Preventive Medicine Reports 12 (2018) 336–342

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Mosquito-borne infectious disease, risk-perceptions, and personal protective behavior among U.S. international travelers

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ARTICLE INFO

Keywords:
Mosquito-borne infectious disease
Personal protective behavior
Zika awareness
Perceived susceptibility
Perceived severity

ABSTRACT

Vector-borne diseases account for a significant amount of the global infectious disease burden, including morbidity and mortality. In particular, mosquito-borne infectious diseases (MBIDs) have the greatest burden in number of cases, mortality, and disability-adjusted life years and their prevention and control is critical. However, prevention efforts are hindered by the absence of vaccines and failure of long-term mosquito vector control for these MBIDs. Thus, personal protective behaviors (PPBs) may offer the most promising and effective mode of prevention. This study examines the impact of awareness, perceived susceptibility, and perceived severity for five MBIDs (e.g., Malaria, Dengue, Zika, Chikungunya and West Nile) on the adoption of PPBs. Study participants (n = 1043) were recruited from a probability-based internet panel of adult United States residents with a history of traveling outside of the country in the past year. Data were collected in the U.S. between June 7, 2017 and June 12, 2017. Our findings show that awareness of Zika disease among respondents was consistently associated with adoption of all three PPBs. Respondents that reported high-perceived severity for all five MBIDs were also more likely to report adopting the PPBs of wearing covering clothing and use of mosquito repellent spray. Our findings indicate that U.S. travelers are largely more concerned about Zika, Chikungunya, and Dengue than Malaria and West Nile and that these concerns drive their adoption of the three recommended PPBs. This information should inform the development and design of future public health campaigns for behavior modification to prevent MBIDs.

1. Introduction

Vector-borne diseases (VBDs) cause significant morbidity and mortality worldwide, accounting for as much as 17% of the global infectious disease burden (Organization, W.H, 2017a). Over one billion people are infected with VBDs annually and more than one million die from those infections each year (Organization, W.H, 2014). Of all the known VBDs, mosquito-borne infectious diseases (MBIDs) account for the highest number of reported cases, mortality, and disability-adjusted life years (World Health Organization, 2018a). Malaria, for example, has an enormous burden globally. In 2016, there were an estimated 216 million cases of malaria worldwide—a slight increase from the previous year—and an estimated 445,000 deaths (Organization, W.H, 2017b). Dengue also has a large global burden with researchers estimating that there are 96 million disease cases per year with > 390 million infections annually (Organization, W.H, 2017a; Bhatt et al., 2013). Although the global burden resulting from Zika, Chikungunya, and West Nile respectively are not as high as those for Malaria, and Dengue, their impact are nevertheless important, particularly, as there have been several large-scale outbreaks of these diseases and transmission has expanded to regions previously unaffected (Kraemer et al., 2015; Campos et al., 2015; Van Bortel et al., 2014; Nash et al., 2001). For example, in the U.S., the CDC reported a statistically significant increase in birth defects associated with Zika virus infection in the second half of 2016 (Delaney et al., 2018). Human risks of Zika virus infection include pregnancy loss, microcephaly, Guillain-Barré syndrome, and other central nervous system malformations (Prevention, U.S.C.f.D.C.a, 2018; World Health Organization, 2018b). In the same year, WNV as the leading cause of domestically acquired arthropod-borne viruses in the continental U.S. was reported in 47 states and the District of Columbia, with 61% of cases being classified as neuroinvasive (Burakoff et al., 2018). The economic costs to national health systems resulting from long-term sequelae for survivors of these MBIDs, the negative impact on travel, tourism, and trade (Focosi et al., 2016) of these

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https://doi.org/10.1016/j.pmedr.2018.10.018
Received 31 July 2018; Received in revised form 4 October 2018; Accepted 25 October 2018
Available online 31 October 2018

Table 1
Predicting wearing covering clothes to keep mosquitoes away among U.S. International Travelers.

	Row %	p-Value	UOR[a]	95% CI	AOR[b]	95% CI
Have you heard about Zika disease?						
- No	14% (13)	0.002	1.00		1.00	
- Yes	30% (284)		2.51	1.42–4.81	1.91	0.96–4.07
Have you heard about Dengue disease?						
- No	28% (157)	0.7644	1.00		1.00	
- Yes	29% (140)		1.04	0.80–1.36	0.75	0.52–1.06
Have you heard about West Nile Virus disease?						
- No	21% (31)	0.0413	1.00		1.00	
- Yes	30% (266)		1.55	1.03–2.40	1.35	0.80–2.30
Have you heard about Chikungunya disease?						
- No	25% (193)	< 0.0001	1.00		1.00	
- Yes	39% (104)		1.94	1.44–2.61	2.03	1.39–2.99
Have you heard about Malaria disease?						
- No	19% (12)	0.0647	1.00		1.00	
- Yes	29% (285)		1.82	0.99–3.61	1.60	0.71–3.80
Perceived Susceptibility to Zika disease during international travel						
- High	40% (60)		1.00		1.00	
- Neither high nor low	28% (133)		0.59	0.40–0.87	0.4	0.21–0.74
- Low	25% (104)		0.50	0.34–0.75	0.35	0.18–0.69
Perceived Susceptibility to Dengue disease during international travel						
- High	31% (33)	0.6263	1.00		1.00	
- Neither high nor low	29% (138)		0.91	0.58–1.46	4.87	1.75–14.36
- Low	27% (126)		0.82	0.52–1.31	4.46	1.45–14.46
Perceived Susceptibility to West Nile disease during international travel						
- High	32% (43)	0.4919	1.00		1.00	
- Neither high nor low	29% (133)		0.84	0.56–1.29	1.08	0.51–2.33
- Low	27% (121)		0.78	0.51–1.19	1.12	0.49–2.61
Perceived Susceptibility to Chikungunya disease during international travel						
- High	34% (38)	0.3821	1.00		1.00	
- Neither high nor low	27% (132)		0.73	0.48–1.15	0.48	0.18–1.27
- Low	28% (127)		0.77	0.50–1.20	0.69	0.22–2.11
Perceived Susceptibility to Malaria disease during international travel						
- High	34% (45)	0.1513	1.00		1.00	
- Neither high nor low	30% (125)		0.84	0.56–1.28	1.05	0.51–2.19
- Low	26% (127)		0.69	0.46–1.05	0.82	0.37–1.84
Perceived Severity of Zika disease						
- High	33% (255)	< 0.0001	1.00		1.00	
- Neither high nor low	15% (20)		0.37	0.22–0.59	0.41	0.21–0.75
- Low	16% (22)		0.39	0.24–0.62	0.62	0.31–1.24
Perceived Severity of Dengue disease						
- High	34% (220)	< 0.0001	1.00		1.00	
- Neither high nor low	23% (58)		0.57	0.41–0.80	0.64	0.37–1.07
- Low	13% (19)		0.29	0.17–0.47	0.34	0.14–0.79
Perceived Severity of West Nile disease						
- High	31% (234)	0.0027	1.00		1.00	
- Neither high nor low	23% (36)		0.67	0.44–0.99	1.34	0.74–2.41
- Low	19% (27)		0.50	0.32–0.78	1.93	0.93–4.02
Perceived Severity of Chikungunya disease						
- High	34% (201)	< 0.0001	1.00		1.00	
- Neither high nor low	24% (73)		0.62	0.45–0.85	1.02	0.36–1.70
- Low	16% (23)		0.36	0.22–0.57	0.79	0.36–1.70
Perceived Severity of Malaria disease						
- High	31% (244)	0.0013	1.00		1.00	
- Neither high nor low	24% (31)		0.69	0.44–1.05	1.23	0.67–2.23
- Low	17% (22)		0.44	0.27–0.70	0.96	0.44–2.02

[a] UOR = Unadjusted Odds Ratio.
[b] AOR = Adjusted Odds Ratio.

diseases further highlights the urgent need for their prevention and control. More so, because more than half of the world's human population live in areas infested with mosquito vectors of these diseases (Tam et al., 2016). For these MBIDs there are not vaccinations, asymptomatic infections are common, and control of the mosquito vectors has proven difficult to maintain over the long term. Accordingly, the most promising prevention mechanisms may lie in the adoption of personal protective behaviors (PPBs), which have been shown to be effective in MBID risk reduction (Loeb et al., 2005; Gujral et al., 2007). Recommended PPBs include, but are not limited to, 1) wearing covering clothes to prevent mosquito bites, 2) using mosquito repellent spray on self, and 3) use of mosquito coils or lighting fires to deter mosquitoes from lingering near occupied areas.

Due to the transmission dynamics and nature of MBIDs, it is critical that targeted and effective prevention messages be disseminated to at-risk populations in order to encourage adoption of the recommended PPBs (Zielinski-Gutierrez and Hayden, 2006). Awareness, perceived susceptibility and perceived severity (Janz and Becker, 1984), collectively referred to as 'risk perceptions' in this study, have been studied extensively and reported to significantly predict health behavior including adoption of MBIDs PPBs (Omodior et al., 2017a; Omodior et al., 2017b; Donohoe et al., 2018; Sheeran et al., 2014; Raude et al., 2012). Perceived susceptibility and perceived severity are constructs drawn from the Health Belief Model (Hochbaum et al., 1952). The former refers to an individual's subjective assessment of the risk of developing a specific health problem, while the latter relates to her/his beliefs

Table 2
Predicting use of Mosquito repellent spray on self among U.S. International Travelers.

	Row %	p-Value	UOR[a]	95% CI	AOR[b]	95% CI
Have you heard about Zika disease?						
- No	19% (17)	0.0003	1.00		1.00	
- Yes	39% (371)		2.74	1.63–4.86	2.44	1.26–4.98
Have you heard about Dengue disease?						
- No	36% (200)	0.3386	1.00		1.00	
- Yes	39% (188)		1.14	0.89–1.47	0.85	0.62–1.18
Have you heard about West Nile Virus disease?						
- No	31% (45)	0.1181	1.00		1.00	
- Yes	38% (343)		1.37	0.95–2.02	1.07	0.66–1.74
Have you heard about Chikungunya disease?						
- No	34% (263)	0.0002	1.00		1.00	
- Yes	47% (125)		1.73	1.31–2.30	1.77	1.23–2.55
Have you heard about Malaria disease?						
- No	25% (16)	0.0418	1.00		1.00	
- Yes	38% (372)		1.88	1.08–3.46	1.47	0.68–3.26
Perceived Susceptibility to Zika disease during international travel						
- High	51% (77)	0.0006	1.00		1.00	
- Neither high nor low	36% (170)		0.54	0.37–0.78	0.38	0.20–0.71
- Low	34% (141)		0.49	0.34–0.72	0.33	0.17–0.64
Perceived Susceptibility to Dengue disease during international travel						
- High	42% (44)	0.4361	1.00		1.00	
- Neither high nor low	35% (167)		0.77	0.50–1.19	6.41	2.34–18.73
- Low	38% (177)		0.87	0.57–1.34	10.42	3.46–33.53
Perceived Susceptibility to West Nile disease during international travel						
- High	45% (60)	0.1184	1.00		1.00	
- Neither high nor low	37% (170)		0.71	0.48–1.04	0.92	0.46–1.86
- Low	35% (158)		0.67	0.45–0.99	0.75	0.35–1.63
Perceived Susceptibility to Chikungunya disease during international travel						
- High	46% (52)	0.0567	1.00		1.00	
- Neither high nor low	34% (166)		0.61	0.40–0.92	0.39	0.15–1.01
- Low	38% (170)		0.70	0.46–1.07	0.44	0.14–1.27
Perceived Susceptibility to Malaria disease during international travel						
- High	46% (62)	0.061	1.00		1.00	
- Neither high nor low	37% (153)		0.67	0.45–1.00	0.84	0.42–1.69
- Low	35% (173)		0.63	0.43–0.93	0.74	0.35–1.57
Perceived Severity of Zika disease						
- High	43% (335)	< 0.0001	1.00		1.00	
- Neither high nor low	21% (28)		0.36	0.23–0.55	0.40	0.22–0.69
- Low	18% (25)		0.29	0.18–0.46	0.46	0.24–0.87
Perceived Severity of Dengue disease						
- High	44% (284)	< 0.0001	1.00		1.00	
- Neither high nor low	31% (28)		0.56	0.41–0.77	0.76	0.46–1.23
- Low	18% (26)		0.27	0.17–0.42	0.53	0.24–1.13
Perceived Severity of West Nile disease						
- High	41% (306)	< 0.0001	1.00		1.00	
- Neither high nor low	33% (50)		0.69	0.47–0.99	1.59	0.91–2.77
- Low	22% (32)		0.41	0.27–0.62	1.36	0.68–2.70
Perceived Severity of Chikungunya disease						
- High	44% (263)	< 0.0001	1.00		1.00	
- Neither high nor low	33% (98)		0.60	0.45–0.81	0.91	0.58–1.42
- Low	18% (27)		0.28	0.18–0.44	0.54	0.26–1.11
Perceived Severity of Malaria disease						
- High	41% (319)	0.0001	1.00		1.00	
- Neither high nor low	29% (37)		0.58	0.38–0.86	0.90	0.50–1.60
- Low	24% (32)		0.46	0.30–0.70	1.54	0.78–3.06

[a] UOR = Unadjusted Odds Ratio.
[b] AOR = Adjusted Odds Ratio.

about the seriousness of a disease (Janz and Becker, 1984). Within the framework of the Health Belief Model (HBM), a positive linear relationship is said to exist between high perceived susceptibility for a negative health outcome and adoption of a health behavior. Similarly, the HBM posits that the stronger an individual's perceived severity of a negative health outcome, the more likely they will be motivated to avoid it by adopting the recommended preventive behavior (Rosenstock, 1974). This evaluation results from awareness, which is based on health information and knowledge. While mixed results have been reported on the relationship between perceived susceptibility and infectious disease preventive behavior (Donohoe et al., 2018; Chen et al., 2007), the evidence consistently supports a strong positive relationship between perceived severity and adoption of infectious disease preventive behavior (Omodior et al., 2017b; Ibuka et al., 2010; van der Snoek et al., 2006). However, because the impact of risk perceptions on preventative health behavior is not the same, it is necessary to determine the extent to which MBIDs risk perceptions predict PPBs with a view to designing targeted interventions. Specifically, for different MBIDs for which the same set of PPBs are prescribed, it is essential for effective health promotion messaging to determine which risk perceptions drive the adoption of the recommended behavior. Very few studies have investigated how risk perceptions for different MBIDs affect adoption of specific PPBs among U.S. international travelers, who are a particularly at-risk group. The aim of this study is to determine if awareness, perceived susceptibility, and perceived severity respectively for Malaria, Dengue, Zika, Chikungunya and West Nile, are associated

Table 3
Predicting use of mosquito coil/lighting fires to keep mosquitos away among U.S. International Travelers.

	Row %	p-Value	UOR[a]	95% CI	AOR[b]	95% CI
Have you heard about Zika disease?						
- No	8% (07)	0.0051	1.00		1.00	
- Yes	20% (189)		2.93	1.43–7.08	3.98	1.66–11.07
Have you heard about Dengue disease?						
- No	17% (96)	0.1505	1.00		1.00	
- Yes	21% (100)		1.26	0.92–1.72	0.91	0.61–1.35
Have you heard about West Nile Virus disease?						
- No	19% (27)	0.9546	1.00		1.00	
- Yes	19% (169)		1.01	0.65–1.62	1.14	0.66–2.02
Have you heard about Chikungunya disease?						
- No	16% (121)	< 0.0001	1.00		1.00	
- Yes	28% (75)		2.13	1.53–2.96	2.07	1.36–3.17
Have you heard about Malaria disease?						
- No	19% (12)	0.9439	1.00		1.00	
- Yes	19% (184)		1.02	0.55–2.04	0.57	0.25–1.39
Perceived Susceptibility to Zika disease during international travel						
- High	33% (49)	< 0.0001	1.00		1.00	
- Neither high nor low	17% (81)		0.43	0.28–0.65	0.52	0.27–1.04
- Low	16% (66)		0.39	0.25–0.60	0.59	0.29–1.23
Perceived Susceptibility to Dengue disease during international travel						
- High	32% (34)	0.0011	1.00		1.00	
- Neither high nor low	18% (83)		0.45	0.28–0.73	1.53	0.54–4.42
- Low	17% (79)		0.43	0.27–0.70	2.79	0.90–8.98
Perceived Susceptibility to West Nile disease during international travel						
- High	30% (40)	0.0013	1.00		1.00	
- Neither high nor low	18% (84)		0.52	0.33–0.80	1.03	0.47–2.28
- Low	16% (72)		0.45	0.29–0.70	0.84	0.35–2.05
Perceived Susceptibility to Chikungunya disease during international travel						
- High	31% (35)	0.0011	1.00		1.00	
- Low	16% (72)		0.42	0.26–0.68	0.54	0.17–1.79
- Neither high nor low	19% (89)		0.50	0.32–0.80	0.91	0.34–2.58
Perceived Susceptibility to Malaria disease during international travel						
- High	31% (41)	0.0006	1.00		1.00	
- Neither high nor low	18% (77)		0.51	0.33–0.80	0.85	0.40–1.84
- Low	16% (78)		0.43	0.28–0.67	0.65	0.28–1.54
Perceived Severity of Zika disease						
- High	21% (161)	0.0194	1.00		1.00	
- Neither high nor low	12% (16)		0.53	0.30–0.90	0.51	0.24–1.00
- Low	14% (19)		0.61	0.36–1.00	0.67	0.31–1.38
Perceived Severity of Dengue disease						
- High	21% (135)	0.0503	1.00		1.00	
- Neither high nor low	17% (42)		0.75	0.51–1.09	0.87	0.48–1.56
- Low	13% (19)		0.56	0.33–0.93	0.70	0.28–1.70
Perceived Severity of West Nile disease						
- High	20% (146)	0.557	1.00		1.00	
- Neither high nor low	16% (25)		0.80	0.49–1.25	1.11	0.56–2.12
- Low	17% (25)		0.86	0.53–1.36	2.01	0.93–4.29
Perceived Severity of Chikungunya disease						
- High	21% (123)	0.1442	1.00		1.00	
- Neither high nor low	17% (52)		0.80	0.55–1.13	1.19	0.69–2.02
- Low	14% (21)		0.64	0.38–1.04	0.97	0.41–2.22
Perceived Severity of Malaria disease						
- High	20% (153)	0.4549	1.00		1.00	
- Neither high nor low	18% (23)		0.88	0.53–1.41	1.23	0.63–2.38
- Low	15% (20)		0.73	0.43–1.19	0.92	0.41–2.03

[a] UOR = Unadjusted Odds Ratio.
[b] AOR = Adjusted Odds Ratio.

with the adoption of PPBs. We hypothesize that the association between risk perceptions for each of these 5 MBIDs and adoption of the following PPBs, 1) wearing covering clothes for mosquito bite prevention, 2) use of mosquito repellent spray, and 3) use of mosquito coil or lighting fires, among U.S. international travelers, is not the same. These study outcomes have important implications for designing health messaging aimed at increasing the adoption of recommended PPBs in at risk populations. Additionally, the findings of this study may be used to monitor the effectiveness of existing interventions aimed at increasing adoption of PPBs.

2. Methods

2.1. Data collection

2.1.1. Study participants

Study participants were recruited from a probability-based internet panel by Qualtrics (Qualtrics, Provo, Utah, USA) (Qualtrics, 2017) between June 7, 2017 and June 12, 2017. The eligibility criteria for study participation were: (1) adult men and women age ≥18 years of age, (2) residence in the United States, (3) spoke English, and (4) had a history of traveling outside of the United States. An Internet survey panel was selected because it is cost-effective and permits the collection of a large and diverse sample over a short timeline (Hays et al., 2015). In total,

Table 4
Summary table of adjusted multivariate logistic regressions: significant predictors of Mosquito Borne Infectious Diseases Personal Protective Behaviors.

	Wearing covering clothing	Using mosquito repellent spray on self	Using mosquito coil/lighting fires
Zika awareness	No	Yes	Yes
Dengue awareness	No	No	No
West Nile awareness	No	No	No
Chikungunya awareness	Yes	Yes	Yes
Malaria awareness	No	No	No
Perceived susceptibility to Zika	Yes	Yes	No
Perceived susceptibility to Dengue	Yes	Yes	No
Perceived susceptibility to West Nile	No	No	No
Perceived susceptibility to Chikungunya	No	No	No
Perceived susceptibility to Malaria	No	No	No
Perceived severity of Zika	No	Yes	No
Perceived severity of Dengue	No	No	No
Perceived severity of West Nile	No	No	No
Perceived severity of Chikungunya	No	No	No
Perceived severity of Malaria	No	No	No

Note: Yes indicates a significant association, not the directionality of the association. No indicates that no significant association was found in the adjusted multivariate logistic regression.

Qualtrics elicited 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 < 30 s and were omitted, and 3101 (90.2%) reported no history of international travel. Of the remaining 1150 responses, 107 (9.3%) were omitted due to partial survey completion (< 50% of the survey was completed). Therefore, the final sample size for analysis was 1043 responses, which comprised 22.8% of all those elicited and 90.6% of those who met the eligibility requirements for the study. Participants were provided with a small incentive by Qualtrics for participating in the survey. The total recruitment costs (including incentives) were $6.71 (U.S. Dollars) per completed survey. The study protocol was approved by the Institutional Review Board at Indiana University-Bloomington (protocol #: 1705563810).

2.1.2. Survey questionnaire

Questionniare items were adapted from the WHO Knowledge, Attitudes and Practice survey about Zika virus, and the U.S. Census Bureau's American Community Survey (Bureau, U.S.C, 2017; World Health Organization, 2016). Study participants who met the eligibility criteria were asked to self-report demographics such as their age, gender, race/ethnicity, educational attainment, income, and health insurance status. Awareness for each of the 5 MBIDs was measured using the question “Have you heard about the following diseases?” Response categories used in data analysis were binary (Yes/No). The following question was adapted to assess perceived susceptibility to each of the MBIDs under study; “What is the *likelihood* that you will contract the following diseases when you travel internationally?” (Likert scale of “Almost certainly will not”, “Certainly will not”, “Not sure”, “Certainly will”, and “Almost certainly will”). Thereafter, we created 3 categories of perceived susceptibility thus, 1) low perceived susceptibility (“Almost certainly will not” & “Certainly will not”), 2) neutral perceived susceptibility (“Not sure”) and, 3) high perceived susceptibility (“Certainly will” & “Almost certainly will”). Perceived severity of each of the 5 MBIDs was assessed using the following question, “How *serious* a health problem do you think the following diseases are?” (Likert scale of “Not at all”, “Somewhat”, “Neither”, “Very”, and “Most”). For data analysis purposes, we created 3 categories of perceived severity thus, 1) low perceived severity (“Not at all” & “Somewhat”), 2) neutral perceived severity (“Neither”) and, 3) high perceived severity (“Very” & “Most”).

2.2. Statistical analysis

All analyses were conducted using R version 3.4.2 (Team, R.C, 2017). Responses for study participants' level of education were recoded thus: “GED or less” (< 9th grade, 9–12th grade, High School graduate), “College” (Some college, Associates, Bachelors), and “Graduate school degree” (Graduate school). Based on Chi square cross-tabulation, we derived row percentages and the corresponding p-values to represent the proportion of subjects in each attribute category who adopted the recommended PPB under consideration. Next, we ran logistic regression models to determine which variables had significant predictive power for each of the three PPBs. We fit separate models to examine the relationship between PPBs and awareness, perceived susceptibility, and perceived severity for each of the five MBIDs. The first model used the PPB of ‘wearing covering clothes to keep mosquitoes away’ as the dependent variable. The second and third models were similar to the first, except that the dependent variables utilized were the ‘use of mosquito repellent spray on self’ and ‘use of mosquito coil or lighting fires to keep mosquitos away’ respectively. An a priori significance of $p < 0.05$ was used to determine statistical significance.

3. Results

Study participants' mean age was 36.1 years (SD = 13.77). The gender distribution was, female 68% (n = 710) and male = 32% (n = 333). Seventy-two percent (n = 754) reported their race as white, 13% (n = 133) as Black/African American, 7% (n = 77) as Asian, < 1% as Native American (n = 08) and Native Hawaiian (n = 04), while 4% (n = 42) reported more than one race. Twenty-eight percent (n = 297) of study participants reportedly wore covering clothes to keep mosquitoes away. Thirty-seven percent (n = 388) used mosquito repellent or spray on self, and 19% (n = 196) said they used mosquito coils or lit fires to keep mosquitoes away.

We found statistically significant differences in row percentages for awareness of Zika ($p < 0.002$) and Chikungunya ($p < 0.0001$), and wearing covering clothing to keep mosquitoes away. We also found significant differences in row percentages for the three categories of perceived severity (‘High’, ‘Neither high nor low’, ‘Low’) for all five MBIDs, among participants who wore covering cloth to keep mosquitoes away (Table 1). Bivariate logistic regression revealed significant differences in the odds of wearing covering clothing to keep mosquitoes away for the following variables, 1) awareness of Zika, West Nile and Chikungunya, 2) perceived susceptibility to Zika and, 3) perceived severity of Zika, Dengue, West Nile, and Chikungunya. After adjusting for demographic variables (age, gender, race, education, and income) in multivariate logistic regression, the odds of wearing covering clothing to keep mosquitoes away was significantly associated with, 1) awareness of Chikungunya disease, 2) perceived susceptibility to Zika and Dengue diseases respectively, and 3) perceived severity of Zika and Dengue diseases respectively.

We found statistically significant differences in row percentages for

awareness of Zika ($p < 0.0003$), Chikungunya ($p < 0.0002$), and Malaria ($p < 0.0418$) respectively, and use of mosquito repellent spray on self, among U.S international travelers. Row percentages for the 3 categories of perceived susceptibility ('High', 'Neither high nor low', 'Low') to Zika during international travel were significantly different in association with use of mosquito repellent spray on self. We also found significant differences ($p < 0.05$) in row percentages for the 3 categories of perceived severity ('High', 'Neither high nor low', 'Low') for all 5 MBIDs, among participants who use mosquito repellent spray on self (Table 2). Bivariate logistic regression revealed significant differences in the odds of use of mosquito repellent spray on self, and 1) awareness of Zika, Chikungunya and, Malaria, 2) perceived susceptibility to Zika and, 3) perceived severity of all 5 MBIDs (i.e. Zika, dengue, West Nile, Chikungunya and Malaria). After adjusting for demographic variables (age, gender, race, education, and income) in multivariate logistic regression, the odds of use of mosquito repellent spray on self among U.S. international travelers was significantly associated with, 1) awareness for Zika and Chikungunya diseases respectively, 2) perceived susceptibility to Zika disease and Dengue respectively and, 3) perceived severity of Zika disease.

We found evidence of statistical significance in the proportion of study participants who reported use of mosquito coil/lighting fires to keep mosquitoes away, and 1) awareness of Zika disease ($p < 0.0051$) and Chikungunya ($p < 0.0001$) respectively, 2) perceived susceptibility to all 5 MBIDs (i.e. Zika ($p < 0.0001$), Dengue ($p < 0.0011$), West Nile ($p < 0.0013$), Chikungunya ($p < 0.0011$), and Malaria ($p < 0.0006$), and 3) perceived severity of Zika ($p < 0.0194$) and Dengue ($p < 0.0503$) respectively (Table 3). Bivariate logistic regression revealed significant differences in the odds of use of mosquito coil/lighting fires to keep mosquitoes away and, i) awareness of Zika and Chikungunya respectively, ii) perceived susceptibility to all 5 MBIDs (i.e. Zika, Dengue, West Nile, Chikungunya, and Malaria), iii) perceived severity of all 5 MBIDs (i.e. Zika, dengue, West Nile, Chikungunya and malaria). After adjusting for demographic variables (age, gender, race, education, and income) in multivariate logistic regression, the odds of using mosquito coil/lighting fires to keep mosquitoes away was significant in association with, awareness for Zika and Chikungunya diseases respectively. No other significant differences were observed.

4. Discussion

A major challenge for instructional content designers when creating messages for behavior modification in disease risk prevention, is ascertaining what motivates the target population to engage in the recommended behavior. For U.S. travelers to regions of the world where various MBIDs are endemic, understanding the strength of risk perceptions for different MBIDs and how these work either in isolation or together, to ultimately drive the adoption of PPBs, has important public health implications for MBID control and prevention. Our findings show that awareness of Zika disease among U.S. international travelers was consistently associated with adoption of all three personal protective behaviors as indicated by row percentages and significant Chi-square p-values. Additionally, U.S. international travelers with high-perceived severity for all five MBIDs were also more likely to report adopting wearing covering clothing and use of mosquito repellent spray to keep mosquitoes away. The only PPB for which perceived severity for all five MBIDs did not show significant association across board was using mosquito coil/lighting fires to keep mosquitoes away. Although effective in preventing mosquito exposure, use of mosquito coil/lighting fires is less universally available as a PPB, compared to wearing covering clothing and use of mosquito repellent sprays. Diminished availability may lead to reduced self-efficacy for adoption of the behavior, which may partly explain why perceived severity was not associated with this particular recommended PPB.

As seen in Table 4, after adjusting for the presence of other variables in separate logistic regression models, awareness of Chikungunya disease was significantly associated with the odds of engaging in all three recommended PPBs. Further, awareness of Zika and Chikungunya diseases were significantly associated with odds of engaging in both use of mosquito repellent and use of mosquito coils or lighting fires. Previous studies have demonstrated the association between exposure to health messages, awareness and behavior modification (Carleton et al., 1996; Kaskutas and Graves, 1994). A possible explanation for the effect of Chikungunya and Zika awareness on PPB is that awareness increases overall intention to adopt the recommended behavior which, studies have shown is a significant predictor of actual behavior (Omodior et al., 2015; Ajzen, 1985). Additionally, the odds of wearing covering clothing and using mosquito repellant were associated with perceived susceptibility to Zika disease and Dengue. Although perceived susceptibility to Chikungunya was not significantly associated with the odds of adoption of any of the three personal protective behaviors in the current study, previous studies have reported association (Omodior et al., 2017b).

Although this study did not investigate the proportion of U.S. international travelers who specifically adopted all three protective behaviors, identifying predictors of multiple behaviors is significant. This is because it has been recommended that individuals at risk of MBIDs should adopt multiple components of an insect repellent system (which includes use of repellents on skin/clothing, wearing covering clothing, etc.) for maximum protection (US Army Public Health Center, 2016). It is also interesting to note that a previous study of U.S. international travelers reported low Chikungunya awareness (Omodior et al., 2017a). It would therefore seem that raising awareness for Chikungunya disease together with Zika, with a focus on encouraging increased adoption of personal protective behavior among U.S. international travelers is an effective health promotion strategy. Our study findings seem to indicate that U.S. international travelers are largely more concerned about Zika, Chikungunya, and Dengue compared to Malaria and West Nile and these concerns drive their adoption of the three recommended MBID personal protective behaviors. This could indicate that information campaigns surrounding these three diseases have been more effective than others, especially because outbreaks and epidemics of these diseases have been featured in the news media more recently in relation to travel (U.S. Centers for Disease Control and Prevention, 2017; US Centers for Disease Control and Prevention, 2015; U.S. Centers for Disease Control and Prevention, 2016). Our findings further support previous studies which indicate that perceived severity is consistently predictive of MBID preventive behavior (Omodior et al., 2017b; Ibuka et al., 2010; van der Snoek et al., 2006).

A major limitation of this study is that the associations modeled between the explanatory and outcome variables are based on self-reporting. Whether these associations reflect actual behavior cannot be determined from this study. Secondly, study participants were drawn from an internet-based panel. This leaves out non-internet users, who may be significantly different from the former. Additionally, because study participants were volunteer U.S. international travelers, the risk-perceptions of non-volunteer subjects may not have been captured in our study. In spite of these limitations, the findings from this study provide useful insights into the risk perceptions of U.S. international travelers and how these predict adoption of three recommended personal protective behaviors. Individuals and groups charged with instructional design of health promotion messages for control and prevention of mosquito-borne infectious diseases would find the information valuable, as they plan and develop content for mosquito-borne disease prevention and control interventions.

Conflict of interest disclosures

The authors whose names are listed on this article certify that they have NO affiliations or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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