Challenges to Arboviral Surveillance in Tennessee: Health-Care Providers' Attitudes and Behaviors

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Abstract. Surveillance of arboviruses depends on health-care providers' ability to diagnose and report human cases of disease. The purposes of this study were to assess Tennessee providers' 1) self-efficacy toward diagnosis and management, 2) clinical practices, and 3) variation in these measures by provider characteristics. A survey was e-mailed to 13,851 providers, of which 916 (7%) responded. Respondents diagnosed more arboviruses in the previous year than were recorded in surveillance records, an indication of underreporting. Respondents had low to moderate self-efficacy toward diagnosis and management of arboviruses. Although more than 70% ($N = 589$) used paired serology, only 46% ($N = 396$) asked patients to return for a convalescent specimen draw within the correct time frame. One of the most commonly reported barriers to testing was uncertainty about which tests to order. Providers working in family medicine and urgent care, nurse practitioners, and those at outpatient facilities had lower rates of high self-efficacy than their counterparts working in other settings and from other specialties. Clinical practices were influenced by specialty, designation, setting, and geography but not by years of experience. Education to improve arboviral surveillance in Tennessee is warranted. Topics could include proper diagnosis and management, appropriate testing and overcoming barriers to testing, and public health reporting.

INTRODUCTION

Arboviruses (arthropod-borne viruses) are transmitted through the bite of an infected arthropod, such as a mosquito or tick.¹ In Tennessee, reportable arboviruses include West Nile virus (WNV), La Crosse encephalitis virus, Eastern equine encephalitis virus (EEEV), St. Louis encephalitis virus, dengue virus, and chikungunya virus. Tennessee residents are at risk of contracting these illnesses both at home and when traveling to areas experiencing outbreaks. Health-care providers, laboratories, and hospitals are responsible for reporting suspected cases to the health department within 1 week for most arboviruses (EEEV is the exception, which requires notification by telephone within one business day). The Tennessee Department of Health (TDH) conducts surveillance for arboviral infections by investigating and reporting human and horse cases, by trapping and testing mosquitoes, and through passive bird surveillance.² Human cases of arboviral disease are "confirmed" or "probable" cases when an individual has symptoms clinically compatible with arboviral disease and positive laboratory test results.³ Traditionally, human cases of arboviruses are underreported for a number of reasons: 1) many people experience mild symptoms and thus never seek health care; 2) health-care providers might not recognize the symptoms and order appropriate diagnostic testing; 3) a patient might not complete the diagnostic testing process; and 4) at times, the results of diagnostic tests or case investigations might not reach TDH and thus not be counted in the surveillance system.^{4,5}

This system relies on health-care providers to recognize the possibility of an arboviral diagnosis and respond to and report it appropriately. The purpose of this study was to conduct an assessment of health-care providers (including medical doctors, doctors of osteopathic medicine, nurse practitioners, and physician assistants) to better understand their behaviors

relating to arboviral disease diagnosis, treatment, and public health reporting and to determine whether these behaviors vary by provider characteristics (such as experience, specialty, designation, practice setting, or geography). The results of this assessment will be used to inform and target interventions, which may include educational outreach to providers and surveillance system improvement.

A previous assessment of Rocky Mountain spotted fever (a tick-borne bacterial disease) in Tennessee revealed gaps in provider knowledge of treatment, diagnoses, and reporting practices.^{6,7} The study also revealed differences between medical specialties and designations. We suspected that similar differences might exist among providers regarding arboviruses.

METHODS

An online survey was developed, and the link to access it was e-mailed to health-care providers, including physicians (doctors of medicine [MDs] and doctors of osteopathic medicine [DOs]), nurse practitioners (NPs), and physician assistants (PAs) in primary care specialties listed by the TDH medical licensing board. Two reminders to complete the survey were sent; the first was sent 7 days after the initial invitation, and the second was sent 10 days after the first reminder. The survey instrument was organized into six major categories.

Provider characteristics. The assessment included 1) specialty area (emergency medicine, family medicine, infectious diseases, internal medicine, pediatrics, or urgent care); 2) number of years in practice; 3) designation (MD, DO, PA, or NP); 4) practice setting (academic medical center, emergency department, health department, hospital, or outpatient clinic); 5) region of the state (west, middle, or east); and 6) practice area population density (metropolitan or rural). The three regions of the state are distinct geographically, culturally, and economically. Surveillance data indicate that rates of arboviral disease vary by location within Tennessee, so it is expected that provider attitudes and behaviors may vary by these factors as well. To analyze by professional designation, MDs and DOs were collapsed into a single group

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(“doctors”) for further analyses because of the low number of responses from DOs.

Self-efficacy toward diagnosis and treatment. Self-efficacy is a psychological construct of one’s belief in their ability to accomplish a task or reach a goal.⁸ To develop an understanding about how confident providers felt about their ability to diagnose and treat arboviruses, respondents were asked whether they strongly agreed, agreed, disagreed, strongly disagreed, or were undecided about the following three statements:

I understand how arboviruses are transmitted.
I recognize the clinical presentation of arboviral infections.
I am familiar with the clinical management of arboviral infections.

Those who “strongly agreed” or “agreed” with a statement were said to have high self-efficacy in their ability to complete the task described in the statement, whereas those who “strongly disagreed” or “disagreed” had low self-efficacy for that action.

Clinical practices. We assessed the clinical practices of respondents toward arboviruses by asking them to estimate the number of patients they had seen in the previous 12 months for whom they suspected, ordered laboratory tests for, and/or diagnosed with an arbovirus.

Laboratory testing behaviors. Respondents were asked questions about laboratory testing behaviors: 1) which laboratory tests were ordered in general, 2) which serology tests were ordered, 3) the timing of paired serology testing, 4) which laboratory(ies) were used for testing, and 5) barriers to ordering laboratory tests. It is important to note that paired serology, though desirable, is not the only laboratory criteria that can be used to confirm a case. The laboratory criteria for a confirmed case also include 1) isolation of virus from (or demonstration of specific viral antigen or nucleic acid in) tissue, blood, cerebrospinal fluid (CSF) or other body fluid; 2) virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen; or 3) virus-specific IgM antibodies in CSF, with or without a reported pleocytosis, and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.³

To develop an understanding of barriers to testing, respondents were asked to consider patients they treated in the last 12 months for whom they suspected an arbovirus but did not order a laboratory test. A dichotomous “barriers” measure was created by analyzing those respondents who reported at least one of the following barriers to laboratory testing in the previous 12 months: 1) cost of laboratory testing (either to the patient or to their practice), 2) anticipated patient

noncompliance, or 3) uncertainty about the appropriate test to order.

Public health reporting. Providers were asked whom they notified when they had a patient diagnosed with an arbovirus on the basis of laboratory testing results, with the following choices of responses: 1) county/local health department, 2) state health department, 3) Centers for Disease Control and Prevention (CDC), 4) official at my practice/hospital, or 5) other.

Interest in continuing medical education. Provider interest in continuing medical education (CME) regarding arboviruses was gauged by asking whether they strongly agreed, agreed, disagreed, strongly disagreed, or were undecided about the following two statements:

CME on diagnosing arboviral infections would be beneficial to my practice.

CME on clinical management of arboviral infections would be beneficial to my practice.

The final page of the survey included links to information and resources about arboviral diagnosis, management, and reporting.

Pearson’s χ^2 was used to identify differences between groups. For some comparisons, the assumptions for Pearson’s χ^2 were not met. In those instances (where greater than 20% of expected values were less than five), the likelihood ratio value was used as an omnibus test. When warranted, Fisher’s exact or Pearson’s χ^2 were used for a post hoc test for significance.

RESULTS

Provider characteristics. Of the 13,851 primary care practitioners contacted, 916 (7%) responded. Table 1 presents designation-specific response rates. The largest groups of respondents were among practitioners who were in family medicine (40%, $N = 624$), had more than 20 years of experience (30%, $N = 668$), and were used by an outpatient clinic (64%, $N = 616$).

Self-efficacy toward diagnosis and treatment. More than 85% ($N = 909$) of all respondents agreed that they understand (by responding “strongly agree” or “agree”) how arboviruses are transmitted. However, only 61% ($N = 910$) agreed they could recognize the clinical presentation of arboviruses. Fewer (51%, $N = 904$) indicated they were familiar with the clinical management of arboviral infections.

Provider estimations of arboviruses in patients. Table 2 presents the number of cases respondents recalled diagnosing in the previous 12 months, compared with the numbers of confirmed and probable cases in TDH’s surveillance records for each disease during 2012–2014.

TABLE 1
Response rates by provider designation

Professional designation	Contacted no.	Response no.	Designation-specific response rate	Percentage of respondents
MD	5,307	317	5.97	47.74
DO	280	15	5.36	2.26
NP	7,216	275	3.81	41.42
PA	1,048	57	5.44	8.58
No designation provided	—	252	—	—
Total	13,851	916	6.61	

DO = doctor of osteopathic medicine; MD = doctor of medicine; NP = nurse practitioners; PA = physician assistants.

TABLE 2
Providers' estimations vs. TDH surveillance records

Disease	Respondents' estimated no. of cases they diagnosed in the previous 12 months*	No. of confirmed and probable cases (TDH surveillance data)		
		2012	2013	2014
WNV	46–230	33	24	16
La Crosse encephalitis virus	26–70	9	23	11
St. Louis encephalitis	2–10	0	0	0
Eastern equine encephalitis	7–35	0	0	0
Dengue	25–125	6	9	2
Chikungunya	22–110	n/a†	n/a†	42

TDH = Tennessee Department of Health; WNV = West Nile virus.

*These ranges created by multiplying the number of respondents for each category by the range for that category. For example, 46 respondents reported diagnosing between one and five patients with WNV, leading to a range of 46–230.

†Chikungunya was not made reportable in Tennessee until 2014.

Laboratory testing behaviors. Table 3 identifies which laboratory tests were ordered. For general laboratory tests, 72% ($N = 589$) of respondents reported ordering paired serology tests. Of those who ordered any serology tests, 71% ($N = 548$) used qualitative IgM (enzyme-linked immunosorbent assay [ELISA], enzyme immunoassay [EIA]) tests.

In response to the question, “If you order paired serology tests (acute and convalescent titers) for a suspected arbovirus, when do you tell the patient to return for the convalescent titer?” 54% ($N = 396$) of responses indicated inappropriate timing; 31% of respondents would ask a patient to return for a convalescent sample too early (fewer than 2 weeks after the acute test), and 23% too late (more than 3 weeks after the acute test). Of respondents, 46% chose 14–21 days after the acute sample, which is the appropriate timing. Respondents were able to select multiple locations when asked about where they sent laboratory specimens for testing. Nearly one-third (32%, $N = 591$) reported using a commercial laboratory only, 20% used a hospital laboratory only, 20% used the state laboratory only, and 29% used some combination of laboratories for arboviral testing.

Table 4 outlines barriers to laboratory testing. Respondents were able to select multiple barriers. Excluding respondents who did not order laboratory tests because they made a different (non-arboviral) diagnosis, the most frequently reported barriers were 1) cost to the patient, 2) uncertainty about which laboratory tests to order, and 3) the determination that they could treat symptoms without making a specific arboviral diagnosis.

Public health reporting. Multiple responses were allowed in response to the question about where providers were

reporting arboviruses; the sum of percentages of responses exceeds 100%. More than three-quarters (76%, $N = 470$) reported arbovirus diagnoses to their local/regional health department, 43% reported to the state health department, 24% reported to a hospital official, and 16% reported to CDC.

Variation in responses by provider characteristics. Variation by provider characteristics in self-efficacy, clinical practices, and barriers to testing is shown in Table 5.

How does self-efficacy vary by provider characteristics? More experienced providers (those practicing 20 years or more) had a higher proportion of respondents with high self-efficacy (for all three measures) than their colleagues with fewer years of experience.

There were statistically significant differences by provider designation for self-efficacy ($P < 0.001$ for all three self-efficacy items). Doctors had the highest proportion of respondents with high self-efficacy regarding understanding transmission, clinical presentation, and clinical management of arboviruses. PAs had slightly lower rates of high self-efficacy, followed by NPs.

Providers who worked in infectious diseases had greater proportions of respondents with high self-efficacy than those working in other fields (transmission, $P = 0.046$; presentation, $P = 0.004$; management, $P < 0.001$). The specialties with the lowest proportion of respondents with high self-efficacy were family medicine, urgent care, and internal medicine.

Self-efficacy regarding arboviral transmission did not vary by practice setting; self-efficacy toward clinical presentation ($P = 0.007$) and management ($P = 0.004$) did vary by this factor. Those who practiced in hospitals, emergency departments, and academic medical centers have greater rates of

TABLE 3
Frequency of ordering laboratory tests

Test	Always		Sometimes		Never	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Laboratory tests						
Single serology (acute titer only)	171	28	201	33	231	38
Paired serology (acute and convalescent titer)	199	34	224	38	166	28
PCR (whole blood)	106	20	205	38	231	43
CSF antibody immunoassay	76	14	180	33	282	52
Blood culture	74	14	161	31	288	55
Serology tests						
Qualitative, IgM (ELISA, EIA)	220	40	168	31	160	29
Qualitative, IgG (ELISA, EIA)	174	33	166	32	185	35
Quantitative titer, IgM (IFA)	183	33	188	34	179	33
Quantitative titer, IgG (IFA)	144	28	172	33	202	39

CSF = cerebrospinal fluid; ELISA = enzyme-linked immunosorbent assay; EIA = enzyme immunoassay; PCR = polymerase chain reaction; IFA = indirect immunofluorescence assay.

TABLE 4
Barriers to laboratory testing

Barrier to laboratory testing	No. of respondents reporting barrier
Clinical symptoms and patient history led me to a different (non-arboviral) diagnosis	214
Laboratory testing is expensive for the patient	108
I am not sure what laboratory tests are appropriate for arboviruses	105
I felt I could treat the patient's symptoms without a specific arboviral diagnosis	103
I referred the patient to another provider	77
I ordered laboratory tests for every patient for whom I considered an arboviral diagnosis	70
I felt I could make an arboviral diagnosis without laboratory test results, based on the patient's symptoms and history	57
Other (please specify)	47
Laboratory testing is expensive for my practice/hospital/clinic	34
I felt the patient would not comply with an order for a laboratory test	16

high self-efficacy toward clinical presentation and management than those who practiced in health departments and outpatient clinics.

Provider self-efficacy did not vary by practice area population density or by Tennessee geographic region.

How do clinical practices vary by provider characteristics? Clinical practices for arboviruses varied by every provider characteristic except for years of experience.

Infectious disease providers had the highest proportion of respondents who had suspected an arboviral disease, ordered a laboratory test, or diagnosed an arboviral illness in the previous 12 months ($P < 0.001$ for all three behaviors).

There were statistically significant differences by provider designation for all three behaviors ($P < 0.001$ for suspecting, ordering laboratory tests for, and diagnosing) when considering all arboviruses combined, with higher proportions of MDs/DOs reporting these behaviors than PAs or NPs.

Respondents working in hospitals, emergency departments, and academic medical centers reported suspecting ($P < 0.001$), ordering laboratory tests for ($P < 0.001$), and diagnosing ($P = 0.001$) arboviruses in greater proportions than those in outpatient clinics or health departments.

Greater proportions of providers in metropolitan areas reported that they had suspected, ordered laboratory tests

TABLE 5
Variation in behaviors by provider characteristics

Characteristic	No. (%)	High SE* toward transmission (%)	High SE* toward clinical presentation (%)	High SE* toward clinical management (%)	Suspected arboviral disease in a patient† (%)	Ordered a laboratory test for an arboviral disease‡ (%)	Diagnosed any patient with an arboviral disease‡ (%)	Experienced barriers§ to testing patients for arboviral disease (%)
Specialty	624	$P = 0.046§$	$P = 0.004$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P = 0.144$
Emergency medicine	88 (14)	75 (85)	63 (72)	58 (66)	50 (57)	35 (40)	13 (15)	30 (34)
Family medicine	249 (40)	211 (85)	136 (55)	120 (48)	86 (35)	65 (26)	17 (7)	77 (31)
Infectious disease	26 (4)	26 (100)	25 (96)	23 (88)	22 (85)	22 (85)	11 (42)	6 (23)
Internal medicine	133 (21)	112 (84)	79 (59)	66 (50)	55 (41)	44 (33)	18 (14)	31 (23)
Pediatrics	86 (14)	81 (94)	58 (67)	52 (60)	34 (40)	25 (29)	10 (12)	16 (19)
Urgent care	42 (7)	36 (86)	24 (57)	18 (43)	13 (31)	8 (19)	2 (5)	12 (29)
Years in practice	668	$P = 0.017$	$P < 0.001$	$P = 0.001$	$P = 0.552$	$P = 0.683$	$P = 0.617$	$P = 0.024$
≤ 5	173 (26)	146 (84)	90 (52)	73 (42)	64 (37)	50 (29)	22 (13)	55 (32)
6–20	295 (44)	242 (82)	180 (61)	155 (53)	118 (40)	89 (30)	29 (10)	85 (29)
≥ 20	200 (30)	185 (93)	142 (71)	124 (62)	85 (43)	65 (33)	20 (10)	40 (20)
Professional designation	664	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P = 0.571$
MD/DO	332 (50)	306 (92)	244 (73)	210 (63)	159 (48)	123 (37)	51 (15)	86 (26)
PA	57 (9)	50 (88)	35 (61)	31 (54)	19 (33)	13 (23)	3 (5)	13 (23)
NP	275 (41)	215 (78)	132 (48)	109 (40)	85 (31)	65 (24)	16 (6)	79 (29)
Practice setting	616	$P = 0.172§$	$P = 0.007$	$P = 0.004$	$P < 0.001$	$P < 0.001$	$P = 0.001§$	$P = 0.005$
Academic medical center	42 (7)	38 (90)	30 (71)	28 (67)	24 (57)	22 (52)	5 (12)	11 (26)
Emergency department	89 (14)	76 (85)	64 (72)	58 (65)	52 (58)	37 (42)	13 (15)	32 (36)
Health department	12 (2)	10 (83)	7 (58)	6 (50)	3 (25)	2 (17)	1 (8)	5 (42)
Hospital	78 (13)	73 (94)	60 (77)	50 (64)	49 (63)	40 (51)	20 (26)	9 (12)
Outpatient clinic	395 (64)	335 (85)	221 (56)	186 (47)	136 (34)	101 (26)	31 (8)	117 (30)
Practice area	617	$P = 0.995$	$P = 0.135$	$P = 0.813$	$P = 0.010$	$P < 0.001$	$P < 0.001$	$P = 0.025$
Metropolitan	305 (49)	261 (86)	195 (64)	161 (53)	138 (45)	114 (37)	46 (15)	73 (24)
Rural	312 (51)	267 (86)	177 (57)	158 (51)	109 (35)	73 (23)	19 (6)	100 (32)
Region	617	$P = 0.595$	$P = 0.954$	$P = 0.962$	$P < 0.001$	$P = 0.013$	$P = 0.418$	$P = 0.017$
East	245 (40)	214 (87)	150 (61)	126 (51)	79 (32)	62 (25)	23 (9)	54 (22)
Middle	259 (42)	220 (85)	153 (59)	135 (52)	109 (42)	79 (31)	26 (10)	79 (31)
West	113 (18)	94 (83)	59 (52)	58 (51)	59 (52)	46 (41)	16 (14)	40 (35)

DO = doctor of osteopathic medicine; MD = doctor of medicine; NP = nurse practitioners; PA = physician assistants; SE = self-efficacy. Shaded areas indicate significant P values.

*"High SE" includes those who either strongly agreed or agreed with the following statements: "I understand how arboviruses (arthropod-borne viruses) are transmitted," "I recognize the clinical presentation of arboviral infections," and "I am familiar with the clinical management of arboviral infections."

†In the preceding 12 months.

‡"Experienced barriers" included all those who agreed with at least one of the following statements: "I'm not sure what lab tests are appropriate for arboviruses," "I felt the patient would not comply with an order for a laboratory test," "Laboratory testing is expensive for the patient," and "Laboratory testing is expensive for my practice/hospital/facility."

§Likelihood ratio value was used for an omnibus test in those instances where the assumptions for Pearson's χ^2 were not met

for, and diagnosed arboviruses than their counterparts who practiced in rural areas ($P < 0.001$). In addition, there were differences by region in the proportion of providers reporting suspecting ($P < 0.001$) and testing ($P = 0.013$) for arboviruses but not in the proportion of those who reported diagnosing a patient with an arboviruses. A greater proportion of providers in the west reported ordering a laboratory test for an arbovirus than those in the middle and east regions. All three regions were significantly different from each other in terms of the proportion of providers reporting that they had suspected an arbovirus in at least one patient in the previous 12 months (west 53%, middle 43%, east 33%; $P < 0.001$). This variation is likely due to the high numbers of cases of WNV, the most frequently occurring arbovirus in Tennessee, seen in the state's western region (specifically Shelby County), although this does not explain the discrepancy between the middle and east regions.

How does perception of barriers to laboratory testing vary by provider characteristics? Providers with the most years of experience were less likely ($P = 0.024$) to report experiencing barriers to laboratory testing (20%, $N = 81$) than those with the least experience (≤ 5 years, 32%). Barriers to laboratory testing also varied by practice setting ($P = 0.005$) with the greatest proportion of those reporting experiencing barriers among those who work at health departments (42%, $N = 174$). The practice setting with the lowest proportion of respondents reporting barriers to testing were those who work in hospitals (12%).

In addition, the rates of experiencing barriers to laboratory testing also varied by geography: those practicing in rural areas reported experiencing barriers at a greater rate (32%, $N = 173$) than their colleagues practicing in urban areas (24%, $P = 0.025$). More than one-third of providers (35%, $N = 173$) in the west region of the state reported experiencing barriers, a greater rate than those in middle Tennessee (31%) or east Tennessee (22%) ($P = 0.017$).

Provider interest in CME. Nearly of all respondents agreed or strongly agreed that CME on diagnosis (89%, $N = 906$) or clinical management (89%, $N = 905$) of arboviral infections would be beneficial to their practice.

DISCUSSION

Health-care providers and the public have become increasingly aware of arboviruses since the emergence of WNV in 1999.^{9,10} In 2014, cases of chikungunya virus in travelers to the Caribbean began being reported in the United States, again bringing arboviral diseases into the forefront in media reports and public attention nationwide. This study of provider behaviors was administered during this latest season of heightened awareness of arboviral disease. Even with this increased awareness, we have identified areas for improvement in the practices of health-care providers in Tennessee.

The number of arbovirus disease cases as estimated by the respondents suggests that underreporting to TDH is occurring. For most conditions, the numbers of diagnosed illnesses (as estimated by fewer than 7% [$N = 13,851$] of the primary care providers in the state) exceed any single year of statewide surveillance data for the past 3 years. If the rate of diagnosis is consistent among health-care providers, we would have expected 686–3,432 cases of West Nile disease, 388–1,045 cases of La Crosse encephalitis, 373–1,866 cases of

dengue, and 328–1,642 cases of chikungunya in 2014 (as opposed to 16, 11, 2, and 42 cases, respectively). There are a number of potential reasons for this discrepancy between provider estimates and number of cases captured by TDH's surveillance system. The first is that respondents are not necessarily representative of all primary care providers in Tennessee. Those who took the time to respond to the survey likely have some interest in or knowledge of arboviruses and are perhaps more likely than nonrespondents to diagnose a patient with arboviral disease. Respondents are also susceptible to recall bias, which would lead to inaccuracies in estimates. To be counted as an arboviral disease case by TDH's surveillance system, the individual must have both clinically compatible symptoms and laboratory evidence of the disease. Some providers might give a clinical diagnosis without laboratory confirmation of the disease; in those instances the individuals would not be counted as cases in the surveillance system. Finally, it is also possible that laboratory confirmation is obtained by a physician but the disease goes unreported. The implementation of electronic laboratory reporting for reportable diseases should reduce the likelihood of underreporting.

Laboratory testing behaviors identified in this study indicate the need for specific, concise guidance on arboviral laboratory testing. Any training or materials developed in light of these findings should include testing algorithms to guide providers toward the appropriate test(s) based on the patient's symptoms, onset date, and specimen collection date. Paired serology tests were problematic since most respondents who reported using paired serology did not request that their patients return within the appropriate time frame. One in five respondents reported relying solely on the state laboratory for arboviral testing. This demonstrates a need for the state laboratory to maintain its capacity to test for arboviruses.

The reported barriers to laboratory testing provided insight into the thought processes of providers. The most frequently reported barrier was perceived cost to the patient. Because the state laboratory can test for arboviruses, this barrier could be reduced. The uncertainty about which laboratory test to order, the second most common response, again emphasizes the need for clear and concise guidance on this subject. The variation in reported barriers, with greater rates of barriers occurring among rural providers and those in the western part of the state, should also be taken into account for outreach and education.

The results from the questions on self-efficacy indicate that providers have good, basic knowledge in the transmission of arboviruses but need education and training on the clinical presentation and management of these illnesses. In addition, providers had high interest in CME on these topics. The more relevant the training and the materials are, they are more likely to be well received by the intended participants.¹¹ For example, education on La Crosse virus encephalitis could be targeted to providers in the eastern part of the state where the majority of cases are found. Providers with lower rates of high self-efficacy should be prioritized for educational outreach. This includes providers working in family medicine and urgent care, NPs, and providers used by health departments and other outpatient clinics.

In general, infectious disease physicians in hospitals, emergency departments, and academic medical centers reported

greater confidence about their understanding of the clinical presentation and management of patients with arboviral disease. They were also more likely than their counterparts in other specialty areas, designations, or settings to suspect an arboviral disease in their patients. Providers in metropolitan areas were more likely than those in rural areas to suspect an arboviral disease. Interestingly, number of years in practice did not influence providers' likelihood of suspecting arboviral disease. This suggests that it is not the number of years of experience, but rather the specialty area and where a physician practices—both type of practice setting and geographic location—that influence behavior. To ensure surveillance systems accurately capture arboviral incidence, providers should consider arboviruses whenever clinical evidence is suggestive, regardless of the presence of neuroinvasive or other severe symptoms. Therefore, future educational efforts should include guidance on recognizing and responding to mild cases of arboviral illness as well as severe cases.

Providers in the west region were more likely to report suspecting an arbovirus and ordering an arboviral laboratory test for their patients than their counterparts in the middle or east region of the state. This likely reflects the greater concentration of WNV cases in the western part of the state rather than a difference in provider attitudes or willingness to order tests.

The findings of this study are subject to a few limitations. First, only those providers with an e-mail address associated with their state licensure were contacted to complete the survey. Respondents are not necessarily representative of all providers across the state of Tennessee; those who already had some interest in arboviruses might have been more likely to respond to such a survey than those who were not interested in the subject matter. In addition, the response rate was low, making generalizability of the results difficult. The recommendations for future educational and outreach efforts should be considered with these limitations in mind.

Public health will continue to rely on health-care provider partners to identify potential cases of reportable diseases. Without alert clinicians, the accuracy of passive surveillance systems suffers. To improve Tennessee's surveillance for arboviral infections and ultimately learn more about the burden of disease on the population, targeted education and outreach efforts should be considered to address gaps in the following major areas: clinical presentation and management

of arboviruses, appropriate laboratory testing for arboviruses, and public health reporting of arboviruses.

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