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ORIGINAL PAPER

Knowledge of the Sexual Transmission of Zika Virus and Preventive Practices Against Zika Virus Among U.S. Travelers

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Abstract
Individuals are often at increased risk of acquiring infectious disease while traveling. We sought to understand knowledge, attitudes and practices (KAP) regarding Zika virus among travelers from the United States. A total of 1043 study participants were recruited from a probability-based internet panel. Participants self-reported their knowledge of Zika infection and modes of transmission, and identified actions they had taken to prevent Zika infection and transmission including actions to prevent unintentional pregnancy since becoming aware of the Zika virus. Logistic regression was used to model the odds of taking preventive actions against Zika infection with adjustment for potential confounding factors. Knowledge of the sexual transmissibility of Zika virus significantly increased the odds of taking a preventive action against Zika infection, especially condom use or sexual abstention. Participants reported preferences for receiving information about Zika from private doctors and from the Internet. Discrepancies between where travelers seek information about Zika and how they would like to receive information regarding Zika were also found. These findings suggest that improving targeted messaging through online media may increase awareness of the sexual transmissibility of Zika as well as improve health communications with U.S. travelers. Travelers who are unaware of potential disease risks are less likely to adopt personal protective measures to protect themselves and reduce disease spread. Thus, future work should focus on improving communication and providing education to adopt effective prevention strategies while traveling.

Keywords Zika virus · Travelers · Sexually transmitted diseases · Knowledge, attitudes and perceptions

Introduction

From February to November of 2016 Zika virus was listed as a public health emergency of international concern by the World Health Organization [1] after a large outbreak in Brazil that rapidly spread throughout South America, Central America and the Caribbean [2, 3]. Imported, sexually transmitted, and isolated autochthonous cases were later seen in Europe, Japan, the United States and elsewhere [4–9]. While it no longer holds the same public health emergency classification, Zika remains a significant public health problem for many countries. Travelers have contributed substantially to the spread of Zika virus and have been the focus of early detection strategies [10–13]. In the United States, the U.S. Centers for Disease Control and Prevention (CDC) recommends that vulnerable populations (e.g., pregnant women or couples considering pregnancy) avoid > 90 countries that have an increased risk for Zika virus infection [14]. Accordingly, understanding the knowledge and behaviors of travelers who frequent Zika-endemic locations and their travel patterns is paramount.

Zika virus has three primary modes of transmission including vector transmission, via sexual contact, and from mother to child [15]. The most common method of transmission is through the bite of either an *Aedes aegypti* or *Aedes albopictus* mosquito infected with the Zika virus [15]. Initial symptoms of infection typically last between 2 and 7 days and can include fever, rash, headache, joint and muscle pain, and conjunctivitis [16, 17]. Most infections are asymptomatic, with a recent meta-analysis estimating that 38% of Zika infected individuals develop clinical symptoms

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[18]. Symptomatic cases often result from persistent infections that may further develop into more serious conditions [19]. Zika virus has also been linked to microcephaly and Guillian-Barré syndrome [20–22]. Though there are several vaccines against Zika infection in development, there is no vaccine currently available [23]. This means that communicating infection risk through health education and promotion are the best available methods for reducing Zika infections and the complications associated with these infections.

The current CDC recommendations to protect travelers from Zika infection include taking precautions against mosquitos (e.g., bed nets, insect repellent, treating clothes with permethrin prior to travel) and abstaining from sex or using condoms to prevent sexual transmission [17]. The CDC also recommends that pregnant women avoid traveling to areas with risk of Zika transmission and that precautions should be taken for the duration of pregnancy should a partner suspect they have been infected with Zika [17]. For men who may have been infected during travel, the CDC recommends using condoms for at least 6 months since studies have shown that the virus can persist in semen for more than 6 months [17, 24, 25].

The objective of this research was to understand knowledge, attitudes, and practices used to reduce the risk of Zika infection among travelers living in the United States. In particular, the present study aimed to identify knowledge of the different modes of Zika transmission, specific actions that travelers employed to prevent Zika infection and their preferred sources of information for future emerging diseases that might affect travel.

Materials and Methods

Data Collection

Study participants were recruited from a probability-based internet panel of 6 million Americans which is hosted by Qualtrics (Qualtrics, Provo, Utah, USA) [26] between June 7, 2017 and June 12, 2017. For the purposes of our study, members of the panel who were ≥ 18 years of age, residents of the United States, English speaking, and had traveled outside of the United States in the past 12 months were considered eligible for the study. Pregnant women were not oversampled for study inclusion as the aim of this study was to assess Zika knowledge among the general U.S. population that engages in international travel. We selected an online probability-based panel because it is cost-effective [27], permits the collection of a large and diverse sample in a short timeline [28], and allows for response patterns that are equivalent to in-person surveys [29]. In total, Qualtrics prompted 4567 survey responses. Of these, 309 (9%) did not consent to participate, 5 (0.2%) were < 18 years of age, 2 (0.06%) completed the entire survey in less than 30 s and were omitted, and 3101 (90.2%) reported no history of international travel. Of the remaining 1,150 responses, 107 (9.3%) were omitted due to partial survey completion (less than 50% of the survey was completed). Therefore, the final sample size for analysis was 1043 responses, which comprised 22.8% of all those invited and 90.6% of those who met the eligibility requirements for the study. All participants provided informed consent and voluntarily participated in the study. Participants were provided with a small incentive by Qualtrics for participating in the survey. The total recruitment costs, including a $5 (U.S. dollars) incentive, were $6.71 (U.S. dollars) per completed survey. The study protocol was approved by the Indiana University Institutional Review Board (Protocol # 1705563810).

Online Survey Instrument

Study participants who met the eligibility criteria were asked to self-report sociodemographic information such as their age (in years), sex (male/female), race/ethnicity (white or Caucasian, black or African-American, or other race/ethnicity), educational attainment (less than high school education, high school graduate, some college, or college graduate or higher), annual household income (< $15,000; $15,000–$24,999; $25,000–$34,999; $35,000–$49,999; $50,000–$74,999; $75,000–$99,999; ≥ $100,000), employment status (employed for wages, unemployed, or retired/out of the workforce), and health insurance status (yes/no). We also asked participants to report their sexual orientation (heterosexual; homosexual, lesbian, gay, queer, or transgender; bisexual; other). We classified sexual orientation as either heterosexual or lesbian, gay, bisexual, transgender or queer (LGBTQ) due to small counts. Sociodemographic questions were taken from the U.S. Census Bureau's American Community Survey [30]. Respondents were also asked to report the destination(s) (e.g., city and country) outside of the United States to which they had traveled in the past 12 months. These cities were then categorized as Zika-endemic or Zika non-endemic based upon the WHO's Zika virus classification table released in 2017 [31]. Participants were also asked to report the purpose of their trip (vacation/pleasure or business or other) to each foreign destination. Those who selected 'other' were asked to specify the reason for their travel. We classified visiting family (n = 12), attending a wedding (n = 6), mission or religious trip (n = 4), or fun (n = 3) as vacation/pleasure. Those who responded that the purpose of their travel was for a study abroad (n = 10) or medical reasons (n = 2) were classified as business. Additionally, participants were asked to report sources they would trust if they needed to ask questions about Zika and how they would like to obtain further information about Zika. Finally, participants were asked to respond to questions regarding

their knowledge of Zika infection and modes of transmission, as well as to identify actions they had taken to prevent Zika infection and transmission including actions to prevent unintentional pregnancy since learning of the Zika virus. These preventive actions included using mosquito repellant, wearing covering clothes, using window or door screens, using mosquito nets, fumigating the home, condom use, abstaining from sexual intercourse, or oral contraceptive use. Engaging in ≥ 1 of these preventive actions was considered as actively seeking to prevent Zika virus infection and served as the dependent variable for all analyses. All Zika-related survey questions were adapted from the WHO's Knowledge, Attitudes and Practice survey about Zika virus [32].

Statistical Analysis

We first tabulated the frequency of actions undertaken to prevent Zika infection, reasons for not taking actions to prevent infection, actions taken to prevent unintended pregnancy, sources from which participants would seek Zika-related news and information, and sources from which participants would prefer to receive Zika-related news and information. These frequencies were stratified by travel destination (Zika-endemic or Zika non-endemic locations) and also by knowledge of Zika transmission via sexual contact (yes or no). Differences in frequencies were determined using Pearson's Chi square and Fisher's exact test for variables with small (< 5) counts.

Next, we performed logistic regression to examine associations between several demographic and behavioral characteristics and taking preventive actions against Zika virus among travelers. We first examined bivariate relationships between each characteristic/behavior and taking preventive action. We then fit a multivariable logistic regression model with adjustment for all of the aforementioned survey measures. Finally, we exponentiated the model coefficients (i.e., exp[β]) in order to present odds ratios (OR) with their corresponding 95% confidence intervals. All statistical analyses used an a priori alpha level of 0.05 to determine statistical significance, and all analyses were performed in R version 3.4.0 [33].

Results

Table 1 presents the characteristics of the study sample by sex. The mean age was 36.1 years [standard deviation (SD) = 13.8; Min = 18; Max = 75], and 68.1% of respondents were female. 80% of participants had some college education or were college graduates. Nearly three quarters (74.1%) or respondents were employed and 66.4% had an annual household income > $50,000. Additionally, 72.3% self-identified as white, 91.7% as heterosexual, and 92.7% reported having health insurance. Females were more likely than males to have traveled to a Zika endemic location (47.5% vs. 36.9%), to travel for vacation/pleasure (88.6% vs. 76.2%) and to be unemployed (71.3% vs. 80.2%).

Our findings show that knowledge of the sexual transmissibility of Zika virus significantly increased the odds of taking any preventive action against Zika infection (Table 2). Specifically, the odds of taking preventive action against Zika were 1.55 (95% CI 1.12–5.77) times higher among those with knowledge of sexual transmissibility than were those without this knowledge after adjusting for potential confounding by endemic Zika destination, trip purpose, race, sexual orientation, health insurance, education, annual household income, employment status and age. Higher odds of preventive actions were also significantly associated with African-American race (OR 1.68; 95% CI 1.12–2.53) and having an annual household income < $15,000 (OR 2.53; 95% CI 1.27–5.05). Conversely, lower odds of preventive actions were associated with traveling to Zika endemic locations (OR 0.75; 95% CI 0.57–0.98) and traveling for vacation or pleasure (OR 0.51; 95% CI 0.40–0.85).

Frequencies of reported actions implemented to prevent Zika virus infection and transmission as well as reasons actions were not implemented are presented in Table 3 stratified by sexual transmission knowledge and Zika endemic travel destinations. Significant differences were found for the adoption of sexually-related prevention, including condom use (Zika endemic: $\chi^2 = 32.7$, 1df, $p \leq 0.0001$; Zika non-endemic: $\chi^2 = 23.9$, 1df, $p = < 0.0001$) and abstention from intercourse (Zika endemic: $\chi^2 = 22.5$, 1df, $p \leq 0.0001$; Zika non-endemic: $\chi^2 = 18.1$, 1df, $p \leq 0.0001$) for both endemic and non-endemic destinations. Notably, among those who did not engage in preventive actions, there were no significant differences in the reasons for not engaging in prevention between those that knew of the sexual transmission of Zika and those that did not know. Further, 361 out of the 533 (67.7%) travelers that did not take any action to prevent Zika reported the reason as being that they did not perceive that they were at risk, irrespective of their knowledge about the sexual transmission of Zika or their travel destination.

Table 3 also presents actions taken to prevent unintended pregnancy stratified by sexual transmission knowledge and Zika endemic travel destinations. Those with knowledge of the sexual transmission of Zika were more likely to use condoms regardless of their travel destination. However, among those traveling to Zika endemic locations, use of oral contraceptives ($\chi^2 = 6.09$, 1df, $p = 0.014$) and long acting reversible contraceptives such as intrauterine devices or implants ($\chi^2 = 4.57$, 1df, $p = 0.033$) were significantly more likely to be used among those with knowledge of sexual transmission than those without that knowledge. By contrast, those traveling to non-Zika locations reported significant higher usage

Table 1 Characteristics of the study population, stratified by sex

Characteristic	Female (n = 710) n (%)	Male (n = 333) n (%)	Total (n = 1043) n (%)
Knowledge of sexual transmission of Zika virus			
Yes	202 (28.5)	84 (25.2)	286 (27.4)
No	508 (71.5)	249 (74.8)	757 (72.6)
Traveled to Zika endemic location in past 12 months			
Yes	337 (47.5)	123 (36.9)	460 (44.1)
No	373 (52.5)	210 (63.1)	583 (55.9)
Trip purpose			
Vacation/pleasure	627 (88.6)	253 (76.2)	880 (84.4)
Business	81 (11.4)	79 (23.8)	160 (15.6)
Race			
White/Caucasian	512 (72.7)	242 (72.1)	754 (72.3)
Black or African American	86 (12.1)	47 (14.1)	133 (12.8)
Other	112 (15.8)	43 (13.2)	155 (14.9)
Asian	54 (7.6)	23 (6.9)	77 (7.4)
American Indian or Alaska Native	8 (1.1)	0 (0.0)	8 (0.8)
Native Hawaiian or other Pacific Islander	2 (0.3)	2 (0.6)	4 (0.4)
More than one race	34 (4.8)	9 (2.7)	43 (4.1)
Hispanic or Latino	14 (2.0)	10 (3.0)	24 (2.3)
Sexual orientation			
Heterosexual	642 (90.4)	314 (94.3)	956 (91.7)
LGBTQ	68 (9.6)	19 (5.7)	87 (8.3)
Health insurance			
Yes	647 (92.8)	303 (92.4)	950 (92.7)
No	50 (7.2)	25 (7.6)	75 (7.3)
Education			
Less than high school graduate	10 (1.4)	5 (1.5)	15 (1.5)
High school graduate	124 (17.5)	69 (20.7)	193 (18.5)
Some college	258 (36.3)	89 (26.7)	347 (33.2)
College graduate	318 (44.8)	170 (51.1)	488 (46.8)
Annual household income			
Less than $15,000	39 (5.7)	17 (5.3)	56 (5.6)
$15,000–$24,999	47 (6.9)	17 (5.3)	64 (6.4)
$25,000–$34,999	71 (10.5)	24 (7.4)	95 (9.5)
$35,000–$49,999	92 (13.5)	43 (13.3)	135 (13.5)
$50,000–$74,999	152 (22.4)	64 (19.8)	216 (21.6)
$75,000–$99,999	112 (16.5)	65 (20.1)	177 (17.7)
$100,000 or more	166 (24.4)	93 (28.8)	259 (25.9)
Employment status			
Employed	506 (71.3)	267 (80.2)	773 (74.1)
Unemployed	164 (23.1)	43 (12.9)	207 (19.8)
Retired/out of workforce	40 (5.6)	23 (6.9)	63 (6.1)
Age, years (mean, SD)	35.8 (13.7)	36.9 (13.9)	36.1 (13.8)

LGBTQ homosexual, lesbian, gay, bisexual, transgender, or queer; *SD* standard deviation

of abstention from intercourse ($\chi^2 = 6.12$, 1df, $p = 0.013$) and emergency contraceptive use ($\chi^2 = 4.35$, 1df, $p = 0.037$).

Finally, the most commonly reported information and preferred communication sources accessed by travelers for learning about Zika virus are presented in Table 4. Among travelers to Zika endemic destinations, most sought information about Zika from private doctors, the Internet, and community health officials. Among travelers to non-endemic destinations, most sought information from the previously mentioned three sources in addition

Table 2 Factors associated with the odds of taking preventative actions against Zika virus (n = 1043)

Characteristic	Unadjusted		Adjusted[a]	
	OR	95% CI	OR	95% CI
Knowledge of sexual transmission of Zika virus				
Yes	1.39	(1.06, 1.83)	1.55	(1.12, 5.77)
No	1.0	Reference	1.0	Reference
Traveled to Zika endemic location in past 12 months				
Yes	0.67	(0.52, 0.85)	0.75	(0.57, 0.98)
No	1.0	Reference	1.0	Reference
Trip purpose				
Vacation/pleasure	0.51	(0.36, 0.72)	0.58	(0.40, 0.85)
Business	1.0	Reference	1.0	Reference
Race				
White/Caucasian	1.0	Reference	1.0	Reference
Black or African American	2.05	(1.40, 3.01)	1.68	(1.12, 2.53)
Other	1.10	(0.78, 1.56)	1.10	(0.75, 1.61)
Sex				
Female	0.75	(0.58, 0.98)	0.84	(0.63, 1.11)
Male	1.0	Reference	1.0	Reference
Sexual orientation				
GLBTQ+	1.02	(0.66, 1.59)	0.83	(0.51, 1.33)
Heterosexual	1.0	Reference	1.0	Reference
Health insurance				
Yes	0.82	(0.51, 1.32)	0.85	(0.51, 1.41)
No	1.0	Reference	1.0	Reference
Education				
Less than high school graduate	1.22	(0.44, 3.42)	0.84	(0.25, 2.83)
High school graduate	1.20	(0.86, 1.67)	1.16	(0.79, 1.70)
Some college	0.96	(0.73, 1.26)	0.92	(0.68, 1.26)
College graduate	1.0	Reference	1.0	Reference
Annual household income				
Less than $15,000	2.36	(1.30, 4.30)	2.53	(1.27, 5.05)
$15,000–$24,999	1.80	(1.03, 3.13)	1.66	(0.90, 3.08)
$25,000–$34,999	0.95	(0.59, 1.54)	0.82	(0.49, 1.39)
$35,000–$49,999	1.55	(1.02, 2.35)	1.39	(0.89, 2.17)
$50,000–$74,999	1.34	(0.93, 1.92)	1.27	(0.87, 1.87)
$75,000–$99,999	1.39	(0.95, 2.04)	1.31	(0.88, 1.95)
$100,000 or more	1.0	Reference	1.0	Reference
Employment status				
Employed	1.0	Reference	1.0	Reference
Unemployed	0.82	(0.61, 1.12)	0.80	(0.56, 1.14)
Retired/out of workforce	0.56	(0.33, 0.95)	0.90	(0.46, 1.77)
Age, years	0.98	(0.98, 0.99)	0.99	(0.98, 1.01)

LGBTQ homosexual, lesbian, gay, bisexual, transgender, or queer

[a]Odds ratios were mutually adjusted for all other factors, namely, knowledge of sexual transmission of Zika virus, travel to Zika endemic location(s), trip purpose, race, sex, sexual orientation, health insurance status, educational attainment, annual household income, employment status and age

to pharmacists and family. In terms of preference, travelers to both Zika endemic destinations and non-endemic destinations both preferred to (i.e., "would like to") get information about Zika from private doctors, the Internet, and community health officials. However, they also preferred to get information about Zika from various media outlets including posters, television, newspapers, and social media.

Table 3 Commonly reported actions taken and reasons why no action was taken to prevent transmission of Zika virus infection and unintended pregnancy (n = 1043)

	Zika endemic destinations (n = 460)					Non-Zika destinations (n = 583)				
	Knowledge of sexual transmission					Knowledge of sexual transmission				
	Yes (n = 130)		No (n = 330)		p-value*	Yes (n = 156)		No (n = 427)		p-value*
	n	%	n	%		n	%	n	%	
Action(s) taken to prevent Zika virus infection[a]										
Mosquito repellant	57	43.8	108	32.7	0.025	66	42.3	157	36.8	0.223
Wore covering clothes	40	30.8	78	23.6	0.115	56	35.9	120	28.1	0.024
Window/door screens	33	25.4	44	13.3	0.002	40	25.6	62	14.5	0.002
Condom use	25	19.2	11	3.3	< 0.0001	30	19.2	25	5.9	< 0.0001
Mosquito net	19	14.6	54	16.4	0.644	33	21.2	100	23.4	0.564
Fumigated home	19	14.6	34	10.3	0.192	30	19.2	50	11.7	0.019
Abstention from intercourse	15	11.5	5	1.5	< 0.0001	21	13.5	16	3.7	< 0.0001
Used oral contraceptives	8	6.2	5	1.5	0.007	13	8.3	14	3.3	0.010
Why no action was taken to prevent Zika virus infection[b]										
Not at risk	46	35.4	117	35.5	0.989	58	37.2	140	32.8	0.322
Not a priority	12	9.2	26	7.9	0.635	11	7.1	25	5.9	0.595
Don't know how to prevent it	10	7.7	40	12.1	0.169	8	5.1	34	8.0	0.241
Zika is not a problem	5	3.8	22	6.7	0.247	4	2.6	16	3.7	0.613[#]
Other people are doing what is necessary	4	3.1	9	2.7	0.765[#]	4	2.6	8	1.9	0.741[#]
Can't prevent Zika infection	3	2.3	16	4.8	0.301[#]	1	0.6	7	1.6	0.689[#]
Don't have time	2	1.5	4	1.2	0.677[#]	1	0.6	6	1.4	0.681[#]
No effective prevention measures	1	0.8	4	1.2	0.990[#]	2	1.3	9	2.1	0.736[#]
Action taken to prevent unintended pregnancy[c]										
Condom use	36	27.7	61	18.5	0.029	54	34.6	92	21.5	0.001
Used oral contraceptives	26	20.0	37	11.2	0.014	37	23.7	77	18.0	0.126
Used long acting reversible contraceptives (IUD, implants)	11	8.5	12	3.6	0.033	21	13.5	30	7.0	0.149
Abstention from intercourse	8	6.2	14	4.2	0.387	16	10.3	20	4.7	0.013
Used emergency contraceptives	8	6.2	10	3.0	0.120	15	9.6	21	4.9	0.037
Used injectable contraceptives	5	3.8	11	3.3	0.787	17	10.9	32	7.5	0.190
Other family planning method	8	6.2	13	3.9	0.306	9	5.8	22	5.2	0.769

IUD intrauterine device

*Pearson's Chi square test

[#]Fisher's Exact Test was used in place of Pearson's Chi square test

[a]Responses to the question, "Since you heard about Zika, have you taken any action to prevent yourself from getting Zika?"

[b]Responses to the question, "Why have you not taken any action to prevent yourself from getting Zika?"

[c]Responses to the question, "Since you heard about Zika, have you and or your partner taken an action to prevent unintended pregnancy?"

Discussion

The objective of this research was to understand knowledge, attitudes, and practices to reduce the risk of Zika infection among travelers living in the United States. Our findings indicate that knowledge of the sexual transmissibility of Zika virus increases the odds of taking preventive action(s) against Zika infection. Similar to our study, Moise et al. have observed increased Zika knowledge to be associated with higher odds (OR 2.39; 95% CI 1.24–4.61) of taking preventative actions against Zika [34] and Squiers et al. reported higher condom use among individuals with higher knowledge of Zika [35], supporting the notion that Zika knowledge may prompt preventative health behaviors [36]. However, high-risk sexual behaviors (i.e., inconsistent condom use, sexual intercourse with commercial sex workers) and poor adherence to anit-vectorial prevention methods persist despite travelers' knowledge of specific disease risks

Table 4 Reported sources of where travelers seek answers and preferred information sources for learning about Zika virus (n = 1043)

	Zika endemic destinations (n = 460)					Non-Zika destinations (n = 583)				
	Knowledge of sexual transmission					Knowledge of sexual transmission				
	Yes		No		p-value*	Yes		No		p-value*
	(n = 130)		(n = 330)			(n = 156)		(n = 427)		
	n	%	n	%		n	%	n	%	
If you had a question about Zika, who would you ask?										
Private doctor	94	72.3	217	65.8	0.177	98	62.8	250	58.5	0.352
Internet	48	36.9	111	33.6	0.505	52	33.3	111	26.0	0.081
Community health officials	45	34.6	78	23.6	0.017	52	33.3	93	21.8	0.004
Pharmacist	24	18.5	47	14.2	0.259	45	28.8	76	17.8	0.004
Family	18	13.8	34	10.3	0.280	36	23.1	100	23.4	0.931
Friends or neighbors	12	9.2	25	7.6	0.557	19	12.2	61	14.3	0.513
Community meeting/community leaders	5	3.8	13	3.9	0.963	21	13.5	31	7.3	0.020
Social media	6	4.6	13	3.9	0.743	13	8.3	29	6.8	0.524
Religious leader	5	3.8	3	0.9	0.048#	10	6.4	19	4.4	0.335
Teacher	2	1.5	5	1.5	0.985	8	5.1	17	4.0	0.545
Radio call in program	0	0.0	3	0.9	0.562#	7	4.5	8	1.9	0.078
From where/whom would you like to get information about Zika?										
Private doctor	73	56.2	146	44.2	0.021	86	55.1	186	43.6	0.013
Internet	60	46.2	130	39.4	0.185	74	47.4	151	35.4	0.008
Community health officials	61	46.9	92	27.9	< 0.001	68	43.6	124	29.0	< 0.001
Posters	44	33.8	72	21.8	0.007	52	33.3	75	17.6	< 0.001
Television	37	28.5	83	25.2	0.467	57	36.5	94	22.0	< 0.001
Newspapers	31	23.8	65	19.7	0.324	47	30.1	64	15.0	< 0.001
Social media	31	23.8	63	19.1	0.255	39	25.0	64	15.0	0.005
Pharmacist	25	19.2	47	14.2	0.185	37	23.7	64	15.0	0.014
Family	20	15.4	52	15.8	0.921	37	23.7	127	29.7	0.152
Community meeting/community leaders	15	11.5	26	7.9	0.215	38	24.4	55	12.9	< 0.001
Friends or neighbors	15	11.5	23	7.0	0.109	29	18.6	69	16.2	0.487
Radio	17	13.1	27	8.2	0.108	25	16.0	43	10.1	0.047
Smartphone app	17	13.1	22	6.7	0.026	14	9.0	25	5.9	0.182
Religious leader	7	5.4	5	1.5	0.019	10	6.4	26	6.1	0.887

*Pearson's Chi square test

#Fisher's Exact Test was used in place of Pearson's Chi square test

[37–42]. The potentially high sexual transmissibility of Zika necessitates educating vulnerable populations, especially those engaging in risky sexual behaviors (e.g., having unprotected sex), couples trying to conceive, and pregnant women. Additionally, infection risk may be further accentuated for individuals who are traveling and are unaware of the transmission routes, signs and symptoms of infection, or the mere presence of risk for infection [35, 43]. From a public health standpoint, this may indicate a failure to disseminate actionable knowledge of effective prevention strategies. Preliminary evidence indicates that Zika awareness and knowledge can increase over time [44] through both media coverage and through pre-travel health consultations with healthcare providers [45], though innovative educational interventions that intentionally promote Zika awareness and preventive practices are needed, particularly among travelers.

We observed that sexual prevention methods were more likely to be used by individuals who reported having knowledge of the sexual transmissibility of Zika than those who did not have this knowledge. Participants also reported a variety of preventative actions (i.e., oral, injectable and emergency contraceptive use) which indicates that some individuals may be more concerned about the potential adverse fetal outcomes caused by maternal Zika infection, but not necessarily concerned about the acute symptomology and associated consequences of Zika infection. Our findings are similar to other

Zika KAP surveys although it should be noted that they were conducted among pregnant women [35, 46–48]. More than two-thirds of travelers that did not take any action to prevent Zika reported the reason as being that they did not perceive that they were at risk, irrespective of their knowledge about the sexual transmission of Zika or their travel destination. Future interventions are needed to address risk perceptions and increase knowledge of the modes of transmission.

Importantly, this study also reveals discrepancies between where travelers seek information about Zika infection and how they would like information regarding Zika to be communicated to them (Table 4). For example, 63.2% of all travelers reported that they would ask a private doctor about Zika whereas only 30.9% reported they would ask questions via the Internet. However, when asked where travelers would prefer to receive information about Zika, 47.1% reported wanting information from a private doctor and 39.8% indicated they wanted information directly from the Internet. Clear communication with health care providers will be important as they are the most trusted source of health information [49]. This implies that healthcare providers must not only be aware of current travel-related disease guidelines, but also versed in diagnosing and managing Zika, GBS, and other travel-related illnesses [50]. However, it should be noted that travelers are increasingly turning toward the Internet for travel information, including for health information and risks associated with travel, thus there is opportunity for communicating risks and effective preventive strategies for Zika and other travel-acquired diseases in digital settings [35, 51]. Understanding the communication preferences of travelers and their desire to rely on both healthcare providers and valid Internet sources will enhance travel medicine strategies and services to reduce the spread of diseases [52, 53].

This study has some limitations. First, the study only included respondents who had traveled outside of the U.S. in the past 12 months. Second, participants were recruited by Qualtrics from a survey panel and the sample may not be demographically representative of the overall U.S. population. Third, the cross-sectional design of the study does not permit causal inference. Fourth, survey responses were self-reported by participants over the Internet and may be subject to under- or over-reporting. However, other Internet-based studies have demonstrated validity and reduction in potential biases (e.g., interviewer bias or social desirability) [54, 55]. Finally, we report actions taken to avoid Zika infection and unintended pregnancy which may be influenced by small numbers and should thus be interpreted with caution.

Conclusions

Overall, the findings from this study have important public health implications. First, knowledge of the sexual transmission of Zika virus significantly increased the odds of taking preventive action(s) against Zika infection. This indicates that increasing knowledge through public health education and messaging may increase preventive actions. Second, travelers' preferences for seeking and obtaining information about Zika virus may provide opportunities to supplement current travel advisories with targeted campaigns through healthcare providers and through online resources and digital outreach. Innovative strategies to communicate risk and promote actions to prevent disease transmission will reduce disease among travelers.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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