Geographic proximity to specialized pediatric neurosurgical care in the contiguous United States

Abdul-Kareem Ahmed, SM,1 Ann-Christine Duhaime, MD,2 and Timothy R. Smith, MD, PhD, MPH3

1Department of Neurosurgery, Warren Alpert Medical School of Brown University, Providence, Rhode Island; 2Department of Neurosurgery, Massachusetts General Hospital; and 3Department of Neurosurgery, Brigham & Women’s Hospital, Harvard Medical School, Boston, Massachusetts

OBJECTIVE Absent from an analysis of supply is consideration of the geographic distribution of pediatric neurosurgeons. Several patient socioeconomic metrics are known to be associated with outcome in pediatric neurosurgical diseases, such as hydrocephalus. The purpose of this study was to determine current geographic proximity to pediatric neurosurgical care using professional society databases. This study also sought to establish how socioeconomic factors are related to distance to care, using federal government–collected data.

METHODS A list of currently practicing American Board of Pediatric Neurological Surgery (ABPNS)–certified neurosurgeons was compiled (ABPNS group). A separate list of practicing members of the Joint Pediatric Section (JPS) of the American Association of Neurological Surgeons/Congress of Neurological Surgeons was prepared (JPS group). Current primary practice locations were collected from each professional society database for each ABPNS or JPS neurosurgeon and were charted using ArcGIS mapping software (ESRI, version 10.3) on a United States Census Bureau map. The straight distance from the centroid of each zip code tabulation area (ZCTA) to the nearest neurosurgeon was determined by group type of neurosurgeon (ABPNS vs ABPNS + JPS). ZCTA-level data on demographic and socioeconomic factors were acquired from the American Community Survey, including data in children and young adults (0–18 or 0–24 years old) and the general population. These data were compared by distance to care and by groups of neurosurgeons (Pearson’s chi-square analysis; the threshold of significance was set at 0.05).

RESULTS Three hundred fifty-five practicing neurosurgeons providing pediatric care were located, of whom 215 surgeons were certified by the ABPNS and 140 were JPS members only. The analysis showed that 1 pediatric neurosurgeon is in practice for every 289,799 persons up to the age of 24 years. The average distance between a ZCTA and the nearest pediatric neurosurgeon is 63.3 miles (SE 0.3, range 0.0–499.7 miles). Geographic analysis showed that 27.1% of children live farther than 60 miles from an ABPNS-certified neurosurgeon and 19.7% from either an ABPNS-certified neurosurgeon or a JPS member. ZCTAs with children who live farther than 60 miles from a neurosurgeon providing pediatric care had a marginally higher rate of uninsured children, a higher percentage of families with children living below the federal poverty level, and a higher proportion of persons living in rural areas compared with ZCTAs with children who live within 60 miles of care (p < 0.005 for each finding).

CONCLUSIONS The results of this study indicate that there is considerable variation in proximity to pediatric neurosurgical subspecialty care by geographic region. In addition, there is a relationship between distance to neurosurgical care and socioeconomic indicators. Optimization of access to pediatric neurosurgical care may involve strategies to overcome long geographic distances, particularly in rural and underserved areas. Such areas may have disproportionately lower socioeconomic levels, which may further limit access to care and affect outcomes. Both the total number of pediatric neurosurgeons per pediatric population and their geographic distribution could be important in determining appropriate subspecialty supply factors (e.g., the number of accredited pediatric neurosurgical fellowship training programs), as well as being important drivers of neurosurgical patient outcomes.

https://thejns.org/doi/abs/10.3171/2017.9.PEDS17436

KEY WORDS pediatric neurosurgery; socioeconomic status; health care; hydrocephalus; distance to care
In 2012, the Congress of Neurological Surgeons (CNS) and the American Association of Neurological Surgeons (AANS) issued a statement before the Institute of Medicine describing the modern American neurosurgical workforce.1 One of the key issues of concern in this statement was the shortage of pediatric neurosurgeons in active practice. A survey of pediatric neurological practitioners published in 2009 determined that within the next decade, 41.7% of the current pediatric neurological workforce will probably be retired.2 Simultaneously, over 15 years (1992–2006), 4–16 trainees per year entered a pediatric neurosurgery fellowship program.6 More recently, some years have had a higher number of fellows in accredited fellowships; however, the relationship between workforce supply and demand remains unclear.

Absent from this analysis of supply (that is, total number of pediatric neurosurgeons in the current practicing workforce) is the additional consideration of the geographic distribution of pediatric neurosurgeons. Little is known about the distribution of pediatric subspecialists relative to their demand.11 The 2012 Children’s Hospital Association survey of 69 children’s hospitals revealed that the shortage of pediatric neurosurgeons was among 5 pediatric specialist shortages that most affected the ability of a hospital to deliver comprehensive care.2 Considering pediatric primary care, an analysis of the pediatrician workforce in the United States showed that the distribution of physicians does not parallel the distribution of the child population and has not changed substantially in more than a decade, despite a 38.6% increase in the pediatrician-to-child population ratio.3 The geographic distribution of pediatric neurosurgeons in the United States remains largely unknown.

A better-studied patient metric with regard to pediatric neurological intervention and outcomes is socioeconomic status. Hydrocephalus is an often chronic condition that is managed by pediatric neurosurgeons. It has been demonstrated that Medicaid insurance status was associated with nonroutine discharge (transfer to short-term hospital, transfer other, home health care, against medical advice) after pediatric CSF shunting compared with private insurance status.4 Patients with public insurance also experience increased delays in discharge after ventriculoperitoneal shunting.5 Low socioeconomic status has also been associated with an increased rate of shunt complications.13

The purpose of this study was to determine current geographic proximity to pediatric neurological care using professional society databases. This study also sought to establish how socioeconomic factors are related to distance to care, using federal government–collected data. We expected that farther distance to care would be associated with rurality and socioeconomic disadvantage.

Methods

A list of currently practicing American Board of Pediatric Neurological Surgery (ABPNS)–certified neurosurgeons was compiled (ABPNS group). A separate list of practicing members of the Joint Pediatric Section (JPS) of the AANS/CNS (JPS group) was prepared. ABPNS members are determined by subspecialty training, a case log showing a predominant focus on pediatric patients, and a subspecialty examination. JPS membership is open to any neurosurgeon who is a member of one of the parent organizations (AANS or CNS) and who has applied and has been accepted to the JPS, which hosts subspecialty meetings and educational events. Taken together, these can serve as a reasonable estimate of the number of neurosurgeons in the United States who either focus on or express subspecialty interest in pediatric neurosurgery. However, general neurosurgeons who have graduated from accredited training programs are also able to provide pediatric neurological care, but their practices typically do not have a predominant pediatric focus. Thus, the ABPNS and JPS groups were used to identify neurosurgeons with an expressed interest in providing care to pediatric patients, designated as “pediatric neurosurgeons” in this study.

Current primary practice locations were collected from each professional society database for each ABPNS or JPS neurosurgeon and were charted using ArcGIS mapping software (ESRI, version 10.3) on a United States Census Bureau map, excluding Alaska, Hawaii, and Puerto Rico (https://www.census.gov/geo/maps-data/data/tiger.html). The straight distance from the centroid of each zip code tabulation area (ZCTA) to the nearest neurosurgeon was determined by group type of neurosurgeon (ABPNS vs ABPNS + JPS).

ZCTA-level data on demographic and socioeconomic factors were acquired from the American Community Survey, including data on children and young adults (0–18 or 0–24 years old) and the general population (https://www.census.gov/programs-surveys/acs/). Data were used on persons 0–24 years old where available to reflect the longitudinal care that pediatric patients often receive into early adulthood. The age of 24 years (when young adults, particularly those with chronic conditions, may still receive medical care from pediatric providers) was chosen to reflect longitudinal care. These data were compared by distance to care (dichotomized at 60 miles to approximate a 1-hour driving distance) and by groups of neurosurgeons (Pearson’s chi-square analysis; the threshold of significance was set at 0.05).

Results

A total of 355 practicing neurosurgeons providing pediatric care were identified, of whom 215 were certified by the ABPNS and 140 were JPS members only. Among ABPNS-certified neurosurgeons, 182 were also JPS members. There is 1 pediatric neurosurgeon for every 289,799 persons up to the age of 24 years. The results showed that the average distance between a ZCTA and the nearest pediatric neurosurgeon is 63.3 miles (SE 0.3 miles, range 0.0–499.7 miles). The median distance is 48.8 miles.

Geographic analysis showed that 27.1% of children live farther than 60 miles from an ABPNS-certified neurosurgeon and 19.7% from either an ABPNS-certified neurosurgeon or a JPS member (Fig. 1). ZCTAs with children who live farther than 60 miles from a neurosurgeon providing
A. K. Ahmed et al.

J Neurosurg Pediatr Volume 21 • April 2018

pediatric care had a marginally higher rate of uninsured children, a higher percentage of families with children living below the federal poverty level, and a higher proportion of persons living in rural areas compared with ZCTAs with children who live within 60 miles of care (Table 1).

Discussion

To our knowledge, this study determines for the first time the geographic proximity to pediatric-focused neurosurgical care in the contiguous United States. Most children live within a 60-mile radius of an ABPNS-certified neurosurgeon, and JPS members increase this proportion and extend access to care. Socioeconomic disparities are correlated with distance to care. Families and children who live beyond a 60-mile radius of a pediatric neurosurgeon were more likely to be economically disadvantaged as well as more likely to be living in a rural area. Although these results may not be surprising, this study quantitates the proportion of children who live a farther distance from pediatric subspecialty care and how this is correlated with socioeconomic indicators. These parameters have implications for systems of care delivery.

As one link between access to care and quality of life in a common pediatric neurosurgical condition, distance to a pediatric neurosurgical center has been determined to be a predictor for lower overall quality of life in children being treated for hydrocephalus in Canada.10 In addition, lower family income is a determinant for poorer health-related quality of life in children with hydrocephalus; this relationship has been demonstrated despite the presence of a national universal health care system.9 To our knowledge, similar studies have not been performed for children in the United States, where health care coverage for needs such as ambulance and helicopter transport remains highly variable.

In response to these findings, identifying ways to improve access to children in underserved areas remains a challenge. Currently, 4–16 neurosurgery graduates train each year in Accreditation Council for Pediatric Neuro-

Table 1. Socioeconomic factors and distance to care stratified by pediatric neurosurgeon group

<table>
<thead>
<tr>
<th>Population Characteristic</th>
<th>ABPNS Only (n = 215)</th>
<th>ABPNS + JPS (n = 355)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤60 Miles</td>
<td>&gt;60 Miles</td>
</tr>
<tr>
<td>Persons aged 0–24 yrs (%)</td>
<td>72.9</td>
<td>27.1</td>
</tr>
<tr>
<td>Socioeconomic factors (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uninsured persons aged 0–24 yrs</td>
<td>10.4</td>
<td>12.2</td>
</tr>
<tr>
<td>Families w/ children aged 0–18 yrs living below FPL</td>
<td>20.3</td>
<td>25.2</td>
</tr>
<tr>
<td>Population in rural areas (all)</td>
<td>12.6</td>
<td>37.1</td>
</tr>
</tbody>
</table>

FPL = federal poverty level.
* Chi-square test.

FIG. 1. Sixty-mile radial distances to pediatric neurosurgical care. Radial boundaries represent a distance of 60 miles from a pediatric neurosurgeon. Neurosurgeons (n = 355) are designated either as those certified by the ABPNS or as JPS members, overlaying a population density map of persons 0–24 years of age per square mile. White spaces inland are areas without defined ZCTAs due to a minimal population. Figure is available in color online only.
surgical Fellowships–certified programs, although these numbers have increased recently. Perceived deterrents to pediatric specialization included the intrinsic nature of the field, financial and reimbursement concerns, additional training time, longer work hours, and medicolegal issues. However, for many people, the opportunity to deal with many different surgical conditions, the unique rewards of working with children and their families, and long-term relationships with patients serve as incentives in this subspecialty.

Improving access to care by encouraging pediatric neurosurgeons to practice in underserved areas is unlikely to be a viable solution, because neurosurgeons need a specific population of children to maintain a pediatric-focused practice. A requisite volume and diversity of cases, which is naturally available in urban areas, is also needed to ensure proficiency. It is not surprising that patients living beyond a 60-mile radius of a pediatric neurosurgeon were more likely to be living in a rural area. Optimizing distribution would probably require political efforts, goal-directed policies, and economic incentives.

Alternatively, rather than focusing on locating subspecialty physicians in remote areas, it may be helpful to facilitate access to more centralized care by making patient travel costs reimbursable or by using strategies such as intermittent outreach clinics and promotion of telemedicine. Although some families of children with chronic, emergency care–dependent conditions treated by pediatric neurosurgeons may choose to relocate to facilitate access, this solution may be particularly difficult for families with few means.

There are several limitations to this study. Absent from this study are data on general neurosurgeons who might respond to pediatric needs in remote areas. It is difficult to determine which general neurosurgeons are willing to care for which types of pediatric problems. This study also considered straight distance as the representative metric for travel distance, which is imprecise. The age cutoff of 24 years was used to reflect longitudinal care; however, there was no difference in the analysis using the cutoff of 18 versus 24 years. In addition, ZCTA-level data on the pediatric population is limited, for example, as it does not include the distribution of various health insurance types. Similarly, the American Community Survey is limited in the number and nature of variables at the level of ZCTAs, which may be important to explore regarding pediatric neurosurgical patients. We also acknowledge that even within purely urban or rural areas, associations between pediatric neurosurgical outcomes and socioeconomic status probably exist.

Whereas ABPNS certification requires evidence of a pediatric focus of practice, JPS members are self-identified. Because membership requires the payment of dues and meetings are open to all neurosurgeons, the relationship between JPS membership and pediatric expertise compared with that of general neurosurgeons who are not JPS members is unclear. In addition, there are recently graduated pediatric neurosurgeons who have not yet achieved ABPNS certification. Recent changes in the maintenance of certification with subspecialty expertise may allow for tracking of subspecialty focus with more precision in the future. Nonetheless, at present, these 2 groups of neurosurgeons—ABPNS and JPS—represent the best available estimate of pediatric focus and provide a useful estimate of access to subspecialty care.

Conclusions

This study estimates the number of pediatric patients per pediatric-focused neurosurgeon in the United States. Our results indicate that there is considerable variation in proximity to pediatric neurosurgical subspecialty care by geographic region. In addition, there is a relationship between distance to neurosurgical care and socioeconomic indicators, as well as between these indicators and some aspects of pediatric neurosurgical outcomes. Future directions of research include investigating the role of appropriate subspecialty supply factors, such as the number of accredited pediatric neurosurgical fellowship training programs. A more granular analysis of relationships between distance to care and pediatric neurosurgical outcomes is also a point of further investigation.

Acknowledgments

We thank Susan Durham, MD, for help in planning and accessing data, and Sarah Gaskill, MD, for help in accessing JPS information.

References

9. Kulkarni AV, Cochrane DD, McNeely PD, Shams I: Medical,

Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: Ahmed. Acquisition of data: Ahmed. Analysis and interpretation of data: Ahmed. Drafting the article: Ahmed. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Statistical analysis: Smith. Administrative/technical/material support: Duhaime, Smith. Study supervision: Duhaime, Smith.

Supplemental Information
Previous Presentations
Portions of this paper were presented in poster format at the AANS 2017 Annual Scientific Meeting, Los Angeles, CA, April 22–26, 2017.

Correspondence
Abdul-Kareem Ahmed: Warren Alpert Medical School of Brown University, Providence, RI. abdul-kareem_ahmed@brown.edu.