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Preliminary Report
A Geospatial Analysis of Distances to Hospitals that Admit Pediatric Asthma Patients

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Abstract

Background: Pediatric care is now concentrated in urban specialty centers (“regionalization”), even for common conditions such as asthma. At the same time, rural EMS faces challenges related to adequate workforce staffing and financing. This statewide study describes how regionalization of pediatric inpatient care for asthma exacerbations affects EMS operations, particularly for rural agencies.

Methods: This is a statewide cross-sectional study of EMS encounters for pediatric asthma in patients aged 2-18 years from 2011 to 2016 using Florida’s EMS Tracking and Reporting System (EMSTARS) database. EMSTARS encounters were deterministically linked to Florida’s Agency for Healthcare Administration (AHCA) database. We categorized AHCA hospital facilities that received included patients by whether they did or did not admit pediatric asthma patients during the study period (“admitting facility”). We used geospatial analysis to map the EMS agency’s home county and the admitting facilities’ addresses. For each county in Florida, we calculated the average estimated EMS travel distance to the nearest admitting facility using a dasymetric mapping approach.

Results: The study included a total of 11,226 EMS pediatric asthma encounters, of which 11,153 (99%) matched to an EMS home county. AHCA data was available for 3,812 (34%) patients. Most counties with distances to admitting facilities less than or equal to 15 miles were urban (31 of 39). For distances of 31 – 45 miles to an admitting facility, 7 of 8 of counties were rural, and for distances greater than 46 miles, all 4 counties were rural.

Conclusion: In this statewide study in Florida, we found long average estimated EMS travel distances to admitting facilities for Florida’s pediatric population in rural counties for pediatric asthma exacerbations. Those long distances have great implications for rural EMS operations, including pediatric destination decisions, transport times, and availability for others who call 911. Further research on bypass and secondary transport rates, and outcomes for asthma and other pediatric conditions are required to further characterize pediatric regionalization’s impact on rural EMS.

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Preliminary Report

A Geospatial Analysis of Distances to Hospitals that Admit Pediatric Asthma Patients

Introduction

Pediatric care is increasingly concentrated in urban specialty centers (“regionalization”) in the United States (US).^{1,2} Even care for asthma, the most common chronic disease of childhood,³ is now regionalized.^{1,2} For children with asthma exacerbations severe enough to require emergency medical services (EMS) treatment and transport, pediatric regionalization’s effects on EMS are unknown. Rural EMS faces challenges related to workforce staffing and financing,⁴⁻⁶ therefore measuring regionalization’s impact on operations is important. Since asthma is the second-most common cause of the estimated 1-2 million annual pediatric EMS encounters,^{7,8} this study

describes how regionalization of inpatient pediatric asthma care impacts EMS operations, especially for rural agencies, in the state with the fourth-largest pediatric population.⁹

Methods

Study Setting and Population

This is a statewide cross-sectional study of EMS encounters for pediatric asthma in patients aged 2-18 years from 2011 to 2016 using Florida's EMS Tracking and Reporting System (EMSTARS) database.¹⁰ The Florida Department of Health (DOH) manages EMSTARS, which contains EMS encounters from over 100 agencies covering 64 of Florida's 67 counties, including 74% of all statewide 911 EMS calls during the study period. Of the 64 counties covered by EMSTARS, 28 are rural, and the 3 excluded counties are rural.¹¹

We included EMSTARS patients ages 2 to 18 years, transported by EMS to an ED, whose EMS provider primary impression was respiratory distress, and who received at least one inhaled albuterol from EMS. EMSTARS does not contain an asthma-specific diagnosis, therefore we chose to combine respiratory distress with albuterol administration to indicate an acute exacerbation. We excluded patients who were classified as a trauma/injury, seizure, pregnancy-related complication, or interfacility transport, and those younger than 2 years of age to avoid confounding with bronchiolitis.

Data Analysis

Prior to this study, EMSTARS encounters were deterministically linked to Florida's Agency for Healthcare Administration (AHCA) database by Florida DOH staff.¹² Florida's AHCA database

includes greater than 90% of acute care facilities in the state.¹² For each EMS agency that transported an included patient, we identified the county in which it operates. Using the AHCA database, we categorized hospital facilities that received included EMS patients by whether they did or did not admit pediatric asthma patients during the study period (“admitting facility”).

For each county in Florida, we modeled the average estimated EMS travel distance to the nearest admitting facility using ArcGIS Desktop v10.4.1 (Redlands, CA). Because EMSTARS data for incident locations was not available, we modeled estimated EMS incident locations using a dasymetric mapping approach. Dasymetric mapping is a technique that uses one or more ancillary data layers to more accurately represent the spatial distributions of data within a zone or area.¹³ We represented potential incident locations as points, mapped at the 2010 US Census block level based on the population under 18 years of age.¹⁴ To more accurately represent the distribution of incidents within census blocks, points were randomly distributed along address range segments of the 2015 HERE street network database.¹⁵ We geocoded admitting facilities to their addresses in the AHCA database.¹² Using the Network Analyst extension in ArcGIS Desktop, we calculated road network distance from each estimated incident location to the closest admitting facility, then averaged by county. Both the University of Florida and Florida Department of Health Institutional Review Boards approved this study with waiver of informed consent.

Results

There were a total of 11,226 EMS pediatric asthma encounters, of which 11,153 (99%) matched to an EMS home county. No data was available for 7 counties (3 not in EMSTARS, and 4 with

no EMS encounters meeting inclusion criteria). AHCA data was available for 3,812 (34%) patients. Table 1 displays the average estimated EMS travel distance by county to the nearest pediatric asthma admitting facility. The majority of counties with average distances less than or equal to 15 miles were urban (31 of 39). For average distances of 31 – 45 miles to an admitting facility, 7 of 8 of counties were rural, and for average distances of 46 miles or greater, all 4 counties were rural. Translated to population percentages, one quarter (25.1%) of Florida's pediatric population lives in a county with an average distance greater than 10 miles to a pediatric asthma admitting facility, 5.1% greater than 20 miles, and 1.8% greater than 30 miles. Figure 1 displays the number of EMSTARS pediatric asthma EMS patients by county and county-level average distances to admitting facilities.

Discussion

In this statewide study in Florida, we found long average estimated EMS travel distances to admitting facilities for Florida's pediatric population in rural counties for pediatric asthma exacerbations. Since asthma is the most common chronic disease of childhood,³ those results have implications for rural EMS operations. If rural EMS desires to directly transport pediatric asthma patients to admitting facilities, that ambulance and crew may be out of service for prolonged periods of time. Such longer run times may strain rural EMS systems which already have workforce staffing and financial challenges.⁴⁻⁶ Specific to this study's setting, the Florida Association of Rural EMS in 2009 reported workforce recruitment and retention as the highest priority issue for their agencies.¹⁶ In that same report, one-third of agencies reported they needed additional ambulances, and over half of agencies stated Pediatric Advanced Life Support (PALS) training was their greatest educational need.¹⁶ Potential longer pediatric transports combined

with a lack of PALS training, in systems understaffed with providers and ambulances, raises concerns for patient safety and EMS' availability for the next person who calls 911.

On the other hand, if EMS transports pediatric asthma patients to the closest facility, some patients may require a second, interfacility transport to an admitting facility ("secondary transport"). The number of those potential patients is significant, with prior studies estimating 20-36% of pediatric asthma ED patients are admitted.^{17,18} Secondary transport is associated with increased adverse events, repeat testing and imaging (including the use of ionizing radiation), and delays in definitive care.¹⁹ In some EMS systems, the interfacility transport may use the same EMS agency if there is no availability of a private or hospital-based ambulance company. Additionally, patient transfers out of the EMS agency's jurisdiction makes patient outcomes more difficult to track for follow-up and EMS quality improvement programs.⁴ Regardless of the whether EMS transports to the closest facility or bypasses in favor of an admitting facility, the distances revealed by this study indicate that rural patients and caregivers may be separated far from their home and primary care network for a pediatric asthma admission.

This study also describes decreasing inpatient hospital resources for pediatric asthma patients with increasing rurality and distance from urban centers, which has been termed the "tyranny of distance."²⁰ The Department of Health and Human Services (HHS) has established a goal of increasing the proportion of rural populations reached by EMS within 10 minutes.⁴ However, that goal overlooks how far rural pediatric patients must then travel for inpatient care. While more attention is being focused on the accelerating pace of rural hospital closures,²¹ Florida saw just one rural hospital closure between 2013-2017.²¹ For pediatric care, it may not be the closure

of “brick and mortar” hospital facilities, but rather the *closure of pediatric services* that matters. Such pediatric services movement is undoubtedly to urban areas: of the 97 pediatric hospitals tracked by the Centers for Medicare and Medicaid Services in the US, 96 are located in urban areas.²² Further research on EMS bypass and secondary transport rates, and outcomes for asthma and other pediatric conditions are required to further characterize pediatric regionalization’s impact on rural EMS.

Limitations

This study’s limitations include a one-state sample, although Florida is the state with the fourth-largest pediatric population and almost half of its counties are classified as rural.^{9,11} Not every EMS agency and county was included in the EMSTARS database, and so results may not apply to every locality in Florida. The study design only includes transports to an ED, which may have excluded patients who self-administered medications, and then upon EMS arrival, were clinically improved and not administered albuterol and/or not transported. Additionally, not all EMSTARS patients linked to the AHCA database, so results should be interpreted cautiously. However, in the context of other EMS to hospital linkages, our linkage percentage of 34% is comparable.²³⁻²⁶ Our inclusion criteria of respiratory distress plus administration of albuterol may not have captured all pediatric asthma patients. However, nearly all (99%) of EMSTARS patients ages 2-18 with a provider primary impression of respiratory distress were treated by a paramedic who can administer albuterol.^{27,28} Therefore, we believe most patients not given albuterol had respiratory distress from a different condition (e.g., pneumonia, croup). Despite those limitations, our results are concordant with other statewide studies of pediatric regionalization.^{1,2}

Conclusion

In this statewide study in Florida, we found long average estimated EMS travel distances to admitting facilities for Florida's pediatric population in rural counties for pediatric asthma exacerbations. Those results have implications for rural EMS operations, including pediatric destination decisions, transport times, and availability for others who call 911. Further research on outcomes and other pediatric conditions are required to fully characterize the impact of pediatric regionalization on rural EMS.

References

1. França UL, McManus ML. "Availability of definitive hospital care for children." *JAMA Peds*. 2017;171(9):e171096.
2. Aledhaim A, Fishe JN, Hirshon J, Anders JF. "Pediatric conditions requiring interfacility transport from emergency departments: A statewide study of regionalization." *Pediatr Emerg Care*. 2018. DOI: 10.1097/PEC.0000000000001578. [Epub ahead of print]
3. 1. Asthma Facts: CDC's National Asthma Control Program Grantees. 2013 Available at https://www.cdc.gov/asthma/pdfs/asthma_facts_program_grantees.pdf. Accessed November 21, 2018.
4. United States General Accounting Office, Report to Congressional Requesters. "Emergency Medical Services: Reported Needs Are Wide-Ranging, With a Growing Focus on Lack of Data." GAO-02-28. October 2001.
5. Overton J. "Reimbursement in emergency medical services: how to adapt in a changing environment." *Prehosp Emerg Care*. 2002;6(1):137-40. PMID11789643.
6. Gelburd R. "A spotlight on the problems of ambulance balance billing." RealClearHealth, December 23, 2017. Available at: https://www.realclearhealth.com/articles/2017/12/23/a_spotlight_on_the_problems_of_ambulance_balance_billing_110758.html. Accessed September 28, 2018.
7. Lerner EB, Dayan PS, Brown K, Fuchs S, Leonard J, Borgialli D, Babcock L, Hoyle Jr JD, Kwok M, Lillis K, Nigrovic LE, Mahajan P, Rogers A, Schwartz H, Soprano J, Tsarouhas N, Turnipseed S, Funai T, Foltin G, for the Pediatric Emergency Care Applied Research Network. "Characteristics of the pediatric patients treated by the Pediatric Emergency Care Applied Research Network's affiliated EMS agencies." *Prehosp Emerg Care*. 2014;18:52-9.

8. Shah MN, Cushman JT, Davis CO, Bazarian JJ, Auinger P, Friedman B. "The epidemiology of emergency medical services use by children: an analysis of the National Hospital Ambulatory Medical Care Survey." *Prehosp Emerg Care*. 2008;12(3):269-76. PMID18584491. PMC5237581.
9. United States Census Bureau. Quick Facts: Florida. Available at: <https://www.census.gov/quickfacts/fact/table/fl/PST045217>. Accessed November 21, 2018.
10. Florida's Prehospital EMS Tracking and Reporting System (EMSTARS) Data Dictionary Version 1.4. <http://www.floridaemstars.com>. Accessed December 15, 2018.
11. Florida's Rural Counties. Available at: http://www.floridahealth.gov/programs-and-services/community-health/rural-health/_documents/ruralcountiespdf.12.pdf. Accessed October 23, 2018.
12. Florida Health Finder, Data Dictionary. Agency for Health Care Administration. Available at: <http://www.floridahealthfinder.gov/Researchers/OrderData/order-data.aspx>. Accessed December 2, 2018.
13. Eicher CL, Brewer CA. "Dasymetric mapping and Areal interpolation: Implementation and evaluation." *Cartography and geographic information science*. 2001;2:125-138.
14. 2010 Decennial Census of Population and Housing. United States Census Bureau. Available at: Florida Geographic Data Library (FGDL) ftp://ftp.fgdl.org/pub/state/cenblk2010_aug11.zip. Accessed August 2, 2018.
15. StreetMap Premium for ArcGIS North America HERE (formerly NAVTEQ) 2015 Release 3. Downloaded from www.myesri.com on 9/27/2016.
16. 2009 Rural Florida EMS Agency Survey, Survey Report. Florida Association of Rural EMS Providers. September 2009. Available at:

<http://www.farems.org/Sites/126/Downloads/2009SurveyReport.pdf>. Accessed: December 2, 2018.

17. Bhogal SK, McGillivray D, Bourbeau J, Benedetti A, Bartlett S, Ducharme FM. “Early administration of systemic corticosteroids reduces hospital admission rates for children with moderate and severe asthma exacerbation.” *Ann Emerg Med*. 2012;60(1):84-91.

18. Fishe JN, Gautam S, Hendry P, Blake KV, Hendeles L. “Emergency medical services administration of systemic corticosteroids for pediatric asthma: A statewide study of emergency department outcomes.” *Acad Emerg Med*. 2018. DOI: 10.1111/acem.13660. [Epub ahead of print]

19. Fratta KA, Fishe JN. “EMS, Pediatric Transport Safety and Secondary Transport.” *StatPearls*. 2018. Treasure Island (FL): StatPearls Publishing. PMID 30020606.

20. Leeuwenburg T, Hall J. “Tyranny of distance and rural prehospital care: Is there potential for a national rural responder network? *Emerg Med Australas*. 2015;27(5):481-4.

21. United States General Accounting Office, Report to Congressional Requesters. “Rural Hospital Closures: Number and Characteristics of Affected Hospitals and Contributing Factors.” GAO-18-634. August 2018.

22. Hospitals defined by Federal Office of Rural Health Policy
Provider of Services, 2016. Centers for Medicare and Medicaid Services. Available at:
<https://www.cms.gov/Research-Statistics-Data-and-Systems/Downloadable-Public-Use-Files/Provider-of-Services/POS2016.html>. Accessed December 2, 2018.

23. Newgard CD, Malveau S, Staudenmayer K, Wang E, Hsia RY, Mann NC, Holmes JF, Kuppermann N, Haukoos JS, Bulger EM, Dai M, Cook LJ, and the WESTRN investigators. Evaluating the use of existing data sources, probabilistic linkage, and multiple imputation to

build population-based injury databases across phases of trauma care. *Acad Emerg Med*. 2012;19(4):469-480.

24. Swor R, Qu L, Putman K, Sawyer KN, Domeier R, Fowler J, Fales W. Challenges of using probabilistic linkage methodology to characterize post-cardiac arrest care in Michigan. *Prehosp Emerg Care*. 2018;22(2):208-213.

25. Coster J, O’Cathain A, Jacques R, Crum A, Siriwardena AN, Turner J. Outcomes for patients who contact the emergency ambulance service and are not transported to the emergency department: A data linkage study. *Prehosp Emerg Care*. 2018. DOI: 10.1080/10903127.2018.1549628. [EPub ahead of print].

26. Mumma BE, Diercks DB, Danielsen B, Holmes JF. Probabilistic linkage of prehospital and outcomes data in out-of-hospital cardiac arrest. *Prehosp Emerg Care*. 2015;19(3):358-364.

27. National Association of State EMS Officials. National Model EMS Clinical Guidelines, Version 2.0, 2017. Available at: <https://www.nasemso.org/documents/National-Model-EMS-Clinical-Guidelines-Version2-Sept2017.pdf>. Accessed September 28, 2018.

28. EMS Protocols. Available at: <http://emsprotocols.org>. Accessed September 28, 2018.

Table 1: Average estimated EMS travel distance to the nearest pediatric asthma admitting facility by county

Number of Florida Counties (Total N=67)	Number of Florida Rural Counties (Total N=31)	Average Distance to Nearest Facility which Admits Children for Asthma (miles)
39	8	<= 15
16	12	16 – 30
8	7	31 – 45
2	2	46 – 60
2	2	> 60

¹Table 1 includes the 7 counties for which there were no pediatric asthma EMS patients. 5 were in the <= 15 miles distance category, and 2 were in the 16-30-mile distance category.

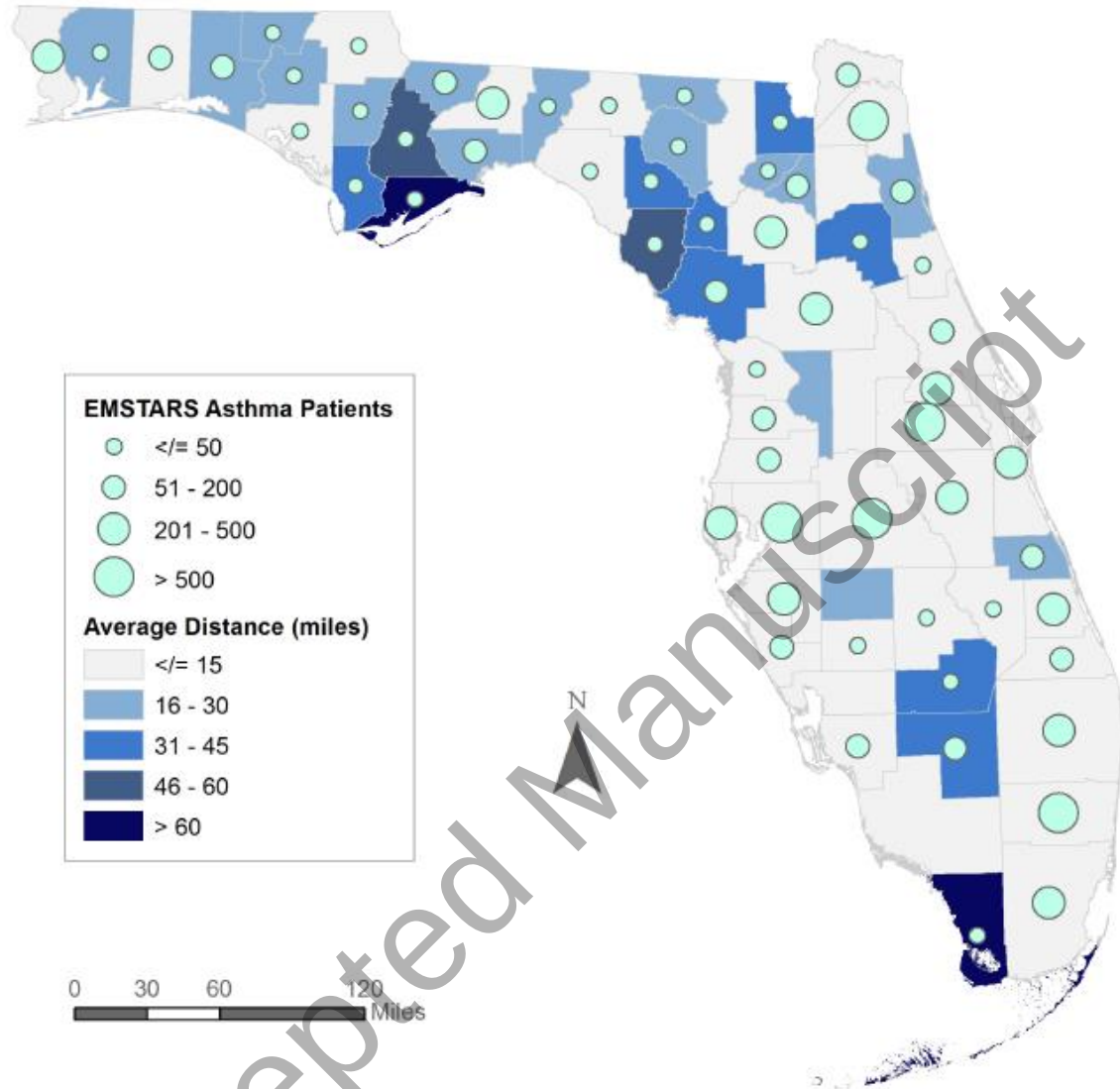


Figure 1: Average estimated EMS travel distance by county to nearest hospital admitting pediatric asthma patients