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Pre-West Nile Virus Outbreak: Perceptions and Practices to Prevent Mosquito Bites and Viral Encephalitis in the United States

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ABSTRACT

Mosquitoes can transmit over 100 of the viruses that can cause encephalitis, meningitis, and hemorrhagic disease in humans (Chin 2000; Gubler 1996; Monath 1989). While much is known about the ecology, epidemiology, and clinical manifestations of the arboviral encephalitides (Campbell et al. 2002; Centers for Disease Control and Prevention 1997; Gubler 1998; Hayes 1989; Hubálek and Halouzka 1999), little empirical research exists regarding the U.S. population's knowledge of mosquitoes and arboviral encephalitis, particularly prior to the U.S. outbreak of West Nile virus (WNV) in 1999. A nationally representative 55-item survey instrument was successfully administered to 1,500 adults in the United States and an additional 250 adults in six states in the Northeast (Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island) regarding mosquitoes and mosquito-borne viral encephalitis. A summary outcome measure for mosquito bite prevention was created. Analyses revealed that the following were statistically significant predictors of behaviors taken to prevent mosquito bites: being concerned about being bitten by mosquitoes, perceived effectiveness of staying indoors in late afternoon and early evening was protective, perceived effectiveness that mosquito repellent is not harmful to health, owning dogs and/or cats as pets, being married, and being ≥18–44 years old. Being concerned about being bitten by mosquitoes was the most robust predictor of behavioral action to prevent mosquito bites (OR = 7.3; 95% CI = 4.3, 12.2). Observed misperceptions and inadequate knowledge regarding insect repellents suggest increased promotion of the safety and efficacy of DEET-containing insect repellents is warranted. Key words: Mosquitoes—West Nile virus—Encephalitis—Vector-borne—DEET—Insect repellent—Risk perceptions. Vector-Borne Zoonotic Dis. 3, 157–173.

INTRODUCTION

MOSQUITOES CAN TRANSMIT over 100 of the viruses that can cause encephalitis, meningitis, and hemorrhagic disease in humans (Chin 2000; Gubler 1996; Monath 1989). These "arboviruses" (**ar**thropod-**bo**rne viruses) exist in a intricate natural life cycle that involves nonhuman vertebrate hosts, such as birds, and arthropod vectors, such as a mosquitoes (Gubler 1996; Monath 1989). Female mosquitoes acquire the viruses while taking a bloodmeal (male mosquitoes feed on plant nectar) from vertebrate hosts and then transmit the viruses to other vertebrates, such as birds, horses, and humans, during subsequent blood feeding (Nasci et al., 1993; Nasci and Moore CG 1998). In some mosquito species, transovarial transmission occurs whereby viruses are passed to the female's eggs. The emergent mosquitoes are then infective without having taken a bloodmeal from a viremic host (Nasci et al. 1993; Nasci and Moore 1998).

Passive arboviral surveillance data collected

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in the United States reported 8,433 cases of arboviral encephalitis from 1964 through 2001, of which St. Louis encephalitis comprised 54.1% of reported cases; LaCrosse encephalitis, 34.5%, Western equine encephalitis, 7.6%, eastern equine encephalitis, 2.3%, and West Nile virus encephalitis, 1.5%, respectively. Until recently, St. Louis encephalitis and LaCrosse encephalitis infections were the most frequently reported of the five major encephalitides in the United States, with an annual mean of 121 and 75 cases, respectively, for the 38-year period 1964–2001 (Fig. 1) (Campbell 2003; Campbell et al. 2002; Centers for Disease Control and Prevention [CDC] 2002a, 2002b). The National Electronic Telecommunications System for Surveillance does not collect mortality data for arbovirus infection; hence, case-fatality rates for mosquito-borne illness in the United States are not routinely available (CDC 1995).

In August 1999, an arboviral encephalitis outbreak was recognized in New York City and in contiguous counties in New York State. Analysis of virus recovered from human, avian, and mosquito samples revealed West Nile virus encephalitis (WNV), an agent (Shope 1999) previously not known to occur in North America (CDC 1999a, 1999c; Hayes 1989; Hubálek and Halouzka 1999). By November 1999, 56 (31 confirmed and 25 probable) cases of WNV infection had been identified, including seven deaths (12.5% case fatality rate) (CDC, 1999a). WNV was found to overwinter in mosquito vectors, primarily Culex species, in the Northeastern (NE) United States (CDC, 2000b, 2000d). Active surveillance in 1999 for WNV in 17 states along the Eastern Seaboard and Gulf of Mexico revealed WNV infection in mosquitoes, sentinel chicken flocks, wild birds, and potentially susceptible mammals, such as horses and humans (CDC 2000e). Researchers correctly anticipated that in 2001 widespread WNV epizootic activity would most likely persist and expand in the United States with pos-

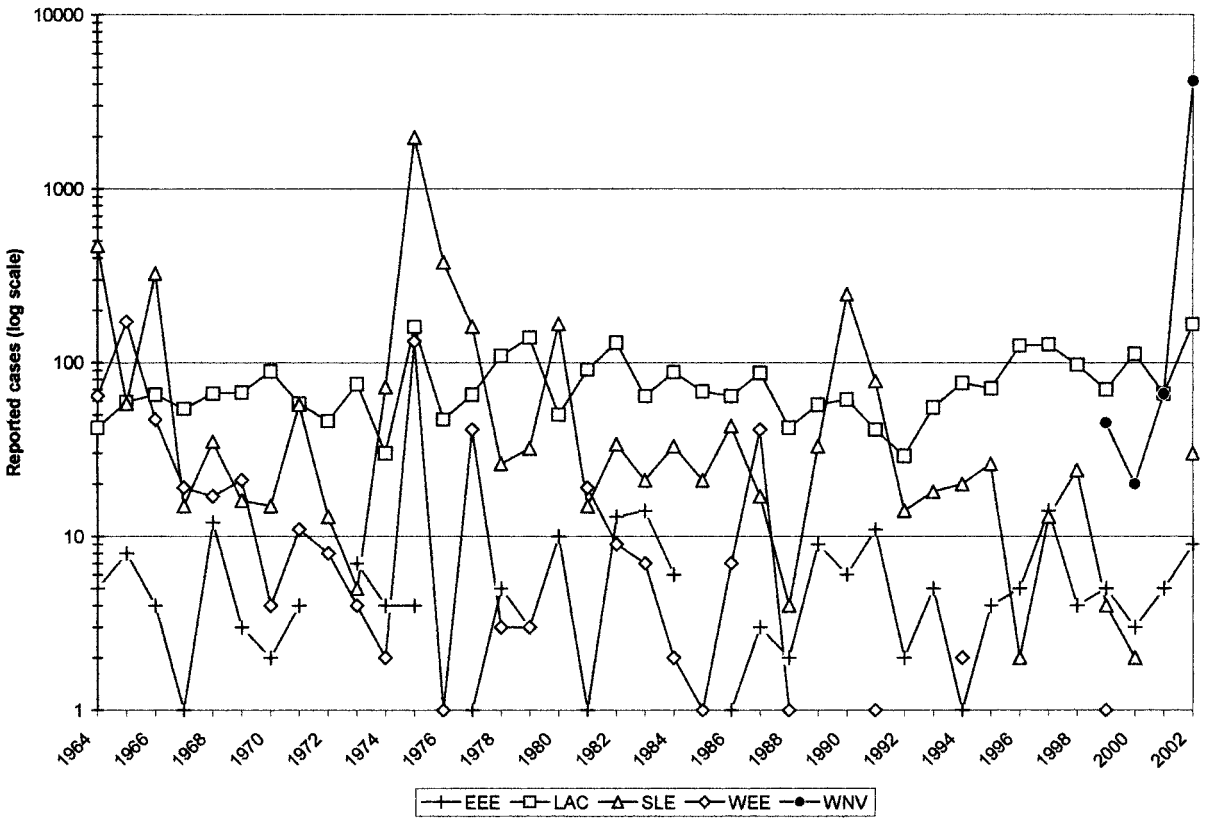

FIG. 1. Reported cases of eastern equine encephalitis (EEE), Lacrosse encephalitis (LAC), St. Louis encephalitis (SLE), Western equine encephalitis (WEE), and West Nile virus encephalitis (WNV), United States, 1964–2002 (Centers for Disease Control and Prevention 2002; Campbell 2003). Note: 2002 data are provisional.

sibly larger outbreaks of WNV infection and human illness (CDC 2000a).

During the 40-month period from August 1999 through December 2002, 4,287 persons from 40 states had confirmed cases of WNV illness, of whom 295 died (case-fatality rate: 6.9%) (Campbell 2003; Campbell et al. 2002). Although all persons residing in areas where WNV has been identified are potentially at risk, severe neurological disease occurs most frequently in persons ≥50 years old (Peterson and Marfin 2002). Onset of illness has generally been in late August and early September, although cases have been reported as early as mid-July and as late as early December (CDC 2000f, 2000g, 2001).

Although much is known about the ecology, epidemiology, and clinical manifestations of the arboviral encephalitides (Campbell et al. 2002; CDC 1997; Gubler 1998; Hayes 1989; Hubálek and Halouzka 1999), little empirical research exists regarding U.S. adults' knowledge of mosquitoes and arboviral encephalitis, their perceptions regarding the severity of and susceptibility to mosquito-borne infections, and their perceptions about the effectiveness of practices to prevent mosquito bites as recommended by federal (CDC 2000a), state (Connecticut Department of Environmental Protection 2002), and local government agencies (New York City Department of Health 2001) and national medical associations (Fradin 1998). Thus, the purpose of this paper is to describe, prior to the WNV outbreak of 1999, the prevalence of U.S. adults' perceptions and practices regarding the prevention of mosquito bites and arboviral encephalitis (Chin 2000; Fradin and Day 2002).

MATERIALS AND METHODS

In collaboration with the United States Centers for Disease Control and Prevention (CDC), a national survey on vector-borne infectious diseases was developed and administered by the Survey Research Center, University of Maryland at College Park (Survey Research Center 1998). The 55-item instrument was based on extensive focus-group research and pretesting (Survey Research Center 1997) and was administered using a computer-assisted telephone interview system. As part of larger national study described elsewhere (Herrington 2002), this study drew two samples: a cross-section, designed to yield 1,500 interviews from the 48 contiguous states plus the District of Columbia, and an over sample, designed to yield 250 additional interviews, from six northeastern (NE) states (Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island) with high incidence of reported cases of Lyme disease, a tick-borne spirochetal infectious disease (CDC 2000c).

In 1998, the WNV epizootic in the New York City metropolitan area had not yet occurred (CDC 1999a, 1999c). Serendipitously for this study, the over sampled NE states were also affected by the 1999 WNV epizootic (Campbell et al. 2002; CDC 2002b). Thus, the over sample and national data sets provide a unique baseline of knowledge, perceptions, and behaviors of U.S. adults regarding mosquitoes and arboviral encephalitis prior to the 1999 WNV epizootic that began in and subsequently spread from the NE United States. Post stratification design weights were developed for the demographic variables of sex, age, education, race, and census region to correct the sample distributions to resemble those of the U.S. population.

SPSS statistical software (version 9.01) was used to perform univariate and multivariate analyses. The chi-square statistic, with Yates correction (Fleiss 1981), was used to compare proportions in 2×2 and $2 \times n$ tables that considered the full United States sample, the United States sample excluding Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island (non-NE states), and the stratum that included the over sampled states of Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island (NE states).

The variables of interest addressed by this study reflect thematic areas common to theories of health behavior, namely, levels of knowledge about a given hazard, perceived severity of the hazard, perceived susceptibility of others and oneself to the hazard, and perceived effectiveness of recommended measures to prevent exposure to a hazard (Ajzen and

Fishbein 1980; Bandura 1977; Bandura 1995; Becker 1974; Conners and Norman 1996; Green and Kreuter 1991; Janz and Becker 1984; Weinstein 1988; Weinstein 1993; Weinstein and Sandman 2002). Sociodemographic variables were also addressed, including newspaper readership and frequency, sources of news information, cat and dog ownership, international travel, education level, age, Hispanic origin, employment status, race, marital status, household size, residence type, urbanicity of residence, length of residence occupancy, health insurance status of respondent and respondent's household, household income, number of telephone numbers in the residence, and gender.

Statistically significant ($p < 0.25$) and behaviorally plausible independent variables were dichotomized and entered into a logistic regression model simultaneously (Homser and Lemeshow 1989; Menard 1995). Concurrently, sociodemographic variables shown to be statistically significant were also entered into the logistic regression equation. Logistic regression analyses were performed in order to ascertain, within a 95% level of confidence while controlling for possible confounding factors, those independent variables that would be predictive of respondents' self-reported mosquito-bite prevention practices.

Further, a summary outcome measure was developed to represent the combination and frequency of performing specific behaviors to prevent mosquito bites. Those respondents who indicated they had done something to prevent mosquito bites were asked whether and how often they preformed specific behaviors. The mosquito bite prevention summary measure represents the sum of the behavioral variables plus the frequency of action variables, yielding an individual action score ranging from 0, for performing none of the behaviors, to 11, for performing all the behaviors with more than occasional frequency. The summary measure was then dichotomized such that a score of ≥ 1 reflected a respondent who performed at least one or more behaviors more than occasionally and <1 reflected a respondent who did nothing to prevent mosquito bites.

Sample description

The overall study sample of 1,750 eligible persons was predominately White (84.1%) and consisted of an almost equal number of men (47%) and women (53%) and had a greater proportion of married persons (60.7%). About half of the sample was employed full-time (54.5%) and reported having completed high school (51.1%). Almost three-fourths lived in single family homes (71.7%) with an average length of occupancy of 11.8 years. The majority of respondents reported having an annual household income of at least $50,000 (54.8%). The average age of respondents was 45 years. About 14% of respondents indicated their families had no health insurance.

RESULTS

For the U.S. cross-sectional sample, interviewers dialed 4,200 random telephone numbers and successfully interviewed 1,489 eligible persons ≥ 18 years living in private residences, yielding a 60% cross-sectional response rate (completed interviews divided by 2,466 eligibles, less 504 refusals, 332 not-at-homes, and 141 miscellaneous problems, such as non-English-speaking respondents). For the NE states over-sample, interviewers made 800 random telephone calls and successfully interviewed 261 eligible persons ≥ 18 years living in private residences, yielding an over sample response rate of 52% (completed interviews divided by 499 eligibles, less 107 refusals, 102 not-at-homes, and 29 miscellaneous problems, such as non-English-speaking respondents). The "next birthday" selection method was used such that the interviewer asks to speak with the person who will next celebrate a birthday, thereby randomly sampling within a household of >1 persons and thus reducing potential bias associated with whoever customarily answers the telephone (Oldendick et al. 1988). The overall sample standard error was 2.9%.

Among U.S. residents, 76.8% had seen mosquitoes the previous summer, primarily in the respondent's state. Forty-three percent said they were somewhat concerned to very con-

cerned about being bitten by mosquitoes. A total of 922 (68.8%) respondents reported they did something to avoid being bitten, of whom 80.5% reported using an insect repellent. Nearly all (91.4%) reported using insect repellent on their skin with about one-fourth stating that they used insect repellent on their skin "often." When all 1,750 respondents were asked if they thought using insect repellent was effective, 84.5% stated it was a somewhat effective to very effective method for preventing mosquito bites (Table 1). Juxtaposed against these favorable perceptions regarding the effectiveness of insect repellent, 45.2% of all 1,750 respondents stated they thought it was somewhat likely to very likely that using an insect repellent could make an adult sick. Among those 600 respondents with children, 56.2% said it was somewhat likely to very likely that a repellent could make a child sick. However, only 15.8% of respondents who used an insect repellent were certain that it did or did not contain DEET (Table 1).

Of the 922 respondents who stated they did something to avoid being bitten by mosquitoes, about the same percentage, 41.9% and 41.6%, respectively, said they stayed indoors in the late afternoon/early evening and/or wore long sleeves and long pants. Slightly less than half (47.6% and 46.4%, respectively) of these respondents said they did these behaviors "often." When all 1,750 respondents were asked if they thought staying indoors during late afternoon and early evening and/or wearing long sleeves and long pants was effective, 77.6% and 79.6%, respectively, said these were somewhat effective to very effective methods for preventing mosquito bites.

Of the 922 who took preventive measures, 251 (27.5%) reported taking additional precautions to avoid mosquito bites. Of these open-ended responses, the most commonly cited included burning/using citronella candles (Jensen et al. 2000; Lindsay et al. 1996; Matsuda et al. 1996; U.S. Environmental Protection Agency 1999), spraying insecticide, emptying/draining water sites, and using Avon Skin-So-Soft, a bath oil (Fradin and Day 2002; Lindsay et al. 1996).

Regarding encephalitis, 56.7% of U.S. respondents reported having heard of the illness. Of these, 34.6% reported that television was their primary source, 15.6% newspapers, 13.3% magazines, 8.2% doctors, and 1.1% radio. Over 22% of respondents reported that their primary source for information on encephalitis was from "somewhere else," which included friends, family members, co-workers, books, or personal experience.

Respondents who had heard about encephalitis were also asked to estimate their likelihood of ever getting the illness. Using a continuous scale of 0 (never) to 100 (definitely), a total of 823 (83%) stated their likelihood of ever getting encephalitis was 50 or less on the 100-point scale ($\bar{x} = 24$; SD = 22.8), while 118 (12%) said they did not know. The 272 respondents who had heard about encephalitis and had children were also asked to estimate a child's likelihood of ever getting encephalitis. Using the same continuous scale, 80% stated their children's likelihood of ever getting encephalitis was 50 or less on the 100-point scale ($\bar{x} = 29$; SD = 23.1), while 30 (11%) stated they did not know. No differences were observed between the U.S., non-NE states, and the NE states samples.

Crude odds ratios (OR) and 95% confidence intervals (CI) were calculated for univariate relationships between self-reported behavior to prevent mosquito bites and select independent variables (Table 2). Being somewhat concerned to very concerned about being bitten by mosquitoes was the factor found across all three sample groups to be statistically significantly associated with adopting preventive measures to prevent mosquito bites (Table 2).

Multivariate analyses

Several factors emerged from the logistic regression analyses that were predictive of respondents' self-reported practices to prevent mosquito bites. Also, some differences were observed between the NE states, the non-NE states, and the U.S. sample. For all three sample groups, the most robust predictor of preventive behavior was being somewhat concerned to very concerned about being bitten by mosquitoes (Table 3). In other words, respon-

Table 1. Frequencies Regarding Knowledge, Attitudes, and Practices Regarding Mosquitoes and Encephalitis by Sample

	Number (%)		
Variable	*U.S. (maximum n = 1750)*	*U.S., excluding six NE states (maximum n = 1247)*	*NE states (maximum n = 503)*
Knowledge			
Saw mosquitoes last summer	1341 (76.8)	969 (77.9)	364 (72.3)
In respondent's state	965 (71.9)	699 (72.1)	257 (70.6)
Has heard about encephalitis	992 (56.7)	709 (57.2)	286 (56.9)
Perceived susceptibility			
Somewhat concerned to very concerned about being bitten by mosquitoes	576 (43.0)	417 (43.1)	151 (41.8)
Perceived severity			
Knows someone who has had encephalitis	154 (15.6)	111 (15.7)	44 (15.3)
Knows how someone gets encephalitis	438 (44.1)	320 (45.2)	115 (40.3)
Encephalitis is an extremely serious illness	348 (35.1)	240 (33.9)	113 (39.5)
Encephalitis is an extremely serious illness for your children (asked of respondents with children)	141 (51.9)	100 (51.5)	42 (52.9)
Practices			
Did something to avoid mosquitoes	922 (68.8)	682 (70.6)	224 (61.7)
Used repellent to avoid bites	742 (80.5)	547 (80.2)	185 (82.5)
Used repellent on skin	679 (91.4)	501 (91.7)	166 (90.0)
Often on skin	177 (26.1)	135 (27.0)	33 (20.0)
Used repellent on clothes	437 (58.9)	327 (59.8)	103 (55.7)
Often on clothes	118 (27.1)	91 (27.8)	22 (21.3)
Stayed indoors late afternoon and evenings	386 (41.9)	289 (42.5)	85 (38.2)
Often stayed indoors	184 (47.6)	142 (49.2)	31 (36.0)
Wore long sleeves and pants	383 (41.6)	289 (42.4)	85 (38.1)
Often wore long sleeves and pants	177 (46.4)	135 (46.9)	34 (39.6)
Took additional measures to avoid mosquitoes	251 (27.5)	183 (26.9)	62 (28.5)
Perceptions of recommendations			
Using insect repellent is somewhat effective to very effective	1479 (84.5)	1058 (84.8)	420 (83.4)
Staying indoors in late afternoon and evening is somewhat effective to very effective	1358 (77.6)	977 (78.3)	370 (73.5)
Wearing long pants/sleeves is somewhat effective to very effective	1393 (79.6)	994 (79.7)	398 (79.1)
It is somewhat likely to very likely that using insect repellent can make you sick	735 (45.2)	517 (44.4)	222 (48.2)
It is somewhat likely to very likely that using insect repellent can make your children sick (asked of respondents with children)	317 (56.2)	213 (54.2)	114 (63.8)
Repellent used contained the chemical DEET			
Yes	125 (15.8)	90 (15.6)	38 (19.0)
No	147 (18.6)	107 (18.5)	37 (18.2)
Don't know/not sure	516 (65.5)	381 (65.9)	126 (62.7)

dents were much more likely to use insect repellent to avoid mosquito bites, to use insect repellent on their skin, to use insect repellent on their clothes, to stay indoors in late afternoon and early evening, to wear long sleeves and long pants, and to report that they took additional actions to prevent mosquito bites, when compared with the referent group of respondents who said that they were not too concerned or not at all concerned about being bitten by mosquitoes. Thus, a high level of perceived susceptibility about being bitten by mosquitoes was the only independent variable that was strongly predictive of all seven dependent variables considered across all three sample groups. By contrast, knowledge levels of encephalitis and perceived severity of the disease were generally poor predictors of preventive behavior (Table 3). However, positive perceptions about the recommendation to stay indoors in late afternoon and early evening were observed to be predictive of this behavior across all three samples. Further, positive perceptions about the recommendation to wear long sleeves and long pants reduced the likelihood that a respondent would use insect repellent on their skin or stay indoors in the late afternoon and early evening. Most interestingly, and in line with intuitive expectations, respondents who stated that it was unlikely that insect repellent could make them sick were significantly more likely to use insect repellent on their skin and less likely to stay indoors in the late afternoon and early evening, when compared with the referent group of respondents who said that it was somewhat likely or very likely that insect repellent could make them sick (Table 3).

Certain sociodemographic and lifestyle factors also appear predictive of respondents' adopting precautions to prevent mosquito bites. Pet ownership (dogs and/or cats) among U.S. respondents was statistically significant in predicting use of insect repellent, use of insect repellent on clothes, and taking additional measures to prevent mosquito bites. Similar results were observed for respondents from the non-NE states. For the NE states group, respondents who said they owned pets were more likely to use insect repellent on skin than were respondents who reported not owning pets (neither dogs nor cats) (Table 3). Respondents who reported being married were more likely to adopt precautions to prevent mosquito bites, as measured by the mosquito bite prevention summary measure, to use insect repellent on skin, and to use insect repellent on clothes, when compared with respondents who reported not being married, that is, were separated, divorced, widowed, or never married. Respondents who reported living in a city or suburb were also more likely to use insect repellent, to use insect repellent on skin, and to use insect repellent on clothes, when compared with respondents who reported living in a small town or rural area (Table 3).

Respondents' ≥18–44 years old were more likely to use insect repellent on skin, use insect repellent on clothes, but less likely to stay indoors during late afternoon and early evening, when compared with the referent group ≥45 years old. Respondents from the United States sample who reported being white, as compared with the referent group of non-white respondents, were more likely to use insect repellent. However, white respondents from the non-NE states were slightly less likely to stay indoors in late afternoon and evening, than non-white respondents. Having known someone who had encephalitis, reporting that the insect repellent used contained DEET, and being a regular newspaper reader were not statistically significant predictors of any of the dependent variables considered (Table 3).

DISCUSSION

From a behavioral epidemiologic perspective, it is important to understand what factors best predict preventive measures against mosquito bites. As a snapshot in time prior to the WNV outbreak in late 1999, this point prevalence study establishes a baseline of factors that appear to predispose and influence an individual's taking one or more preventive measures against mosquito bites. Knowing what factors are most or least predictive can help public health prevention programs be more effective in designing targeted educational and behavioral interventions.

These survey results indicate that three-

Table 2. Crude Odds Ratios for Select Independent Variables and the Outcome Variable of Self-Reported Behavior to Prevent Mosquito Bites, United States, 1998 (Cont'd)

	U.S. (n = *1750*)		*U.S., excluding NE states* (n = *1247*)		*NE states* (n = *503*)	
Variable	N *(%)*	*OR (95% CI)*[a]	N *(%)*	*OR (95% CI)*	N *(%)*	*OR (95% CI)*
KNOWLEDGE						
Saw mosquitoes last summer in own state or elsewhere:						
Yes	834 (90.7)	1.34 (0.92, 1.93)*	619 (91.0)	1.44 (0.93, 2.24)*	198 (88.4)	0.99 (0.51, 1.92)
No	86 (9.3)		61 (9.0)		26 (11.6)	
Has heard about encephalitis:						
Yes	549 (59.8)	1.27 (1.01, 1.61)**	401 (59.1)	1.28 (0.97, 1.69)*	148 (66.4)	1.46 (0.94, 2.25)*
No	369 (40.2)		278 (40.9)		75 (33.6)	
PERCEIVED SUSCEPTIBILITY						
Somewhat concerned to very concerned to be bitten by mosquitoes:						
Yes	501 (54.3)	5.35 (4.03, 7.09)****	363 (53.2)	4.92 (3.52, 6.87)****	131 (58.5)	8.31 (4.83, 14.31)****
No	421 (45.7)		319 (46.8)		93 (41.5)	
On scale 0 = never and 100 = definitely, likelihood respondent will ever get encephalitis:						
0–50	454 (94.6)	0.55 (0.22, 1.35)*	332 (93.8)	0.58 (0.22, 1.58)	122 (99.2)	0.63 (0.57, 0.71)
51–100	26 (5.4)		22 (6.2)		1 (0.8)	
On scale 0 = never and 100 = definitely, likelihood respondent's children will ever get encephalitis:						
0–50	156 (88.6)	0.67 (0.16, 2.01)	114 (88.4)	0.52 (0.11, 2.42)	41 (89.1)	0.77 (0.67, 0.90)
51–100	20 (11.4)		15 (11.6)		5 (10.9)	
PERCEIVED SEVERITY						
Knows someone who has had encephalitis:						
Yes	84 (15.4)	0.93 (20.61, 1.43)	61 (15.3)	0.94 (0.56, 1.57)	25 (16.8)	1.14 (0.54, 2.42)
No	463 (84.6)		338 (84.7)		124 (83.2)	
Knows how someone gets encephalitis:						
Yes	248 (45.1)	0.99 (0.73, 1.36)**	185 (46.3)	0.59 (0.22, 1.58)**	59 (39.9)	0.63 (0.57, 1.58)
No	302 (54.9)		215 (53.8)		89 (60.1)	

Encephalitis is a somewhat serious to extremely serious illness:						
Yes	432 (87.3)	1.66 (1.07, 2.58)	315 (87.3)	1.78 (1.05, 3.00)	118 (88.1)	1.35 (0.59, 3.10)
No	63 (12.7)		46 (12.7)		16 (11.9)	
Encephalitis is extremely serious illness for your children (asked of respondents with children):						
Yes	164 (93.7)	1.24 (0.33, 4.77)	120 (93.8)	1.25 (0.25, 6.26)	43 (93.5)	1.10 (0.11, 11.52)
No	11 (6.3)		8 (6.3)		3 (6.5)	
PERCEPTIONS OF RECOMMENDATIONS						
Using insect repellent is somewhat effective to very effective:						
Yes	829 (92.5)	2.01 (1.38, 2.94)****	618 (93.2)	2.34 (1.48, 3.69)****	196 (89.5)	1.33 (0.69, 2.58)
No	67 (7.5)		45 (6.8)		23 (10.5)	
Staying indoors in late afternoon and evening somewhat effective to very effective:						
Yes	776 (86.0)	1.95 (1.45, 2.62)****	579 (86.9)	2.02 (1.41, 2.89)****	178 (80.2)	1.57 (0.95, 2.58)*
No	126 (14.0)		87 (13.1)		44 (19.8)	
Wearing long pants/sleeves somewhat effective to very effective:						
Yes	740 (80.8)	0.86 (0.64, 1.17)	584 (80.8)	0.91 (0.64, 1.31)	178 (80.2)	0.65 (0.36, 1.16)*
No	176 (19.2)		130 (19.2)		44 (19.8)	
It is somewhat to very likely that using insect repellent can make you sick:						
Yes	402 (45.9)	1.23 (0.97, 1.57)*	291 (44.9)	1.29 (0.91, 1.63)*	106 (50.5)	1.42 (0.91, 2.20)*
No	473 (54.1)		357 (51.1)		104 (49.5)	
It is somewhat to very likely that using insect repellent can make children sick (asked of respondents with children):						
Yes	201 (57.9)	0.97 (0.65, 1.46)	142 (56.6)	0.91 (0.56, 1.48)	58 (63.7)	1.42 (0.69, 2.91)
No	146 (42.1)		109 (43.4)		33 (36.3)	
Repellent used contained the chemical DEET:						
Yes	120 (16.0)	0.72 (0.26, 1.97)	89 (16.1)	2.68 (0.35, 20.64)	32 (17.3)	0.25 (0.07, 0.87)**
No	631 (84.0)		465 (83.9)		153 (82.7)	

(*continued*)

TABLE 2. CRUDE ODDS RATIOS FOR SELECT INDEPENDENT VARIABLES AND THE OUTCOME VARIABLE OF SELF-REPORTED BEHAVIOR TO PREVENT MOSQUITO BITES, UNITED STATES, 1998 (CONT'D)

	U.S. (n = *1750)*		*U.S., excluding NE states* (n = *1247)*		*NE states* (n = *503)*	
Variable	N *(%)*	*OR (95% CI)*[a]	N *(%)*	*OR (95% CI)*	N *(%)*	*OR (95% CI)*
SOCIODEMOGRAPHICS						
Reads newspaper four or more days per week:						
Yes	443 (70.8)	0.70 (0.51, 0.97)**	325 (70.2)	0.67 (0.46, 1.00)*	37 (23.7)	0.92 (0.52, 1.63)
No	183 (29.2)		138 (29.8)		156 (100)	
Respondent has only dogs as pets:						
Yes	260 (42.3)	1.49 (1.11, 1.20)***	196 (43.2)	1.50 (1.06, 2.12)**	56 (37.3)	1.35 (0.80, 2.27)
No	356 (57.7)		258 (56.8)		84 (62.7)	
Respondent has only cats as pets:						
Yes	131 (27.0)	1.61 (1.10, 2.35)**	88 (17.3)	1.41 (0.89, 2.22)*	50 (34.7)	2.93 (1.51, 5.69)***
No	355 (73.0)		258 (74.6)		94 (65.3)	
Respondent has dogs and cats:						
Yes	174 (32.9)	1.45 (1.04, 2.01)**	140 (35.2)	1.40 (0.96, 2.06)	22 (19.0)	1.29 (0.62, 2.68)
No	355 (57.1)		258 (64.8)		94 (81.0)	
Respondent has been to: Asia/Africa/ South America:						
Yes	141 (15.3)	0.83 (0.61, 1.13)	103 (15.1)	0.79 (0.55, 1.14)*	36 (16.2)	1.03 (0.58, 1.84)
No	779 (84.7)		578 (84.9)		186 (83.8)	
Employment status:						
Full time:						
Part time						
Not employed	651 (72.4)	1.06 (0.82, 1.38)	487 (73.5)	1.05 (0.77, 1.44)	148 (57.0)	1.05 (0.67, 1.64)
	248 (27.6)		176 (26.5)		73 (33.0)	
Marital status:						
Married	594 (66.3)	1.65 (1.30, 2.10)****	439 (66.4)	1.69 (1.27, 2.25)****	140 (63.9)	1.36 (0.88, 2.12)*
Other	302 (33.7)		222 (33.6)		79 (36.1)	
Type of home:						
Single house	675 (75.5)	1.39 (1.07, 1.80)*	514 (77.6)	1.55 (1.13, 2.12)**	138 (63.9)	0.81 (0.51, 1.29)
Other	219 (24.5)		148 (22.4)		78 (36.1)	
Location where respondent lives:						
City	274 (54.4)	0.96 (0.71, 1.31)	212 (57.5)	1.02 (0.70, 1.48)	53 (40.5)	0.80 (0.46, 1.38)
Suburb	230 (45.6)		157 (42.5)		78 (59.5)	

Location where respondent lives:						
City	274 (58.3)	0.80 (0.58, 1.13)*	212 (69.7)	0.90 (0.58, 1.29)	53 (52.0)	0.59 (0.31, 1.14)*
Small town	196 (41.7)		143 (40.3)		49 (48.0)	
Location where respondent lives:						
City	274 (57.9)	0.87 (0.62, 1.20)	212 (58.1)	0.88 (0.60, 1.30)	53 (58.2)	0.98 (0.52, 1.85)
Rural area	199 (42.1)		153 (41.9)		38 (41.8)	
Location where respondent lives:						
Suburb	230 (54.0)	0.85 (0.59, 1.19)	157 (52.3)	0.85 (0.56, 1.29)	78 (61.4)	0.74 (0.40, 1.38)
Small town	196 (46.0)		143 (47.7)		49 (38.6)	
Location where respondent lives:						
Suburb	230 (53.6)	0.91 (0.64, 1.27)	157 (50.6)	0.87 (0.58, 1.31)	79 (67.2)	1.22 (0.67, 2.24)
Rural area	199 (46.4)		153 (49.4)		38 (32.8)	
Location where respondent lives:						
Small town	196 (49.6)	1.07 (0.74, 1.55)	143 (48.3)	1.20 (0.66, 1.57)	49 (56.3)	1.64 (0.81, 3.31)*
Rural area	199 (50.4)		153 (51.7)		38 (43.7)	
Years respondent has lived at current residence:						
≤10 years	672 (82)	1.09 (0.79, 1.49)	502 (83.0)	1.12 (0.76, 1.64)	156 (77.2)	0.99 (0.58, 1.69)
11 years +	148 (18)		103 (17.0)		46 (22.8)	
Respondent family is covered by health insurance:						
Yes	729 (87.0)	1.03 (0.71, 1.49)	540 (87.2)	0.92 (0.58, 1.46)	173 (85.2)	1.19 (0.64, 2.21)
No	109 (13.0)		79 (12.8)		30 (14.8)	
Respondent's age:						
18 to 44 years	539 (60.8)	1.11 (0.88, 1.42)	400 (60.9)	1.08 (0.81, 1.43)	128 (60.4)	1.28 (0.82, 2.00)
≥45 years	347 (39.2)		257 (39.1)		84 (39.6)	
Responent's race:						
White	772 (85.7)	1.01 (0.72, 1.41)	569 (85.6)	1.07 (0.73, 1.59)	191 (86.8)	0.81 (0.42, 1.57)
Other	129 (14.3)		96 (14.4)		29 (13.2)	
Respondent's level of education:						
≤High school	429 (47.1)	0.81 (0.64, 1.03)*	315 (46.7)	0.75 (0.56, 0.99)**	109 (49.5)	1.14 (0.75, 1.78)
>Some college	482 (52.9)		360 (53.3)		111 (50.5)	
Household income:						
≤$50,000	364 (51.6)	0.84 (0.64, 1.10)*	276 (53.2)	0.84 (0.61, 1.18)	76 (42.9)	0.74 (0.45, 1.21)
>$50,001	341 (48.4)		243 (46.8)		101 (57.1)	
Respondent's sex:						
Female	407 (44.1)	0.60 (0.48, 0.76)****	309 (45.3)	0.92 (0.58, 1.46)	96 (42.9)	1.19 (0.64, 2.21)
Male	515 (55.9)		373 (54.7)		128 (57.1)	

[a]OR = crude odd ratio and 95% confidence interval.
*$p < 0.25$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$.

Table 3. Logistic Regression Analysis Predicting Several Self-Reported Behaviors to Prevent Mosquito Bites and a Summary Outcome Measure, United States, 1998 (Cont'd)

Predictor variables	*Sample*[b]	*Individual behaviors (OR, 95% CI)*[a]						
		Used repellent to avoid bites	*Used repellent on skin*	*Used repellent on clothes*	*Stayed indoors late afternoon and evenings*	*Wore long sleeves and long pants*	*Took additional measures to avoid mosquitoes*	*Mosquito bite prevention summary measure*[c]
KNOWLEDGE								
Knows how someone gets encephalitis (Y/N)	I					0.66 (0.45, 0.97)*		
	II					0.64 (0.41, 0.99)*		
Perceived susceptibility								
Somewhat concerned to very concerned to be bitten by mosquitoes (Y/N)	I	3.56 (2.40, 5.28)***	3.29 (2.24, 4.83)***	3.11 (2.13, 4.54)***	3.58 (2.42, 5.30)***	3.52 (2.39, 5.18)***	2.46 (1.61, 3.75)***	7.26 (4.31, 12.23)***
	II	3.10 (1.95, 4.94)***	2.93 (1.87, 4.60)***	2.85 (1.83, 4.45)***	3.38 (2.13, 5.36)***	3.14 (2.00, 4.93)***	2.58 (1.57, 4.24)***	6.38 (3.45, 11.79)***
	III	10.18 (4.03, 25.74)***	7.76 (3.19, 18.88)***	4.16 (1.84, 9.38)***	7.22 (2.66, 19.63)***	6.13 (2.50, 15.04)***		20.21 (6.14, 66.51)***
PERCEIVED SEVERITY								
Encephalitis is a somewhat serious to extremely serious illness (Y/N)	I						0.53 (0.30, 0.94)*	
	II						0.15 (0.05, 0.46)***	
PERCEPTIONS OF RECOMMENDATIONS								
Using insect repellent is somewhat to very effective (Y/N)	III					0.20 (0.05, 0.82)*		
Staying indoors	I				2.80 (1.54, 5.07)***			

in late afternoon	II				2.40 (1.23, 4.67)**			
and early evening is somewhat to very effective (Y/N)	III				10.95 (2.04, 58.87)**	3.67 (1.08, 12.41)*		
Wearing long pants/sleeves is somewhat to very effective (Y/N)	I		0.56 (0.34, 0.93)*		0.58 (0.35, 0.97)*			0.40 (0.21, 0.77)**
	II							0.42 (0.19, 0.95)**
	III	0.16 (0.05, 0.52)**	0.19 (0.06, 0.59)**		0.13 (0.04, 0.45)***			0.15 (0.04, 0.53)**
Insect repellent will make you sick (N/Y)	I	1.45 (1.00, 2.12)*	1.67 (1.15, 2.43)**		0.66 (0.44, 0.97)*	0.68 (0.47, 1.00)*		
	II	1.62 (1.04, 2.52)*	1.82 (1.17, 2.83)**		0.62 (0.39, 0.98)*			
	III						0.33 (0.11, 0.88)*	
SOCIODEMOGRAPHICS								
Has dogs and/ or cats as pets (Y/N)	I	1.42 (0.98, 2.06)*		1.59 (1.10, 2.33)*			1.58 (1.02, 2.44)*	
	II			1.68 (1.07, 2.64)*			1.94 (1.14, 3.28)**	
	III		2.84 (1.23, 6.55)**					
Is married (Y/N)	I	2.07 (1.37, 3.14)***	1.80 (1.19, 2.70)**					2.81 (1.75, 4.50)***
	II	2.18 (1.34, 3.55)**	1.89 (1.17, 3.06)**	1.64 (1.00, 2.67)*				3.08 (1.77, 5.35)***
Lives in city/ suburb (Y/N)	I	1.51 (1.04, 2.19)*	1.61 (1.11, 2.32)**	1.49 (1.03, 2.16)*				
	II	1.66 (1.06, 2.59)*	1.64 (1.06, 2.54)*					
≥18–44 years (Y/N)	I		2.04 (1.41, 2.97)**	1.90 (1.30, 2.77)***	0.63 (0.42, 0.93)*			
	II	1.66 (1.06, 2.58)*	1.76 (1.13, 2.72)*	1.80 (1.16, 2.80)**	0.62 (0.39, 0.98)*			
	III	3.69 (1.54, 8.84)**	6.08 (2.55, 14.50)***	2.39 (1.09, 5.20)*				3.17 (1.20, 8.36)*
Is white (Y/N)	I	1.83 (1.25, 2.67)**						
	II				0.62 (0.39, 1.00)*			

[a]OR = adjusted odds ratio; CI = confidence interval.

[b]I = 48 coterminus states and the District of Columbia; II = 42 coterminus states and the District of Columbia (non-NE) that excludes Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island; III = Six northeastern (NE) states that includes Connecticut, Delaware, New Jersey, New York, Pennsylvania, and Rhode Island.

[c]The summary outcome measure for the prevention of mosquito bites equals the sum of six behavioral variables (where respondent stated they had performed the action coded yes = 1 and no = 0) plus the sum of four frequency of action variables (where respondent stated they had performed the action "sometimes or often vs. occasionally"; coded 1 and 0 respectively) that yielded an action score (range 0 to 10). The index measure was dichotomized and coded such that "action" equaled scores greater than or equal to 1 and no action equaled scores of 0.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$; nonsignificant data not shown.

fourths of the U.S. adult population has had experience with mosquitoes, mostly in their own state. However, less than half (43%) expressed being somewhat concerned to very concerned about being bitten by mosquitoes. Nonetheless, over 68% of respondents who had seen mosquitoes the previous summer took action to avoid being bitten. The most frequently cited behavior was the use of insect repellent on skin and clothes. Less than half of the respondents who took action reported staying indoors during late afternoon or early evenings or wearing long sleeves and long pants, practices that probably interfere with personal freedom of movement. Of the 1,750 respondents surveyed, approximately one-third perceived the following measures as very effective: insect repellent use, staying indoors during late afternoon or early evenings, and wearing long sleeves and long pants.

Clearly, those respondents from the national sample who perceived that insect repellent was unlikely to make oneself sick were 1.45 times more likely to use repellent to avoid bites (and 1.67 times to use it on their skin), when compared with respondents who had a negative perception of repellent in terms of it being potentially toxic to the user. Why was repellent use not higher? Among many possible factors, the perception of human toxicity of insect repellents appears to persist, even though DEET has an exceptional safety record after 40+ years of worldwide use (Fradin 1998). Marketing campaigns for alternative "DEET-free" repellent products are evident from a pedestrian survey of most sporting goods store shelves, even though citronella-containing products and Avon Skin-So-Soft bath oil, for example, have been shown in various controlled studies to be much less effective than DEET in preventing mosquito bites (Fradin 1998; Fradin and Day 2002; Lindsay et al., 1996; Lindsay et al. 1996). Thus, despite scientific evidence that indicates that the combination of permethrin-treated clothing and DEET applied to skin can achieve almost 100% protection against insect bites (Fradin 1998), the perceived susceptibility to toxicity from an insect repellent may outweigh a person's perceived susceptibility to encephalitis, thus, obviating use of the repellent. The behavior to adopt the use an insect repellent seems to be strongly influenced by misperceptions and a lack of knowledge, given only 16% of respondents surveyed could state with certainty whether their repellent contained DEET or not. This evidence suggests greater emphasis is needed in promoting the safety and efficacy of DEET-containing insect repellents.

A majority of the U.S. public (57%) stated that they had heard about encephalitis, mostly through television, newspapers, magazines, and friends/family, though less than 20% of respondents had known anyone who had encephalitis. Slightly more than 40% of respondents stated they knew how someone gets encephalitis, with the vast majority stating that it was caused by mosquitoes. Given that only one-third of respondents perceived that encephalitis was an extremely serious illness, and 90% stated that their chances of getting encephalitis was less than 50 on a 100-point scale, it is not surprising there were few strong knowledge, attitude, or sociodemographic predictors for taking action to prevent mosquito bites. This may reflect an overall weak perception, at the time of this survey, that the susceptibility to harm from mosquito bites was not great enough to warrant widespread adoption of preventive practices. Further, perceptions about the severity of mosquito-borne encephalitis illness appeared to be insufficient in eliciting the adoption of behaviors to prevent mosquito bites. This is not entirely unexpected, given that the real risk of arboviral encephalitis infection in the United States has been historically low, with an annual mean of 121 and 75 cases for St. Louis encephalitis and Lacrosse encephalitis, respectively, for the 38-year period 1964–2001 (Fig. 1) (CDC 2002; Campbell 2002).

However, the introduction of WNV into North America in late 1999 has undoubtedly altered the landscape of U.S. public perception regarding the potential harm that mosquitoes can cause, that is, susceptibility to infection and severity of illness. The ensuing explosion of national and local media coverage following the WNV illness outbreak generated thousands of phone requests to the New York City Health Department (Fine and Layton 1999), thousands of email requests to CDC for information on

the prevention of WNV (CDC 1999b), and a deluge of popular newspaper and magazine stories regarding WNV (Fig. 2). With the steady westward expansion of WNV illness in multiple species across the U.S., and the exponential increase in human cases of WNV encephalitis and associated human mortality between 1999 and 2002, it is assumed that the salient factors affecting U.S. adult perceptions of susceptibility to mosquitoes and the severity of viral encephalitis illness have changed. In any case, this assumption remains to be validated.

In summary, an attempt has been made to measure, from a behavioral epidemiologic perspective, the prevalence of U.S. adults' knowledge and perceptions about the severity of and susceptibility to mosquitoes and arboviral encephalitis, as well as perceptions about the effectiveness of recommended preventive behaviors that may affect the likelihood of people adopting precautions to prevent mosquito bites. As with any random-digit-dialed telephone survey, this study had limitations. Reliance on self-reported data obtained through telephone interviewing methods does not allow the interviewer to validate respondents' answers. The observed sociodemographic, lifestyle characteristics, and responses to other variables may not accurately represent their true prevalence, given a respondent may report what they perceive is socially desirable, thus confounding attempts to examine the nature of relationships between the variables under study. Further, the intrusive nature of telemarketing may deter some respondents from participating in the study, even after being recontacted by a refusal conversion specialist (Kristal et al. 1993), thus biasing the representativeness of the sample. Only respondents with telephones were interviewed. This excluded approximately 5.1% of households that did not have a telephone in the home at the time of this survey (U.S. Department of Commerce 1999), such as those that may have been economically disadvantaged or from minority populations, and may have been another potential source of selection bias. Also, the lack of a temporal sequence of events inherent in cross-sectional studies effectively limits statements about causality and causal pathways (Grimes and Schultz 2002). Finally, this study did not address the adoption of mosquito-bite preventive behavior for non-health reasons, such as the discomfort of itchy skin caused by a mosquito bite or the "annoyance" factor when confronted by hungry mosquitoes while outdoors, variables worthy of consideration in future behavioral epidemiologic research. Thus, build-

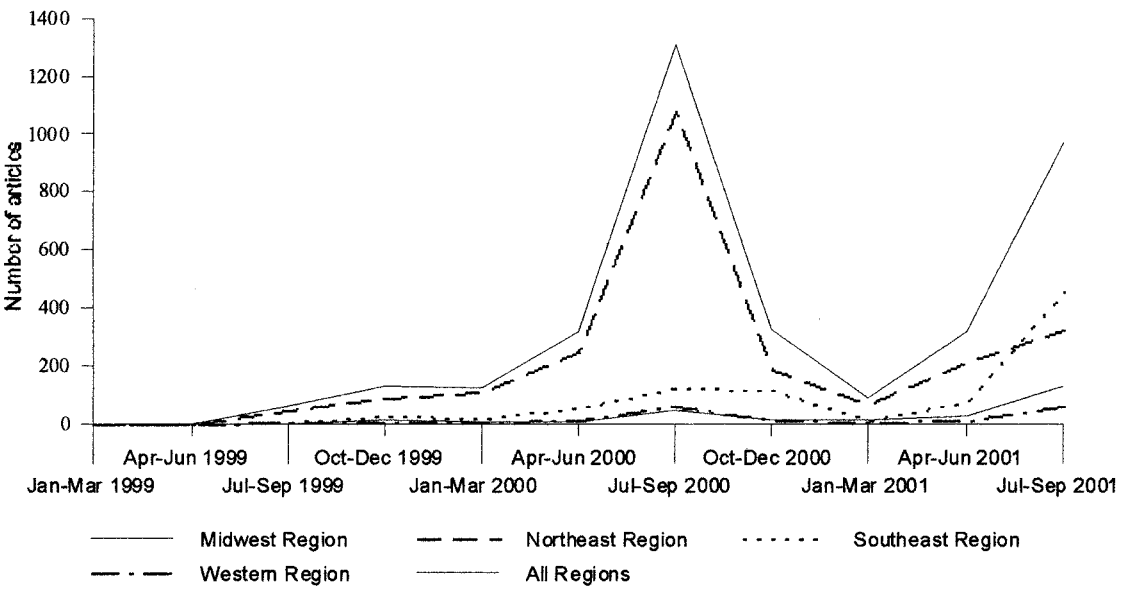

FIG. 2. Number of articles published in newspapers and magazines with keywords "West Nile virus" in the title or text body, January 1, 1999 through September 30, 2001, by Region, United States (Lexis-Nexis Academic Universe 2001).

ing from this rich baseline of data points, longitudinal studies would be invaluable in identifying regional and local behavioral trends and variance in mosquito bite and arboviral encephalitis prevention.

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