

# Exposure to West Nile Virus During the 2002 Epidemic in Cuyahoga County, Ohio: A Comparison of Pediatric and Adult Behaviors

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## SYNOPSIS

**Objectives.** Emerging evidence suggests that children are at higher risk for West Nile virus (WNV) exposure, but may have a lower risk for infection-related morbidity and mortality. Limited data exist regarding risk determinants of childhood WNV infection. We conducted a survey to analyze the differences between pediatric and adult behavior relevant to WNV exposure.

**Methods.** Residents of participating sampled households responded to a questionnaire that measured knowledge, attitudes, personal protective behaviors, and clinical history to evaluate the association between personal behavior and exposure to WNV.

**Results.** Children were more likely to have high levels of outdoor exposure compared to adults (83% vs. 70%). Children were less likely to avoid going outdoors (4% vs. 13%) and to wear long sleeves or pants compared to adults (8% vs. 19%). Both groups were highly educated about WNV. Television, not health-care provider education, was the most common source of WNV information. Participants were more concerned about WNV infection than pesticide usage.

**Conclusions.** Our study demonstrates that children exhibit behaviors that could put them at greater risk for WNV infection and suggests that children could benefit from greater education about practices that can decrease WNV exposure to limit their risk for infection.

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Since its arrival in the eastern United States in 1999, West Nile virus (WNV) has spread across North America, affecting all of the continental U.S. and parts of Canada by 2004.<sup>1,2</sup> In 2002, the State of Ohio reported intense epidemic activity with 341 cases of WNV encephalitis and/or meningitis with 31 fatalities.<sup>3,4</sup> In that same year, Cuyahoga County in Northeastern Ohio reported 221 cases of WNV illness, including 11 fatalities and 155 cases of West Nile-associated neurologic disease<sup>5</sup> (WNND), 11.1 cases/100,000 population, all ages.

At the end of 2002, Case Western Reserve University and the Cuyahoga County Board of Health conducted a systematic household-based seroprevalence survey to determine neighborhood and countywide human WNV infection rates and risk factors for infection.<sup>5</sup> Stratified survey sampling indicated that the countywide prevalence of West Nile seropositivity was 1.9% at that time. The risk of WNV infection was age-dependent, with children 4.5 times more likely to become infected yet 110 times less likely to develop neuroinvasive disease.<sup>5</sup> Our hypothesis was that children may exhibit behaviors that put them at risk for WNV infection. This report contrasts the age-specific behaviors relevant to WNV exposure during the 2002 transmission season.

## MATERIALS AND METHODS

A household survey of Cuyahoga County residents was performed from December 5–12, 2002, approximately 14 weeks after the WNV epidemic peak in Northeastern Ohio. Design details of this stratified survey sample have been previously published.<sup>5</sup> Briefly, in conjunction with the previously reported serological survey, residents of participating sampled households responded to a questionnaire that measured knowledge, attitudes, personal protective behaviors, and clinical history during the months of July, August, and September 2002. The study sample consisted of 1,209 participants from 806 households. The mean participant age was 43.2 years (based on an age range of 5–94 years). The survey used a stratified cluster sample design based on WNV information from human cases and infected mosquitoes; therefore, all percentages are weighted to account for this design. Of 1,209 participants, 168 were children <18 years of age and four (6.5%, weighted) of the children were seropositive for WNV.

To evaluate the association between personal behavior and risk for WNV infection, all participating residents were asked detailed questions regarding the amount of time spent outdoors during different times of day and the number of mosquito bites experienced, using questionnaires previously developed by the Centers for Disease Control and Prevention (CDC)<sup>6</sup>

(Figure). Personal mosquito avoidance behavior was assessed in questions involving clothing, mosquito repellent use, and outdoor area activities. Knowledge about WNV infection was determined by asking residents what and from which source they received their information about WNV. Attitude-related questions assessed how concerned subjects were about contracting WNV infection, in contrast to their concern about local pesticide usage. Institutional Review Board (IRB) approval was obtained from University Hospitals of Cleveland.

## Statistical analysis

SPSS version 11.5<sup>7</sup> was used for the preliminary analysis. Formulas that allowed weighting of the survey data were developed to account for the multistage sampling study design. Subsequently, data were analyzed using SUDAAN version 8.0.<sup>8</sup> The standard Horvitz-Thompson estimator was used to calculate point estimates. For variance estimates, all sources of variation (i.e., households within blocks, blocks within census tracts, census tracts with municipalities, and municipalities within strata) were included using standard Taylor series approximations. To calculate the confidence interval for the true prevalence ratio (PR), we took the logarithm of the sample PR, approximated its variance using standard Taylor series methodology, and formed a confidence interval for the logarithm of PR. The end points of this interval were exponentiated to obtain the interval for PR. In this report, survey results are weighted unless otherwise indicated. The adjusted variance estimates were used to test for significant differences between child and adult behaviors, with  $p < 0.05$  taken as significant.<sup>5,9</sup>

## RESULTS

### Pediatric behaviors that influence WNV infection risk: age differences in knowledge, attitudes, and practices

To investigate the apparent fivefold greater risk of WNV infection among children as compared to adults, we evaluated individual behavioral factors related to mosquito exposure and use of preventive techniques. Results of our population sample survey ( $n = 1,209$ ) indicated the following significant factors:

***Influence of outdoor activity on risk of WNV infection—day-time vs. evening.*** Greater outdoor exposure was associated with higher rates of seropositivity among survey participants. Among 886 individuals who reported spending more than 15 minutes outdoors in the day-time (8 a.m. to 5 p.m.) and more than 15 minutes in the evening (5 to 9 p.m.), 26 (2.6%) were seroposi-

**Figure. Knowledge, attitudes, and behaviors questionnaire<sup>a</sup>**

<i>On a typical day this summer, how much time did you spend outdoors during the following time periods?</i>					
Early morning (4–8 a.m.)	Less than 15 minutes	15 minutes or more			
Daytime (8 a.m.–5 p.m.)	Less than 15 minutes	15 minutes or more			
Evening (5–9 p.m.)	Less than 15 minutes	15 minutes or more			
Nighttime (9 p.m.–4 a.m.)	Less than 15 minutes	15 minutes or more			
<i>During this past July, August, and September, did you do any of the following to protect yourself from mosquitoes?</i>					
Avoid areas where mosquitoes are likely to be a problem	Always	Most of the time	Sometimes	Never	
Avoid going outdoors	Always	Most of the time	Sometimes	Never	
Wear long sleeves and long pants when outside for 15 minutes or more	Always	Most of the time	Sometimes	Never	
Wear mosquito repellent when outdoors for 15 minutes or more	Always	Most of the time	Sometimes	Never	
<i>How satisfied have you been with the local mosquito-control efforts this past summer?</i>					
	Satisfied	Neutral	Not satisfied	Don't know	
<i>This summer, did you receive any information about West Nile virus and/or how to avoid mosquito bites from the following sources:</i>					
Newspaper	Yes	No	Don't know		
Radio	Yes	No	Don't know		
TV news	Yes	No	Don't know		
Internet	Yes	No	Don't know		
Information from local health department	Yes	No	Don't know		
City newsletters	Yes	No	Don't know		
Local health-care providers	Yes	No	Don't know		
<i>During this past July, August, and September, how often were you bitten or bothered by mosquitoes on this property?</i>					
Daily	More than once a week	Once a week	Once/twice a month	Never	Don't know
<i>How worried were you about getting West Nile virus?</i>					
Very worried	A little worried	Not worried at all	Never heard of it	Don't know	
<i>How worried were you about getting exposed to pesticides used to kill mosquitoes?</i>					
Very worried	A little worried	Not worried at all	Never heard of it	Don't know	
<i>What worried you more?</i>					
Getting West Nile virus	Getting sick from pesticides	Equally worried about both	Not worried about either		

<sup>a</sup>This Centers for Disease Control and Prevention-based questionnaire was given to Cuyahoga County, Ohio, survey participants to analyze knowledge, attitudes, and practices regarding West Nile virus exposure during the 2002 epidemic transmission season.

tive. These individuals were 20 times more likely to be seropositive than those who spent less than 15 minutes outdoors during either time period. Of 114 people who only spent time outdoors during the daytime but not during the evening, only three (0.07%) were seropositive. People who specifically avoided going outdoors also had a low seropositivity rate of 0.12%.

Summaries of adult and pediatric behavior characteristics are shown in Table 1. All four seropositive children captured in the county survey reported spending more than 15 minutes outside during a typical summer evening. As a group, children were more likely to have high levels of outdoor exposure than adults (83% vs. 70%). Conversely, in terms of protective behavior, children were less likely to regularly avoid going outdoors than adults (4% vs. 13%) and less likely to regularly wear long sleeves or pants when outside compared to adults (8% vs. 19%). Not shown, children reported a higher mosquito bite frequency than adults. There

were no statistically significant differences between adult and child avoidance of mosquito-ridden areas or in reported use of repellents.

**Background knowledge and attitudes regarding WNV.** Of the 1,209 survey participants, fewer than 1% of adults and 2% of children reported never hearing about WNV infection. Both adults and children received most of their WNV information from local television news broadcasts (Table 2). Similar to the adult cohort of whom 96% received information regarding WNV via television news, 92% of children received their information from the local news. Children were less likely than adults to receive information via radio programming (42% vs. 63%) or newspaper (38% vs. 78%). Use of the Internet for information was comparable between the child and adult cohorts (17% vs. 16%). Adults were more likely than children to use their local health department, their city newsletter,

**Table 1. Behavioral characteristics of adults and children in Cuyahoga County, Ohio, survey: a comparison of adult and child behaviors regarding outdoor and mosquito exposure, personal protective clothing, and repellent usage in 2002**

Reported activity	Percent 5–17 year-olds <sup>a</sup> (n=168)	Percent 18+ year-olds <sup>a</sup> (n=1,007)	P-value for differences between age groups, $\chi^2$ test
Time spent outdoors			0.0230
Daytime >15 min, evening <15 min	83.4	70	
Daytime <15 min, evening >15 min	4.4	12.2	
Daytime >15 min, evening <15 min	10	10.6	
Daytime <15 min, evening <15 min	2.2	7.2	
Avoid areas with mosquitoes			0.3474
Regularly	36.6	44.5	
Sporadically	63.4	55.1	
Avoid going outdoors			0.0107
Regularly	4	13.4	
Sporadically	96	86.6	
Wear long sleeves and pants			0.0065
Regularly	8.3	18.8	
Sporadically	91.7	80.6	
Repellent use			0.5041
Regularly	19.8	16.1	
Sporadically	80.2	83.6	

<sup>a</sup>All percentages are weighted estimates derived from stratified survey samples of Cuyahoga County during the systematic household-based seroprevalence survey in 2002.

and their health-care providers. Usage of health-care providers for WNV information was considerably low in both groups.

Attitudes regarding pesticide usage and concern for WNV infection are summarized in Table 3. Overall, 722 (60%) of the surveyed individuals were somewhat concerned about WNV infection, whereas 498 people (41%) worried about pesticide usage. When asked what worried them more—WNV infection or pesticide use—41% chose WNV infection, 3% chose pesticide use, 22% chose both, and 34% chose neither. Overall, 572 (47%) participants were satisfied with local mosquito control efforts. Children's attitudes about WNV and pesticides mirrored those of their parents.

## DISCUSSION

Our survey of risk-related behaviors enabled us to identify significant differences in personal protective behaviors (PPBs) between children and adults that almost certainly contributed to the children's higher WNV seroprevalence. Protective behaviors for WNV infection have been evaluated only rarely in the literature, but have been shown to decrease infection risk when utilized appropriately.<sup>10</sup> In contrast to Aquino's British Columbia study<sup>11</sup> and the CDC's Connecticut data,<sup>12</sup> where approximately 60% of people practiced mosquito-avoidance behavior and used DEET-containing repellents, only 44% of our study population avoided mosquitoes and, more surprisingly, only 17% reported

**Table 2. Respondents' reported sources of information about West Nile virus (WNV):<sup>a</sup> a comparison of adult and child information sources on WNV as reported in the Cuyahoga County, Ohio, survey**

Age group	TV (percent)	Newspaper (percent)	Radio (percent)	Internet (percent)	Health department (percent)	City newsletter (percent)	Health-care provider (percent)
5–17 years	91.7	37.7	42.2	16.5	12.2	24.9	10.9
18+ years	95.5	77.5	63	15.7	31.4	42.4	21
P-value	0.4087	0.0002	0.0522	0.5500	0.0025	0.0429	0.0327

<sup>a</sup>All percentages are weighted estimates derived from stratified survey samples of Cuyahoga County during the systematic household-based seroprevalence survey in 2002.

**Table 3. Attitudes regarding possible West Nile virus (WNV) infection and pesticide usage: a comparison of adult and child attitudes regarding WNV and pesticides as reported in the Cuyahoga County, Ohio, survey**

Variable (percent)	Very worried <sup>a</sup> (percent)	A little worried <sup>a</sup> (percent)	Not worried <sup>a</sup> (percent)	Never heard of it <sup>a</sup> (percent)	Don't know <sup>a</sup> (percent)	Which is more worrisome: WNV or pesticides? <sup>a</sup> (percent)
<i>How do you feel about WNV?<sup>b</sup></i>						
Children (5–17 years)	17.6	31.2	43.5	2.7	4.9	WNV worse: 43.4
Adults (18+ years)	15.7	46.5	36.2	1.0	0.5	WNV worse: 42.1
Overall	15.3	44.4	38.0	1.2	1.1	WNV worse: 41
<i>How do you feel about pesticides?</i>						
Children (5–17 years)	4.3	21.9	59.8	0.4	13.5	Pesticides worse: 2.7
Adults (18+ years)	9.2	34.5	54.7	0.8	0.9	Pesticides worse: 2.8
Overall	8.4	32.8	55.7	0.7	2.4	Pesticides worse: 2.9

<sup>a</sup>All percentages are weighted estimates derived from stratified survey samples of Cuyahoga County during the systematic household-based seroprevalence survey in 2002.

<sup>b</sup> $P=0.1397$ ,  $\chi^2$  test for difference between age groups;  $-p=0.1012$ ,  $\chi^2$  test for difference between age groups

using repellents regularly. Although there is little published evidence that children are at higher risk for DEET toxicity than adults,<sup>13,14</sup> concern regarding childhood toxicity from DEET may have contributed to the low repellent usage among children, despite them being outside for longer periods of time and more often than adults.<sup>15</sup>

Not surprisingly, children spent more time outside than adults and reported suffering more mosquito bites. In prior studies, one of the most prominent barriers to practicing protective behaviors included participating in outdoor leisure activities during peak mosquito hours—a behavior expected of summertime childhood play.<sup>11</sup> Adults in our study were more likely to avoid going outdoors and to wear personal protective clothing, such as long sleeves and pants, than were children. These PPBs were likely to have been at least partially effective against WNV infection.

As in previous studies, survey respondents in our study were well informed about WNV infection.<sup>12</sup> Both children and adults received the majority of their information about WNV from local television news broadcasting, as found by other investigators.<sup>11</sup> This observation demonstrates the capacity of television as an effective medium to reach audiences for public health education. Whether or not WNV education improved mosquito avoidance behaviors or practices could not be elucidated from our survey. In prior studies, knowledge and concern about WNV infection has not predicted usage of PPBs.<sup>12</sup> Unfortunately, very few survey respondents—11% of children and 21% of adults—received WNV information from their health-care providers. These figures represent a missed opportunity for physicians, especially pediatricians, to

give informative and important health advice to their patients.

This study has several limitations. We did not have adequate power to detect small differences in risk of infection associated with surveyed behaviors or in clinical symptomatology between infected and uninfected subjects. Survey data is reliant on self-reporting, which may bias results by overestimation of PPBs. Also, questionnaire administration occurred 14 weeks after the mosquito season, which may introduce recall bias. The youngest survey participant may have had limited understanding of the study questions, therefore parental answers would have been used by proxy, introducing possible reporting bias in those results.

In conclusion, although differences in behaviors between adults and children cannot explain the WNV disease attack rate variation, they may determine important risk-behavior links for exposure to infection. Children in our study reported behaviors that were likely to put them at greater risk for WNV infection and may have contributed to the substantial discrepancy between child and adult WNV infection rates. As ongoing WNV transmission leads to increasing protective immunity among adults, children will become a greater proportion of the population at risk for WNV infection and disease. Finding ways to limit WNV exposure to protect this vulnerable population is essential.

WNV is still present in our community; therefore, future epidemics may be inevitable. Reducing risk of mosquito bites is currently the only way to reduce the risk of WNV infection, as no vaccine for WNV is yet available. Regular assessment of public knowledge, attitudes, and behaviors is needed to guarantee the effec-



tiveness of public health messages. For now, the focus should remain on targeted health education outreach, especially among school-aged children, particularly via television broadcasting, in concert with ongoing, countywide mosquito-control efforts to decrease the risk of new WNV and other arboviral infections. In addition, pediatricians should take an active role in informing their patients about using personal protective measures to guard against WNV infection.

The authors would like to thank the residents of Cuyahoga County, Ohio, who participated in this study. The authors also thank the agencies that supported this effort, including the St. Luke's Foundation, the Mt. Sinai Health Care Foundation, the George Gund Foundation, the Sisters of Charity/St. Ann's Foundation, the City of Lakewood Health Department, the Ohio Department of Health, the Centers for Disease Control and Prevention, the City of Cleveland Health Department, and the Cuyahoga County Board of Health.

This work was supported in part by NIH grant K23 HD40982 and NIH grant T32 AI52067. The authors have complied with the Public Health Code of Ethics.

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