

BRIEF REPORT

Visualizing Patterns in Pediatric and Adult Hospital Care

Michael L. McManus, MD, MPH,^{ab} Urbano L. França, PhD^{ab}

OBJECTIVES: We aimed to design a graphical tool for understanding and effectively communicating the complex differences between pediatric and adult hospital care systems.

PATIENTS AND METHODS: We analyzed the most recent hospital administrative data sets for inpatient admission and emergency department visits from 7 US states (2014: Arkansas, Florida, Kentucky, Maryland, Massachusetts, and New York; 2011: California). Probabilities of care completion (Pcc) were calculated for pediatric (<18 years old) and adult conditions in all acute-care hospitals in each state. Using the Pcc, we constructed interactive heatmap visualizations for direct comparison of pediatric and adult hospital care systems.

RESULTS: On average, across the 7 states, 70.6% of all hospitals had Pcc >0.5 for more than half of all adult conditions, whereas <14.9% of hospitals had Pcc >0.1 for half of pediatric conditions. Visualizations revealed wide variation among states with clearly apparent institutional dependencies and condition-specific gaps (full interactive versions are available at <https://goo.gl/5t8vAw>).

CONCLUSIONS: The functional disparities between pediatric and adult hospital care systems are substantial, and condition-specific differences should be considered in reimbursement strategies, disaster planning, network adequacy determinations, and public health planning.

ABSTRACT

www.hospitalpediatrics.org

DOI:<https://doi.org/10.1542/hpeds.2018-0259>

Copyright © 2019 by the American Academy of Pediatrics

Address correspondence to Michael L. McManus, MD, MPH, Division of Critical Care, Department of Anesthesiology, Critical Care and Pain Medicine, Boston Children's Hospital, Bader Sixth Floor, 300 Longwood Ave, Boston, MA 02115. E-mail: michael.mcmanus@childrens.harvard.edu

HOSPITAL PEDIATRICS (ISSN Numbers: Print, 2154-1663; Online, 2154-1671).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: Supported by The Anesthesia Research Distinguished Trailblazer Award from the Boston Children's Hospital Department of Anesthesiology, Critical Care, and Pain Medicine; and by the Boston Children's Hospital Chair for Critical Care Anesthesia.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Drs McManus and França conceptualized and designed the study, drafted the manuscript, conducted the analyses, reviewed and revised the manuscript, had full access to all the data in the study, and take responsibility for the integrity of the data and accuracy of the data analysis; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

^aDivision of Critical Care Medicine, Department of Anesthesiology, Critical Care, and Pain Medicine, Boston Children's Hospital, Boston, Massachusetts; and
^bHarvard Medical School, Harvard University, Boston, Massachusetts

Pediatric hospital care is consolidating, with increasing reliance on large referral centers is being seen.^{1,2} As a result, care that was once available in community hospitals, even for common conditions, now frequently requires longer travel or interhospital transfer. Because pediatric and adult systems of care differ dramatically, they should be considered separately in discussions of disaster preparedness, network adequacy, and access to care.² These considerations are particularly relevant to Medicaid, which is the primary insurer of hospitalized children. Because network adequacy schemes designed to serve adults may inadequately serve the needs of children, a functional understanding of the differences between pediatric and adult hospital care systems is essential.³ This understanding must be communicable in a nontechnical manner that is accessible to a wide range of stakeholders and policy makers. We have developed condition-specific measures of hospital capability based on historical experience with admissions and transfers.⁴ These measures reflect the functional activity of hospitals and may be stratified by age, sex, insurance status, and other variables of interest. To illuminate the differences between pediatric and adult hospital care systems, we constructed state-based heatmap visualizations based on these measures.

METHODS

Hospital admission and discharge information was obtained from Healthcare Cost and Utilization Project (HCUP) State Inpatient and Emergency Department

Databases data sets encompassing all acute-care hospital encounters in Arkansas, California, Florida, Kentucky, Maryland, and New York. Similar information was also obtained directly from the Massachusetts Center for Health Information and Analysis. Encounters from 2014 were considered for all states except California, which last reported data to the HCUP in 2011.

We calculated condition-specific probabilities of care completion (Pcc) for all hospitals in all states and stratified by age, defining pediatric patients as <18 years old. Patients presenting to hospitals may be treated as outpatients, admitted, or transferred to other institutions. The Pcc concerns conditions that require inpatient services or some higher level of care and are calculated as the number of admissions (A) for a given condition at a given hospital divided by the number of admissions plus transfers (T) from both emergency department and inpatient settings— $Pcc = A/(A+T)$ —for each Clinical Classifications Software (CCS) condition seen at each hospital during the period of the study.⁴ When averaged across all conditions, it yields a summary measure, the Hospital Capability Index, which can be used to compare hospitals and systems of care.^{2,5} In any hospital over any study period, $Pcc = 1$ when patients with a given condition are admitted but never transferred, and $Pcc = 0$ when patients with the condition are never seen or always transferred. We have previously shown that calculations based on single-year data do not differ significantly from those based on multiyear data.⁴ Conditions are presented according to the HCUP's CCS, which aggregates all

International Classification of Diseases, Ninth Revision, Clinical Modification codes into 285 mutually exclusive categories.⁶ To compare hospital systems among the states and cohorts, we estimated the percentage of hospitals that completed the care of at least 10% and 50% of patients ($Pcc >0.1$ and $Pcc >0.5$, respectively) for at least half of the CCS conditions.

For visualization, Pcc are presented as heatmaps indicating their magnitude for all acute-care hospitals and CCS conditions within a state. Hospital identities were redacted and rare conditions excluded in compliance with privacy considerations and data-use agreements. Mental health conditions were also excluded because most transfers for definitive mental health care terminate outside the acute-care hospital system. To aid interpretability of the heatmaps, hospitals were ordered on the horizontal axis by increasing capability, and conditions were ordered on the vertical axis by increasing availability of care. The ordering varies in pediatric and adult heatmaps and among states because of the differences in capability and availability of care among systems. This work was administratively approved by the Boston Children's Hospital Committee on Clinical Investigation. All calculations and image preparations were performed within Jupyter Notebook by using Python 3.6.⁷

RESULTS

The general pattern of pediatric and adult hospital care was similar in all 7 states. Definitive adult care was available for most conditions in most hospitals, whereas definitive pediatric care was unavailable in

TABLE 1 Hospital Capability Characteristics in 2014

	Arkansas, % (n)	California, ^a % (n)	Florida, % (n)	Kentucky, % (n)	Massachusetts, % (n)	Maryland, % (n)	New York, % (n)
Pediatric							
Hospitals with Pcc >0.5 for >50% of the CCS codes	5.6 (4)	14.8 (46)	13.6 (25)	2.0 (2)	9.0 (6)	10.9 (5)	18.6 (31)
Hospitals with Pcc >0.1 for >50% of the CCS codes	11.1 (8)	18.4 (57)	15.2 (28)	4.1 (4)	14.9 (10)	21.7 (10)	18.6 (31)
Adult							
Hospitals with Pcc >0.5 for >50% of the CCS codes	36.1 (26)	83.5 (259)	85.9 (158)	44.9 (44)	80.6 (54)	87.0 (40)	76.0 (127)
Hospitals with Pcc >0.1 for 80% of the CCS codes	50.0 (36)	89.4 (277)	87.5 (161)	59.2 (58)	91.0 (61)	95.7 (44)	79.6 (133)

^a California information is from 2011.

most hospitals for most conditions. Table 1 contains descriptive characteristics of the hospitals comprising health care systems in different states. Across all states, 90% of children presented with 77 CCS conditions, whereas 90% of adults presented with 97 CCS conditions. On average, across all states, 70.6% of all hospitals had $Pcc > 0.5$ for $>50\%$ of adult conditions, whereas only 14.9% of hospitals had $Pcc > 0.1$ for $>50\%$ of pediatric conditions. Considering the states separately, the percentage of hospitals with $Pcc > 0.5$ for $>50\%$ of pediatric conditions ranged from 2.0% to 18.6%.

Heatmap visualizations revealed the stark differences between pediatric and adult hospital care systems. Figure 1 demonstrates the high contrast between the range of conditions treated and the number

of hospitals caring for children versus adults in a representative state. The high degree of dependence on a small number of specialized centers is readily apparent. Full and interactive versions of similar visualizations for all states are available for closer inspection at <https://goo.gl/5t8vAw>.

DISCUSSION

Pediatric hospital care is consolidating and has become much less available than adult care. Although this is clear to those who routinely look after children, it is less so to those who do not. To help communicate the current status of hospital systems to policymakers, administrators, health services researchers, families, and other stakeholders, we used administrative data sets to create visualizations of 7 statewide

hospital systems. Within these visualizations, systemic differences, institutional dependencies, care gaps, and the degree of regionalization can be readily discerned. These visualizations provide concise “snapshots” of care systems, and their interactive versions can be used for health service research.

Hospitals differ widely in their capabilities, and many hospitals have abandoned their less profitable pediatric services. Access to pediatric hospital care is additionally threatened by insurers pursuing narrow-network strategies to reduce their costs.⁸ Unfortunately, the transfer of current regulatory schemes designed for adults cannot ensure that children will obtain the care they need.⁵ Instead, new schemes based on a deeper understanding of pediatric condition-specific needs and capabilities are required. These visualizations make clear that most hospitals care for most adult conditions but not most pediatric conditions. Their interactive versions allow researchers and other interested parties to explore the availability of care for specific conditions. We believe that this is important for policy makers to understand in disaster planning, resource allocation, and assessment of network adequacy.

It is important to recognize that these visualizations carry information concerning the scope of conditions for which care has been demonstrated and provide snapshots of how hospitals are actually functioning within their health care systems. They carry no information concerning care volume, quality, or physical capacity. Thus, small community hospitals may provide high-quality care for a limited number of conditions and, in aggregate, serve many children. At the same time, hospitals that always transfer or do not regularly see patients with a particular condition may be capable of caring for them. Additional limitations to be considered include all of those attendant to retrospective research with large administrative data sets.⁹ Also, our data are organized according to state boundaries and cannot fully capture the dynamics within metropolitan areas that span multiple states. Perhaps most

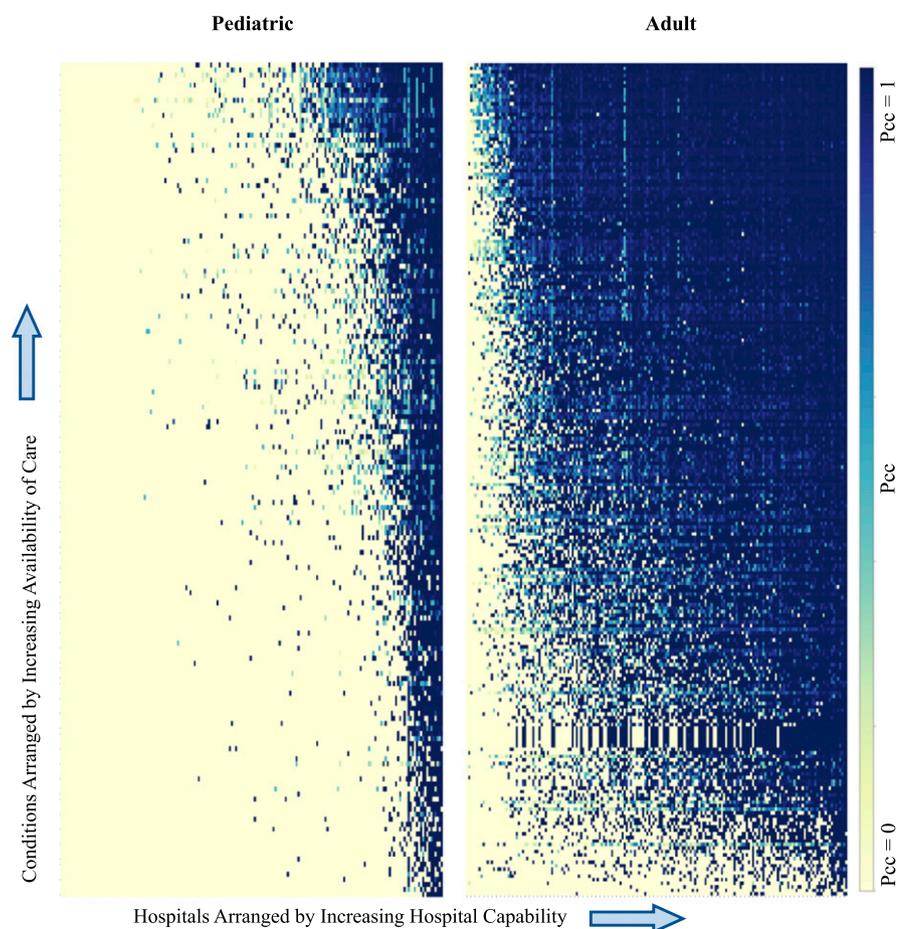


FIGURE 1 Pediatric and adult acute-care hospital systems: representative heatmap visualization of a single state’s pediatric (left) and adult (right) acute-care hospital systems. Each cell reflects a specific condition in a specific hospital and is colored by the Pcc. See <https://goo.gl/5t8vAw> for full-size interactive figures for all states and additional details.

importantly, our visualizations do not include time and distance parameters that are typically taken into account when defining network adequacy standards.³ Finally, although we acknowledge their critical importance, we have elected to separately study mental health conditions because their definitive care usually resides outside the acute-care hospital system.

CONCLUSIONS

Functional differences between pediatric and adult hospital care are significant, are similar across states, and present unique challenges to network adequacy, disaster management, and public health. Condition-specific analysis and visualization of hospital activity holds potential for communicating these differences and informing policy.

REFERENCES

1. Rosenthal JL, Hilton JF, Teufel RJ II, Romano PS, Kaiser SV, Okumura MJ. Profiling interfacility transfers for hospitalized pediatric patients. *Hosp Pediatr*. 2016;6(6):345–353
2. França UL, McManus ML. Trends in regionalization of hospital care for common pediatric conditions. *Pediatrics*. 2018;141(1):e20171940
3. Colvin JD, Hall M, Thurm C, et al. Hypothetical network adequacy schemes for children fail to ensure patients' access to in-network children's hospital. *Health Aff (Millwood)*. 2018;37(6):873–880
4. França UL, McManus ML. Transfer frequency as a measure of hospital capability and regionalization. *Health Serv Res*. 2017;52(6):2237–2255
5. França UL, McManus ML. Outcomes of hospital transfers for pediatric abdominal pain and appendicitis. *JAMA Netw Open*. 2018;1(6):e183249
6. HCUP. Clinical Classifications Software (CCS) for ICD-9-CM, 2006–2009. 2013. Available at: <https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp>. Accessed November 28, 2018
7. Kluyver T, Ragan-Kelley B, Perez F, et al. Jupyter Notebooks: a publishing format for reproducible computational workflows. In: *Positioning and Power in Academic Publishing: Players, Agents and Agendas, Proceedings of the 20th International Conference on Electronic Publishing*; June 7–9, 2016; Göttingen, Germany
8. Wong CA, Kan K, Cidav Z, Nathenson R, Polsky D. Pediatric and adult physician networks in Affordable Care Act Marketplace plans. *Pediatrics*. 2017; 139(4):e20163117
9. Lawson EH, Louie R, Zingmond DS, et al. Using both clinical registry and administrative claims data to measure risk-adjusted surgical outcomes. *Ann Surg*. 2016;263(1):50–57

Visualizing Patterns in Pediatric and Adult Hospital Care

Michael L. McManus and Urbano L. França

Hospital Pediatrics 2019;9;398

DOI: 10.1542/hpeds.2018-0259 originally published online April 12, 2019;

Updated Information & Services	including high resolution figures, can be found at: http://hosppeds.aappublications.org/content/9/5/398
Supplementary Material	Supplementary material can be found at:
References	This article cites 7 articles, 3 of which you can access for free at: http://hosppeds.aappublications.org/content/9/5/398#BIBL
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Hospital Medicine http://www.hosppeds.aappublications.org/cgi/collection/hospital_medicine_sub
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.hosppeds.aappublications.org/site/misc/Permissions.xhtml
Reprints	Information about ordering reprints can be found online: http://www.hosppeds.aappublications.org/site/misc/reprints.xhtml

Hospital Pediatrics®

AN OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Visualizing Patterns in Pediatric and Adult Hospital Care

Michael L. McManus and Urbano L. França

Hospital Pediatrics 2019;9;398

DOI: 10.1542/hpeds.2018-0259 originally published online April 12, 2019;

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://hosppeds.aappublications.org/content/9/5/398>

Hospital Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Hospital Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 345 Park Avenue, Itasca, Illinois, 60143. Copyright © 2019 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

