Racial and socioeconomic disparities in outcomes following pediatric cerebrospinal fluid shunt procedures

Frank J. Attenello, MD,¹ Alvin Ng, BS,² Timothy Wen, MPH,³ Steven Y. Cen, PhD,^{4,5}
Nerses Sanossian, MD,⁴ Arun P. Amar, MD,¹ Gabriel Zada, MD,¹ Mark D. Krieger, MD,^{1,6}
J. Gordon McComb, MD,^{1,6} and William J. Mack, MD¹

Departments of ¹Neurosurgery, ²Preventive Medicine, ⁴Neurology, and ⁵Radiology, Keck School of Medicine of University of Southern California; ⁶Division of Neurosurgery, Children's Hospital of Los Angeles, ³Keck School of Medicine of University of Southern California, Los Angeles, California

OBJECT Racial and socioeconomic disparities within the US health care system are a growing concern. Despite extensive research and efforts to narrow such disparities, minorities and economically disadvantaged patients continue to exhibit inferior health care outcomes. Disparities in the delivery of pediatric neurosurgical care are understudied. Authors of this study examine the impact of race and socioeconomic status on outcomes following pediatric CSF shunting procedures.

METHODS Discharge information from the 2000, 2003, 2006, and 2009 Kids' Inpatient Database for individuals (age < 21 years) with a diagnosis of hydrocephalus who had undergone CSF shunting procedures was abstracted for analysis. Multivariate logistic regression analyses, adjusting for patient and hospital factors and annual CSF shunt procedure volume, were performed to evaluate the effects of race and payer status on the likelihood of inpatient mortality and non-routine hospital discharge (that is, not to home).

RESULTS African American patients ($p < 0.05$) had an increased likelihood of inpatient death and nonroutine discharge compared with white patients. Furthermore, Medicaid patients had a significantly higher likelihood of nonroutine discharge ($p < 0.05$) as compared with privately insured patients.

CONCLUSIONS Findings in this study, which utilized US population-level data, suggest the presence of racial and socioeconomic status outcome disparities following pediatric CSF shunting procedures. Further studies on health disparities in this population are warranted.

<http://thejns.org/doi/abs/10.3171/2014.11.PEDS14451>

KEY WORDS hydrocephalus; neurosurgery; outcomes; inpatient death; routine discharge

DISPARITIES in health care delivery due to race and/or ethnicity and socioeconomic status (SES) have been studied and reported on extensively.^{1,24} Compared with the general population, racial minorities and patients of a lower SES have higher mortality rates in the setting of cancer,^{16,17} heart disease,¹² stroke,⁶ and diabetes.¹¹ These inequalities are due in part to limited access and utilization of health care resources and compromised quality of care. Substantial efforts have been made to offset these disparities (<http://www.healthypeople.gov>).

Recent attention has focused on health care disparities across medical specialties in the pediatric popula-

tion. Studies have demonstrated that racial minorities face health care access barriers, lack routine sources of care, are less likely to be covered by medical insurance, and have difficulty obtaining specialty care.^{2,7} The pediatric neurology literature suggests that racial minority children are more likely to suffer from stroke or cerebral palsy.^{9,25} Decreased access to high-volume centers has been noted to contribute to inferior outcomes in minority pediatric patients undergoing neurooncological surgery.¹⁴ Overall, however, very few studies have investigated disparities in pediatric neurosurgical care.

Hydrocephalus is the second most common brain ab-

ABBREVIATIONS KID = Kids' Inpatient Database; SES = socioeconomic status.

SUBMITTED August 30, 2014. **ACCEPTED** November 12, 2014.

INCLUDE WHEN CITING Published online March 20, 2015; DOI: 10.3171/2014.11.PEDS14451.

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

normality in the pediatric population worldwide and accounts for approximately 0.6% of pediatric admissions.^{3,19} Similarly, CSF shunting is the surgery most frequently performed by pediatric neurosurgeons. Prior studies have evaluated the impact of patient comorbidities, hospital characteristics, and surgeon or hospital volume on CSF shunting outcomes by using large administrative data sets.^{19,20} Further, a single-institution study described the impact of SES and race on outcomes following pediatric shunting procedures.²³ However, no studies have assessed these racial and socioeconomic disparities at the population level in the US.

To further our understanding of the impact of SES and race on CSF shunting procedures in pediatric patients, we performed a retrospective analysis of national outcomes. We aimed to identify the effects of race and/or payer status on inpatient mortality and the likelihood of a nonroutine discharge. We hypothesized that outcome disparities exist with respect to race and payer status among pediatric patients undergoing CSF shunting operations. Investigating outcome disparities in CSF shunting procedures is very likely to provide important insight into broader pediatric neurosurgical disparities in the US.

Methods

Data Sample

The Kids' Inpatient Database (KID) is the largest pediatric (age < 21 years) inpatient discharge database in the US, containing information on 2–3 million pediatric inpatient records from over 2500 hospitals. As of 2009, 44 states provide discharge information to the KID. The database is assembled by the Healthcare Cost and Utilization Project and is sponsored by the Agency for Healthcare Quality and Research, and is available every 3 years. The KID also contains a weighting system that, when applied, allows for the calculation of national estimates.

Study Cohort

Discharge information from the 2000, 2003, 2006, and 2009 KID was abstracted for analysis in this study. Patients were selected according to the ICD-9-CM codes for the diagnosis of hydrocephalus (331.3, 331.4, 741.0, 742.3) with a corresponding CSF shunting procedure of ventriculoatrial shunt (02.32), ventriculopleural shunt (02.33), ventriculoperitoneal shunt (02.34), or replacement of a ventricular shunt (02.42). This ICD-9 search algorithm has been used in multiple previous neurosurgical and ventriculoperitoneal shunting studies.²⁰

The KID includes patient and hospital factors as categorical demographic variables. Patient variables, such as race (white, African American, Hispanic, Asian/Pacific Islander, Native American, other), payer status (Medicare, Medicaid, private insurance, self-pay, no charge), and sex (male, female) were included as categorical variables and unaltered for analysis. Age was included as a continuous variable in the KID and recoded into categorical variables for analysis (age < 1 year, 1–4 years, 5–9 years, 10–17 years, ≥ 18 years). Hospital-level variables, such as hospital bed size (small, medium, large), teaching status (nonteaching, teaching), region (Northeast, Midwest, South,

West), and location (urban, rural), were obtained from the KID as categorical variables and were unaltered for analysis. Hospital type based on the National Association of Children's Hospitals and Related Institutions (NACHRI) was included as a 3-level variable and was recoded as "not identified as a children's hospital by NACHRI," "children's general/specialty hospital," or "children's unit in a general hospital" for analysis. Admission severity was accounted for by including case complexity (not complex, complex), admission source (emergency room, another hospital, other health facility, routine), and admission type (emergency, urgent, elective, newborn, trauma, other) into our analysis. Cases were defined as complex if they had a co-occurring diagnosis of shunt infection (996.63), meningitis (320, 322.9), peritonitis (567, 032.83), septicemia (027.0, 038), infection not otherwise specified (041), myelodysplasia (740, 741.00–741.03, 741.90–741.93, 742.59), cerebral palsy (343.0–343.9), congenital cardiac/circulatory defects (745–747), and urinary tract infection (599).²⁰ Additionally, annual institutional shunt procedure volume was calculated and included as a linear variable in multivariate analyses.

Statistical Analysis

The primary exposures of interest in this study were patient race and patient payer status. We used these 2 exposures to model the disparity with 2 general outcomes: probability of a nonroutine discharge and inpatient death. Discharge disposition was coded as a multilevel categorical variable in the KID (routine, transfer to short-term hospital, transfer other, home health care, against medical advice) and was subsequently recoded as a dichotomous variable for our analysis (routine vs nonroutine discharge). Inpatient mortality was included as a dichotomous variable and unaltered for analysis. Two multivariate logistic regression models using survey-adjusted generalized estimating equations were fit to model these outcomes with 2 primary predictors (patient race and payer status) and were adjusted for patient factors (sex, age), hospital factors (bed size, teaching status, hospital region, location, hospital type), admission severity (complexity, admission source, admission type), and CSF shunt procedure volume.

Statistical significance was predetermined as $p < 0.05$. All descriptive univariate and multivariate analyses were conducted in SAS 9.3 (SAS Institute Inc.).

Results

Sample

There were 37,103 hydrocephalus-related shunting procedures identified from the 2000, 2003, 2006, and 2009 KID. Of those procedures, 20,816 (56.1%) were performed in male patients and 12,724 (34.3%) in nonwhite patients (13.5% African American, 14.5% Hispanic, 1.6% Asian/Pacific Islander, 0.4% Native American, and 4.3% other; Table 1). In addition, 44% (16,486) of the admissions involved Medicaid-insured patients, whereas 48.5% (18,012) involved privately insured patients. There were 5139 nonroutine discharges (Table 2) and 409 inpatient deaths (Table 3) among the pediatric patients with hydrocephalus who underwent shunting procedures.

TABLE 1. Demographic data among 37,103 patients undergoing shunt procedures

Factor	No. (%)
Race	
White	16,786 (45.2)
African American	5001 (13.5)
Hispanic	5394 (14.5)
Asian/Pacific Islander	580 (1.6)
Native American	155 (0.4)
Other	1594 (4.3)
Missing	7593 (20.5)
Payer status	
Medicare	64 (0.2)
Medicaid	16,486 (44.4)
Private insurance	18,012 (48.5)
Self-pay	621 (1.7)
No charge	52 (0.1)
Other	1831 (4.9)
Missing	37 (0.1)
Sex	
Male	20,816 (56.1)
Female	16,125 (43.5)
Missing	162 (0.4)
Age in yrs	
<1	13,078 (35.2)
1–4	8169 (22.0)
5–9	5692 (15.3)
10–17	7808 (21.0)
≥18	2356 (6.3)
Hospital bed size	
Small	6090 (16.4)
Medium	9170 (24.7)
Large	19,908 (53.7)
Missing	1934 (5.2)
Teaching status	
Nonteaching	2081 (5.6)
Teaching	33,088 (89.2)
Missing	1934 (5.2)
Hospital region	
Northeast	6092 (16.4)
Midwest	8535 (23.0)
South	13,002 (35.0)
West	9475 (25.5)
Hospital location	
Urban	327 (0.9)
Rural	34,842 (93.9)
Missing	1934 (5.2)
Hospital type	
Not children's	6003 (16.2)
Children's hospital	14,013 (37.8)

(continued)

TABLE 1. Demographic data among 37,103 patients undergoing shunt procedures (continued)

Factor	No. (%)
Hospital type (continued)	
Children's unit	14,608 (39.4)
Missing	2479 (6.7)
Complexity	
Not complex	27,500 (74.1)
Complex	9603 (25.9)
Admission source	
ER	10,992 (29.6)
Another hospital	3322 (8.9)
Other health facility	520 (1.4)
Routine	14,958 (40.3)
Missing	7311 (19.7)
Admission type	
Emergency	13,707 (36.9)
Urgent	7751 (20.9)
Elective	8953 (24.1)
Newborn	1513 (4.1)
Trauma	98 (0.3)
Missing	5081 (13.7)
Total	37,103 (100)

ER = emergency room; Missing = information missing.

Nonroutine Discharge

Specifically, we examined patient race and payer status as primary predictors of nonroutine discharge (not to home). There was a disparity in the likelihood of nonroutine discharge after a shunt procedure when assessing patient race. Analysis showed that African American pediatric patients (OR 1.30, 95% CI 1.14–1.48, $p < 0.05$) had a 30% higher likelihood of a nonroutine discharge than white pediatric patients (Table 4). There was also a disparity when comparing payer status: Medicaid patients had a significantly greater likelihood of a nonroutine discharge (OR 1.12, 95% CI 1.02–1.24, $p < 0.05$) than privately insured patients.

Inpatient Death

Multivariate analysis was performed to compare the effects of race and payer status on the likelihood of inpatient death. African American pediatric patients (OR 1.56, 95% CI 1.02–2.40, $p < 0.05$) had a 56% increased likelihood of inpatient death compared with white pediatric patients (Table 5). There was no significant difference in the likelihood of inpatient death between patients with Medicaid (OR 1.10, 95% CI 0.82–1.49, $p = 0.51$) and those with private insurance.

Discussion

Racial and socioeconomic disparities within the US health care system are a growing concern. Despite extensive research and efforts to narrow such disparities,

TABLE 2. Frequency and rate of nonroutine discharge, according to race and payer status

Factor	Total	No. w/ Nonroutine Discharge (%)
Race		
White	16,786	2088 (12.4)
African American	5001	808 (16.2)
Hispanic	5394	764 (14.2)
Asian/Pacific Islander	580	118 (20.3)
Native American	155	16 (10.3)
Other	1594	326 (20.4)
Missing	7593	1019 (13.4)
Payer status		
Medicare	64	19 (29.7)
Medicaid	16,486	2499 (15.2)
Private	18,012	2281 (12.7)
Self-pay	621	63 (10.1)
No charge	52	3 (5.8)
Other	1831	272 (14.8)
Missing	37	2 (5.4)
Total	37,103	5139 (13.8)

minorities and economically disadvantaged patients continue to exhibit inferior health care outcomes (<http://www.healthypeople.gov>). Although statewide initiatives have been advanced to provide adequate coverage for pediatric populations, inequalities in the delivery of care still exist.²¹ In a 2010 systematic review, Flores identified racial disparities in children's health care across medical specialties.⁷ However, very few studies have examined racial and socioeconomic inequalities in pediatric neurosurgical care. Our study identifies significant disparities in the most commonly performed pediatric neurosurgical procedure: CSF shunting. These findings may serve as an accurate proxy for access to quality pediatric neurosurgery care in general.

Our study demonstrates that African American pediatric patients are significantly more likely to experience inpatient death than white patients following a CSF shunting procedure (Table 5). This trend has been corroborated in studies of children and adults undergoing neurosurgical and non-neurosurgical procedures.^{10,22} Nuño et al. found that African American patients had a higher inpatient mortality rate than white patients following craniotomy procedures.¹⁵ In 2013, Stone et al. demonstrated that African American children had an increased risk of in-hospital death following surgeries.²² Racial disparities remain when discharge disposition is considered. Patient race has been shown to affect the likelihood of a nonroutine discharge in emergency medicine and cardiology reports.^{5,10} Our study demonstrated that race is associated with the likelihood of a nonroutine discharge following CSF shunting procedures in pediatric patients. African Americans were significantly more likely to have a nonroutine discharge (not to home) than whites (Table 4). Discharge disposition is probably a more sensitive outcome measure

TABLE 3. Frequency and rate of inpatient death, according to race and payer status

Factor	Total	No. of Inpatient Deaths (%)
Race		
White	16,786	136 (0.8)
African American	5001	72 (1.4)
Hispanic	5394	68 (1.3)
Asian/Pacific Islander	580	14 (2.4)
Native American	155	4 (2.6)
Other	1594	32 (2.0)
Missing	7593	83 (1.1)
Payer status		
Medicare	64	0 (0.0)
Medicaid	16,486	208 (1.3)
Private	18,012	168 (0.9)
Self-pay	621	11 (1.8)
No charge	52	0 (0.0)
Other	1831	22 (1.2)
Missing	37	0 (0.0)
Total	37,103	409 (1.1)

than inpatient mortality given the relative health of the hydrocephalic pediatric population and the low mortality rates of shunting procedures. Our findings are also consistent with racial disparities reported in prior studies using alternative outcome measures.^{19,23} In 2014, Walker et al. reported a significant increase in the duration of hospital stay following CSF shunting procedures among non-white patients.²³ Simon et al. found that African American pediatric patients had higher complication rates following CSF shunt insertion procedures.¹⁸ These outcome differences may be explained by racial disparities in childhood health, referral patterns, or geographical access to specialized health care centers.^{7,8}

Our study also suggests that the insurance provider, a commonly used proxy for SES, is associated with the likelihood of a nonroutine discharge following CSF shunting procedures. Pediatric patients insured by Medicaid were 12% more likely to be nonroutinely discharged than were patients with private insurance (Table 4). This finding is consistent with results in studies that have examined the effect of SES on other outcome measures in neurosurgical pediatric patients.^{18,23} A single-institution study demonstrated that pediatric patients of a lower SES have a longer hospital length of stay after CSF shunting procedures than patients with private insurance.²³ Simon et al. demonstrated that publicly insured pediatric patients have higher infection rates following CSF shunting procedures than privately insured individuals.¹⁸ Notably, although "discharge to original admitting hospital" is not a discharge category, it is possible that Medicaid patients may occasionally be coded as "nonroutine" discharges when they are discharged back to an admitting facility. Medicaid effects on nonroutine discharge must be tempered with this potential in mind. When we analyzed the odds of inpatient death,

TABLE 4. Multivariate analysis of nonroutine discharge

Factor	OR	95% CI	p Value
Race			
White		Reference	
African American	1.30	1.14–1.48	<0.01
Hispanic	1.11	0.94–1.31	0.21
Asian/Pacific Islander	1.59	1.08–2.34	0.02
Native American	0.69	0.22–2.14	0.52
Other	1.48	1.13–1.93	<0.01
Payer status			
Medicare	1.83	0.80–4.18	0.15
Medicaid	1.12	1.02–1.24	0.01
Private		Reference	
Self-pay	0.69	0.44–1.08	0.11
No charge	0.31	0.06–1.57	0.16
Other	1.21	0.95–1.54	0.12
Sex			
Male		Reference	
Female	1.05	0.96–1.15	0.31
Age in yrs			
<1	0.74	0.60–0.92	0.01
1–4	0.52	0.42–0.64	<0.01
5–9	0.43	0.34–0.54	<0.01
10–17	0.52	0.43–0.62	<0.01
≥18		Reference	
Hospital bed size			
Small		Reference	
Medium	0.94	0.64–1.35	0.72
Large	0.82	0.55–1.21	0.32
Teaching status			
Nonteaching		Reference	
Teaching	0.85	0.66–1.09	0.20
Hospital region			
Northeast		Reference	
Midwest	0.56	0.43–0.73	<0.01
South	0.44	0.35–0.54	<0.01
West	0.59	0.43–0.80	<0.01
Hospital location			
Urban		Reference	
Rural	1.92	1.13–3.27	0.02
Hospital type			
Not children's	2.16	1.54–3.01	<0.01
Children's hospital		Reference	
Children's unit	2.11	1.53–2.91	<0.01
Complexity			
Not complex		Reference	
Complex	2.04	1.84–2.27	<0.01
Admission source			
ER	1.08	0.91–1.28	0.40
Another hospital	4.42	3.68–5.31	<0.01

(continued)

TABLE 4. Multivariate analysis of nonroutine discharge (continued)

Factor	OR	95% CI	p Value
Admission source (continued)			
Other health facility	4.77	3.24–7.02	<0.01
Routine		Reference	
Admission type			
Emergency	1.66	1.35–2.04	<0.01
Urgent	1.75	1.44–2.12	<0.01
Elective		Reference	
Newborn	3.65	2.75–4.83	<0.01
Trauma	4.07	1.19–13.90	0.03
Shunt vol			
Annual vol	0.99	1.00–1.00	0.01

we did not find a significant association with payer status. Because CSF shunting is a common procedure with low mortality rates in pediatric patients, it is possible that the incidence of inpatient mortality is not frequent enough to reveal significant between-group differences according to insurance provider.

There are several limitations to our study. Its retrospective nature and use of an administrative national database make it subject to variability in data collection, recording, and individual-level hospital reporting. The ICD-9-CM coding from national administrative data sources has been estimated to be 80% accurate.⁴ Oversight of data reporting is often significantly limited, with resulting reporting subject to information bias and local variability. For example, the KID data classifying hydrocephalus etiology (communicating, obstructive, spina bifida, congenital, other) remain significantly limited; therefore, we have omitted this variable from our reported analysis. Notably, the inclusion of etiology in a multivariate analysis does not alter variables noted to associate with poor outcome (data not shown). The KID represents overall national trends in health care outcomes but is inherently limited as regards generalizability. Furthermore, the KID database comprises individual and unique patient hospitalizations, preventing longitudinal follow-up or evaluation of unique patient admissions. Also concerning are missing data; sometimes a portion of the patient's race was considered "missing," which could theoretically impact reported results. Furthermore, Asian/Pacific Islanders and Native Americans composed only 1.6% and 0.4% of the overall population, respectively. Given these low sample sizes, we have refrained from making definitive statements regarding associations noted in these subgroups. Finally, errors in ICD-9-CM coding could underestimate the true number of pediatric hydrocephalus cases and/or number of CSF shunting procedures.¹³ Given the inherent limitations of available data, interpretation of the resulting associations must be guarded. Instead, our results suggest national trends that indicate a need for further study in racial and socioeconomic disparities in pediatric neurosurgical care.

TABLE 5. Multivariate analysis of inpatient death

Factor	OR	95% CI	p Value
Race			
White		Reference	
African American	1.56	1.02, 2.39	0.04
Hispanic	1.36	0.88, 2.09	0.17
Asian/Pacific Islander	2.46	1.23, 4.90	0.01
Native American	2.83	0.76, 10.60	0.12
Other	1.98	1.06, 3.68	0.03
Payer status			
Medicare	<0.01	<0.01, <0.01	<0.01
Medicaid	1.11	0.82, 1.49	0.51
Private		Reference	
Self-pay	2.01	0.96, 4.24	0.07
No charge	<0.01	<0.01, <0.01	<0.01
Other	1.15	0.65, 2.03	0.63
Gender			
Male		Reference	
Female	1.00	0.78, 1.28	0.99
Age in yrs			
<1	1.14	0.64, 2.01	0.66
1–4	0.89	0.48, 1.65	0.71
5–9	0.70	0.36, 1.36	0.29
10–17	0.94	0.50, 1.74	0.83
≥18		Reference	
Hospital bed size			
Small		Reference	
Medium	1.40	0.79, 2.50	0.25
Large	1.51	0.82, 2.80	0.18
Teaching status			
Nonteaching		Reference	
Teaching	2.06	0.78, 5.48	0.15
Hospital region			
Northeast		Reference	
Midwest	0.99	0.57, 1.72	0.97
South	1.02	0.61, 1.71	0.93
West	0.97	0.53, 1.78	0.93
Hospital location			
Urban		Reference	
Rural	>999.999	>999.99, >999.99	0.47
Hospital type			
Not children's	0.79	0.42, 1.49	0.74
Children's hospital		Reference	
Children's unit	0.90	0.50, 1.63	<0.01
Complexity			
Not complex		Reference	
Complex	3.77	2.80, 5.07	<0.01
Admission source			
ER	0.92	0.57, 1.47	0.72
Another hospital	2.23	1.42, 3.50	<0.01

(continued)

TABLE 5. Multivariate analysis of inpatient death (continued)

Factor	OR	95% CI	p Value
Admission source (continued)			
Other health facility	2.32	1.09, 4.91	0.03
Routine		Reference	
Admission type			
Emergency	2.63	1.44, 4.80	<0.01
Urgent	2.43	1.33, 4.44	<0.01
Elective		Reference	
Newborn	7.77	3.98, 15.19	<0.01
Trauma	4.76	0.44, 51.87	0.20
Shunt Vol			
Annual Vol	0.99	0.99, 1.00	<0.01

Conclusions

Using population-level data, we found the presence of racial and SES outcome disparities following CSF shunting procedures in pediatric patients. Ours is among the first studies to leverage a robust national data set to evaluate the effects of race and SES on outcomes in pediatric neurosurgical populations. Identification of these factors may help to prompt further investigation focused on health care policy solutions designed to offset disparities.

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Author Contributions

Conception and design: Wen, Attenello. Acquisition of data: Wen, Cen. Analysis and interpretation of data: Wen, Attenello, Ng, Cen. Drafting the article: Wen, Ng, Zada. Critically revising the article: Wen, Attenello, Ng, Sanossian, Amar, Zada, Krieger, McComb, Mack. Reviewed submitted version of manuscript: Wen, Attenello, Ng, Sanossian, Amar, Zada, Krieger, McComb, Mack. Approved the final version of the manuscript on behalf of all authors: Wen. Statistical analysis: Wen, Cen. Study supervision: Wen, Attenello, Mack.

Correspondence

Timothy Wen, Keck School of Medicine of USC, c/o William Mack, 1520 San Pablo St., Ste. 3800, Los Angeles, CA 90033. email: wentimot@usc.edu.