Clinician Survey to Determine Knowledge of Dengue and Clinical Management Practices, Texas, 2014

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Abstract. Dengue, a mosquito-borne viral disease, is increasingly being identified as a cause of outbreaks in the United States. During July–December 2013, a total of three south Texas counties reported 53 laboratory-confirmed dengue cases; 26 were locally acquired, constituting the largest outbreak in Texas since 2005. Because dengue outbreaks are expected to continue in south Texas and early case identification and timely treatment can reduce mortality, we sought to determine clinicians' knowledge of dengue and its clinical management. A survey was sent to 2,375 south Texas clinicians; 217 (9%) completed the survey. Approximately half of participants demonstrated knowledge needed to identify dengue cases, including symptoms (56%), early indicators of shock (54%), or timing of thrombocytopenia (48%). Fewer than 20% correctly identified all prevention messages, severe dengue warning signs, or circumstances in which a dengue patient should return for care. Knowledge of clinical management was limited; few participants correctly identified scenarios when plasma leakage occurred (10%) or a crystalloid solution was indicated (7%); however, 45% correctly identified when a blood transfusion was indicated. Because of the ongoing threat of dengue, we recommend clinicians in south Texas receive dengue clinical management training.

INTRODUCTION

Dengue is a mosquito-borne acute febrile illness that is caused by one of four dengue viruses (DENV-1, 2, 3, and 4).¹ Dengue is endemic throughout the tropics and subtropics worldwide, including the Americas where the incidence of dengue has increased greater than 4-fold during the last three decades.² During the same period, the region has experienced an increase in both frequency of dengue outbreaks and disease severity.

In the United States, dengue is endemic in the territories of Puerto Rico and the U.S. Virgin Islands.³ The majority of dengue cases identified in the 50 states are travel associated, and dengue is the leading cause of febrile illness among U.S. travelers returning from southeast Asia, Latin America, and the Caribbean.⁴ Travel-associated dengue cases have led to outbreaks with local DENV transmission in Hawaii,⁵ Florida,⁶ and Texas.^{7,8} Since 1980, Texas border communities have experienced multiple dengue outbreaks concurrent with epidemics in Mexico.^{8–10} The possibility of dengue outbreaks in Texas is a continual threat because of its proximity to Mexico, substantial cross-border traffic, presence of *Aedes aegypti* mosquitoes,¹¹ and a predominantly nonimmune U.S. population.

Although the majority of DENV infections result in asymptomatic infection or mild acute febrile illness, a limited number (~5%) of symptomatic infected persons will develop severe dengue, a potentially life-threatening illness with a vascular leakage syndrome resulting in hypovolemic shock and hemorrhage.^{12–14} Fatality rates for hospitalized patients with severe dengue can be as high as 10%; however, studies have reported that mortality rates can be reduced to

< 0.5% with early case identification and timely initiation of correct clinical management.^{1,15,16}

During May–October 2013, the Mexican state of Tamaulipas, which borders Texas, experienced a dengue epidemic and ~5,500 suspected dengue cases were reported.¹⁷ During the same period in Texas, 53 laboratory-confirmed dengue cases (median patient age = 28 years, range = 1–85 years) were detected in south Texas border counties; 26 (49%) were locally acquired.¹⁸ Although sporadic cases of dengue have been detected in south Texas during past decades, this outbreak was the largest since the 2005 outbreak in Brownsville, TX.^{9,19} Because of the substantial increase in dengue cases reported along the United States–Mexico border, the Texas state and local public health officials partnered with Centers for Disease Control and Prevention (CDC) to develop strategies to reduce morbidity and mortality associated with dengue. One objective was to survey local Texas clinicians' knowledge of dengue and its clinical management to guide intervention strategies.

MATERIALS AND METHODS

Physicians, physician extenders (nurse practitioners [NPs], and physician assistants [PAs]) practicing medicine in the Texas counties of Cameron, Hidalgo, Starr, Willacy, and Zapata (collectively known as south Texas) were invited by e-mail to participate in the dengue clinical survey. We also invited clinicians from the Houston metropolitan area (HMA) to participate because of identification of both locally acquired and travel-associated dengue cases in the HMA.²⁰ We specifically sought participation from clinicians in general practice, family medicine, internal medicine, pediatrics, emergency medicine, infectious disease, hematology, obstetrics, and intensive care, because these medical specialties might be more likely to encounter a patient with dengue.

We developed our survey instrument by using multiple data sources to formulate the survey questions. We conducted key informant interviews with treating clinicians and

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a medical record review of confirmed and suspected dengue patients at south Texas hospitals to identify clinical management practices and whether these practices varied from the World Health Organization 2009 dengue guidelines²¹. Findings of deficiencies in recommended clinical management practices (e.g., failure to recognize dengue and warning signs for developing severe dengue, inaccurate understanding of dengue diagnostics, and use of non-steroidal anti-inflammatory drugs [NSAIDs]) were used to develop survey questions.

The 28-question survey included 10 optional demographic questions and 18 technical questions. The technical questions were divided into three knowledge areas, including dengue prevention messages and anticipatory guidance, clinical presentation and course, and dengue clinical management. We also asked questions to assess clinical practice habits. We piloted the survey to assess for clarity and level of difficulty by using a convenience sample of nine physicians and incorporated feedback. The survey was administered online through SurveyMonkey® (SurveyMonkey, Palo Alto, CA).²² Answering all technical questions was required to advance and complete the survey. After survey completion, participants were redirected to a webpage that provided the correct answers with explanations. Participants had the option to redirect to the CDC dengue website (<http://www.cdc.gov/dengue>) for additional information. Data were analyzed using IBM SPSS Statistics for Windows (Version 20.0; IBM Corporation, Armonk, NY) and difference in responses among groups was analyzed using Pearson's χ^2 test. Time in practice was analyzed using clinicians in practice > 30 years as the comparator. Some of the 18 technical questions had multiple correct answers, so each answer was treated like a true or false question. We decided a priori to exclude surveys from clinicians who were no longer practicing clinical medicine, practicing outside the catchment area, and did not return complete survey instruments. We chose to exclude the first and second categories of clinicians since our goal was to evaluate clinical decision-making in dengue-prone areas.

Potential participants included all members of local medical societies in south Texas and HMA. In addition, we partnered with the two major health systems in HMA to distribute our survey via e-mail to their clinician employees. All participants were invited via e-mail either through their membership with a local medical society or in the case of the HMA clinicians; many received an invitation from their employer. We were unable to access a list of all licensed clinicians in the catchment area. A letter of endorsement from the Regional Medical Director of south Texas was included with the e-mail containing the survey website link. As an incentive, participants completing the survey were entered in a drawing to win a tablet device provided by the CDC U.S. Mexico Unit. Participants were asked to complete the survey within 2 weeks; a reminder e-mail was sent after the first week had passed, if the survey had not been completed.

This survey was reviewed by CDC for human subjects protection, and was deemed to be nonresearch.

RESULTS

The survey was sent to 2,375 clinicians, including 1,410 (59%) physicians, 400 (17%) NPs, and 565 (24%) PAs

(Figure 1). A total of 339 (14%) clinicians responded, although 71 (21%) did not complete all the technical questions and were excluded from analysis. Of 268 completed surveys, 51 (15%) were excluded because the participant was either not active in direct patient care or practiced outside of the defined catchment area. Data from the remaining 217 (9%) surveys were included in our analysis.

Response rates differed by the following geography and clinician type: HMA physicians had the highest response rate (16%), followed by HMA physician extenders (15%), south Texas physician extenders (8%), and south Texas physicians (4%). Participants from all regions were approximately equally split between physicians (54%) and physician extenders (46%) (Table 1). The majority (73%) of participants had been in practice for ≤ 20 years and reported working in an outpatient setting (86%). The majority (90%) of participants practiced in a primary care specialty, and a substantial number (42%) were pediatricians. The majority (81%) of participants had never diagnosed a case of dengue; 25 (12%) participants had diagnosed 1–4 cases. Seven (3%) participants (all south Texas physicians) reported having diagnosed > 20 dengue cases during their career; the majority of these participants were trained in infectious disease. Deficiencies in knowledge of dengue

FIGURE 1. Clinician enrollment for dengue clinical survey in Texas during 2014.

TABLE 1
Dengue survey respondent characteristics by practice site and clinician type, Texas, 2014

Characteristic	All	South Texas		Houston metropolitan area	
		MD	NP or PA	MD	NP or PA
Response rate (%)		33/854 (4)	40/537 (7)	85/556 (15)	59/456 (13)
Total respondents, <i>n</i> (%)	217 (100)	33 (15)	40 (18)	85 (39)	59 (27)
Practice duration, years (<i>N</i> = 217)					
< 5	47 (22)	5 (15)	15 (38)	11 (13)	16 (27)
5–10	45 (21)	8 (24)	15 (38)	9 (11)	13 (22)
11–20	64 (30)	7 (21)	9 (23)	28 (33)	20 (34)
21–30	29 (13)	4 (12)	0 (0)	19 (22)	6 (10)
> 30	32 (15)	9 (27)	1 (3)	18 (21)	4 (7)
Practice site (<i>N</i> = 217)*					
Outpatient clinic	187 (86)	22 (67)	39 (98)	81 (95)	45 (76)
Community health center	11 (5)	3 (9)	1 (3)	1 (1)	6 (10)
ED or urgent care	28 (13)	11 (33)	4 (10)	4 (5)	9 (15)
Inpatient ward	48 (22)	12 (36)	1 (3)	21 (25)	14 (24)
ICU	19 (9)	6 (18)	2 (5)	8 (9)	3 (5)
Specialty (<i>N</i> = 217)*					
General practice	14 (7)	3 (9)	5 (13)	0 (0)	6 (10)
Family practice	57 (26)	7 (21)	17 (43)	10 (12)	23 (39)
Internal medicine	23 (11)	5 (15)	1 (3)	12 (14)	5 (9)
Pediatrics	90 (42)	9 (27)	18 (45)	54 (64)	9 (15)
Emergency medicine	11 (5)	8 (24)	1 (3)	0 (0)	2 (3)
Infectious disease	6 (3)	0 (0)	0 (0)	3 (4)	3 (5)
Hematology	6 (3)	1 (3)	1 (3)	0 (0)	4 (7)
Obstetrics or gynecology	9 (4)	1 (3)	2 (5)	3 (4)	3 (5)
Intensivist	3 (1)	0 (0)	1 (3)	1 (1)	1 (2)
Other	23 (11)	2 (6)	3 (8)	5 (6)	13 (22)
Dengue cases diagnosed (<i>N</i> = 204)					
None	166 (81)	13 (41)	33 (85)	66 (84)	54 (100)
1–4	25 (12)	9 (28)	6 (15)	10 (13)	0 (0)
5–10	6 (3)	3 (10)	0 (0)	3 (4)	0 (0)
11–20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
> 20	7 (3)	7 (22)	0 (0)	0 (0)	0 (0)

ED = emergency department; ICU = intensive care unit; MD = medical doctor; NP = nurse practitioner; PA = physician assistant.

*Categories are not mutually exclusive.

were present among all groups, and no differences were noted among specialties.

Knowledge of anticipatory guidance and prevention messages. Participant knowledge of anticipatory guidance (education about expected dengue clinical course) and prevention messages did not vary by duration of practice (Table 2), but did vary by level of clinical experience with dengue patients (Table 3). Only a limited number of participants (6%) correctly identified two of two prevention messages (Table 4). Although nearly all (99%) participants knew that avoidance of mosquito bites is necessary to avoid dengue, only 38% correctly identified that febrile dengue patients should take precautions to avoid mosquito bites to prevent transmitting DENV to household members or neighbors. Participants who reported having diagnosed ≥ 1 case of dengue (i.e., dengue-experienced clinicians) were more likely than those who had never diagnosed a case (i.e., dengue-inexperienced clinicians) to identify both of these prevention messages (21% versus 2%, $P = 0.001$; Table 3).

Fewer than 1% of participants correctly identified all warning signs for severe dengue (Table 4), and the majority (59%) did not recognize severe abdominal pain as a warning sign for severe dengue. Dengue-experienced clinicians did not perform better than dengue-inexperienced clinicians in identifying warning signs (Table 3). Approximately one-fifth (19%) of participants were able to correctly identify all three situations that should prompt a patient with suspected dengue to return for care (e.g., persistent

vomiting, drowsiness or lethargy, or hematemesis) (Table 4); dengue-experienced clinicians were more likely than dengue-inexperienced clinicians to correctly identify all three situations (34% versus 15%, $P = 0.006$; Table 3). The majority (70%) of participants correctly reported avoidance of administering NSAIDs (Table 4), although dengue-experienced clinicians were more likely to report doing so than dengue-inexperienced clinicians (84% versus 68%, $P = 0.041$; Table 3).

Knowledge of clinical presentation and course. Participant knowledge concerning clinical presentation and course of dengue did not vary by duration of medical practice or level of clinical experience with dengue patients (Tables 2 and 3). Approximately half (56%) of participants were able to identify all clinical signs and symptoms of dengue presentation (Table 4). A greater number (65%) of participants were able to correctly identify when plasma leakage might occur than were able to correctly identify when thrombocytopenia might be expected (46%). Approximately half (54%) of participants correctly identified tachycardia in the absence of fever or delayed capillary refill as the best early indicator of shock.

Knowledge of dengue clinical management. Participant knowledge of dengue clinical management varied somewhat by duration of practice (Table 2), but not by level of clinical experience with dengue patients (Table 3). A limited number (10%) of participants correctly identified two ways to detect clinically significant plasma leakage (i.e., a 20%

TABLE 2
Dengue knowledge and reported practices by clinical practice duration, Texas, 2014

	Practice duration, years				
	≤ 10	P value	11–30	P value	> 30
Total respondents, <i>n</i> (%)	92 (42)		93 (43)		32 (15)
Knowledge of anticipatory guidance and prevention messaging					
Correctly identified all prevention messages	7 (8)	0.001	5 (5)	0.001	13 (6)
Correctly identified all warning signs for severe dengue	0 (0)	0.867	1 (1)	0.635	1 (3)
Correctly identifies circumstances when patients should return for care	16 (17)	0.634	20 (22)	0.473	5 (16)
Correctly tells patient to avoid NSAIDs	61 (66)	0.697	71 (76)	0.129	20 (63)
Knowledge of clinical presentation and course					
Understood timing of thrombocytopenia	48 (52)	0.606	41 (44)	0.784	15 (47)
Understood timing of plasma leakage	60 (65)	0.128	66 (71)	0.999	16 (50)
Correctly identified dengue signs and symptoms	52 (57)	0.739	53 (57)	0.704	17 (53)
Correctly identifies early indicators of shock	45 (49)	0.308	54 (58)	0.897	19 (59)
Knowledge of dengue clinical management					
Correctly identified scenarios of plasma leakage	6 (7)	0.139	15 (16)	0.015	0 (0)
Correctly identified indications for crystalloids	4 (4)	0.289	7 (8)	0.740	3 (9)
Identified crystalloids as initial fluid in setting of elevated hematocrit	41 (45)	0.078	55 (59)	0.200	23 (72)
Correctly identified indications for blood transfusion	32 (35)	0.033	47 (51)	0.577	18 (56)
Identified blood transfusion as initial fluid in the setting of clinical bleeding	64 (70)	0.268	73 (79)	0.861	24 (75)
Correctly identified when discharge criteria met	11 (12)	0.691	12 (13)	0.596	3 (9)
Considered comorbidities before discharge	33 (36)	0.003	39 (42)	0.021	21 (66)
Identified hemoconcentration as indication for further monitoring	56 (61)	0.633	53 (57)	0.391	21 (66)
Correctly identified appropriate dengue diagnostic testing	60 (65)	0.255	55 (59)	0.553	17 (53)
Clinical practice					
Prescribes corticosteroids for dengue patients	1 (1)	0.005	2 (2)	0.018	4 (13)
Understands Texas dengue reporting requirements	69 (75)	0.472	74 (80)	0.838	26 (81)
Orders dengue diagnostic testing*					
On all suspected dengue patients	47 (51)	0.083	40 (43)	0.012	22 (69)
Only patients with low platelet counts	10 (11)	0.802	11 (12)	0.920	4 (13)
Patients in ED	11 (12)	0.935	10 (11)	0.787	4 (13)
Patients admitted to hospital	11 (12)	0.336	20 (22)	0.740	6 (19)
When diagnosis is uncertain	23 (25)	0.491	26 (28)	0.650	10 (31)
Do not test for dengue	11 (12)	0.236	6 (7)	0.147	2 (6)
Never treated a patient	57 (62)	0.236	60 (65)	0.147	16 (50)

ED = emergency department; NSAIDS = nonsteroidal anti-inflammatory drugs.

*Not mutually exclusive categories.

increase of hematocrit above baseline level and chest radiograph with lateral decubitus view to identify pleural effusion) (Table 4). Only 7% correctly identified all three indications for intravenous crystalloids in dengue patients (i.e., initial fluid resuscitation for suspected dengue patient with hypotension, high hematocrit or tachycardia, and low urine output) (Table 4). Approximately half (55%) of participants recognized that intravenous crystalloids should be used as the initial fluid replacement in dengue patients with elevated hematocrit. Dengue-experienced clinicians were more likely than dengue-inexperienced clinicians to correctly identify this indication (76% versus 51%, $P = 0.005$; Table 3). Approximately one-fourth (26%) of all participants failed to recognize the need for blood transfusion instead of intravenous crystalloids in dengue patients with clinically significant bleeding (Table 4). The majority (61%) of participants knew that anti-DENV IgM antibodies are first detectable on days 3–5 after illness onset.

Dengue patients can present for medical care at any point during or after illness, and clinicians should anticipate the need for hospital admission and safe discharge. When presented with four possible scenarios for safe hospital discharge, dengue-experienced clinicians were more likely to take into consideration comorbidities (e.g., diabetes) than dengue-inexperienced clinicians (61% versus 39%, $P = 0.016$; Table 3). Numerous participants (40%) did not know that hemoconcentration is an indication for further monitoring (Table 4).

Clinical practice. Corticosteroid use in the management of dengue patients was correctly low (3%) among all participants (Table 2); a higher proportion of clinicians practicing ≥ 30 years reported prescribing corticosteroid use than those practicing < 30 years (13% versus 1% for < 10 years, $P = 0.005$; 13% versus 2% for 11–30 years of practice, $P = 0.018$; Table 3). A higher proportion of dengue-experienced clinicians reportedly ordered diagnostic tests for all suspected dengue patients than clinicians without dengue experience (74% versus 45%, $P = 0.001$; Table 4). In a similar way, a higher proportion of physicians reportedly ordered diagnostic tests for all suspected dengue patients compared with physician extenders (73% and 50% for south Texas and HMA physicians, respectively, versus 48% and 41% for south Texas and HMA physician extenders, respectively; $P = 0.030$ (Table 4). The majority (78%) of participants correctly identified that dengue is a reportable disease in Texas, and that suspected and confirmed cases should be reported to the health department within 1 week (Table 2).

DISCUSSION

This survey among HMA and south Texas clinicians revealed critical knowledge gaps of dengue and its clinical management. Overall knowledge of anticipatory guidance and prevention messages for dengue and its clinical management was low among all participants regardless of clinician type, years of practice, and experience managing

TABLE 3
Dengue knowledge and reported practices by dengue clinical experience, Texas, 2014

	Ever diagnosed dengue		P value
	No	Yes	
Total respondents, <i>n</i> (%)	166 (81)	38 (19)	
Knowledge of anticipatory guidance and prevention messaging			
Correctly identified all prevention messages	4 (2)	8 (21)	0.001
Correctly identified all warning signs for severe dengue	1 (< 1)	1 (3)	0.176
Correctly identified circumstances patients should return to care	25 (15)	13 (34)	0.006
Correctly tells patients avoids NSAIDs	112 (68)	32 (84)	0.041
Knowledge of clinical presentation and course			
Understood timing of thrombocytopenia	77 (46)	20 (53)	0.487
Understood timing of plasma leakage	106 (64)	26 (68)	0.595
Correctly identified dengue signs and symptoms	93 (56)	22 (58)	0.834
Correctly identifies early indicators of shock	91 (55)	20 (53)	0.807
Knowledge of dengue clinical management			
Correctly identifies scenarios of leakage	14 (8)	7 (18)	0.176
Correctly identifies indications for crystalloids	9 (5)	3 (8)	0.559
Identified crystalloids as initial fluid in setting of elevated hematocrit	85 (51)	29 (76)	0.005
Correctly identifies indications for blood transfusion	70 (42)	19 (50)	0.380
Identified blood transfusion as initial fluid in the setting of clinical bleeding	124 (75)	28 (74)	0.897
Correctly identify when discharge criteria met	149 (90)	30 (79)	0.067
Considered comorbidities before discharge	65 (39)	23 (61)	0.016
Identified hemoconcentration as indication for further monitoring	99 (60)	23 (61)	0.920
Clinical practice			
Prescribes corticosteroids for dengue patients	3 (2)	3 (8)	0.
Understands Texas dengue reporting requirements	130 (78)	28 (74)	0.538
Orders dengue diagnostic testing*			
On all suspected dengue patients	74 (45)	28 (74)	0.001
Only on patients with low platelet counts	14 (8)	9 (24)	0.007
Patients in emergency department	17 (10)	8 (21)	0.067
Patients admitted to hospital	21 (13)	15 (40)	0.001
When diagnosis is uncertain	39 (24)	17 (48)	0.008
Do not test for dengue	15 (9)	3 (8)	0.823
Never treated a patient	123 (74)	0 (0)	0.001

NSAIDs = nonsteroidal anti-inflammatory drugs.

*Not mutually exclusive categories.

dengue patients. However, numerous clinicians did report correctly avoiding NSAIDs and ordering dengue diagnostic testing for patients suspected of having dengue. Participants understood dengue clinical presentation and course. Specific differences were noted between physicians and physician extenders in the identification of early indicators of shock and indications for blood transfusion. Physician extenders performed better concerning questions related to dengue identification than questions concerning inpatient clinical management, which might be related to training and practice sites (physician extenders may be more commonly involved in primary care versus specialty training). In addition, those in clinical practice > 10 years were more likely to identify the indications for blood transfusion in dengue patients than those practicing ≤ 10 years. Participants in clinical practice > 30 years were less likely to recognize scenarios of plasma leakage and more likely to prescribe corticosteroids to dengue patients than those practicing ≤ 30 years.

This survey was subject to multiple limitations, including participants' response and survey completion rates were low and varied with regard to specialty and geographic region. Specifically, HMA clinicians were more likely to participate, which might be attributable to differing recruitment methods in HMA and south Texas (i.e., the former received survey invitations from their employer and the latter from local medical societies). Second, the number of participating physicians from south Texas was low and prevented

direct comparisons between groups. Third, less knowledge of inpatient clinical management might be attributable to an overrepresentation of outpatient clinicians. Fourth, the survey did not allow participants to leave any question blank, forcing a response to maximize the number of completed surveys for analysis but may have skewed the sample toward those with more knowledge on dengue. Fifth, the sampling method may have selected for clinicians with more interest in dengue and potentially biasing toward those with more dengue knowledge. Finally, we were unable to describe clinicians who did not complete the survey, which limited our ability to fully account for bias.

Response rates in clinician surveys have traditionally been poor with the best response rates being roughly 40–50%.²³ Despite the low response rate, clear deficiencies in knowledge about dengue were evident among all participants. Given the abovementioned limitations and biases, it is possible that knowledge was skewed toward those with greater dengue interest and knowledge, magnifying knowledge deficiencies. Clinicians who reported experience in diagnosing and managing dengue, albeit with a limited number of patients, still scored poorly. We identified knowledge gaps reported from similar clinical surveys administered in dengue-endemic areas; clinicians lacked knowledge about dengue clinical characteristics,²⁴ severe disease warning signs, discharge criteria,²⁵ and prevention methods.²⁶ Limited recognition of the critical phase of disease by clinicians was also demonstrated in

TABLE 4
Dengue knowledge and reported practices by practice site and clinician type, Texas, 2014

	All	South Texas		Houston metropolitan area		P value
		MD	NP or PA	MD	NP or PA	
Total respondents, <i>n</i> (%)	217 (100)	33 (15)	40 (18)	85 (39)	59 (27)	
Knowledge of anticipatory guidance and prevention messages						
Correctly identified two of two prevention messages	13 (6)	4 (12)	3 (8)	5 (6)	1 (2)	0.231
Correctly identified all warning signs for severe dengue	2 (1)	1 (3)	0 (0)	1 (1)	0 (0)	0.460
Correctly identifies circumstances patients should return for care	41 (19)	10 (30)	4 (10)	24 (28)	3 (5)	0.153
Correctly tells patient to avoid NSAIDs	152 (70)	26 (79)	24 (60)	64 (75)	38 (64)	0.162
Knowledge of clinical presentation and course						
Understood timing of thrombocytopenia	104 (48)	18 (55)	24 (60)	33 (39)	29 (49)	0.123
Understood timing of plasma leakage	142 (65)	21 (64)	31 (78)	52 (61)	38 (64)	0.343
Correctly identified dengue signs and symptoms	122 (56)	18 (55)	25 (63)	51 (60)	28 (48)	0.390
Correctly identified early indicators of shock	118 (54)	21 (64)	9 (23)	60 (71)	28 (48)	0.001
Knowledge of dengue clinical management						
Correctly identified scenarios of plasma leakage	21 (10)	2 (6)	0 (0)	14 (17)	5 (9)	0.000
Correctly identified all indications for crystalloids	14 (7)	1 (3)	0 (0)	11 (13)	2 (3)	0.058
Identified crystalloids as initial fluid in setting of elevated hematocrit	119 (55)	23 (70)	12 (30)	58 (68)	26 (44)	0.01
Correctly identified all indications for blood transfusion	97 (45)	17 (52)	12 (30)	49 (58)	19 (32)	0.003
Identified blood transfusion as initial fluid in the setting of clinical bleeding	161 (74)	28 (85)	28 (70)	65 (77)	40 (68)	0.282
Correctly identified when discharge criteria met	26 (12)	7 (21)	2 (5)	10 (12)	7 (12)	0.211
Considered comorbidities before discharge	93 (43)	21 (64)	15 (38)	38 (45)	19 (32)	0.027
Identified hemoconcentration as indication for further monitoring	130 (60)	18 (55)	19 (48)	52 (61)	41 (70)	0.153
Correctly identified appropriate dengue diagnostic testing	132 (61)	21 (64)	28 (70)	56 (66)	27 (46)	0.045
Clinical practice						
Prescribes corticosteroids for dengue patients	7 (3)	1 (3)	2 (5)	4 (5)	0 (0)	0.000
Understands Texas dengue reporting requirements	169 (78)	22 (67)	30 (75)	71 (84)	46 (78)	0.243
Orders dengue diagnostic testing*						
On all suspected dengue patients	109 (50)	24 (73)	19 (48)	42 (50)	24 (41)	0.030
Only patients with low platelet counts	25 (12)	4 (12)	6 (15)	10 (12)	5 (9)	0.794
Patients in ED	25 (12)	4 (12)	8 (20)	9 (11)	4 (7)	0.240
Patients admitted to hospital	37 (17)	11 (33)	6 (15)	17 (20)	3 (5)	0.005
When diagnosis is uncertain	59 (27)	13 (39)	13 (33)	21 (25)	12 (20)	0.194
Do not test for dengue	19 (9)	4 (12)	6 (15)	5 (6)	4 (7)	0.310
Never treated a patient	133 (61)	5 (15)	25 (63)	56 (66)	47 (80)	0.001

ED = emergency department; MD = medical doctor; NP = nurse practitioner; NSAIDs = nonsteroidal anti-inflammatory drugs; PA = physician assistant.

*Not mutually exclusive categories.

a survey conducted in Puerto Rico.¹⁶ These surveys were conducted in endemic areas and reported higher response rates than our survey. However, it is likely that physicians working in areas which see only sporadic dengue (such as south Texas) have less knowledge about dengue, especially since U.S. medical education often lacks tropical medicine training.

These findings highlight a need for clinical management training for U.S. clinicians across all points of care in regions likely to treat dengue patients. Training is especially important in south Texas, because studies have demonstrated a continued risk for dengue outbreaks attributable to a highly mobile and susceptible population, regular DENV introduction, and presence of competent mosquito vectors in south Texas.¹¹ Further, all four DENV have been reported in the region, thereby increasing risk for secondary infections among the susceptible resident U.S. population.⁹ Because dengue patients experiencing secondary DENV infection are associated with increased risk for developing severe dengue, compared with patients with primary infection,¹ future outbreaks in south Texas might be associated with increased incidence of severe dengue.⁸

Focus on clinician training and education in areas at risk for DENV transmission or among clinicians who serve at-risk travelers is an important public health strategy to decrease morbidity and mortality associated with dengue. Previous physician trainings on dengue clinical manage-

ment in Puerto Rico demonstrated improved management of hospitalized dengue patients after the implementation of a classroom-style physician training course.²⁷ Medical curriculum should emphasize identified knowledge gaps, including warning signs for severe dengue and the clinical management of severe dengue. Online curriculum such as the CDC's Dengue Clinical Management Course (<http://www.cdc.gov/dengue/training/cme.html>) is an attractive option for education with free continuing medical education. Clinicians in Texas might also benefit from cross-border collaboration with clinicians in Mexico who have extensive dengue experience; possible projects might include clinical exchange programs or clinical research collaboration.

Received May 9, 2016. Accepted for publication December 2, 2016.

Published online January 30, 2017.

Note: Supplemental information includes the survey and answer key and appears at www.ajtmh.org.

Disclaimer: The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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REFERENCES

- Murray NE, Quam MB, Wilder-Smith A, 2013. Epidemiology of dengue: past, present and future prospects. *Clin Epidemiol* 5: 299–309.
- Martin JLS, 2010. The epidemiology of dengue in the Americas over the last three decades: a worrisome reality. *Am J Trop Med Hyg* 82: 128–135.
- Tomashek KM, Sharp TM, Margolis HS, 2016. Dengue. *CDC Health Information for International Travel: The Yellow Book*. Available at: <http://wwwnc.cdc.gov/travel/page/yellowbook-home-2014>. Accessed December 28, 2016.
- Leder KEA, 2013. GeoSentinel surveillance of illness in returned travelers, 2007–2011. *Ann Intern Med* 158: 456–468.
- Effler PVPL, Kitsutani P, Vorndam V, Nakata M, Ayers T, Elm J, Tom T, Reiter P, Rigau-Perez JG, Hayes JM, Mills K, Napier M, Clark GG, Gubler DJ; Hawaii Dengue Outbreak Investigation Team, 2005. Dengue fever, Hawaii, 2001–2002. *Emerg Infect Dis* 11: 742–749.
- Centers for Disease Control and Prevention, 2010. Locally acquired dengue: Key West, Florida, 2009–2010. *Morb Mortal Wkly Rep* 59: 577–581.
- Centers for Disease Control and Prevention, 2001. Underdiagnosis of dengue: Laredo, Texas, 1999. *Morb Mortal Wkly Rep* 50: 57–59.
- Centers for Disease Control and Prevention, 2007. Dengue hemorrhagic fever: U.S.-Mexico border, 2005. *Morb Mortal Wkly Rep* 56: 785–789.
- Ramos MM, Mohammed H, Zielinski-Gutierrez E, Hayden MH, Lopez JL, Fournier M, Trujillo AR, Burton R, Brunkard JM, Anaya-Lopez L, Banicki AA, Morales PK, Smith B, Munoz JL, Waterman SH; Dengue Serosurvey Working Group, 2008. Epidemic dengue and dengue hemorrhagic fever at the Texas-Mexico border: results of a household-based seroepidemiologic survey, December 2005. *Am J Trop Med Hyg* 78: 364–369.
- Brunkard JM, Robles Lopez JL, Ramirez J, Cifuentes E, Rothenberg SJ, Hunsperger EA, Moore CG, Brussolo RM, Villarreal NA, Haddad BM, 2007. Dengue fever seroprevalence and risk factors, Texas-Mexico border, 2004. *Emerg Infect Dis* 13: 1477–1483.
- Vitek CJ, Gutierrez JA, Dirrigl FJ Jr, 2014. Dengue vectors, human activity, and dengue virus transmission potential in the lower Rio Grande Valley, Texas, United States. *J Med Entomol* 51: 1019–1028.
- Anderson KBCS, Nisalak A, Mammen MP, Libraty DH, Rothman AL, Green S, Vaughn DW, Ennis FA, Endy TP, 2007. Burden of symptomatic dengue infection in children at a primary school in Thailand: a prospective study. *Lancet* 369: 1452–1459.
- Balmaseda ASK, Mercado JC, Matute JC, Tellez Y, Saborio S, Hammond SN, Nuñez A, Avilés W, Henn MR, Holmes EC, Gordon A, Coloma J, Kuan G, Harris E, 2010. Trends in patterns of dengue transmission over 4 years in a pediatric cohort study in Nicaragua. *J Infect Dis* 201: 5–14.
- Porter KRBC, Kosasih H, Tan RI, Alisiahbanana B, Rudiman PI, Widjaja S, Listiyaningsih E, Ma'Roef CN, McArdle JL, Parwati I, Sudjana P, Jusuf H, Yuwono D, Wuryadi S, 2005. Epidemiology of dengue and dengue hemorrhagic fever in a cohort of adults living in Bandung, West Java, Indonesia. *Am J Trop Med Hyg* 72: 60–66.
- Tomashek K, Gregory CJ, Rivera Sanchez A, Bartek MA, Garcia Rivera EJ, Hunsperger E, Muñoz-Jordán JL, Sun W, 2012. Dengue deaths in Puerto Rico: lessons learned from the 2007 epidemic. *PLoS Negl Trop Dis* 6: e1614.
- Tomashek K, Biggerstaff B, Ramos M, Perez-Guerra C, Garcia Rivera E, Sun W, 2014. Physician survey to determine how dengue is diagnosed, treated and reported in Puerto Rico. *PLoS Negl Trop Dis* 8: e3192.
- Secretaría de Salud, 2013. *Panorama Epidemiológico de Fiebre por Dengue y Fiebre Hemorrágica por Dengue*. Available at: http://www.epidemiologia.salud.gob.mx/doctos/panodengue/PANORAMAS_2013/Pano_dengue_sem52_sem2013.pdf. Accessed January 13, 2015.
- Thomas DLSG, Abeyta R, Hinojosa S, Torres-Velasquez B, Adam JK, Evert N, Caraballo E, Hunsperger E, Muñoz-Jordán JL, Smith B, Banicki A, Tomashek KM, Gaul L, Sharp TM, 2016. Reemergence of dengue in southern Texas, 2013. *Emerg Infect Dis* 22: 1002–1007.
- Epidemiología/LESP S, 2012. *Hasta Semana Epidemiológica 46*. Distrito Federal, Mexico: Dirección General de Epidemiología, Secretaría de Salud.
- Murray KO, Rodriguez LF, Herrington E, Kharat V, Vasilakis N, Walker C, Turner C, Khuwaja S, Arafat R, Weaver SC, Martinez D, Kilborn C, Bueno R, Reyna M, 2013. Identification of dengue fever cases in Houston, Texas, with evidence of autochthonous transmission between 2003 and 2005. *Vector Borne Zoonotic Dis* 13: 835–845.
- World Health Organization, 2009. *Dengue Guidelines for Diagnosis, Treatment, Prevention and Control*. Geneva, Switzerland: World Health Organization.
- SurveyMonkey, 2015. Available at: <https://www.surveymonkey.com/>. Accessed December 12, 2013.
- Cunningham CTQH, Hemmelgarn B, Noseworthy T, Beck CA, Dixon E, Samuel S, Ghail WA, Sykes LL, Jette N, 2015. Exploring physician specialist response rates to web-based surveys. *BMC Med Res Methodol* 15: 32.
- Ho TS, Huang MC, Wang SM, Hsu HC, Liu CC, 2013. Knowledge, attitude, and practice of dengue disease among healthcare professionals in southern Taiwan. *J Formos Med Assoc* 112: 18–23.
- Rafique I, Saqib MA, Munir MA, Siddiqui S, Malik IA, Rao MH, Ahmed J, Bashir S, Khan O, Firdous R, Ahmed S, 2015. Dengue knowledge and its management practices among physicians of major cities of Pakistan. *J Pak Med Assoc* 65: 392–396.
- Alzahrani A, 2015. Knowledge and practice of primary healthcare physicians regarding the dengue fever in Makkah Al-Mokarramah city, 2013. *Int J Med Sci Public Health* 4: 266–274.
- Han GSGC, Biggerstaff BJ, Horiuchi K, Perez C, Soto-Gomez E, Matos D, Margolis HS, Tomashek KM, 2016. Effect of a dengue clinical case management course on physician practices in Puerto Rico. *Clin Infect Dis* 63: 1297–1303.