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Readiness for an Increase in Congenital Zika Virus Infections in the United States: Geographic Distance to Pediatric Subspecialist Care

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Abstract

Objective: Investigate readiness for an increase in congenital Zika virus infections (CZI) by describing the distribution of pediatric subspecialists needed for the care of children with CZI.

Methods: We applied county-level subspecialist counts to U.S. maps, overlaying the geocoded locations of children's hospitals to assess correlation of hospital and subspecialist locations. We calculated travel distance from census tract centroids to the nearest in-state children's hospital by state (with/without >100 reported adult Zika virus cases) and by regions corresponding to the likely local Zika virus transmission area and to the full range of the mosquito vector. Travel distance percentiles reflect the population of children <5 years old.

Results: Overall, 95% of pediatric subspecialists across the United States are located in the same county or neighboring county as a children's hospital. In the states where Zika virus transmission is likely, 25% of children must travel more than 50 miles for subspecialty care; in one state, 50% of children must travel >100 miles.

Conclusions: The travel distance to pediatric subspecialty care varies widely by state and is likely to be an access barrier in some areas, particularly states bordering the Gulf of Mexico, which may have increasing numbers of CZI cases.

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Contributor's Statement

Dr. Bertolli drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Holbrook designed the study, performed analyses of data, contributed to the initial draft of the manuscript, and reviewed and revised the manuscript.

Ms. Dutton and Mr. Jones carried out the geospatial analyses, contributed to the initial draft of the manuscript, and reviewed and revised the manuscript.

Dr. Dowling contributed to the initial draft of the manuscript, and reviewed and revised the manuscript

Dr. Peacock conceptualized the study, and reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Echoing an earlier paper by Rasmussen et al.,[1] a recent comprehensive systematic review of the literature by a World Health Organization Expert Panel concluded that the most likely explanation of observations of clusters of microcephaly associated with outbreaks of Zika virus infection is that Zika virus infection during pregnancy is a cause of congenital brain abnormalities.[2] Zika virus infections acquired by pregnant women while traveling in an area with risk of Zika outside the 50 US states, along with local transmission of Zika virus in Florida and Texas,[3,4] resulted in reports of 1,297 pregnant women from 44 states to the US Zika Pregnancy Registry in 2016.[5] The US Zika Pregnancy Registry includes all pregnant women with any laboratory evidence of possible Zika virus infection from all US states, the District of Colombia, and US territories with the exception of Puerto Rico, which has a similar system, the Zika Active Pregnancy Surveillance System. Zika virus–associated birth defects were reported for 24 of the 250 fetuses/infants from completed pregnancies with laboratory-confirmed Zika virus infection [10%, 95% confidence interval [CI] = 7%–14%] reported to the US Zika Pregnancy Registry, including brain abnormalities and/or microcephaly and other early brain malformations, eye abnormalities, other consequences of central nervous system dysfunction, and neural tube defects.[5] It is unclear how many cases of congenital Zika infection (CZI) might occur in the next few years. If a large number of infants are affected in the United States, as in other countries in the Americas,[6] workforce capacity may be insufficient to provide the care that congenitally infected children will need.

Rubella provides a historical precedent for this scenario. The widespread rubella epidemic in 1964–65 resulted in the birth of approximately 20,000 children with serious congenital rubella-associated birth defects.[7] Many of these children had sensorineural hearing loss (SNHL) at birth, brain abnormalities, and vision loss, similar to children with CZI.[8,9] In addition to congenital anomalies, delayed onset endocrine and neurologic disorders, progressive hearing loss, and behavioral and developmental disorders attributable to rubella infection in utero were also documented.[10–13] At the time, the medical community struggled to assemble the multidisciplinary, coordinated care needed by children with long-term sequelae of congenital rubella infection. Their need for intensive diagnostic and therapeutic services required the joint assistance of a wide variety of medical and paramedical professionals with specialized expertise. Identifying and ensuring appropriate timing and use of available services to optimize outcomes and coordinating the large number of service providers were particular challenges.[14] Fortunately, with the licensure of a rubella vaccine in 1969 and subsequent widespread vaccination coverage, widespread rubella outbreaks were eliminated in the United States.[15]

Today, health care systems in the United States face similar challenges in coordinating care for children with complex medical needs; the generally low numbers and uneven distribution of pediatric medical subspecialists add to the challenge.[16] Congenital cytomegalovirus (CMV) infection, the most common nongenetic cause of SNHL as well as a cause of permanent neurologic disabilities and cognitive deficits in childhood, affects approximately

20,000 to 40,000 infants born each year in the United States.[17] In addition, noninfectious congenital conditions like complex congenital heart disease, extreme prematurity, and genetic conditions, like DiGeorge syndrome and Down syndrome, which are associated with neurodevelopmental disabilities, continue to affect children who need complex care.[18] The possibility that increased CZI could add to the number of children with neurodevelopmental disabilities in the coming years raises additional concerns about workforce capacity. Like children with neurodevelopmental disabilities from the infectious and noninfectious congenital causes mentioned above, children with disabilities related to CZI will need multidisciplinary care from pediatric subspecialists, such as neurologists, clinical geneticists, developmental pediatricians, ophthalmologists, audiologists, endocrinologists, orthopedists, physiatrists, pulmonologists or otolaryngologists, and gastroenterologists.[19,20] We assessed the geographic distribution of pediatric subspecialty care across the United States in light of the continuing need and the possibility of increased demand for these services.

Methods

We described the distribution of pediatric medical subspecialty services geographically across the United States, including US states with high likelihood of local Zika virus transmission (Alabama, Florida, Louisiana, Mississippi, Texas) and states reporting the majority of adult travel-associated cases of Zika virus disease as of April 2017 (California, Florida, Georgia, Illinois, Massachusetts, Maryland, North Carolina, New Jersey, New York, Pennsylvania, Texas, Virginia). Data from the February 2017 version of the American Medical Association (AMA) Physician Masterfile (https://www.ama-assn.org/life-career/ama-physician-masterfile) were used to determine the county-specific locations of nine relevant pediatric subspecialties across the continental United States and Hawaii and a subset of four pediatric subspecialties that we judged to be essential for the care of children with CZI, given the frequencies of specific disorders in these children.[21] The nine subspecialties included child neurology, developmental-behavioral pediatrics and neurodevelopmental disabilities (combined for analytic purposes), pediatric orthopedics, pediatric endocrinology, pediatric infectious diseases, pediatric otolaryngology, pediatric gastroenterology, pediatric ophthalmology, and pediatrics/physical medicine and rehabilitation and pediatric rehabilitation medicine (combined for analytic purposes). The subset of essential subspecialties included child neurology, pediatric gastroenterology, pediatric ophthalmology, and either developmental-behavioral pediatrics or neurodevelopmental disabilities. Full complements of essential pediatric subspecialists (ie, one of each of the four subspecialties) were counted by county and state, focusing on the five Gulf states with the highest likelihood of local transmission of Zika virus[22,23] and the 12 states with more than 100 reported laboratory-confirmed travel-associated cases of Zika virus disease in adults as of April 27, 2017.[24] A state was considered to have a full complement if it had one of each of the essential pediatric subspecialists, even if the subspecialists were dispersed across multiple counties.

Next, we examined the proximity of pediatric subspecialists to in-state children’s hospitals to determine whether children’s hospitals might serve as indicators of clusters of pediatric subspecialists. We geocoded street addresses of children’s hospitals that comprise the members of the Children’s Hospital Association, which include specialty children’s hospitals, hospitals that serve as primary teaching sites of organized pediatrics departments of approved medical schools, and hospitals that are pediatric referral centers.[25]

The proximity of children under age 5 years in each census tract to subspecialists was assessed by calculating the travel distance on streets from each census tract's centroid (geographical center) to the nearest in-state children's hospital. We calculated the distance to the nearest in-state children's hospital, without accounting for border crossing, because of restrictions on reimbursement for out-of-state service providers in some health insurance plans. Census tract boundaries and population data by census tract for children under age 5 years were obtained from the 2011–2015 American Community Survey 5-year estimates (US Census).

Network analysis was performed in ArcMap 10.3 (Esri™) to calculate these travel distances on a US street network (StreetMap Premium for ArcGIS Desktop, HERE North America 2016R2). A search radius of 5 km was used to locate the street nearest each census tract centroid and hospital. For any census tract for which the street closest to the centroid was not connected to the network, or for which the centroid was greater than 5 km from the nearest street connected to the network, the travel distance was calculated from the nearest point to the centroid that was on a street within the tract connected to the street network. Some census tracts with a population under age 5 years greater than zero had no street within the tract connected to the street network. In this case, a street connected to the network was on the boundary of the tract or less than or equal to 10 km from the boundary of the tract, and the travel distance was calculated from the nearest point on that street. Census tracts with zero land area (ie, water-only census tracts), with no streets and zero population under age 5 years (n=4), or no streets connected to the street network and zero population under age 5 years (n=2) were excluded from analysis.

Analytically, some states were handled differently than others because of a variety of unique scenarios. Neither Montana nor Wyoming has a children's hospital and they have few pediatric subspecialists (n=5 and n=1, respectively). For all census tracts in both of these states, distance to the nearest out-of-state children's hospital was calculated. Kansas does not have a children's hospital, but Johnson County, in which Kansas City is located, has 30 subspecialists representing eight of the nine types of interest and Sedgwick County, containing Wichita, has 10 subspecialists representing six of the nine types of interest. Therefore, both counties are likely able to provide care for many complex medical cases; these county centroids were processed in the same way as the geocoded children's hospitals. Finally, for Alaska and Hawaii, geodesic distances between census tract centroids and the nearest in-state children's hospitals, rather than travel distances on streets, were calculated in ArcMap 10.3 using the Near tool because travel by air is required between some locations. All census tracts with land area in Alaska (n=167) and Hawaii (n=326) were included in these datasets.

We used SAS v. 9.4 (SAS Institute, Inc., Cary, NC) to examine minimum and maximum travel distances to the nearest in-state children's hospital for census tracts with children under age 5 years, for each state, as well as percentiles of children under age 5 years according to travel distances from the centroids of their census tracts. The travel distance for

50% of children under age 5 years is hereafter referred to as the median travel distance, and the travel distance for 25% to 75% of children under age 5 years is referred to as the interquartile range. Percentiles of travel distance to the nearest in-state children's hospital were also calculated in the same way for children under age 5 years in groups of states: a) those on the Gulf of Mexico, b) those with more than 100 reported cases of Zika virus disease in adults as of April 2017, and c) the remaining states. In addition, travel distance percentiles were compared for children in states within and outside the expected range of *Aedes aegypti* mosquitoes (states "within the range" are those with at least half of their land area covered by the range).[26]

Results

The frequencies of the nine pediatric subspecialist types are displayed in Table 1. Child neurology is the most common subspecialist type (n=1219), followed by pediatric endocrinology (n=1051) and pediatric gastroenterology (n=999). Nationwide, 20 states have all of the pediatric subspecialist types, 28 states have at least eight of the nine types, and 31 states have at least seven of the nine. The distribution of the subset of subspecialist types we consider to be essential for the care of children with neurodevelopmental disorders like congenital Zika syndrome is also limited: 35 states have all four of the essential subspecialist types, and 42 states have at least three of the four. Two of the five Gulf States where local transmission of Zika virus has the highest likelihood of taking hold lack a full complement of essential pediatric subspecialists in any county, although the four essential subspecialist types can be found within these states (Table 2, Figure 1). Of the 12 states that have reported more than 100 cases of Zika virus disease in adults as of April 2017, all but two have a full complement of essential pediatric specialists localized within a county or counties, and these two have a full complement dispersed across multiple counties.

Overall, 95% of subspecialists are located in the same county or a neighboring county as a children's hospital, and no children's hospitals are without pediatric subspecialists nearby (all hospitals except one have at least three subspecialists in the same or a neighboring county; one hospital has two, and most hospitals have at least six subspecialists). Therefore, children's hospitals were used as a proxy for subspecialist location in subsequent analyses. The distributions of pediatric subspecialists and children's hospitals across the country are displayed in Figures 2a and 2b. Similar to the observed distribution of pediatric specialists, numbers of children's hospitals are higher around large cities and in the mid-Atlantic, northeastern corridor. Moreover, the hospitals are clustered geographically on the East and West Coasts, with significant gaps in the middle of the country.

Of the 5119 pediatric subspecialists, 4059 (79.3%) are located in a county with a children's hospital and 785 (15.3%) are located in a county adjacent to a county with a children's hospital. In total, 5.4% of the pediatric subspecialists of interest are located more than one county away from a county with a children's hospital (data not shown).

Figure 3 shows the minimum, maximum, median, and interquartile range of travel distance for children under age 5 years to the nearest in-state children's hospital, by state. Table 3 provides this information for groups of states: the five states bordering the Gulf of Mexico, which have the greatest potential for future local transmission; the 12 states that have reported more than 100 cases of travel-associated Zika virus disease among adults as of April 2017; and the remaining states. For two of the five Gulf states, 50% of children live in census tracts with centroids 50 or more miles from the nearest children's hospital in the state, and for four of these five states, 25% of children are in census tracts with centroids 50 or more miles from the nearest in-state children's hospital. In contrast, in the 12 states that account for 75% of the reported travel-associated cases of Zika virus disease among adults to date, travel distances for 50% of the state's population under age 5 years range from 9 to 35 miles. For eight states—Alaska, Montana, Wyoming, North Dakota, Idaho, Mississippi, Arkansas, and South Dakota—50% of children live in census tracts with centroids more than 100 miles from the nearest children's hospital in the state, and in Alaska, Montana, and Wyoming, 50% live in census tracts with centroids more than 250 miles away from an in-state children's hospital. In 21 states, travel distance to an in-state children's hospital for 50% of children is 25 miles or less. The 75th percentiles for 17 states show that 25% of children under age 5 years live 100 or more miles from a children's hospital.

Mapping of estimated ranges of *Ae. albopictus* and *Ae. aegypti* together with locations of children's hospitals reveals that there are states in addition to the five Gulf states where access to children's hospitals, and hence pediatric subspecialists, could be limited (Figure 4) and where there may be potential for Zika virus transmission. Arizona, Arkansas, and New Mexico each have a single children's hospital, and Kansas has none, although two Kansas counties have full complements of essential pediatric subspecialists. Median and interquartile range of travel distances to a children's hospital within these states (subspecialist location in Kansas) are 19 miles (10–110) for Arizona, 112 miles (41–163) for Arkansas, 97 miles (10–220) for New Mexico, and 31 miles (12–98) for Kansas.

Discussion

Like other investigators[27,28] we found that access to pediatric subspecialists is uneven across the United States and that pediatric subspecialists practice in close proximity to children's hospitals.[29] Further, results of our analysis suggest cause for concern about the degree of preparedness for an increase in cases of CZI. Our data indicate that at least 25% of the children under age 5 years in most of the states with the highest likelihood of establishing local Zika virus transmission must travel at least 50 miles to the nearest in-state children's hospital. This distance may be unmanageable for families with limited transportation, resources, and sick leave benefits when children require frequent health care visits. The data also indicate that this distance barrier exists to a similar extent for children in states for which at least half of the land area is located within the range of the *Ae. aegypti* mosquitoes that transmit Zika virus. However, travel-associated cases of Zika virus disease in adults tend to be reported from population centers in states where there is a large international airport(s), and we also might expect most travel-associated CZI cases to be reported from these population centers in these states, which are well covered by pediatric subspecialist services.

Although only the severe end of the spectrum of CZI outcomes has been described, a pattern of structural anomalies and functional disabilities secondary to central and, perhaps, peripheral nervous system damage is recognized.[21] Congenital Zika syndrome is a medically complex condition, involving multiple organs, functional limitations, and high resource need/use,[30] and requires coordinated care by multiple pediatric medical subspecialists and allied health professionals.[19] A survey of parents of children with special health care needs (SHCN) indicated an inverse relationship between the number of pediatric subspecialists in their states and unmet need for pediatric subspecialty care.[20]

A subset of children with SHCN, including children with congenital Zika syndrome, require complex medical care. Among children in the United States, an estimated 400,000 require complex medical care.[28] Neurodevelopmental disorders, like those associated with CMV infections and Down syndrome, are prevalent among children with complex medical conditions.[30] These children tend to have functional limitations and multisystem comorbidities, including gastrointestinal (eg, feeding or swallowing), musculoskeletal (eg, spasticity), and respiratory (eg, difficulty in handling secretions).[31–34] We found that 50% of children under age 5 years in states that neither are at high risk of local Zika transmission nor have a higher likelihood of travel-associated CZI were even farther from pediatric subspecialist care than states with these characteristics. This highlights the uneven access to pediatric subspecialty care for children with other conditions requiring complex medical care.

Our data indicate that geographic barriers to accessing pediatric subspecialty care are not limited to states that have had local transmission of Zika virus or have the potential for such transmission. The American Board of Pediatrics has also published detailed data showing the variation in ratios of pediatric subspecialists to children, by state.[35] Our findings are consistent with the observation that parents of children with SHCN with neurologic conditions were more likely to report that their child had unmet health care needs than parents of children without SHCN.[36] Other investigators have found that, across the socioeconomic spectrum, children with medical complexity have high levels of unmet need.[37,38]

An increase in supply of pediatric subspecialists alone is unlikely, at least in the short run, to improve the distribution of these subspecialists.[29] The Health Resources and Services Administration National Health Service Corps Zika Response and Preparedness Act loan forgiveness initiative,[39] which aims to increase pediatric subspecialist placement in affected areas, is an important step toward improving access to pediatric subspecialist care needed by families affected by Zika virus. In addition, the Centers for Disease Control and Prevention (CDC) is collaborating with the March of Dimes on Zika Care Connect—a service that helps families find specialty health care services and identify providers whose practices meet their needs through a provider referral network, a website with a searchable database and information resources (https://www.zikacareconnect.org/), and a helpline.[40] Through the Zika Care Connect website, pediatric medical subspecialists can be located in the District of Columbia and 19 states, including three of the five states with a high likelihood of the local Zika virus transmission (Florida, Louisiana, and Texas).

Other possible actions to improve access to pediatric subspecialty care include internet triage systems and telephone consultation to address scheduling barriers in areas with a high supply of subspecialists,[23] and support for telehealth and satellite clinics in areas of low supply. A national pediatric telehealth research network, Supporting Pediatric Research on Outcomes and Utilization of Telehealth (SPROUT), established in 2015, conducted a survey between October 2016 and March 2017 to assess the current state of pediatric telehealth programs across the United States. More than 50 programs in 30 states responded to the survey, including twenty-two sites (40%) with dedicated pediatric programs, and 29 (53%) with combined programs for pediatric and adult telehealth.[41] Twenty-two of the responding programs (25%) were regional, 10 (20%) statewide, 14 (29%) multistate and 8 (16%) nationwide. Neurology and developmental pediatrics, two of the four pediatric subspecialties that we judged to be essential for the care of children with CZI, were among the top 5 most common (established/pilot) pediatric telehealth service lines.[41] However, barriers to implementing telehealth programs remain, including policy barriers. According to the American Telemedicine Association's 2017 State Gaps Analysis, only twenty-one states, including 3 of the 5 with high likelihood of local Zika virus transmission, averaged the highest "composite grade," signifying a supportive policy landscape that accommodates telemedicine adoption and implementation.[42]

Limitations

In this article, we measured access to care by distance to services. Investigating the extent to which the distances documented are barriers to subspecialty care was beyond the scope of this analysis. We presume that they would present a challenge to families with limited access to transportation and/or sick leave benefits. Geographic proximity is an important determinant of access to care, yet we did not consider other factors that affect access, such as demographic factors[28] and insurance status or provider reimbursement.[43] Other investigations have found that the supply of pediatric specialists is associated with significantly higher likelihood of receiving needed specialty care,[20] although parents in areas of high supply often report financial and scheduling barriers.[27] Analyses taking into account demand as well as supply ratios are needed to account for such access challenges as appointment wait lists. Such analyses were beyond the scope of this paper.

The data we used, and hence, our analyses, were focused on pediatric medical subspecialists, of which our "full complement of essential pediatric subspecialists" required by children with congenital Zika syndrome are a subset. However, we recognize that pediatric subspecialists in allied health professions, such as audiologists and physical therapists, are also essential to the care of children with congenital Zika syndrome. [19] Ideally, an evaluation of readiness for an increase in congenital Zika infections in the U.S. would include assessment of the ability to access quality care in a pediatric medical home within a network of coordinated community services; such an assessment was beyond the scope of this paper. Additionally, the analyses we performed may have missed areas with a full complement of essential pediatric subspecialists where subspecialists are in close proximity, although dispersed across county or state lines. And although the AMA Physician Masterfile is used frequently for physician workforce analyses, it may have limitations with respect to estimating the number of pediatric subspecialists. A documented limitation of the Masterfile, which is continuously updated, is that changes to the locations of physicians who have moved and removal of retired and deceased physicians may be delayed. Taken together, these limitations may have caused us either to underestimate or overestimate the pediatric subspecialist workforce.[44]

The simple method that we used to assess geographic proximity to hospitals involved the assumption that the travel distance measured from a census tract centroid was a reasonable estimation of the distance that a given child in that tract would have to travel. Populous, typically urban, census tracts tend to be smaller, with a relatively uniform spatial distribution of population. However, we acknowledge that our assumption is less reasonable for some large, rural tracts, especially in some Western states, for which the centroid is a poor estimate of the location of the tract's residences.

Finally, our findings are not generalizable to other countries. Countries where CZI is having the heaviest impact may have different distance barriers to accessing pediatric subspecialty care.

Conclusion

The travel distance to pediatric subspecialty care varies widely by state and may be a barrier to care access in some areas, particularly in states bordering the Gulf of Mexico, which may have increasing numbers of CZI cases. In addition, our analysis highlights the uneven distance to pediatric subspecialty care across the United States for children with other conditions requiring complex medical care.

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Abbreviations:

SNHL	sensorineural hearing loss
CZI	congenital Zika virus infection
AMA	American Medical Association

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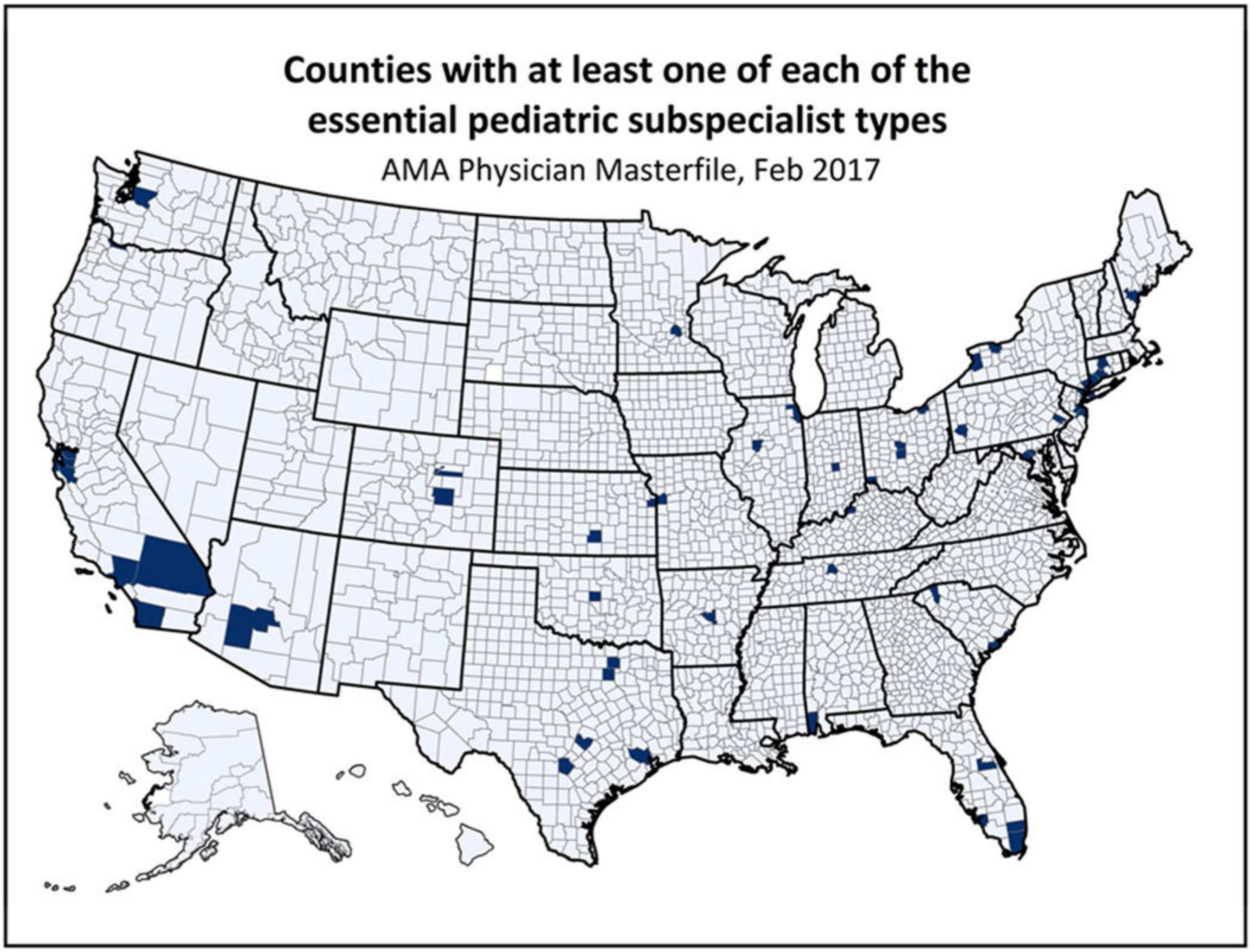

Figure 1.

Notes: Essential pediatric subspecialist types are child neurology, pediatric gastroenterology, pediatric ophthalmology, and either developmental-behavioral pediatrics or neurodevelopmental disabilities. Counties with at least one of each of the essential pediatric subspecialist types are indicated in dark blue.

Data source: American Medical Association Physician (AMA) Masterfile. https://www.ama-assn.org/life-career/ama-physician-masterfile. Accessed February 16, 2017.

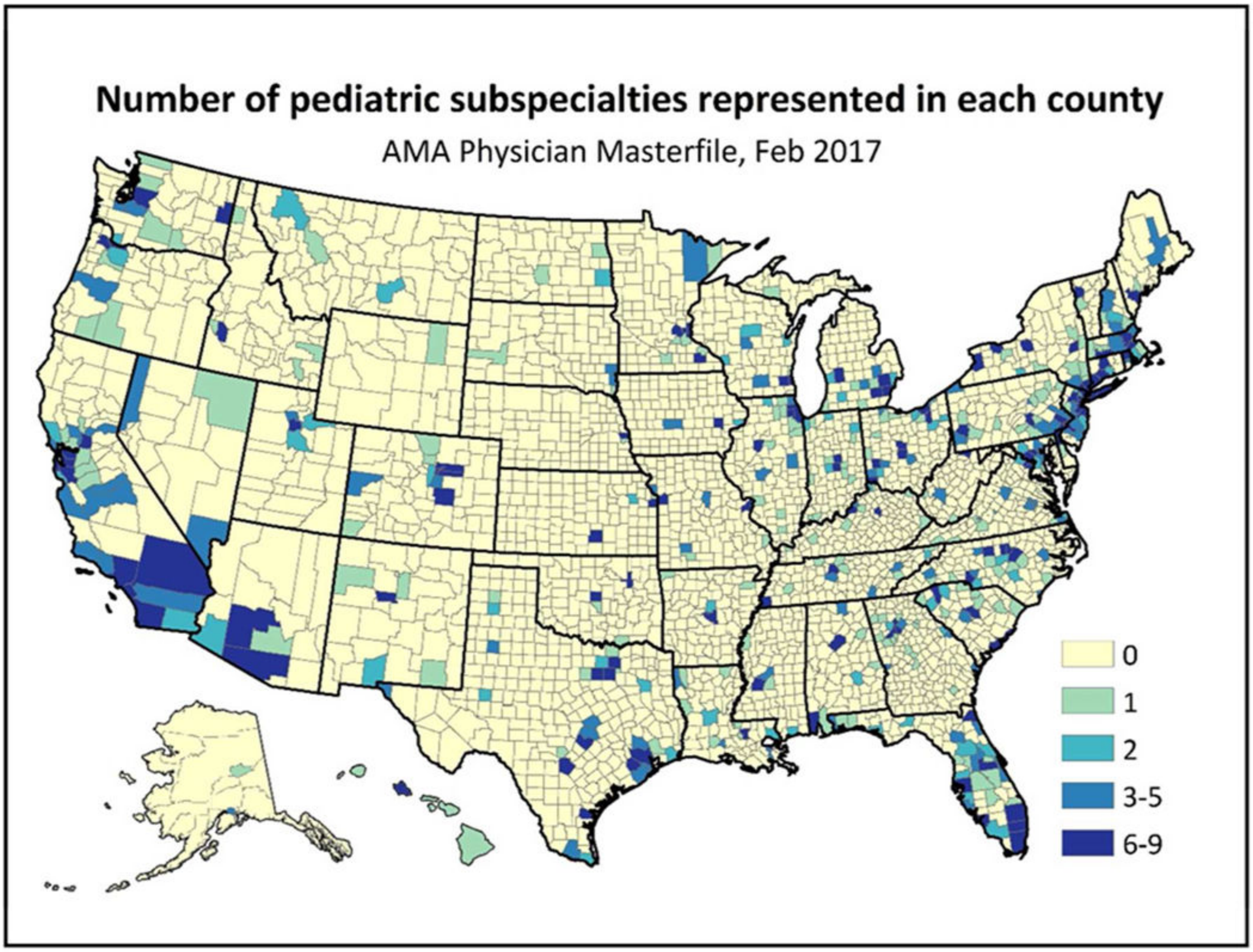

Figure 2a.
Data source: American Medical Association Physician (AMA) Masterfile. https://www.amaassn.org/life-career/ama-physician-masterfile. Accessed February 16, 2017.

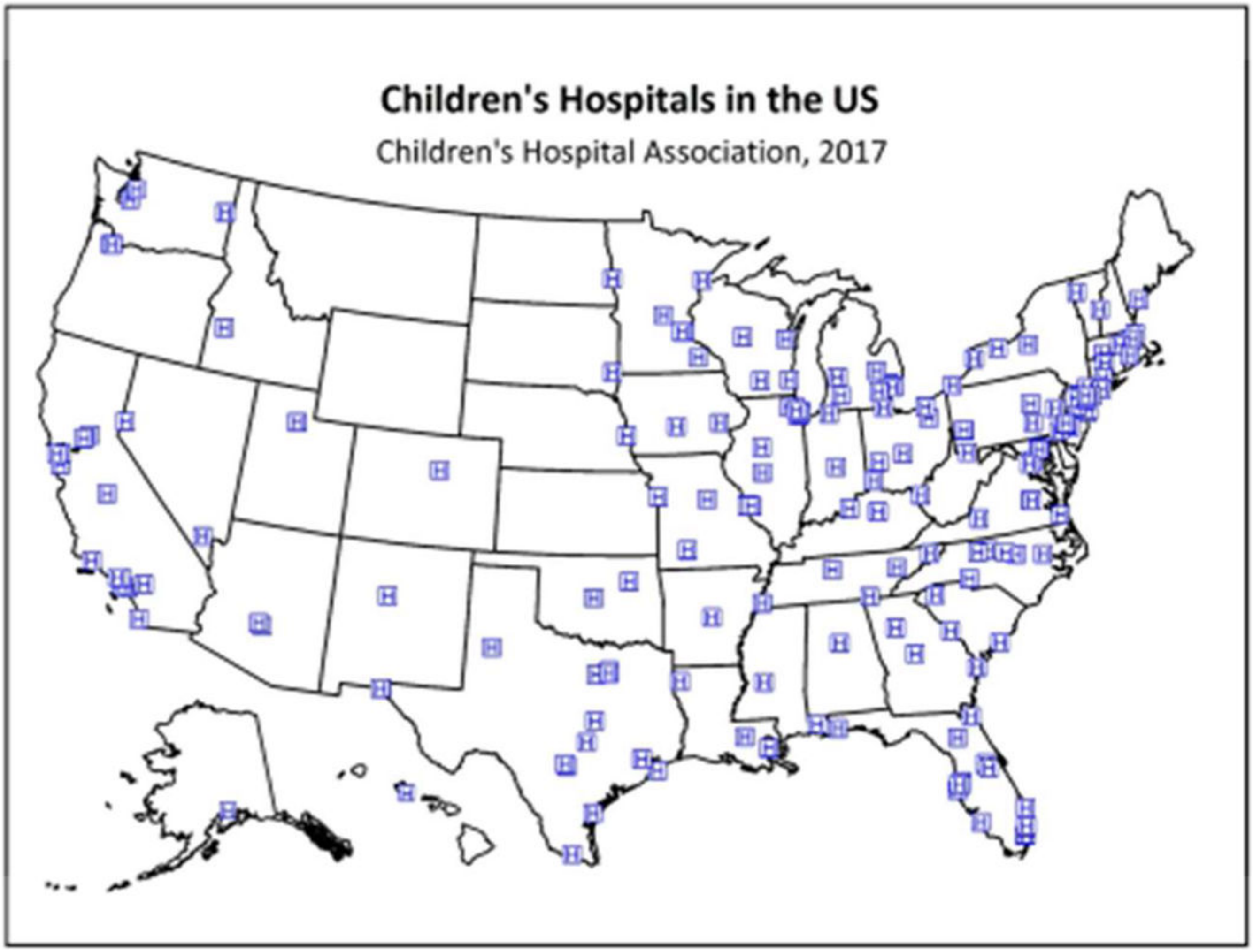

Figure 2b.

Note: Each “H” indicates the location of a children’s hospital.

Data source: Children’s Hospital Association, Children’s Hospital Directory. https://www.childrenshospitals.org/Directories/Hospital-Directory. Accessed March 2, 2017.

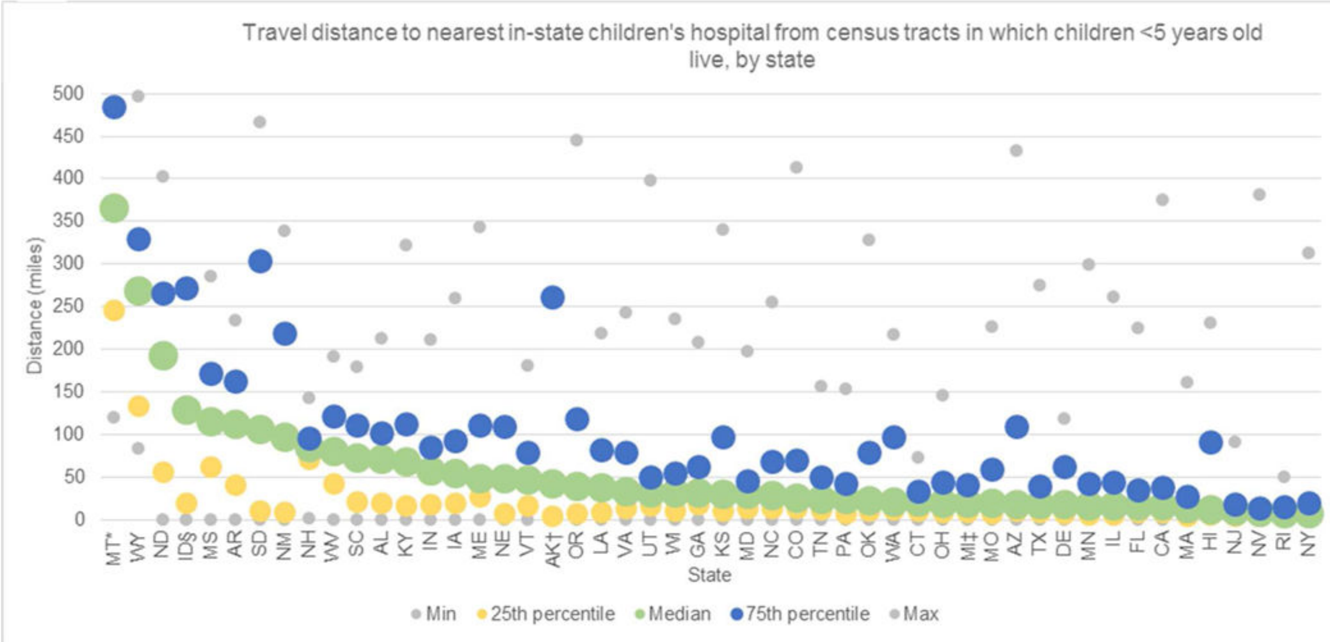

Figure 3.

Notes: Percentiles reflect maximum travel distances by streets from census tract centroids for 25%, 50%, and 75% of children under age 5 years. Minimum and maximum distances are from census tracts that have a non-zero population of children under age 5 years and have the shortest or longest distance, respectively, from the nearest in-state children's hospital. The nearest hospital in any state was used for Montana and Wyoming calculations. For Kansas, centroids of Johnson and Sedgwick Counties were treated as children's hospitals. Geodesic distances, not on-street travel distances, were used for Alaska and Hawaii.

Maximum travel distances from the nearest in-state children's hospital exceeded 500 miles in Montanta (MT), Idaho (ID), Alaska (AK), and Michigan (MI). Exact maximum distances for these states are as follows:

*Max (MT): 569 miles

§Max (ID): 501 miles

†Max (AK): 1142 miles

‡Max (MI): 599 miles

Data source: Children's Hospital Association, Children's Hospital Directory. https://www.childrenshospitals.org/Directories/Hospital-Directory. Accessed March 2, 2017.

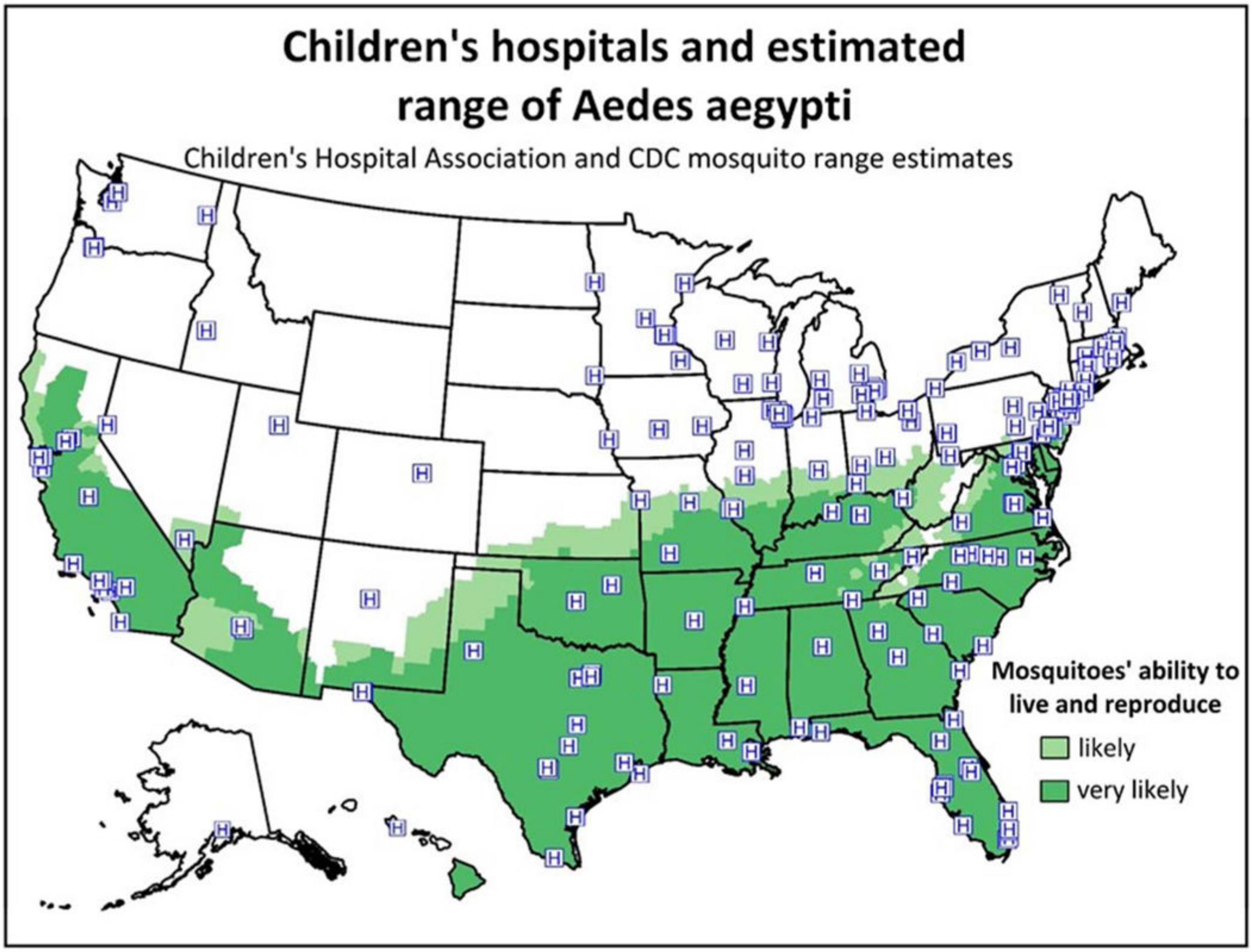

Figure 4.

Note: Each "H" indicates the location of a children's hospital.

Data sources: Children's Hospital Association. Children's Hospital Directory. https://www.childrenshospitals.org/Directories/Hospital-Directory. Accessed March 2, 2017.

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Table 1.

Numbers of Pediatric Subspecialists Nationwide, in States with High Likelihood of Zika Virus Transmission* and in States with >100 Reported Travel-Associated Cases of Zika Virus Disease in Adults,§ by Subspecialty

Pediatric Subspecialist Type	Number in US	Number in States with High Likelihood of Zika Virus Transmission (n=5)	Number in States with >100 Reported Travel-Associated Cases of Zika Virus Disease in Adults (n=12)
Child neurology	1219	207	736
Developmental-behavioral pediatrics and neurodevelopmental disabilities (combined for analytic purposes)	278	33	161
Pediatric orthopedics	482	123	271
Pediatric endocrinology	1051	192	653
Pediatric infectious diseases	540	108	328
Pediatric otolaryngology	258	60	145
Pediatric gastroenterology	999	184	611
Pediatric ophthalmology	207	33	122
Pediatrics/physical medicine and rehabilitation and pediatric rehabilitation medicine (combined for analytic purposes)	85	12	42
Total	5119	952	3069

*Includes Alabama, Florida, Louisiana, Mississippi, and Texas.

§Includes California, Florida, Georgia, Illinois, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Texas, and Virginia.

Table 2.

Number of Counties with Full Complement of Pediatric Subspecialists and Travel Distance to Nearest In-State Children's Hospital, in States with High Likelihood of Local Zika Virus Transmission and >100 Reported Travel-Associated Zika Virus Cases in Adults to Date

	Number of Counties with Full Complement of Essential Pediatric Subspecialists*	Number of Children's Hospitals	Travel Distance to Nearest In-State Children's Hospital Median No. Miles (Interquartile Range)†
States with High Likelihood of Local Zika Virus Transmission			
Alabama	1	2	75 (22–105)
Florida	4	19	17 (9–36)
Louisiana	0§	6	39 (10–82)
Mississippi	0§	1	115 (63–173)
Texas	5	20	19 (10–39)
States with >100 Reported Travel-Associated Cases of Zika Virus Disease in Adults**			
California	7	20	17 (9–39)
Georgia	0§	4	33 (19–63)
Illinois	2	12	17 (7–44)
Maryland	2	5	31 (14–46)
Massachusetts	1	11	14 (5–28)
New Jersey	3	13	10 (6–18)
New York	5	16	9 (4–21)
North Carolina	0§	8	29 (14–68)
Pennsylvania	2	11	25 (9–43)
Virginia	1	10	35 (14–80)

*Full complement of subspecialties for care of children with congenital Zika syndrome include child neurology, pediatric gastroenterology, pediatric ophthalmology, and either developmental-behavioral pediatrics or neurodevelopmental disabilities.

†Median and interquartile range represent distance from the nearest in-state children's hospital from centroids of census tracts accounting for 50%, and 25%–75% of each state's children under age 5 years, respectively.

§States with a full complement of essential pediatric subspecialists dispersed across multiple counties, rather than within a county or counties.

**Cases reported through April 27, 2017; also includes Florida and Texas (not repeated because these states are listed in the first group above).

Table 3.

Travel Distance to the Nearest In-State Children's Hospital for Children Under Age 5 Years in Selected Regions

	a) Gulf Coast States (n=5)	**b) States with >100 Reported Travel-Associated Cases of Zika Virus Disease in Adults (n=12)**	**c) Neither a) nor b) (n=35)**	**d) States with ≥50% of Land Area in the *Aedes aegypti* Range (n=23)**	**e) States with <50% of Land Area in the *Aedes aegypti* Range (n=28)**
Min (miles)	0.1	0.0	0.1	0.1	0.0
25th percentile (miles)*	11.4	8.5	11.7	10.6	8.4
Median (miles)*	23.2	18.2	29.2	22.6	21.0
75th percentile* (miles)	57.6	41.4	79.9	58.6	56.5
Max (miles)	285.5	376.1	599.9	434.0	599.9

*25th percentile, median, and 75% percentile represent distance from the nearest in-state children's hospital from centroids of census tracts accounting for 25%, 50%, and 75% of each region's children under age 5 years, respectively.

[a)] Gulf Coast: AL, FL, LA, MS, TX

[b)] >100 adult cases: CA, FL, GA, IL, MA, MD, NC, NJ, NY, PA, TX, VA

[c)] neither (a) nor (b): AR, AK, AZ, CO, CT, DC, DE, HI, IA, IN, ID, KS, KY, MI, ME, MN, MO, MT, ND, NE, NH, NM, NV, OH, OK, OR, RI, SC, SD, TN, UT, VT, WA, WI, WY

[d)] At least half in *Ae. aegypti* range: AL, AR, AZ, CA, DC, DE, FL, GA, HI, KY, LA, MD, MO, MS, NC, NM, NJ, OK, SC, TN, TX, VA, WV

[e)] Less than half in *Ae. aegypti* range: AK, CO, CT, IA, ID, IL, IN, KS, MA, MI, ME, MN, MT, ND, NE, NH, NV, NY, OH, OR, PA, RI, SD, UT, VT, WA, WI, WY