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Allan M. Joseph, MD, MPH, Andrew J. Lautz, MD, Carlie N. Myers, MD, MS, Ranjit S. Chima, MD, Juan P. Gurria, MD, MSc, Shafee Salloum, MD, Wendy Hasson, MD, Matthew P. Malone, MD, Jenna O. Miller, MD, Reanna Smith, RN, Maya L. Dewan, MD, MPH

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State and Regional Variation in Access to Pediatric Extracorporeal Membrane Oxygenation

Allan M. Joseph, MD, MPH;[1,2,3] Andrew J. Lautz, MD;[1,2] Carlie N. Myers, MD, MS; [1,2,3] Ranjit S. Chima, MD; [1,2] Juan P. Gurria, MD, MSc;[4,5] Shafee Salloum, MD;[1,2] Wendy Hasson, MD;[6] Matthew P. Malone, MD;[7] Jenna O. Miller, MD;[8] Reanna Smith, RN;[9] Maya L. Dewan, MD, MPH[1,2,3]

Affiliations:

1. Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, OH
2. Division of Critical Care Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, OH
3. James M. Anderson Center for Health Systems Excellence, Cincinnati Children's Hospital Medical Center, Cincinnati, OH
4. Department of Surgery, University of Cincinnati College of Medicine, Cincinnati, OH
5. Division of Pediatric General and Thoracic Surgery, Cincinnati Children's Hospital Medical Center, Cincinnati, OH
6. Division of Pediatric Critical Care Medicine, Randall Children's Hospital at Legacy Emanuel
7. Division of Critical Care Medicine, Department of Pediatrics, University of Arkansas for Medical Sciences, Arkansas Children's Hospital, Little Rock, AR
8. Division of Critical Care, Department of Pediatrics, University of Missouri-Kansas City and Children's Mercy Hospital, Kansas City, MO
9. ECMO Program, Patient Services Institute, Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Address correspondence to:

Allan M. Joseph, MD, MPH
Cincinnati Children's Hospital Medical Center
3333 Burnet Avenue, MLC 2005
Cincinnati, OH 45229
Allan.Joseph@cchmc.org
513-636-4334

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Abstract

Extracorporeal membrane oxygenation (ECMO) is only available in specialized medical centers. We conducted a geospatial analysis and found state- and region-level variation in the supply of ECMO centers and the number of children who had access to ECMO. These findings may help target areas for the development of new ECMO programs.

Extracorporeal membrane oxygenation (ECMO) is a highly specialized, resource-intense form of life support for patients with severe cardiac and/or respiratory failure refractory to conventional medical management. Extracorporeal cardiopulmonary resuscitation (ECPR) refers to the use of ECMO to restore circulation during CPR for refractory cardiac arrest while underlying causes are treated. Despite their life-saving potential, these time-sensitive interventions, particularly ECPR, depend on rapid activation and deployment of complex, multidisciplinary systems, limiting their widespread use.[1]

Thus, children generally only receive ECMO support in referral centers such as children's hospitals or large general hospitals, which are not uniformly distributed throughout the United States (US). Recent literature has shown that 1 in 3 children in the US do not live within a 60-minute drive of an ECMO center and that even though interfacility transfer systems could expand access to nearly the entire US pediatric population, this potential has not yet been realized.[2–4] In addition, very few children live close enough to an ECMO center to receive ECPR in the case of out-of-hospital cardiac arrest (OHCA), though there is growing interest in expanding access to selected children who suffer OHCA in light of emerging data that ECPR is associated with improved outcomes.[5–8]

To date, however, all studies of access to ECMO services have been at the national level, which may obscure important variation at the state and regional levels. In the US, child health policies, including hospital regulation and payment policy (eg, Medicaid and the Children's Health Insurance Program) are typically set at the state rather than federal level. Thus, initiatives to improve pediatric ECMO delivery through payment reforms, statewide coordination, or investments in infrastructure (such as air transfer networks), would likely be driven by state-level policymakers, as has been seen in other pediatric conditions.[9–14] However, state borders do not capture coherent systems of acute care that span general emergency care through definitive specialty services (such as children's hospitals).[15] These networks, which are bound together by shared referral and practice patterns, are better

described by regional systems such as Pediatric Emergency Referral Regions (PERRs) defined in the recently developed “Atlas of Pediatric Acute Care”.[16] Although state policy generally drives “top down” system change, regional analysis better captures actual patterns of care delivery in their local context, especially in areas where children frequently cross borders to receive care. [15,17] Thus, regional analysis may enable “anchor” children’s hospitals to coordinate practice and referral patterns across the areas from which they receive patients.[17,18]

State and regional variation in the supply of pediatric ECMO centers, and access to these centers, has not yet been described. Because doing so may inform future changes in the organization of ECMO referral systems in the US, we conducted a cross-sectional geospatial analysis to answer these questions. We hypothesized that there would be significant variation among states and regions in ECMO center supply and access.

Methods

We first identified all centers providing pediatric or neonatal (hereafter “pediatric”) ECMO and ECPR services in the US (consisting of the 50 states and the District of Columbia, hereafter “states”) using the Extracorporeal Life Support Organization (ELSO) registry, which our group and others have previously used to study access to ECMO services.[2,4,19,20] As in prior work, we used ELSO criteria to identify centers who reported providing ECMO services: ELSO classifies any center as providing a service if it reported at least 1 case meeting criteria (ie, a specific support modality and patient age group) in the last 5 years.[2,4] We manually extracted center characteristics, including the services provided and ECMO center addresses, between April 15, 2025 and May 19, 2025.

We additionally accessed the 104 PERRs defined by the “Atlas of Pediatric Acute Care” for the states in our analysis.[16] Analogous to Hospital Referral Regions from the “Dartmouth Atlas for Adult Care”, PERRs describe geographically distinct systems of pediatric acute care at

the tertiary/referral level; in general, more than 90% of pediatric acute care referrals stay within a PERR. These regions frequently cross state borders, and most states have more than 1 PERR.

Because PERRs are constructed from ZIP codes and their associated spatial representations known as ZIP Code Tabulation Areas (ZCTAs), we performed our geospatial analysis at this level. We linked ZIP codes to their population centroids from the US Department of Housing and Urban Development, which enable accurate population-level analyses by representing the average geographic location of a person with a given ZIP code.[21,22] We used the American Community Survey to access the population <15 years of age for each ZCTA, since this approach more specifically identifies pediatric care patterns.[23–25]

We first measured the number of ECMO centers in each region and state and calculated Pearson correlation coefficients between their pediatric population and the number of ECMO centers. Adapting our prior methods, we then measured access at the ZIP code level by using ArcGIS Pro software to define “service areas” around ECMO centers, which represent the geographic area from which a patient could reach an ECMO center under given travel assumptions.[4] If a ZIP code’s population centroid fell within the service area, all children in the ZIP code were assigned as having access to ECMO; if it fell outside the service area, all children in the ZIP code were assigned as not having access.

To facilitate comparison with prior literature, we conducted our analysis using three scenarios we published previously.[4] First, we calculated “direct access” to ECMO, defined as the share of children <15 years of age who could reach an ECMO center by car within 60 minutes under typical traffic or weather conditions. We chose this threshold to align with other studies of access to pediatric services including ECMO, inpatient hospitalization, and certified trauma centers.[2,26–28] Second, we calculated “any access” to ECMO by adding the share of children with “indirect access” to those with direct access. We defined “indirect access” as the share of children <15 years of age living within a 60-minute drive of a hospital capable of

facilitating timely air transfer to ECMO services. “Indirect access” hospitals were defined as those within a 120-mile radius of an ECMO center, representing a 1-hour 1-way helicopter transport or 3-hour round-trip transport (including dispatch time and time at the bedside). We chose this threshold to align with the primary analysis in the largest analogous study of indirect access to ECMO services for adult populations.[29] Third, we calculated potential access to ECPR services in case of OHCA, which we defined as living within 15 minutes of a center providing pediatric ECPR services. We chose this threshold to align with recent models of ground-based EMS transport of adult patients suffering OHCA to ECPR centers.[30,31]

We calculated all access findings at the ZIP code level and then aggregated our findings by state and PERR. Importantly, we intentionally structured our analysis to not require children to have access to services within the state or region in which they live. Rather, we measured the share of children living within a state or region who have timely access to ECMO and ECPR services, even if they must cross a state border to do so, as this better reflects the reality of pediatric acute care delivery.[15]

As analysis of publicly available facility- and census tract-level data, this investigation is not human subjects research and is exempt from Institutional Review Board requirements. We conducted data manipulation in R version 4.4.0 and geospatial analysis in ArcGIS Pro version 3.3.2.

Results

We identified 258 pediatric ECMO centers and 169 pediatric ECPR centers. As shown in **Figure 1**, there was variation in ECMO center supply, with a median of 4 ECMO centers per state (interquartile range [IQR] 2 – 6) and 2 centers per region (IQR 1 – 3). Six states and 14 regions had no ECMO centers. The Pearson correlation coefficient between state population and ECMO center supply was 0.92; the coefficient between regional population and ECMO center supply was 0.80.

Direct access to ECMO centers varied widely by state and region (**see Figure 2**). In the median state, 69.2% of children had direct driving access to ECMO services (IQR 44.1% – 79.5%). In the median region, 70.0% of children had direct access to ECMO services (IQR 64.7% – 89.0%). In 14 states and 27 regions, <50% of children had direct driving access to ECMO services.

However, when accounting for indirect access (**see Figure 3**), access was near-universal. In the median state, 98.5% of children had access via direct and/or indirect methods (IQR 89.7% - 99.8%), with only 5 states having <50% access under this model. In the median region, 99.7% of children had direct and/or indirect ECMO access (IQR 96.4% - 100%), with only 6 regions demonstrating <50% access under this model.

Very few states and regions had meaningful ECPR access (**see Figure 4**). In the median state, 11.2% of children (IQR 4.1% - 14.0%) had access to ECPR services; only 2 states (the District of Columbia and Rhode Island) demonstrated >25% access. In the median region, 10.3% of children had access to ECPR (IQR 4.8% - 15.7%); only 7 regions demonstrated >25% access to ECPR services.

We report the raw data, including the raw number and share of children with access to ECMO and ECPR services, in the **Supplement**.

Discussion

In this geospatial analysis, we found significant variation among states and regions in both the supply of pediatric ECMO centers and the ability of children to access these centers. Despite improvements in potential accessibility using interfacility transport, a meaningful share of children in some areas still lack access to ECMO services. We also found that very few areas have a meaningful share of children with potential access to ECPR for OHCA.

Our study builds upon earlier work by demonstrating variation in ECMO access at the levels of the system at which child health is most directly affected. These findings can directly inform how state policymakers and regional leaders approach the organization of ECMO

centers and the design of high-functioning interfacility transfer systems. Although the state-level variation in ECMO center supply is strongly correlated with population, there is more variation in ECMO supply at the regional level. Although some regions have no ECMO centers, others have as many as 9 centers serving the shared patient population living in the region. Hospital leaders in regions without ECMO centers should consider whether their region needs (and can support) its own pediatric ECMO program, even if located within an adult hospital or a non-academic hospital.[32] Conversely, hospital leaders in regions with many centers should carefully consider whether their region strikes the right balance of competition, coordination, and centralization for ECMO and related services such as cardiac surgery.[33] Though competition can spur quality improvement, it may also reduce patient volume at individual centers, which may not be desirable in light of volume-outcome relationships for ECMO care and cardiac surgery.[34–37]

In some areas where children cross state borders to receive acute care, the organization of ECMO centers within states may not fully reflect the areas served by those centers. However, one strength of our analysis of access is that it allows for children to cross borders to reach ECMO services, yet we still reveal meaningful state- and region-level variation in access to ECMO. In many states, most children live within driving distance of ECMO centers, and in most states, timely interfacility transfers can extend access to ECMO services to nearly all children. However, some important gaps in access remain, especially in sparsely populated parts of the rural western US. In these areas, low population density prohibits the development of specialty centers such as children's hospitals with sufficient volume, and the large geographic area complicates the rapid transfer of patients to specialty centers. Some children's hospitals in the West provide quaternary services to many of these areas through existing transfer networks, but these are above the level of regional tertiary services as defined by PERRs.[38,39] Although this may ultimately extend ECMO access beyond what we model, these long-distance transfers do not represent timely access within existing systems of tertiary care delivery.

Our finding of limited accessibility of ECPR centers aligns with national data. However, studying access at smaller areas reveals one important finding: some regions and states may serve as ideal “laboratories” to develop and refine ECPR systems for pediatric OHCA. In small states such as Rhode Island and the District of Columbia, large shares of the pediatric population live near ECPR centers, as in some densely populated regions (such as New York City). The optimal use of ECPR for pediatric OHCA remains a major evidence gap in the newest Pediatric Life Support guidelines, but retrospective data suggest ECPR may lead to higher survival than conventional CPR in comparable populations.[7,8] Thus, there remains interest in developing streamlined ECPR systems that incorporate prehospital recognition of eligible patients to activate hospital-based ECMO services. There have even been some efforts to provide mobile ECMO and ECPR, with evidence of early success in the Minneapolis-based program.[40] Thus, these states and regions may be poised to lead further expansion of these efforts, especially in pediatric patients.[30,31]

Finally, our findings add to a century’s worth of observations that the structure, function, and outcomes of the health care system vary widely at the regional level.[41–44] Recent decades have seen significant changes in the organization of pediatric acute care services, though these changes have not been uniform across the US.[25,45–47] Future studies should explore how state- and regional-level variation in the structure of pediatric acute care systems relate to outcomes and costs; given the variation we document here, ECMO may be a useful paradigm in which to study these questions.

Although the ELSO database is the largest database of ECMO services in the US, it is voluntary and has limited granularity. Thus, there may be a small number of ECMO-capable centers that are not in the ELSO database, and conversely, some adult centers that provide ECMO only to adult-sized teenagers qualify as providing pediatric ECMO in our study. We expect the net effect of these factors to represent “best-case” scenarios of access. We also are limited by our assumptions about travel, including the availability of rotor-wing transport. Though

these choices are in some ways arbitrary, we chose these assumptions to facilitate comparisons to prior literature.[2,26–29] In some areas, air transfer may not always be available due to weather conditions or lack of available infrastructure; in this case, our data provide an estimate of the potential gains in access available from investments in infrastructure.

In conclusion, we found significant variation among states and regions in both the supply of pediatric ECMO centers and the ability of children to access these center . These findings have the potential to guide policymakers and hospital leaders in the organization of ECMO services as these programs continue to grow.

REFERENCES

[1] Guerguerian A-M, Sano M, Todd M, Honjo O, Alexander P, Raman L. Pediatric Extracorporeal Cardiopulmonary Resuscitation ELSO Guidelines. ASAIO Journal 2021;67:229–37. https://doi.org/10.1097/MAT.0000000000001345.

[2] Moynihan K, Day R, Alizadeh F, Weld J, Barbaro R, Blossom J, et al. Access to pediatric extracorporeal membrane oxygenation according to neighborhood-level determinants of health. Intensive Care Med – Paediatr Neonatal 2025;3:21. https://doi.org/10.1007/s44253-025-00079-0.

[3] Alizadeh F, Gauvreau K, Barreto JA, Hall M, Bucholz E, Nathan M, et al. Paediatric extracorporeal membrane oxygenation use by social determinants: a multicentre retrospective cohort study. The Lancet Child & Adolescent Health 2025;9:565–77. https://doi.org/10.1016/S2352-4642(25)00134-8.

[4] Joseph AM, Lautz AJ, Myers CN, Chima RS, Gurria JP, Salloum S, et al. Geographic Access to Pediatric ECMO and ECPR: A Geospatial Study of Transport Networks and Disparities. Resuscitation Plus 2026;28:101221. https://doi.org/10.1016/j.resplu.2026.101221.

[5] Bilodeau KS, Gray KE, McMullan DM. Extracorporeal cardiopulmonary resuscitation outcomes for children with out-of-hospital and emergency department cardiac arrest. The American Journal of Emergency Medicine 2024;81:35–9. https://doi.org/10.1016/j.ajem.2024.03.035.

[6] Holmberg MJ, Granfeldt A, Guerguerian A-M, Sandroni C, Hsu CH, Gardner RM, et al. Extracorporeal cardiopulmonary resuscitation for cardiac arrest: An updated systematic review. Resuscitation 2023;182. https://doi.org/10.1016/j.resuscitation.2022.12.003.

[7] Olson TL, Kilcoyne HW, Morales-Demori R, Rycus P, Barbaro RP, Alexander PMA, et al. Extracorporeal cardiopulmonary resuscitation for pediatric out-of-hospital cardiac arrest: A review of the Extracorporeal Life Support Organization Registry. Resuscitation 2024;203. https://doi.org/10.1016/j.resuscitation.2024.110380.

[8] Scholefield BR, Acworth J, Ng K-C, Tiwari LK, Raymond TT, Christoff A, et al. Pediatric Life Support: 2025 International Liaison Committee on Resuscitation Consensus on Science With Treatment Recommendations. Circulation 2025;152. https://doi.org/10.1161/CIR.0000000000001362.

[9] Cichon ME, Fuchs S, Lyons E, Leonard D. A Statewide Model Program to Improve Emergency Department Readiness for Pediatric Care. Annals of Emergency Medicine 2009;54:198–204. https://doi.org/10.1016/j.annemergmed.2008.12.030.

[10] Bethell CD, Kogan MD, Strickland BB, Schor EL, Robertson J, Newacheck PW. A National and State Profile of Leading Health Problems and Health Care Quality for US Children: Key Insurance Disparities and Across-State Variations. Academic Pediatrics 2011;11:S22–33. https://doi.org/10.1016/j.acap.2010.08.011.

[11] Caffrey SM. Leveraging EMS for Children State Partnerships to Improve Pediatric EMS Care. Clinical Pediatric Emergency Medicine 2018;19:226–32. https://doi.org/10.1016/j.cpem.2018.09.001.

[12] Fenton SJ, Swendiman RA, Eyre M, Larsen K, Russell KW. The Utah Pediatric Trauma Network, a statewide pediatric trauma collaborative can safely help nonpediatric hospitals admit children with mild traumatic brain injury. Journal of Trauma and Acute Care Surgery 2023;95:376. https://doi.org/10.1097/TA.0000000000003871.

[13] Boggs KM, Voligny E, Auerbach M, Espinola JA, Samuels-Kalow ME, Sullivan AF, et al. A Comparison of State-Specific Pediatric Emergency Medical Facility Recognition Programs, 2020. Pediatric Emergency Care 2024;40:141. https://doi.org/10.1097/PEC.0000000000003119.

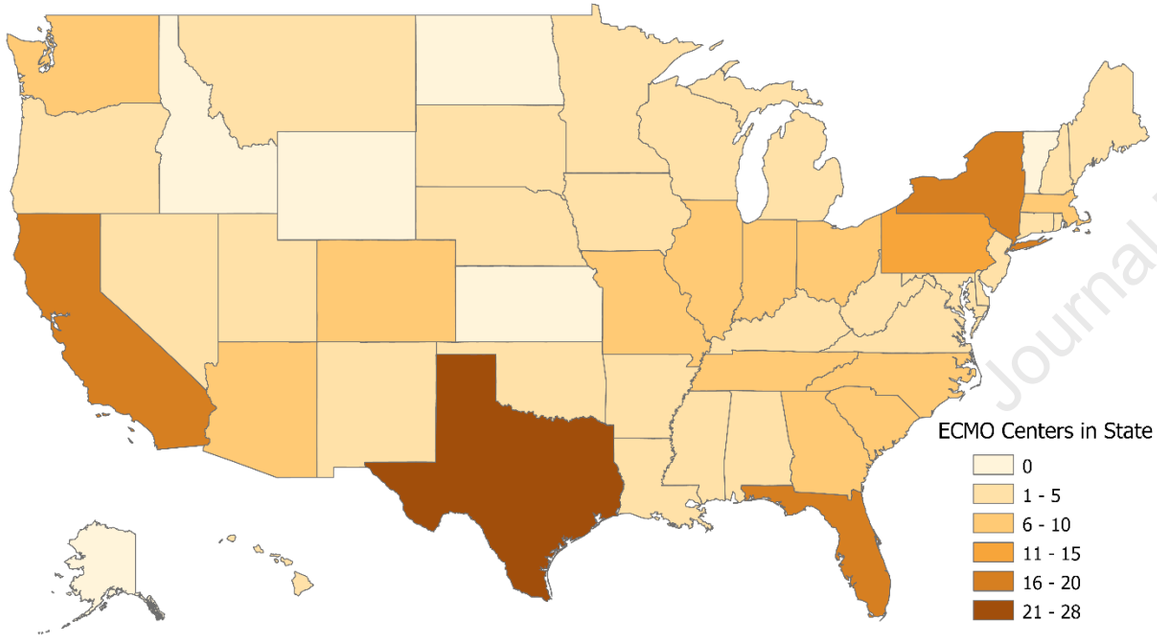
[14] Mitchell SH, Merkel MJ, Eriksson CO, Sakata VL, King MA. Using Two Statewide Medical Operations Coordination Centers to Load Balance in Pediatric Hospitals During a Severe Respiratory Surge in the United States. Pediatric Critical Care Medicine 2023;24:775. https://doi.org/10.1097/PCC.0000000000003301.
[15] Michelson KA, Singamsetty N, Skol AD, Remick KE, Bucholz EM, Graves JA, et al. Out-of-State Acute Care Use Among Pediatric Medicaid Enrollees. JAMA Netw Open 2025;8:e2536236. https://doi.org/10.1001/jamanetworkopen.2025.36236.
[16] Michelson KA, Skol AD, Graves JA, Remick KE, McMullen PD, Singamsetty N, et al. Development of an Atlas for US Pediatric Acute Care. JAMA Pediatr 2025. https://doi.org/10.1001/jamapediatrics.2025.4227.
[17] Wallace DJ, Angus DC, Seymour CW, Barnato AE, Kahn JM. Critical care bed growth in the United States. A comparison of regional and national trends. Am J Respir Crit Care Med 2015;191:410–6. https://doi.org/10.1164/rccm.201409-1746OC.
[18] Joseph AM, Minturn JS, Kurland KS, Davis BS, Kahn JM. Development and Evaluation of Pediatric Acute Care Hospital Referral Regions in Eight States. The Journal of Pediatrics 2025;276:114371. https://doi.org/10.1016/j.jpeds.2024.114371.
[19] ELSO Member Centers by Category n.d. https://elso.org/membership/centersbycategory.aspx (accessed April 15, 2025).
[20] Tonna JE, Barbaro RP, Rycus PT, Wall N, Raman L, Nasr VG, et al. On the Academic Value of 30 Years of the Extracorporeal Life Support Organization Registry. ASAIO Journal 2021;67:1–3. https://doi.org/10.1097/MAT.0000000000001318.
[21] Department of Housing and Urban Development. ZIP Code Population Weighted Centroids n.d. https://hudgis-hud.opendata.arcgis.com/datasets/d032efff520b4bf0aa620a54a477c70e (accessed February 7, 2022).
[22] Berke EM, Shi X. Computing travel time when the exact address is unknown: a comparison of point and polygon ZIP code approximation methods. Int J Health Geogr 2009;8:23. https://doi.org/10.1186/1476-072X-8-23.
[23] Michelson KA, Neuman MI. Age Cutoffs for Hospitalization at Hospitals Without Pediatric Inpatient Capability. Hosp Pediatr 2021;11:284–6. https://doi.org/10.1542/hpeds.2020-003897.
[24] Michelson KA, Alpern ER, Remick KE, Cash RE, Kemal S, Wolk CB, et al. Defining Levels of US Hospitals' Pediatric Capabilities. JAMA Network Open 2024;7:e2422196. https://doi.org/10.1001/jamanetworkopen.2024.22196.
[25] Joseph AM, Ray KN, Kurland KS, Hewes HA, Brown KM, Davis BS, et al. Changes in Access to High Pediatric Readiness Emergency Care in the United States from 2013 to 2021. The Journal of Pediatrics 2026:114834. https://doi.org/10.1016/j.jpeds.2025.114834.
[26] Chien AT, Pandey A, Lu S, Bucholz EM, Toomey SL, Cutler DM, et al. Pediatric Hospital Services Within a One-Hour Drive: A National Study. Pediatrics 2020;146:e20201724. https://doi.org/10.1542/peds.2020-1724.
[27] Hur DG, Ren AL, Yue TM, Spain DA, Choi J. Pediatric Trauma Center Access, Regional Injury Burden, and Socioeconomic Disadvantage. JAMA Surgery 2024. https://doi.org/10.1001/jamasurg.2024.0962.
[28] Melhado C, Hancock C, Wang H, Eldin MM, George N, Miller JA, et al. Pediatric Readiness and Trauma Center Access for Children. JAMA Pediatrics 2025;179:455–62. https://doi.org/10.1001/jamapediatrics.2024.6058.
[29] Wallace DJ, Angus DC, Seymour CW, Yealy DM, Carr BG, Kurland K, et al. Geographic Access to High Capability Severe Acute Respiratory Failure Centers in the United States. PLoS ONE 2014;9:e94057. https://doi.org/10.1371/journal.pone.0094057.
[30] Gottula AL, Shaw CR, Gorder KL, Lane BH, Latessa J, Qi M, et al. Eligibility of out-of-hospital cardiac arrest patients for extracorporeal cardiopulmonary resuscitation in the

United States: A geographic information system model. Resuscitation 2022;180:111–20. https://doi.org/10.1016/j.resuscitation.2022.09.017.
[31] Gottula AL, Qi ,Man, Lane ,Bennett H., Shaw ,Christopher R., Gorder ,Kari, Powell ,Elizabeth, et al. Prehospital Ground and Helicopter-Based Extracorporeal Cardiopulmonary Resuscitation (ECPR) Reduce Barriers to ECPR: A GIS Model. Prehospital Emergency Care 2025;29:53–61. https://doi.org/10.1080/10903127.2024.2355652.
[32] Troy L, Su F, Kilbaugh T, Rasmussen L, Kuo T, Jett E, et al. Characteristics of Pediatric Extracorporeal Membrane Oxygenation Programs in the United States and Canada. ASAIO Journal 2021;67:792. https://doi.org/10.1097/MAT.0000000000001311.
[33] Baicker K, Levy H. Coordination versus Competition in Health Care Reform. N Engl J Med 2013;369:789–91. https://doi.org/10.1056/NEJMp1306268.
[34] Karamlou T, Vafaeezadeh M, Parrish AM, Cohen GA, Welke KF, Permut L, et al. Increased extracorporeal membrane oxygenation center case volume is associated with improved extracorporeal membrane oxygenation survival among pediatric patients. The Journal of Thoracic and Cardiovascular Surgery 2013;145:470–5. https://doi.org/10.1016/j.jtcvs.2012.11.037.
[35] Freeman CL, Bennett TD, Casper TC, Larsen GY, Hubbard A, Wilkes J, et al. Pediatric and Neonatal Extracorporeal Membrane Oxygenation: Does Center Volume Impact Mortality?*. Critical Care Medicine 2014;42:512. https://doi.org/10.1097/01.ccm.0000435674.83682.96.
[36] Barbaro RP, Odetola FO, Kidwell KM, Paden ML, Bartlett RH, Davis MM, et al. Association of Hospital-Level Volume of Extracorporeal Membrane Oxygenation Cases and Mortality. Analysis of the Extracorporeal Life Support Organization Registry. American Journal of Respiratory and Critical Care Medicine 2015;191:894–901. https://doi.org/10.1164/rccm.201409-1634OC.
[37] Barrett CS, Chan TT, Wilkes J, Bratton SL, Thiagarajan RR. Association of Pediatric Cardiac Surgical Volume and Mortality After Cardiac ECMO. ASAIO Journal 2017;63:802–9. https://doi.org/10.1097/MAT.0000000000000558.
[38] Riley T, Umoren R, Kotler A, Feltner J, Billimoria Z, James J, et al. Disparities in access to healthcare services in a regional neonatal transport network. International Journal of Industrial Ergonomics 2024;99:103526. https://doi.org/10.1016/j.ergon.2023.103526.
[39] França UL, McManus ML. Unplanned Regionalization and Interstate Dependence in Pediatric Hospital Care. JAMA Health Forum 2026;7:e256800. https://doi.org/10.1001/jamahealthforum.2025.6800.
[40] Bartos JA, Frascone RJ, Conterato M, Wesley K, Lick C, Sipprell K, et al. The Minnesota mobile extracorporeal cardiopulmonary resuscitation consortium for treatment of out-of-hospital refractory ventricular fibrillation: Program description, performance, and outcomes. eClinicalMedicine 2020;29. https://doi.org/10.1016/j.eclinm.2020.100632.
[41] Glover JA. The Incidence of Tonsillectomy in School Children. Proceedings of the Royal Society of Medicine 1938.
[42] Wennberg J, Gittelsohn A. Small Area Variations in Health Care Delivery: A population-based health information system can guide planning and regulatory decision-making. Science 1973;182:1102–8. https://doi.org/10.1126/science.182.4117.1102.
[43] Song Y, Skinner J, Bynum J, Sutherland J, Wennberg JE, Fisher ES. Regional Variations in Diagnostic Practices. New England Journal of Medicine 2010;363:45–53. https://doi.org/10.1056/NEJMsa0910881.
[44] Newhouse JP, Garber AM. Geographic Variation in Health Care Spending in the United States: Insights From an Institute of Medicine Report. JAMA 2013;310:1227. https://doi.org/10.1001/jama.2013.278139.

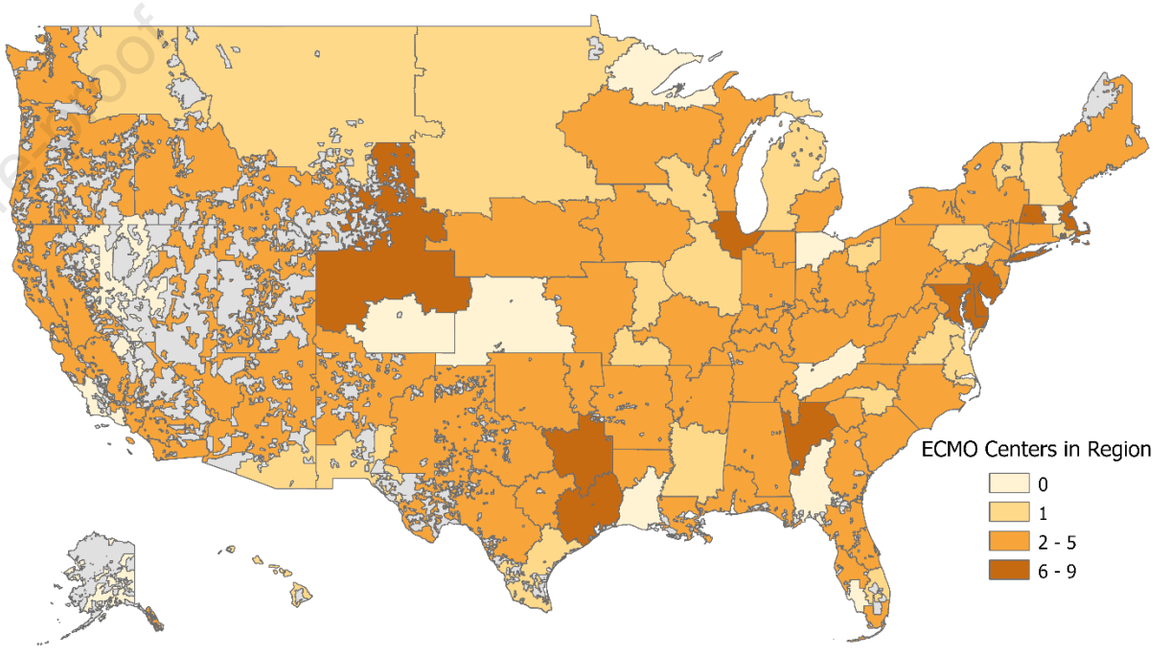
[45] Michelson KA, Hudgins JD, Lyons TW, Monuteaux MC, Bachur RG, Finkelstein JA. Trends in Capability of Hospitals to Provide Definitive Acute Care for Children: 2008 to 2016. Pediatrics 2020;145:e20192203. https://doi.org/10.1542/peds.2019-2203.
[46] Cushing AM, Bucholz E, Michelson KA. Trends in Regionalization of Emergency Care for Common Pediatric Conditions. Pediatrics 2020;145:e20192989. https://doi.org/10.1542/peds.2019-2989.
[47] Cushing AM, Bucholz EM, Chien AT, Rauch DA, Michelson KA. Availability of Pediatric Inpatient Services in the United States. Pediatrics 2021;148:e2020041723. https://doi.org/10.1542/peds.2020-041723.

Figure 1: State and Regional Variation in the Supply of ECMO Centers

A State-Level Variation

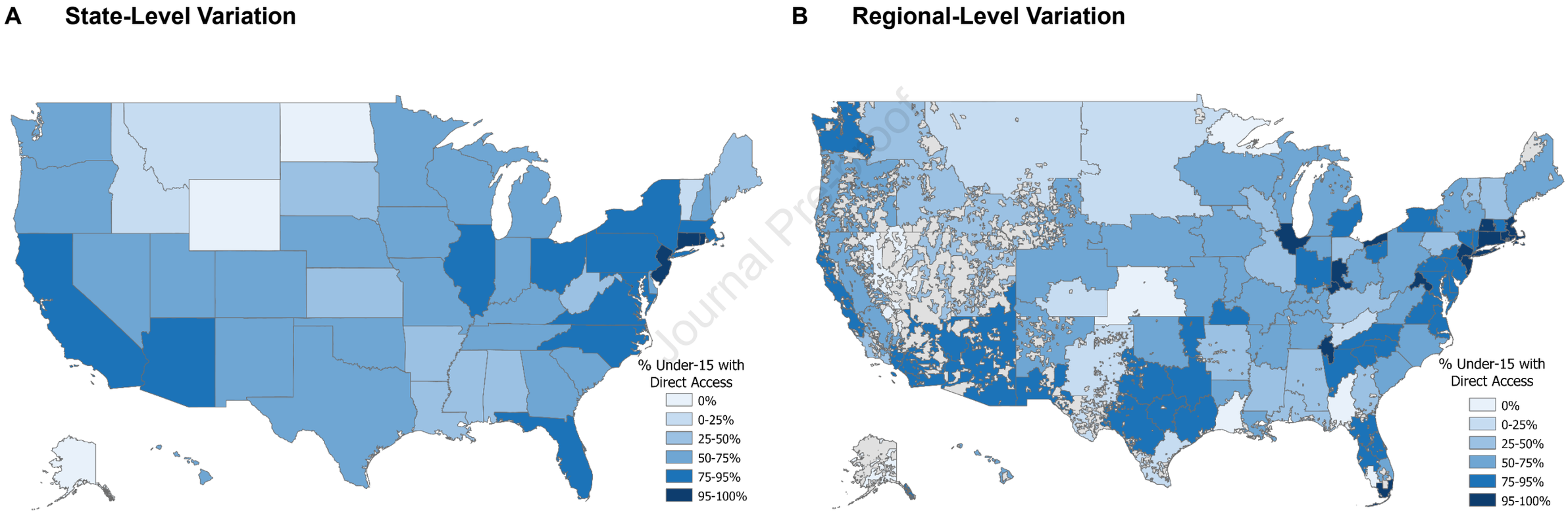


B Regional-Level Variation



Pediatric Emergency Referral Regions (PERRs) from the Atlas of Pediatric Acute Care
Grey areas unassigned to Zip Code Tabulation Areas (e.g., national parks or water).

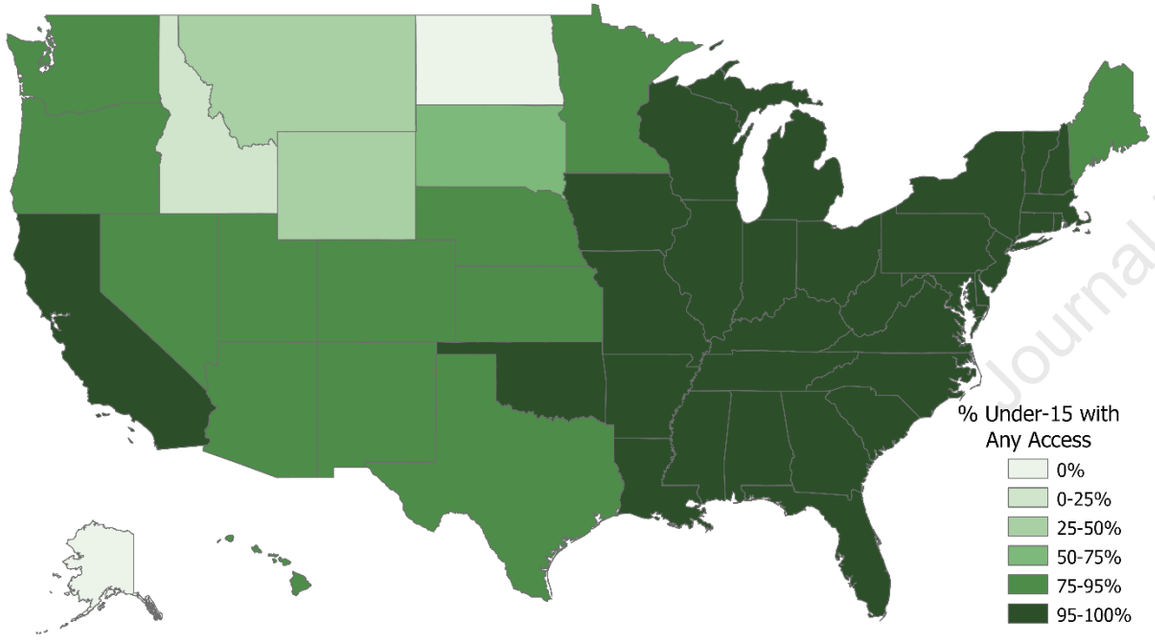
Figure 2: State and Regional Variation in Direct Access to ECMO Centers



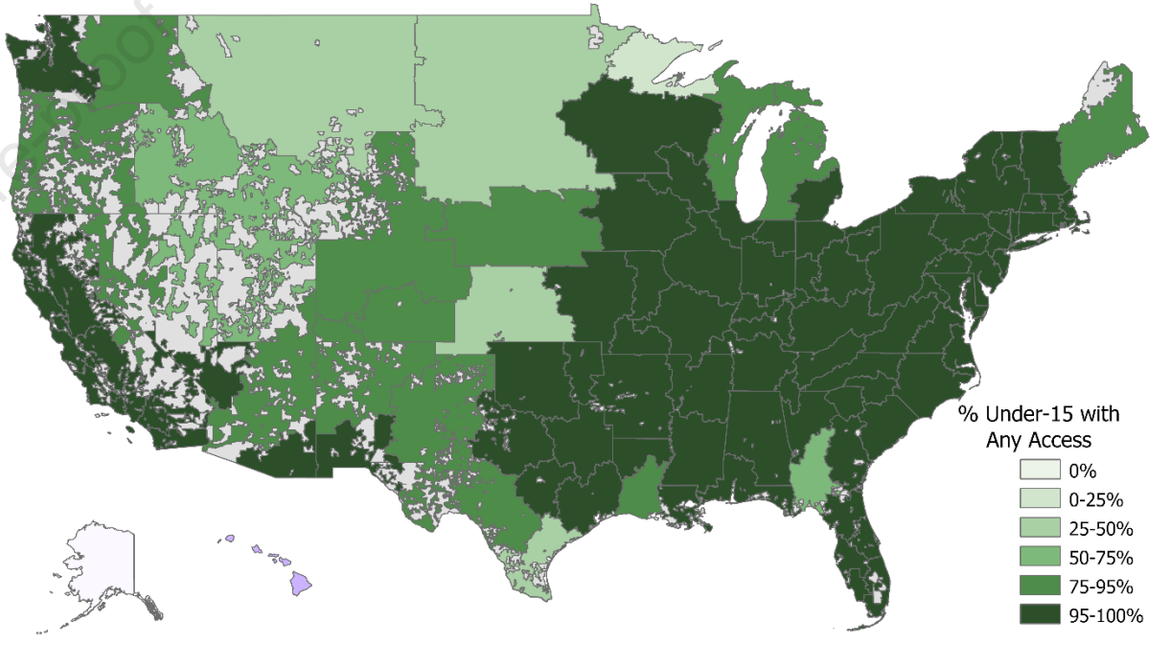
Pediatric Emergency Referral Regions (PERRs) from the Atlas of Pediatric Acute Care
Grey areas unassigned to Zip Code Tabulation Areas (e.g., national parks or water).

Figure 3: State and Regional Variation in Access to ECMO Centers via Direct or Indirect Access

A State-Level Variation



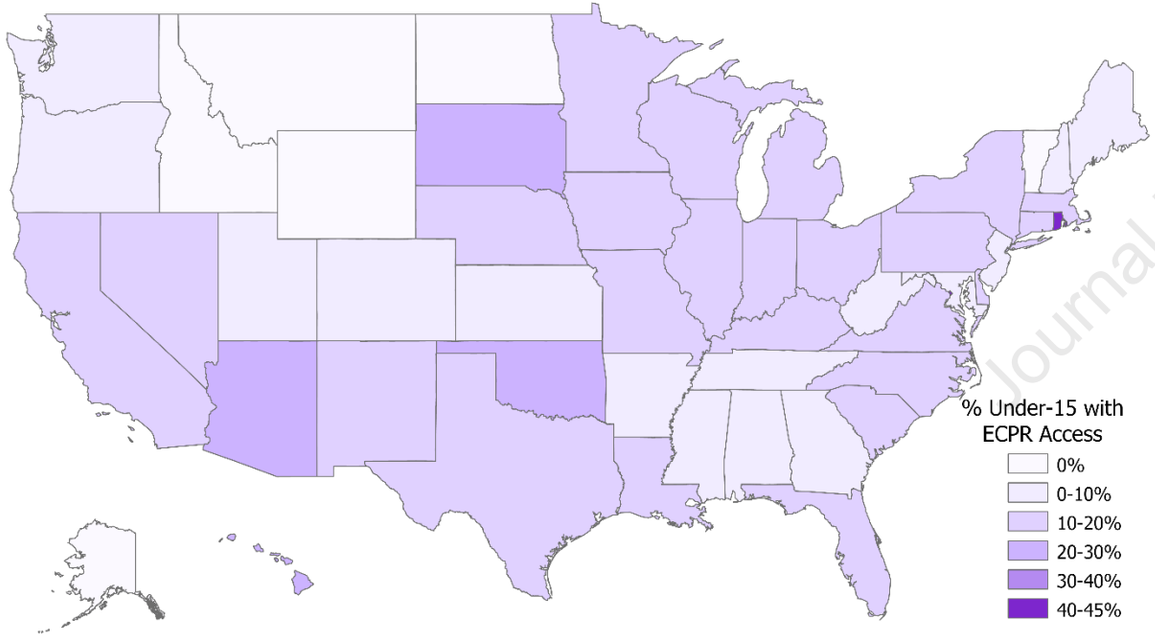
B Regional-Level Variation



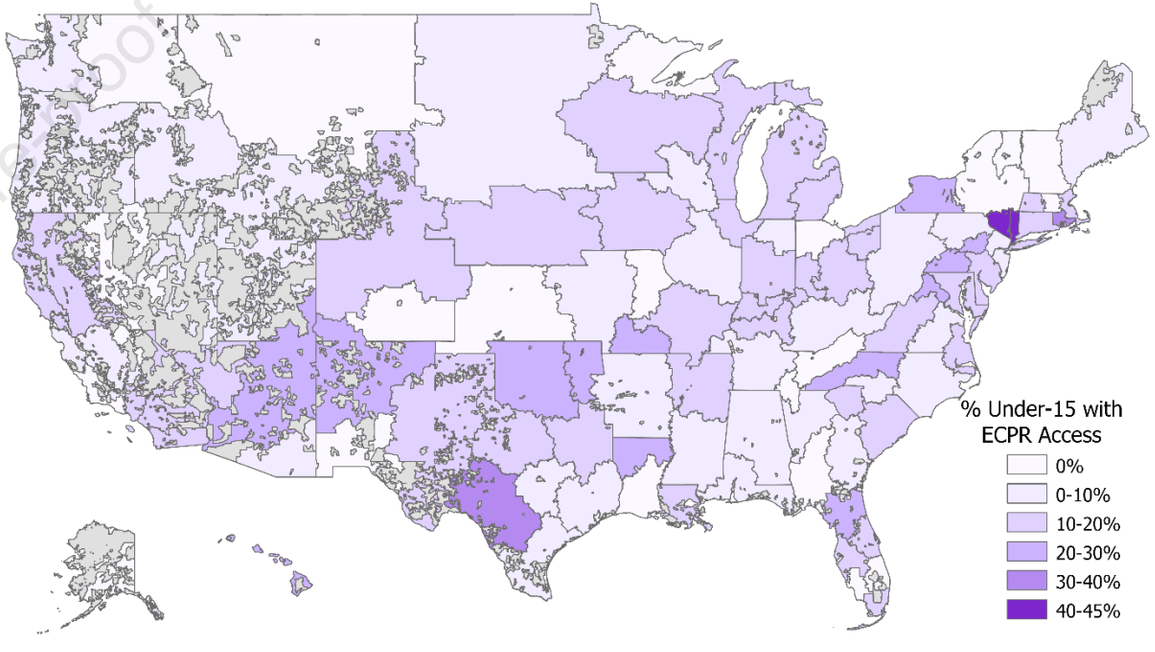
Pediatric Emergency Referral Regions (PERRs) from the Atlas of Pediatric Acute Care
Grey areas unassigned to Zip Code Tabulation Areas (e.g., national parks or water).

Figure 4: State and Regional Variation in Access to ECPR Centers

A State-Level Variation



B Regional-Level Variation



Pediatric Emergency Referral Regions (PERRs) from the Atlas of Pediatric Acute Care
Grey areas unassigned to Zip Code Tabulation Areas (e.g., national parks or water).

Conflicts of Interest Disclosure:

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