

Chikungunya and Dengue Virus Infections among United States Community Service Volunteers Returning from the Dominican Republic, 2014

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Abstract. Chikungunya spread throughout the Dominican Republic (DR) after the first identified laboratory-confirmed cases were reported in April 2014. In June 2014, a U.S.-based service organization operating in the DR reported chikungunya-like illnesses among several staff. We assessed the incidence of chikungunya virus (CHIKV) and dengue virus (DENV) infection and illnesses and evaluated adherence to mosquito avoidance measures among volunteers/staff deployed in the DR who returned to the United States during July–August 2014. Investigation participants completed a questionnaire that collected information on demographics, medical history, self-reported illnesses, and mosquito exposures and avoidance behaviors and provided serum for CHIKV and DENV diagnostic testing by reverse transcription polymerase chain reaction and IgM enzyme-linked immunosorbent assay. Of 102 participants, 42 (41%) had evidence of recent CHIKV infection and two (2%) had evidence of recent DENV infection. Of the 41 participants with evidence of recent CHIKV infection only, 39 (95%) reported fever, 37 (90%) reported rash, and 37 (90%) reported joint pain during their assignment. All attended the organization's health trainings, and 89 (87%) sought a pretravel health consultation. Most (~95%) used insect repellent; however, only 30% applied it multiple times daily and < 5% stayed in housing with window/door screens. In sum, CHIKV infections were common among these volunteers during the 2014 chikungunya epidemic in the DR. Despite high levels of preparation, reported adherence to mosquito avoidance measures were inconsistent. Clinicians should discuss chikungunya with travelers visiting areas with ongoing CHIKV outbreaks and should consider chikungunya when diagnosing febrile illnesses in travelers returning from affected areas.

INTRODUCTION

Chikungunya virus (CHIKV) is an alphavirus most frequently transmitted to humans via an infected *Aedes* species mosquito.^{1,2} Infection with CHIKV frequently results in an acute febrile illness commonly associated with arthralgia. CHIKV disease is rarely fatal, but arthralgia symptoms can be severe, disabling, and recurrent.¹ CHIKV was first identified in Tanzania in 1953 during an outbreak of febrile illness accompanied by arthralgia, referred to locally as “chikungunya.” CHIKV has caused subsequent epidemics in Africa and Asia.^{1,2} Local transmission of CHIKV was first reported in the Western Hemisphere on the Caribbean island of Saint Martin in December 2013, and soon spread throughout the Americas.³ By August 29, 2014, 33 countries and territories in the Americas had reported 659,367 suspected cases.⁴

After the first laboratory-confirmed CHIKV cases were reported by the Dominican Republic (DR) in April 2014,⁵ the virus spread rapidly throughout the country, resulting in > 370,000 suspected cases within 4 months of its emergence.⁶ In addition to CHIKV, the four dengue viruses (DENV 1–4) are endemic in the DR and also result in acute febrile illness in infected individuals.^{7–9} DENVs are flaviviruses that are transmitted by the same mosquito vectors as CHIKV. Historically, dengue has been the leading cause of acute febrile illness among travelers returning from the Caribbean^{7,8}; therefore, risk for infection with both CHIKV and DENV now exists in the DR.

In June 2014, a U.S. service organization (organization A) notified the Centers for Disease Control and Prevention (CDC) and the Texas Department of State Health Services about five supervisory staff members working in the DR with suspected CHIKV disease. Organization A sent high school- and college-aged volunteers from multiple U.S. states for cultural immersion and service projects in countries throughout the Americas, including the DR. For the DR program in 2014, all participants worked in schools; several worked on community centers and public parks; and several were involved in various outdoor activities involving improving the structure of a school, murals, trash and recycling systems, and planting trees. To prepare them for the experience, all volunteers were encouraged to see a health-care provider and attend at least one predeparture training session and one in-country training session to cover topics ranging from health issues in the DR to cultural sensitivity. During the summer months, volunteers typically spend 4–8 weeks and supervisory staff spend 11–13 weeks in the DR.

To evaluate the risk of chikungunya and dengue in organization A volunteers and staff, an investigation was initiated. We sought to determine the incidence of CHIKV and DENV infections among organization A volunteers and staff serving in the DR, to describe self-reported illnesses among volunteers and staff, and to evaluate knowledge of, and adherence to, recommended mosquito bite avoidance measures.

MATERIALS AND METHODS

Participants. The investigative group offered participation to organization A volunteers/staff working on 4-, 8-, and 13-week service projects in the DR. All participants were enrolled after departing the DR and upon arrival to the United States at the Miami International Airport. The majority returned in three

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groups during the summer 2014: the first group on July 9, the second on August 6, and the third on August 14. Individuals with return dates outside of the investigation time frame were excluded from the investigation for logistical reasons.

Participation was defined as completing a self-administered written questionnaire and providing a serum specimen. We obtained written consent from volunteers/staff aged ≥ 18 years and written assent from parents and written assent from volunteers < 18 years. This investigation was considered a public health response and was determined to not meet the definition of research under 45 CFR 46.102(d); therefore, institutional review board review was not required.

Epidemiologic investigation. All participants completed a questionnaire designed to collect information on self-reported episodes of febrile illnesses; associated symptoms, including rash, joint pain and location, neurological symptoms, and gastrointestinal symptoms; and health-seeking behaviors. We also collected information on demographics, pretravel knowledge of chikungunya and dengue, travel preparations, mosquito bite avoidance recommendations received from a health-care provider and from training sessions arranged by organization A, and reported experiences while in the DR, including mosquito bites and use of mosquito bite avoidance measures.

Laboratory methods. A serum specimen was obtained from each participant to detect CHIKV and DENV infection. Diagnostic testing for CHIKV included detection of CHIKV RNA by reverse transcription polymerase chain reaction (RT-PCR)¹⁰ and the CDC enzyme-linked immunosorbent assay (ELISA) for anti-CHIKV IgM antibodies.¹¹ All specimens with equivocal or positive results by anti-CHIKV IgM ELISA were further tested by a CHIKV plaque reduction neutralization test (PRNT). Confirmed laboratory evidence of recent CHIKV infection were defined by 1) detection of CHIKV RNA by RT-PCR or 2) positive or equivocal detection of anti-CHIKV IgM antibody by ELISA with a $\geq 90\%$ reduction in CHIKV plaques by confirmatory CHIKV neutralizing antibody. Probable laboratory evidence of recent CHIKV infection was defined by positive detection of anti-CHIKV IgM antibody by ELISA and unavailable PRNT results. For the purposes of our analysis, we considered confirmed and probable laboratory evidence of recent CHIKV infection as having evidence of recent CHIKV infection. Those not meeting the criteria for confirmed or probable laboratory evidence of recent CHIKV infection were considered to have no evidence of recent CHIKV infection.

Diagnostic testing for DENV included the detection of DENV RNA by DENV-type specific RT-PCR¹² and anti-DENV IgM antibody capture ELISA (InBios International, Inc., Seattle WA).¹³ Laboratory evidence of recent DENV infection was defined by detection of DENV RNA by RT-PCR or anti-DENV-IgM antibody by ELISA.

Analysis. Data were analyzed using SAS version 9.3 (SAS Institute, Inc., Cary, NC). The χ^2 or Fisher's exact tests were used to compare proportions. The Wilcoxon rank sum test was used to evaluate differences between the distributions of continuous variables. All comparisons were two-sided, and $P < 0.05$ was considered statistically significant.

RESULTS

Participants. Of the 147 organization A volunteers/staff in the DR during the summer of 2014, 127 (86%) returned dur-

ing the investigation period and were offered participation in the investigation, whereas 20 individuals including volunteers and all staff were excluded because their return dates were outside the investigation period. Of the 127 eligible volunteers, 102 (80%) agreed to participate, completed a questionnaire, and provided a serum specimen.

Of the 102 participants, eight (8%) returned on July 9, 50 (49%) returned on August 6, and 44 (43%) returned on August 14. Of these participants, 77 (75%) were female, and the median age was 17 years (range: 15–21 years). Ninety-one (89%) reported previous travel outside the continental United States at any stage during their lifetimes. Of those participants who responded to questions regarding vaccination, 32 (31%) of 99 self-reported previous receipt of yellow fever vaccine and one (1%) of 100 self-reported previous receipt of Japanese encephalitis vaccine.

Laboratory analysis. Of 102 participants, 43 (42%) had evidence of recent infection with CHIKV or DENV. Of these, 41 (95%) had evidence of recent CHIKV infection only, one (2%) had evidence of recent DENV infection only, and one (2%) had evidence of recent CHIKV and DENV infection. Of the 42 participants with evidence of recent CHIKV infection, 41 had confirmed evidence of recent CHIKV infection and one had probable laboratory evidence of recent CHIKV infection. Of those with confirmed laboratory evidence of recent CHIKV infection, 34 had positive detection of anti-CHIKV IgM antibody by ELISA with a $\geq 90\%$ reduction in CHIKV plaques by confirmatory CHIKV neutralizing antibody, five had detection of CHIKV RNA by RT-PCR (three of these also had positive detection of anti-CHIKV IgM antibody by ELISA with a $\geq 90\%$ reduction in CHIKV plaques by confirmatory CHIKV neutralizing antibody), and one had equivocal detection of anti-CHIKV IgM antibody by ELISA with a $\geq 90\%$ reduction in CHIKV plaques by confirmatory CHIKV neutralizing antibody. Of the two participants with evidence of recent DENV infection, one (2%) was positive for DENV-2 by RT-PCR and one (2%) was positive by IgM ELISA. The participant with recent evidence of DENV infection with positive detection of anti-DENV IgM by ELISA also had positive detection of anti-CHIKV IgM antibody by ELISA with a $\geq 90\%$ reduction in CHIKV plaques by confirmatory CHIKV neutralizing antibody.

Reported illness and behaviors in the DR. In total, 59 (58%) of 102 participants reported experiencing a febrile illness while in the DR. Of those 59 who reported experiencing a febrile illness, 41 (69%) had evidence of recent CHIKV or DENV infection and 18 (31%) had no evidence of CHIKV or DENV infection. Individuals with evidence of recent CHIKV infection only more frequently reported fever, chills, headache, nausea/vomiting, abdominal pain, muscle pain, calf pain, and joint pain than those without evidence of recent CHIKV or DENV infection (Table 1). Of note, both the participant with evidence of recent DENV infection and the participant with evidence of recent CHIKV and DENV infection reported experiencing febrile illnesses while in the DR.

Among the 59 participants who reported febrile illnesses in the DR, notifying organization A on-call staff was the most common health-seeking behavior; those with evidence of recent CHIKV infection were more likely to notify on-call staff compared with those without CHIKV or DENV infection (23/39 [59%] versus 4/18 [22%], $P = 0.01$). There were no significant differences in the number of participants with

TABLE 1

Reported symptoms among community service volunteers in the DR with and without evidence of recent CHIKV infection ($N = 100$),* July–August 2014

Reported symptoms	CHIKV infection only ($N = 41$)	No CHIKV or DENV infection ($N = 59$)	<i>P</i> value
	<i>n</i> (%)	<i>n</i> (%)	
Fever	39 (95)	18 (31)	< 0.01
Rash	37 (90)	2 (3)	< 0.01
Joint pain	37 (90)	7 (12)	< 0.01
Shoulder	14 (38)†	3 (43)†	1.00
Elbow	12 (32)†	4 (57)†	0.24
Wrist	25 (68)†	6 (86)†	0.65
Thumb	22 (59)†	3 (43)†	0.44
Fingers	26 (70)†	3 (43)†	0.21
Knee	21 (57)†	6 (86)†	0.22
Ankle	28 (76)†	5 (71)†	1.00
Heel	12 (32)†	1 (14)†	0.65
Foot	12 (32)†	1 (14)†	0.65
Toes	17 (46)†	2 (29)†	0.68
Headache	29 (71)	13 (22)	< 0.01
Muscle pain	28 (68)	9 (15)	< 0.01
Chills	24 (59)	7 (12)	< 0.01
Nausea/vomiting	14 (34)	9 (15)	0.03
Abdominal pain	11 (27)	5 (8)	0.01
Diarrhea	10 (24)	10 (19)	0.62
Calf pain	10 (24)	4 (7)	0.01
Rhinorrhea	8 (17)	6 (10)	0.19
Sore throat	8 (17)	6 (10)	0.19
Eye pain	7 (17)	3 (5)	0.09
Cough	6 (15)	2 (3)	0.06
Red/swollen joints	5 (13)	2 (3)	0.12
Bleeding	2 (5)	1 (2)	0.57
Red Eyes	0 (0)	0 (0)	1.00

CHIKV = chikungunya virus; DENV = dengue virus; DR = Dominican Republic.

*Excludes two participants with evidence of recent DENV infection. Both of these participants also reported experiencing febrile illnesses while in the DR.

†Denominator based on those reporting joint pain among returning travelers.

and without CHIKV or DENV infection reporting febrile illnesses who visited a physician (4/39 [10%] versus 4/18 [22%], $P = 0.25$) or required hospitalization (0/39 [0%] versus 1/18 [6%], $P = 0.32$). The participant with evidence of recent DENV infection alone visited a physician; neither participant with evidence of recent DENV infection required hospitalization.

Reports of mosquito bites were similarly common among individuals with evidence of recent CHIKV or DENV infection compared with those without CHIKV or DENV infection (98% versus 95%). Few participants reported staying in housing with window screens, door screens, or air conditioning, and there were no significant differences in the characteristics of the housing between those with and those without evidence of recent CHIKV or DENV infection (Table 2). There were no significant differences between individuals with or without CHIKV or DENV infections in the reported frequency of use or type of insect repellent, reported use of bed nets, or wearing of protective clothing or insecticide-treated clothing. A few (30%) of the infected and noninfected participants reported using insect repellent multiple times a day.

Reported knowledge of dengue and chikungunya. Among the 102 participants, 63 (62%) and 19 (19%) reported any pretravel knowledge of dengue and chikungunya, respectively (Table 3). Of 102 participants, 89 (87%) visited a health-care provider for a pretravel health consultation before arrival in the DR (Table 4). Primary care providers were the most common provider type encountered (57%) followed by travel medicine specialists (27%). Of the 89 who received a pretravel health consultation, 72 (81%) recalled receiving

TABLE 2

Reported mosquito bites, housing characteristics, and mosquito bite avoidance measures used by participants with and without evidence of recent CHIKV and/or DENV infection ($N = 102$), July–August 2014

	CHIKV and/or DENV infection ($N = 43$)	No CHIKV or DENV infection ($N = 59$)	<i>P</i> value
	<i>n</i> (%)	<i>n</i> (%)	
Mosquito bites			
Reported mosquito bites	42 (98)	56 (95)	0.64
Morning	6/42 (14)	1/56 (2)	0.04
Afternoon	3/42 (7)	6/56 (11)	0.73
Early evening	24/42 (57)	29/56 (52)	0.68
Late evening	9/42 (21)	20/56 (36)	0.18
Characteristics of domicile			
Screens on doors	0 (0)	2 (3)	0.51
Screens on windows	0 (0)	5 (8)	0.07
Air conditioning	1 (2)	0 (0)	0.42
Mosquito bite avoidance			
Used insect repellent	40 (93)	56 (95)	0.69
Frequency of application			
Occasionally	15/40 (38)	19/56 (34)	0.72
Once daily	13/40 (33)	20/56 (36)	0.74
Multiple times daily	12/40 (30)	17/56 (30)	0.97
Type of insect repellent used*			
DEET	38/40 (95)	51/56 (91)	0.70
Picaridin	0/40 (0)	0/56 (0)	1.00
PMD	0/40 (0)	4/56 (7)	0.14
IR3535	0/40 (0)	0/56 (0)	1.00
Other†	0/40 (0)	1/56 (2)	1.00
Unknown active ingredient	2/40 (5)	5/56 (9)	0.70
Used bed nets‡	41 (95)	57 (98)	0.57
Wore protective clothing‡§	24 (56)	37 (64)	0.42
Wore insecticide treated clothing	16 (37)	22 (37)	0.99
Used insecticide aerosol spray (room spray)‡	2 (5)	5 (9)	0.70

CHIKV = chikungunya virus; DENV = dengue virus.

*Not mutually exclusive.

†Isopropyl alcohol solution.

‡Missing response from one participant.

§Protective clothing includes long sleeves, long pants, hats, and close-toed shoes.

information about health risks in the DR, 46 (52%) recalled receiving dengue-specific information, 20 (22%) receiving chikungunya-specific information, and 45 (51%) receiving information about mosquito bite avoidance during the pretravel health consultation. All 102 participants attended organization A's predeparture and in-country training sessions.

TABLE 3

Self-reported knowledge of dengue and chikungunya before travel ($N = 102$), July–August 2014

	Dengue	Chikungunya
	<i>n</i> (%)	<i>n</i> (%)
Self-reported pre-travel knowledge		
Any	63 (62)	19 (19)
None	39 (38)	83 (81)
Knowledge	($N = 63$)*	($N = 19$)*
Transmitted by mosquitoes	54/63 (86)	15/19 (79)
Possible risk of exposure in Dominican Republic	49/61 (78)	17/18 (94)
No available vaccine	29/63 (46)	12/18 (67)
No specific treatment of infection	23/63 (37)	13/19 (72)

*Denominator is based on number of individuals reporting any pre-travel knowledge.

TABLE 4

Reported health information received during pre-travel health consultation with health-care provider and organization A training sessions, July–August 2014

	Pretravel health consultation (N = 89)	Organization A predeparture training (N = 102)	Organization A in-country training (N = 102)
	n (%)	n (%)	n (%)
Reported receiving information about			
Health risks in the Dominican Republic	72 (81)	96 (94)	95 (93)
Dengue virus	46 (52)	78 (76)*	73 (72)
Chikungunya virus	20 (22)	48 (47)	85 (83)
Mosquito bite avoidance measures	45 (51)	100 (98)	98 (96)

*Missing response from one participant.

Although similar numbers of participants reported receiving dengue information in the predeparture training compared with the in-country training (76% versus 72%, $P = 0.36$), information about chikungunya was less commonly reported in the predeparture training compared with the in-country training (47% versus 83%, $P < 0.01$).

DISCUSSION

In this investigation, more than 40% of participants had evidence of recent CHIKV infection, and reported febrile illnesses were common among all participants. In all, 58% of participants reported at least one febrile illness while in the DR. Most participants sought a pretravel health consultation with a health-care provider, and all attended predeparture and in-country training sessions arranged by organization A. However, information on CHIKV illness was reportedly received by less than half of participants during the pretravel health consultation. Adherence to recommended mosquito bite avoidance measures was inconsistent.

The cohort of volunteers in this investigation were living and working in communities in the DR during an ongoing chikungunya epidemic. During recent chikungunya epidemics, attack rates ranging from 38% to 63% have been reported,¹⁴ which is similar to that observed in our cohort. Most individuals with recent evidence of CHIKV infection in our investigation reported experiencing a febrile illness during their time in the DR. The clinical symptoms reported among those with recent evidence of CHIKV infection included rash, joint pain, headaches, and myalgias—all consistent with illness previously reported in the literature.^{15,16} Few individuals in our cohort required medical care in the DR beyond alerting organization A on-call staff. According to organization A's protocol, on-call health-care providers in the United States monitor the health status of ill volunteers and staff remotely and advise in-country supervisory staff on treatment recommendations, as well as whether participants should have additional medical attention while in-country or medically evacuated to the United States.

Although ~40% of our cohort had evidence of recent CHIKV infection, and the majority of those individuals reported experiencing a febrile illness while in the DR, causes of febrile illness among the entire cohort likely varied. Two individuals had evidence of a recent DENV infection; both reported febrile illnesses. In addition, of those without evidence of recent CHIKV or DENV infection, 31% reported

febrile illness episodes and 10–20% reported gastrointestinal symptoms. One participant without evidence of recent CHIKV or DENV infection was hospitalized for a gastrointestinal illness. These findings are reminders that travelers remain at risk for other diseases in outbreak settings, such as ongoing CHIKV, as was occurring in the DR. Although CHIKV was causing widespread morbidity in the DR in the summer of 2014, other illnesses, such as dengue, malaria, and leptospirosis, present similarly and can cause severe morbidity and death if not appropriately diagnosed and managed.^{15,17,18} Of note, organization A reported that all travelers to the DR were required to take malaria chemoprophylaxis. Given the similar clinical manifestations of many travel-associated febrile illnesses, especially early in the course of infection, health-care providers evaluating febrile illnesses in returning travelers should consider alternative diagnoses to chikungunya, even in the setting of widespread CHIKV circulation.

Our cohort of travelers was well prepared for the trip to the DR. Most reported having received a pretravel health consultation, and all participants attended at least two educational sessions coordinated by organization A, where they reported receiving information about health risks in the DR, including chikungunya, dengue, and mosquito bite avoidance measures. Despite the high levels of preparation, reported adherence to mosquito avoidance measures while in the DR were inconsistent. Specifically, only one-third of participants reported applying insect repellent more than once a day and few reported wearing long-sleeved shirts and trousers or insecticide-impregnated clothing, despite reportedly having received this information. These findings reflect the real challenges of preventing mosquito-borne illnesses, such as dengue and chikungunya, among travelers to the tropics.

The discrepancy between preparation and practice is not unique to our population,^{8,17,19} and adherence with mosquito avoidance measures may decrease the longer the traveler remains in-country. In contrast, the risk of CHIKV infection for travelers in areas with active virus circulation has been modeled as ranging from 0.3% for travelers staying 1 week up to 1.2% in travelers staying 4 weeks. As was shown in our cohort, however, the risk of infection in longer-term travelers may be substantially higher in the setting of an ongoing epidemic.²⁰ Further, living with a host family in the DR provided a crucial element of cultural exchange and language immersion for participants in organization A's activities. However, the majority of participants lived in housing lacking window/door screens and air conditioning. Given this increased risk based on trip length and housing situation, training materials for these types of programs should emphasize the added importance of adhering to mosquito avoidance measures, including multiple applications of insect repellent daily, wearing long-sleeved shirts and pants, and using insecticide-treated clothing since other prevention options may be unavailable in these settings. Travelers should be encouraged to be especially vigilant about such mosquito bite prevention measures to minimize their risk of chikungunya, dengue, or other vector-borne infections, particularly during ongoing epidemics.

These findings are subject to several limitations. First, the cross-sectional design of the investigation may have influenced recall of pretravel knowledge of CHIKV and DENV and activities performed over the duration of the entire trip. Since the investigation relied on participant recall, it is possible that some of the reported activities, such as frequency of insect

repellent application over the duration of the trip, may not have been reported accurately. Second, we were unable to assess all volunteers/staff, and do not know the proportion of infections in non-participants. Finally, this cohort of travelers was composed of high school- and college-aged volunteers with extensive pretravel preparation who were living in communities in the DR for an extended period. Thus, our results may not be generalizable to all travelers.

This investigation highlights the risk of CHIKV infection among travelers to the DR during the 2014 epidemic and supports the need to educate travelers visiting areas with ongoing CHIKV transmission. Organizations sending travelers to areas with ongoing CHIKV transmission should emphasize the potential risk of infection to their participants. Travelers to areas with ongoing CHIKV transmission should seek pretravel health consultation and adhere to recommended mosquito bite avoidance measures for the entire trip. Health-care providers should discuss chikungunya with travelers visiting areas with ongoing CHIKV transmission and should consider chikungunya when evaluating febrile travelers returning from areas with ongoing CHIKV transmission. However, other serious and potentially life-threatening diagnoses requiring rapid diagnosis and appropriate management must not be discounted. Travelers returning from areas with ongoing CHIKV transmission should see a health-care provider and mention their travel itinerary if they develop fever within 2 weeks of their return. Finally, health-care providers diagnosing returning travelers with laboratory-confirmed chikungunya should report cases to local or state health departments and advise infected travelers to continue mosquito bite avoidance strategies for 1 week to reduce the risk of secondary local CHIKV transmission in the United States.

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