 *No data available