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Emergency Medical Services Utilization Is Associated With Community Deprivation in Children

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Abstract

Background: Pediatric emergency medical services (EMS) utilization is costly and resource intensive; significant variation exists across large-scale geographies. Less is known about variation at smaller geographic levels where factors including lack of transportation, low health literacy, and decreased access to medical homes may be more relevant. Our objective was to determine whether pediatric EMS utilization varied across Hamilton County, Ohio, census tracts and whether such utilization was associated with socioeconomic deprivation. **Methods:** This was a retrospective analysis of children living in Hamilton County, Ohio, transported by EMS to the Cincinnati Children's emergency department between July 1, 2014, and July 31, 2016. Participants' addresses were assigned to census tracts and an EMS utilization rate and deprivation index were calculated for each. Pearson's correlation coefficients evaluated relationships between tract-level EMS utilization and deprivation. Tract-level deprivation was used as a predictor in patient-level evaluations of acuity. **Results:** During the study period, there were 4,877 pediatric EMS transports from 219 of the 222 county census tracts. The county EMS utilization rate during the study period was 2.4 transports per 100 children (range 0.2–11). EMS utilization rates were positively correlated with increasing deprivation ($r = 0.72$, 95% confidence interval [CI], 0.65–0.77). Deprivation was associated with lower illness severity at triage, fewer transports resulting in resuscitation suite use, and fewer transports resulting in hospitalizations (all $p < 0.05$). **Conclusions:** EMS utilization varied substantially across census tracts in Hamilton County, Ohio. A deeper understanding into why certain socioeconomically deprived areas contribute to disproportionately high rates of EMS utilization could support development of targeted interventions to improve use.
Key words: community health; pediatrics; EMS utilization

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LR conceptualized and designed the study, interpreted the data, and drafted the initial article. Dr. CB conceptualized and designed the study, performed data analysis, interpreted the data, and critically reviewed the article. AB conceptualized and designed the study, interpreted the data, and critically reviewed the article. WP conceptualized and designed the study, interpreted the data, and critically reviewed the article. HS conceptualized and designed the study, interpreted the data, and critically reviewed the article. TF conceptualized and designed the study, interpreted the data, critically reviewed the manuscript, supervised the study, and drafted the initial article. All authors approved the final article as submitted and agree to be accountable for all aspects of the work.

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Introduction

Millions of children are transported to emergency departments (ED) each year by emergency medical services (EMS) (1,2). Up to 13% of all EMS transports are for pediatric patients; 7% of all pediatric ED visits occur following such transports (1). Demographic factors associated with pediatric use of EMS transport include young age (<1 year), male sex, African American race, urban residence, and Medicaid insurance (1,3–9). Those with higher acuity illnesses, injuries, and poisonings are also more likely to be transported by EMS (1,4,9,10). The most common diagnoses occurring after EMS transport include trauma, neurologic problems (e.g., seizures), and respiratory illnesses (1,3,4,8–10). Still, though some children transported via EMS are acutely ill or injured and require immediate medical attention, many are transported for nonemergent reasons (3,5–8,11).

Poverty has also been shown to be associated with increased likelihood of using EMS for transport to the ED. Previous studies suggest a significant,

inverse relationship between median family income, measured at the ZIP code level, and transport rate (3,4). In Washington, D.C., a cross-sectional analysis of low-acuity EMS transports identified significant variation across residential ZIP codes. The majority of ZIP codes with high EMS transport rates were clustered in areas of concentrated poverty that also included a high number of African American residents with public insurance (3).

Although ZIP codes have long been used as a marker of neighborhood, they are, in reality, large, heterogeneous geographies that align more with postal routes than sociodemographic characteristics (12). Smaller geographies that are more demographically and socioeconomically homogenous are more reliable proxies for what residents view as their neighborhoods. Census tracts are one such example, capable of providing more granularity and insight into potential relationships between ecological, place-based socioeconomic characteristics and a range of health outcomes (12,13). Here, we examine EMS utilization at this more precise geographic level. Specifically, the objectives of this study were to determine the (1) extent of geographic variation in the utilization of EMS services for children in one county using the census tract as our unit of geography; (2) correlation between tract-level rates of EMS utilization and tract-level socioeconomic deprivation; and (3) association between tract-level deprivation and patient acuity as measured by triage level, resuscitation suite use, and patient disposition status following each transport event.

METHODS

Study Design and Data Source

This was a retrospective analysis of all children transported by EMS to Cincinnati Children's Hospital Medical Center (CCHMC) between July 1, 2014, and July 31, 2016. Clinical and demographic variables attached to each utilization event, defined as a single transport by EMS to the ED, were extracted from the electronic health record (Epic, Verona, WI). Neighborhood-level socioeconomic variables to be used in our computation of census tract deprivation were extracted from the 2011–2015 5-year U.S. Census American Community Survey (ACS) (14). The CCHMC Institutional Review Board approved this study, and informed consent was waived.

Study Population and Setting

This study included all children who were younger than 16 years of age and transported by EMS for any reason to the CCHMC ED. Transported children were excluded if they arrived via helicopter, were transferred by EMS from a non-CCHMC ED, left without being seen before triage, or were referred to the ED but never arrived. Once identified, each participant's residential address was collected from the electronic health record and assigned to a census tract using a custom geocoder based on TIGER/Line address range files (15). Analyses were limited to those children with a residential address that was able to be geocoded and was within Hamilton County, Ohio, where CCHMC is located.

According to the 2016 U.S. Census Bureau statistics, Hamilton County is the third most populous county in Ohio, with 809,099 people; it covers 413 square miles. The median age is 37 years with 23.6% (approximately 191,000) under 18 years of age. When examining children in Hamilton County as a whole, 68.3% identify their race as white and 26.4% as black or African American. With regard to ethnicity, 3.1% identify as Hispanic. The median household income is $49,013 (compared to $55,775 nationally) (16). There are 41 responding or 9-1-1 EMS agencies in Hamilton County; Cincinnati Fire Department is the largest. Of the responding EMS agencies, the majority are all paid EMS providers and about half have EMT paramedics as the highest reported position. EMS utilization in the study county is comparable to other Level 1 trauma pediatric hospitals (1).

Outcome and Predictor Variables

The primary outcomes were the EMS utilization rates in Hamilton County overall and for each in-county census tract. Rates were calculated by dividing the total number of EMS transports by the total number of children under 18 years of age residing within a given census tract, obtained using population estimates from the 2015 5-year ACS (14). Rates were normalized per 100 children. Census tracts with zero EMS runs ($n = 3$ tracts) or less than 3 total EMS runs ($n = 10$) over the 2-year period were excluded from any tract-level analysis; therefore, a total of 209 census tracts were included. We excluded these census tracts to both maintain anonymity and to support more valid outcome estimates. Rates generated using a small population denominator or in census tracts where there are a small number of events are highly unstable.

Our primary tract-level predictor was socioeconomic deprivation. A previously validated census tract–level deprivation index was assigned to each census tract and to each EMS transport event based on census tract from which the patient resided (17).

This allowed the deprivation index to be used in both our tract- and event-level analyses. This deprivation index was created using a principal components analysis of 8 different socioeconomic census tract–level measures from the 5-year 2015 ACS: fraction that graduated high school, fraction of households in poverty, median household income, fraction of population receiving public assistance income, fraction of houses that are vacant, median home value, white fraction of population, and black fraction of population (17). The resulting index quantifies the amount of socioeconomic deprivation in each census tract; it ranges from 0 to 1, with a higher value consistent with higher deprivation.

Patient-level variables extracted from the electronic health record and available for each EMS utilization event included age at the time of the event (measured in years), sex (male, female), race (white, black, other, unknown), ethnicity (Hispanic, non-Hispanic, unknown), insurance status (public, private, self-pay/other, unknown), residential address for geocoding, *International Classification of Diseases*, Ninth Revision, discharge diagnoses codes, chief complaint, triage level, ED disposition (hospitalized, discharged, expired), and resuscitation suite activation. Patients transported more than once were included as separate transport events. Triage level is classified using the Emergency Severity Index (ESI, scored 1–5; higher numbers indicate less urgency based on acuity and resource utilization) (3,18). The resuscitation suite is an area in the ED where high-acuity patients are cared for by a multidisciplinary team of providers. Triage to the resuscitation suite, where emergency care is rapidly provided, is performed by nurses using the ESI in combination with nursing experience and ED protocols (based on acuity reported by EMS providers and existing ED trauma protocols) (18,19). Approximately 6.5% of patients presenting to the CCHMC ED are triaged to the resuscitation suite. Triage level, disposition, and resuscitation suite activation were used as markers of event acuity. The deprivation index was assigned to each event after geocoding the address associated with that event to a specific Hamilton County census tract.

Statistical Analyses

For census tract–level analyses, Pearson's correlation coefficient was used to assess the relationship between the continuous census tract EMS utilization rate and the continuous census tract deprivation index. Event-level analyses used a t test or analysis of variance to determine whether the mean deprivation index differed between children grouped by different levels of acuity (i.e., triage level/ESI values from 1 to 5, disposition status, resuscitation suite activation).

Results

During the 2-year study period, 7,376 events were able to be precisely geocoded (out of a total of 7,508 events). There were 4,877 EMS transport events to CCHMC within Hamilton County that met our inclusion criteria. Children transported by EMS had a mean age of 6.8 years (SD =5.2; Table 1). The majority of transported patients were male (56.0%), African American (53.3%), non-Hispanic (95.3%), and publicly insured (73.2%). A total of 80.9% of transports were triaged to an ESI level of 1–3, consistent with high-moderate acuity. Most children transported by EMS were discharged from the ED (71.5%). Of the 27.9% of children who were hospitalized to CCHMC, 4.9% (n = 237) were admitted to the intensive care unit. The majority of transport events (75.8%) were not directed toward care in the resuscitation suite.

The median EMS utilization rate across the 209 included census tracts was 2.6 per 100 children (range =0.2 to 11.1 per 100; interquartile range =1.4–4.1 per 100; Figure 1). There was a significant correlation between tract-level EMS utilization rates and the sociodemographic deprivation index ($r = 0.72$, 95% confidence interval [CI], 0.65–0.77; Figure 2). To further illustrate the extent of this correlation, we divided the deprivation index into quartiles and mapped the EMS utilization rate with each of these subdivisions (Figure 3).

When examining the association between deprivation and acuity, the mean deprivation index significantly differed for ESI triage category ($p < 0.001$), disposition ($p < 0.001$), and resuscitation suite activation ($p = 0.016$; Figure 4). In general, as the ESI level increased (indicative of decreasing acuity), census tract deprivation increased. The exception was for triage level 1, a triage level that is rarely used and reserved for the most critically ill children. Similarly, patient death in the ED correlated with a higher deprivation index than a disposition of admit or discharge.

Discussion

This retrospective analysis identified significant variation in EMS utilization rates across census tracts in one large county in Ohio. This variation was associated with underlying census tract–level deprivation, suggesting that socioeconomic, environmental, and contextual factors are likely key underlying contributors. Higher levels of deprivation were generally associated with lower acuity ED

TABLE 1. Patient-level demographics and markers of ED acuity for Hamilton County children transported by EMS to CCHMC and the CCHMC ED population, July 2014–2016 (percentages may not add to 100 due to rounding)

Variable	Overall transported by EMS (N = 4,877)	Overall CCHMC ED population
Age, mean (SD)	6.8 (5.2)	7.6 (6.0)
Female sex	2,147 (44%)	48.99%
Race		
White	1,662 (34.1%)	53.94%
Black	2,598 (53.3%)	38.21%
Other	539 (11.1%)	
Unknown	78 (1.6%)	
Ethnicity		
Hispanic	148 (3.0%)	4.64%
Non-Hispanic	4,649 (95.3%)	94.45%
Unknown	80 (1.6%)	0.87%
Insurance		
Public	3,569 (73.2%)	62.64%
Private	1,152 (23.6%)	33.70%
Self-pay/other	148 (3.0%)	3.39%
Unknown	8 (0.2%)	6.5%
Resuscitation suite activation	1,178 (24.2%)	6.5%
Emergency Severity Index triage level		
1 (most emergent)	46 (0.9%)	0.08%
2	2,353 (48.2%)	29.55%
3	1,551 (31.8%)	38.85%
4	816 (16.7%)	24.96%
5 (least emergent)	79 (1.6%)	6.22%
Unknown	32 (0.7%)	0.33%
Disposition		
Admit	1,360 (27.9%)	21.68%
Discharge	3,487 (71.5%)	77.17%
Expired	30 (0.6%)	0.03%

ED = emergency department; EMS = emergency medical services; CCHMC = Cincinnati Children's Hospital Medical Center.

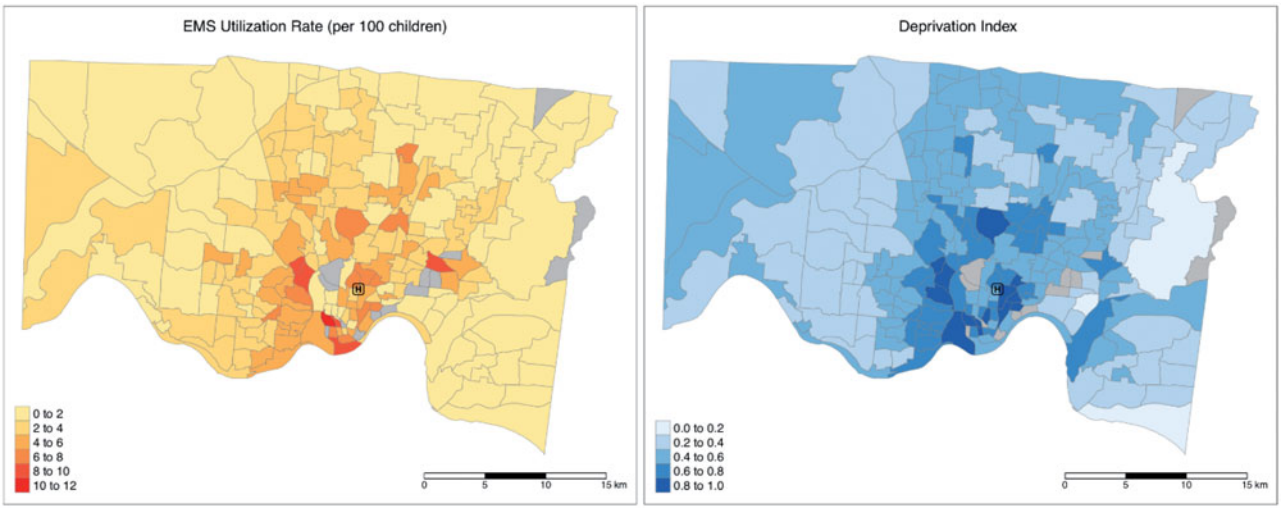

FIGURE 1. Emergency medical services utilization and deprivation index across Hamilton County, Ohio, census tracts. (Left panel): EMS transport rates by Hamilton County census tract. (Right panel): Deprivation index for Hamilton County census tracts. The deprivation index ranges from 0 to 1, with increased values corresponding to increased levels of deprivation. Census tracts that are gray have <3 pediatric EMS runs during July 2014–July 2016, a near-zero total child population, or missing data on the census variables used to compose the deprivation index and were excluded from subsequent analysis. The box containing the letter "H" signifies the location of Cincinnati Children's Hospital. Figure 2 allows for a quantitative comparison of the data in Figure 1.

visits in patients transported by EMS, with the exception of a very small number of critically ill patients.

Our findings are consistent with those of previous studies that have demonstrated geographic variation in EMS utilization rates (3,4). These studies, however, have generally found such variation at the ZIP code level. ZIP codes tend to be heterogeneous and not meant for matching with census data (12,13). Our study builds upon this prior work by using a finer, more homogenous geography allowing for greater granularity. This provides a more directed way to understand differences across geographies and socioeconomic ladders. Moreover, census tracts generally align more closely with established neighborhood boundaries, potentially easing the transition to testable interventions aimed at those factors driving excess EMS utilization (e.g., inequitable health care access) (20).

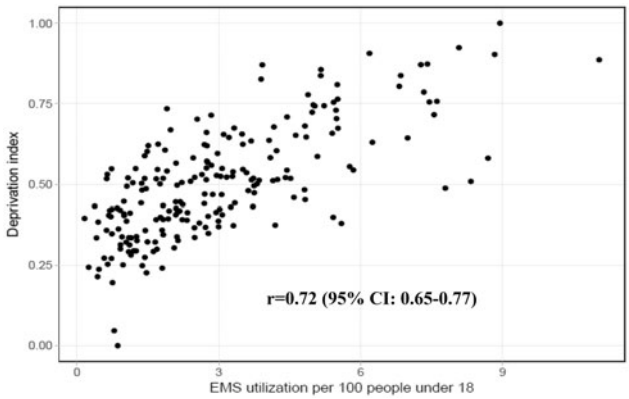

FIGURE 2. Deprivation index and census tract EMS utilization rate in Hamilton County, Ohio.

Deprivation in neighborhoods has been defined in different ways by many investigators. Studies have used markers including racial/ethnic segregation, rates of uninsured or publicly insured individuals, number of elderly, and type of residence/geographic region (21–23). Many of these measures, however, are limited by their narrow focus or a less-established link with socioeconomic deprivation or other factors of potential relevance to health outcomes (e.g., access to reliable transportation, access to care). The deprivation index used in our study was derived using a principal components analysis of 8 socioeconomic census tract–level measures from the ACS that provides a more detailed, holistic view of deprivation. Indeed, we see the deprivation index as an improvement upon individual socioeconomic measures by deriving a single number to represent multiple domains of socioeconomic deprivation that can be assigned to each encounter within individual census tracts.

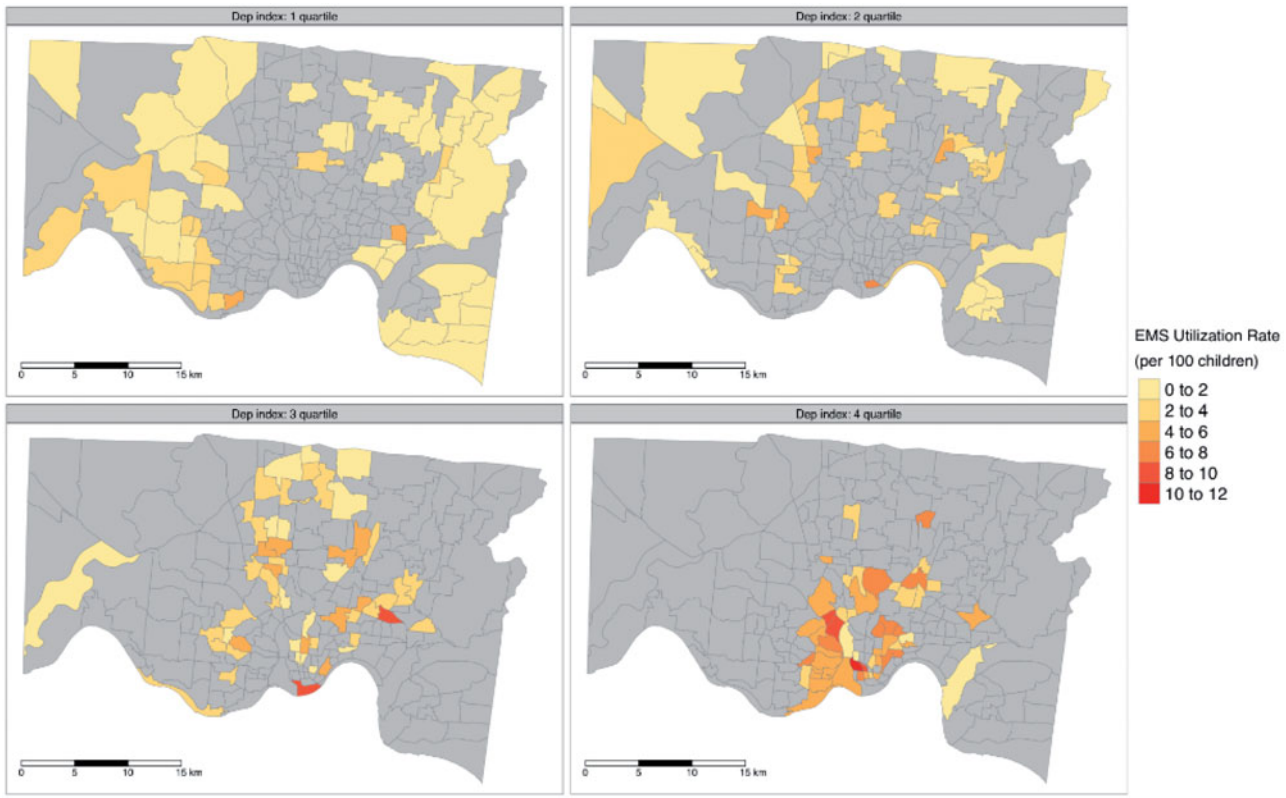

FIGURE 3. EMS utilization rate separated by deprivation index quartiles in Hamilton County, Ohio. Deprivation index quartiles range from least-deprived (first quartile) to most-deprived (fourth quartile) census tracts.

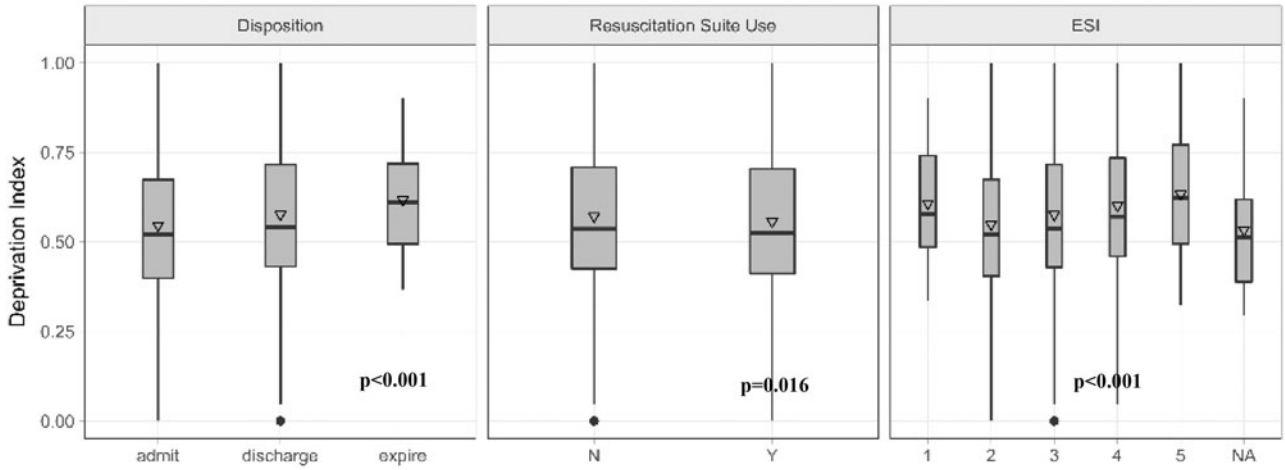

FIGURE 4. Deprivation index and ED visit acuity, as assessed by disposition, resuscitation suite use, and triage code. The dark line in these Tukey box plots represents the median, the boxes represent the interquartile range, and the whiskers represent the most extreme data point that is no more than 1.5 times the interquartile range away from the box. The mean is represented by the open triangle.

As described in the Methods section, the deprivation index is a unitless index that ranges from 0 to 1, with a higher value meaning more deprivation. Among all 222 census tracts in Hamilton County, the mean deprivation index is 0.4 and its standard deviation is 0.156. Thus, a 0.1-unit change in the deprivation index is equivalent to an effect size of 0.64 (i.e., 0.1/0.156) (24). This is considered a medium to large effect by most benchmarks (25,26). For example, Cohen says that an effect size of greater than 0.6 is "grossly perceptible and therefore large" (27). Thus, we feel that a change in the deprivation index of 0.1 is large and likely not due to the sample size alone.

We found a high degree of correlation between census tract–level EMS utilization rates and census tract–level deprivation. These findings are consistent with studies illustrative of links between EMS use and poverty (3,4). In Hamilton County, the children coming to the ED via EMS transport self-identified as predominantly African American and non-Hispanic; more than 70% were publicly insured. Prior studies have demonstrated similar demographic findings (1,3). Although race is used in the principal components analysis, the first component (the deprivation index) does not use race; therefore, definitive statements about the causal effect of deprivation on EMS utilization cannot be made—only associations could be examined. Factors thought to contribute to these demographic trends include limited transport alternatives, diminished access to preventive health services, and more limited health literacy; some other regions see similar trends among children and families with limited English proficiency (3,21,22,28–33). Given the substantial variation in EMS use that we uncovered across our region, hospitals and communities seeking to reduce EMS and ED usage should consider the degree to which socioeconomic deprivation and associated or underlying factors drive use patterns and disparities in those patterns.

EDs are intended to provide care for high-acuity and life-threatening medical conditions but are often used for nonemergent illnesses (34). Visits to the ED for low-acuity illnesses account for a large quantity of health care resources (35). The use of EMS for transport of low-acuity patients diminishes resources to care for higher acuity medical conditions (8,21). Patients who arrive by EMS are often seen by physicians sooner and are more likely to be hospitalized and receive laboratory tests and radiographic imaging, despite controlling for acuity of medical condition (21,36,37). These visits result in a longer length of stay in the ED, and it has been suggested that low-acuity patients transported by EMS may delay care for other ED patients by taking up valuable resources (37,38). Consistent with prior studies, our study found that patients arriving via EMS transport from more deprived census tracts may be more likely to have lower acuity illnesses. Studies have suggested that this nonemergent use of EMS may result from a lack of reliable transportation options, poor access to primary care, caregiver-deemed medical necessity, and misunderstanding of the proper use of EMS transport (5,8).

From the 2015 5-year ACS, 7.8% of commuters utilize public transportation in the Greater Cincinnati Metropolitan area (39). This is a relatively low number compared with other major cities. Public transportation in Cincinnati is primarily through the use of buses, because there is no subway system and a new electric streetcar located

downtown has few users and little access to surrounding communities.

Currently, there is a paucity of literature describing what targeted interventions could be successful in attempting to decrease nonemergent use in children. Potential targets for interventions could include a change in insurance-covered transportation options for acute illnesses, expanded access to primary care, alternative yet rapid ways to evaluate patients (e.g., tele-health programs), or more widespread education campaigns. To date, studies and programs assessing ways to decrease nonemergent EMS and ED use have proposed interventions including the use of community paramedicine and community health workers for medical visitation, as well as implementing new or increasing copayments for nonemergent ED visits (32). Successful interventions to decrease EMS use include implementation of case managers for frequent EMS users, paramedic-initiated nontransport of pediatric patients, and public health information campaigns (3,40,41).

Knowledge of those census tracts or neighborhoods that disproportionately use EMS services could help to target such interventions. Moreover, links with identified socioeconomic factors, namely, deprivation, support the focused deployment of interventions aimed at expanding access to those most in need. Use of such data from small geographies like census tracts could be especially important in deployment population dense areas, because census tracts become smaller (and therefore the geographic target of interventions more focused) as population density increases (20). Similarly, further work looking at specific factors relevant to nonemergent EMS utilization could be a useful next step in planning interventions that drive such usage to more appropriate locations (e.g., primary care).

There were limitations to this study. This study was conducted in one county with EMS transports to a large pediatric tertiary care center. Therefore, generalizability of our results may be skewed to the local population as well as to EMS and ED providers practicing at our institution. More than 90% of children in Hamilton County, Ohio, are transported to CCHMC by EMS providers. We receive approximately 750 EMS transports each month. In our experience, children are preferentially transported to CCHMC and therefore results may be skewed because of this. Second, the CCHMC ED uses the ESI to triage patients. Although the ESI has its limitations, prior studies examining outcomes for several thousand patients have demonstrated triage level to be associated with disease severity (18). Though the triage decision may be susceptible to implicit bias, strong correlations of the ESI with hospitalization, ED length of stay, and mortality are consistently found in the published literature (42–45). Third, retrospective data analysis has inherent limitations with inaccurate, missing, or incomplete data. In addition, EMS calls that did not result in patient transports were not able to be assessed. Lastly, appropriateness of EMS and ED usage is difficult to assess by a child or his or her caregiver. Although objective factors such as lack of transportation, barriers to access to a medical home, and poverty/household income can be measured, subjective factors such as health literacy and caregiver/parent concern also play a role in EMS and ED utilization and are more difficult to decipher.

Conclusions

We identified substantial variability in pediatric EMS transport rates within the diverse communities surrounding a large pediatric academic ED. Increasing deprivation status of these tracts, or neighborhoods, correlated positively with increased EMS utilization. Increasing deprivation was similarly associated with nonemergent ED use, with the exception of a small number of critically ill children. Understanding these patterns of EMS utilization is a critical first step in developing interventions to minimize EMS use for nonemergent conditions. Further work focused on community-based interventions and prehospital care delivery changes could support a reduction in the variability and disparities in EMS utilization that we uncovered.

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