Rural-urban disparities in health care costs and health service utilization following pediatric mild traumatic brain injury

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Objectives: To compare health care costs and service utilization associated with mild traumatic brain injury (mTBI) in rural and urban commercially insured children.

Data Source: MarketScan Commercial Claims and Encounters Data, 2007-2011.

Study Design: We compared health care costs and outpatient encounters for physical/occupational therapy, speech therapy, and psychiatry/psychology encounters 180 days after mTBI among rural versus urban children (<18 years).

Principal Findings: A total of 387 846 children had mTBI, with 13 percent residing in rural areas. Adjusted mean total health care costs in the 180 days after mTBI were \$2778 (95% CI: 2660-2897) among rural children, compared to \$2499 (95% CI: 2471-2528) among urban children (adjusted cost ratio 1.11, 95% CI 1.06-1.16). Rural-urban differences in utilization for specific services were also found.

Conclusions: Total health care costs were higher for rural compared to urban children despite lower utilization of certain services. Differences in health service utilization may exacerbate geographic disparities in adverse outcomes associated with mTBI.

KEYWORDS

health care costs, health service utilization, pediatrics, rehabilitation, rural health

1 | INTRODUCTION

Traumatic brain injury (TBI) is the leading cause of death and disability among children and adolescents in the United States.¹ Adverse outcomes

associated with TBI include reduced capacity for communication and self-care,² compromised health-related quality of life,² behavioral problems,³ and family burden.⁴ In addition, TBI is associated with considerable economic burden, including increased health care utilization and cost after injury.⁵⁻⁷

Until recently, moderate and severe TBIs have historically garnered more attention in the research literature than mild injuries. However, the high incidence of mild TBI (mTBI), including concussions, has been more clearly established in recent years.⁸ Patients with mTBI are hospitalized less frequently and are often treated exclusively on an outpatient basis. Due to limited data on outpatient utilization beyond the emergency department, few studies have described health care utilization and costs for mTBI.⁸⁻¹⁰ This is important because up to 30 percent of patients with mTBI experience ongoing symptoms (eg, cognitive fatigue, inattention, memory difficulties) for weeks to months after injury.¹¹⁻¹⁴ Studies that have examined health care utilization and costs following mTBI report population-level costs for mTBI far exceed those of moderate or severe TBI. For example, an analysis of commercial claims data comparing inpatient and outpatient health care costs pediatric patients with mild, moderate, and severe TBI revealed that although moderate and severe TBI were associated with significantly greater per capita medical costs during the first year after injury,⁸ total costs incurred among children and adolescents who had sustained a mTBI were substantially greater due to the radically higher incidence of mTBI (96.6 percent of all TBIs in the sample).⁸

While these studies reveal the magnitude of health care expenditures associated with mTBI, the burden and distribution of health care costs across specific outpatient services and among various patient groups has yet to be determined. Health care costs associated with mTBI for rural patients are of particular interest due to evidence of lower quality clinical care and worse socioeconomic conditions for rural compared to urban residents.¹⁵ Given burgeoning concerns about the prevalence and potential ramifications of mTBI, it is critical to understand the barriers to optimizing recovery among children and adolescents in rural and urban settings.

Comparing rural-urban differences in health care costs and service utilization for pediatric patients experiencing mTBI may provide important insights about treatment needs and access-related inequities across geographic locales and in health care settings beyond the emergency department. Evidence of rural-urban disparities related to the incidence of pediatric mTBI is mixed. Oregon Trauma Registry data show higher incidence of TBI is greater among rural-dwelling than urban-dwelling children;¹⁶ however, other research has suggested a lower incidence rate of emergency department visits for concussions in rural areas compared to urban areas.¹⁷ It is possible that mTBI is underreported in rural areas, where more limited access to health care, including emergency departments, can contribute to different patterns of health service utilization.¹⁸ However, little is known about geographic inequalities in health care utilization and expenditures for children with mTBI. While some evidence suggests the incidence of pediatric mTBI is lower in rural settings, other evidence suggests that the severity of injury may be higher,¹⁷ which may contribute to higher costs and utilization. Ascertaining geographic differences in utilization may have implications for structuring health systems to ensure equitable access to care across areas of varying population density.

Access to services is a critical consideration in the provision of rural health care, and while certain barriers to care are fixed (eg, geography), others are malleable (eg, supply of providers). Aday and Andersen (1974; modified by Vedom and Cao in 2011) outlined a framework comprising several variables theorized to influence access to care (eg, health policy, characteristics of the health delivery system, utilization of health services, characteristics of the population at risk, consumer satisfaction).^{19,20} Considering health care following mTBI in the context of this framework, comparatively lower rates of utilization (and therefore costs) among rural children may be expected, as a result of reduced access to services, such as rehabilitation therapies.²¹

The purpose of this study was to investigate health care costs and health service utilization associated with mTBI for children living in rural areas compared to those living in urban areas. To analyze these associations, we first compared total health care costs incurred during the 180 days post-TBI to costs incurred during the 180 days prior to injury by service type (eg, rehabilitation therapies, psychiatry/psychology). Second, we characterized the number and type of health care services utilized by rural and urban children and their likelihood of using relevant health care services during the same periods pre- and post-injury.

2 | METHODS

2.1 | Study sample

This retrospective, observational cohort study examined commercial insurance claims of children with mTBI captured in the MarketScan[®] *Commercial Claims and Encounters* database (Truven Health Analytics). MarketScan[®] data provide health care utilization and cost information for over 20 million US employees and their dependents who are insured through private, employer-sponsored health plans.²²

Eligible subjects were identified as enrollees younger than 18 years of age with an outpatient claim associated with at least one TBI diagnosis between January 1, 2007, and December 31, 2011 (termed "index TBI"). TBI diagnoses were defined using the Centers for Disease Control and Prevention definition and included the following International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 800.0-801.9, 803.0-804.9, 850.0-854.1, 950.1-950.3, 959.01, and 995.55.²³ We limited the study sample to cases that were continuously enrolled for at least 180 days prior to and after the index TBI diagnosis to ensure that all health care utilization (for which insurance claims were accepted) was captured before and after the injury. We excluded cases missing region or Metropolitan Statistical Area (MSA) data, which were used to classify cases as rural or urban. To limit the influence of extreme observations of total cost values, we excluded cases with recorded negative total costs (eg, errors from billing) before or after injury.

In order to identify mTBI cases, we used ICD-9-CM diagnosis codes from the index TBI date and the subsequent two weeks

to calculate index TBI severity using the ICD Programs for Injury Categorization (ICDPIC), an ICD-9 mapping module for Stata (College Station, TX).²⁴ ICDPIC has been utilized in previous studies to categorize TBI severity,^{8,25,26} specifically using the Abbreviated Injury Scale for the head and neck region (AIS-HN). The AIS-HN score ranges from 1 to 6, with higher scores indicating more severe injuries. Cases of mTBI were identified as those with AIS-HN <3.²⁷ All other TBI cases were excluded, as they were considered to have moderate or severe injuries. Lastly, cases with an extremity AIS score of ≥ 3 were excluded, because these cases could bias utilization for specific services, such as physical therapy or occupational therapy (PT/OT). Finally, we excluded cases with index TBI dates coincident with a hospital admission, as these were considered to be cases with more severe injuries.

2.2 | Measurement

2.2.1 | Health care utilization

MarketScan® claims were used to determine health care utilization among cases 180 days before and after the index TBI date for the following specialty services: number of office encounters for PT/OT, speech therapy, and psychiatry/psychology. Encounters for PT/OT were defined using CPT-4 codes related to PT or OT evaluative procedures (97001-97004) or revenue codes indicating PT or OT services. Speech therapy encounters were defined using CPT-4 codes for speech evaluation/re-evaluation therapy and treatment codes or revenue codes indicating speech services. Psychiatry/psychology encounters were identified as visits with Current Procedural Terminology (CPT-4) codes related to therapy and psychiatric services and management (908xx), revenue codes for psychiatry/psychology treatment, or provider codes for psychiatry, child psychiatry, psychiatric nurse, or psychologist. We also estimated utilization of outpatient office encounters other than PT/OT, speech therapy, and psychiatry/psychology. All encounters were identified in the outpatient services tables only and reflect overall service use, which may or may not have been related to TBI. We based our office encounter counts on a maximum of one distinct encounter type per day to avoid over-counting services.

2.2.2 | Cost measures

Costs were categorized into four variables for the 180 days before and after index TBI: total health care costs and costs for PT/OT, speech therapy, and psychiatry/psychology encounters. Costs associated with index TBI were captured in the 6-month interval after injury. Total health care costs were calculated as the sum of all outpatient services (payment variable). Costs for PT/OT, speech therapy, and psychiatry/psychology encounters were calculated as the sum of all payments (payment variable) for outpatient encounters in the 180 days before and after the index TBI date and were based on CPT-4, revenue, and provider type codes.

2.2.3 | Rural residence

Patients were classified as residing in an urban area if their county was classified as an MSA (either metropolitan or micropolitan). Patients who did not live in a county with an MSA coding were classified as having a rural residence.

2.2.4 | Demographic variables and comorbidities

Patient age was categorized based on age in years at the date of index TBI; gender was categorized as male and female, based on the MarketScan® variable. Similarly, geographic region of each patient's residence was categorized as northeast, north central, south, or west. Presence of polytrauma was defined as AIS >0 in any body region other than the head or neck. Because Charlson and Elixhauser indices are not appropriate for use in analyzing mild pediatric injuries,^{28,29} in the 180 days prior to index TBI, we included the following comorbid conditions as they may have contributed to health care costs: asthma, seizure, intellectual disability, developmental disorder or delay, headaches, attention deficit disorder with hyperactivity, depression, anxiety, or fatigue (Table S1). Patients were coded as having one or more comorbidities or none.

2.3 | Statistical analysis

Demographic and injury characteristics were examined using descriptive statistics (frequencies and percentages) and compared across rural and urban settings using chi-squared tests. For utilization and costs measures, we calculated the mean number of encounters in the 180-day follow-up period and compared them across rural and urban settings using independent-samples *t* tests. We also calculated the proportion of rural and urban children whose claims record indicated at least one PT/OT, speech therapy, psychiatry/psychology, or other outpatient office encounter.

A two-part model was used to examine the role of rurality on health care utilization. Part one estimated the likelihood of at least one PT/OT, speech therapy, psychiatry/psychology, or other office encounter using modified Poisson regression. Part two examined the intensity of utilization, which was conditional on having at least one encounter, using negative binomial regression models for overdispersed data without excess zeros and zero-truncated negative binomial regression models for data exhibiting overdispersion and excess zeros.

For health care costs, cost ratios (CRs) were estimated using generalized linear models (GLMs). GLMs are frequently utilized to analyze right-skewed and overdispersed cost data.^{30,31} Box-Cox and modified Park tests were used to determine GLM link and family.³⁰ CRs describe the estimated mean difference in costs between rural and urban patients for PT/OT, speech, psychiatry/psychology, and total health care costs.

Regression models included the following covariates: age, sex, region, evidence of polytrauma associated with the index mTBI, and evidence of at least one comorbidity in the 180 days prior to injury.

Utilization and cost models also adjusted for pre-injury health care utilization and costs, respectively, incurred in the 180 days prior to index mTBI. To account for the potential of residual confounding across rural and urban patients, propensity scores were calculated as the inverse probability of rural residence based on demographic (sex, age, region, insurance type), injury (severity, blunt/penetrating), health (comorbidities), and past health care cost and utilization (total costs and number of office visits in 6 months prior to injury) using multivariable logistic regression. Covariates for the propensity score model were chosen based on models of health services utilization and existing literature on mTBI costs and utilization.^{9,19,32-34} We calculated the inverse probability of treatment weights (IPTW) as the reciprocal of the patient's predicted probability of rurality for all cases with common support (overlapping probabilities).³⁵ The IPTWs were incorporated into all multivariable models. To assess covariate balance between rural and urban groups, we calculated standardized differences of means and proportions across quintiles of propensity scores; a standardized difference of <0.05 was used to denote balance between groups (Table S2).

MarketScan[®] data consist of de-identified records, and this research did not directly involve human subjects; therefore, this study was exempt from human subjects review.

3 | RESULTS

3.1 | Patient characteristics

There were 614 105 unique children with a diagnosis of a TBI identified between July 1, 2007, and December 31, 2011. A total of

586 866 were continuously enrolled for 180 days prior to the index TBI and had no other TBI diagnosis in the preceding 180 days. We excluded 199 020 children who sustained severe injuries or were missing important data elements, such as costs (Figure 1). A total of 387 846 children were deemed eligible for this study. Eighty-seven percent of children who sustained a mTBI during the study period resided in urban areas ($n = 338\,203$) and 13 percent ($n = 49\,643$) resided in rural areas.

Rural children with mTBI were older than urban children (mean 10.0 years vs 8.7 years) and more frequently had polytrauma (Table 1). Compared to children in urban areas, more rural children were located in the South and North Central regions of the United States. In the 180 days prior to mTBI, rural children had slightly lower total health care costs than urban children (median costs \$278 vs \$345; Table 1).

Approximately the same proportion of rural and urban children had at least one PT/OT encounter in the 180 days after injury (3.2 vs 3.5 percent, respectively). Among children with at least one PT/OT encounter, rural children had more encounters than urban children on average (3.0 vs 2.6). More urban children had at least one speech therapy encounter (4.9 percent), compared to rural children (2.3 percent), but there was no difference in the number of speech encounters among children with one or more encounters. Among urban children, 5.5 percent had at least one psychiatry/psychology encounter, compared to 4.3 percent of rural children. Among children who had at least one psychiatry/psychology encounter, urban dwellers averaged 4.2 encounters, compared to 3.5 among rural dwellers. Nearly all rural (98.3 percent) and urban (98.7 percent) children had at least one other outpatient office encounter in the

FIGURE 1 Study sample identification from the MarketScan[®] Commercial Claims and Encounters research database from Truven Health Analytics, 2007-2011

TABLE 1 Characteristics of study population of commercially insured rural- and urban-dwelling children with mild TBI, 2007-2011

	Urban (N = 338 203)	Rural (N = 49 643)	Total (N = 387 846)
<i>Demographic characteristic</i>			
Age			
4 years and younger	107 106 (31.7)	11 894 (24.0)	119 000 (30.7)
5 to 9 y	68 686 (20.3)	9238 (18.6)	77 924 (20.1)
10 to 14 y	87 142 (25.8)	13 677 (27.6)	100 819 (26.0)
15 to 17 y	75 269 (22.3)	14 834 (29.9)	90 103 (23.2)
Sex			
Male	208 234 (61.6)	30 760 (62.0)	238 994 (61.6)
Female	129 969 (38.4)	18 883 (38.0)	148 852 (38.4)
Region			
Northeast	64 153 (19.0)	4575 (9.2)	68 728 (17.7)
North central	87 357 (25.8)	17 168 (34.6)	104 525 (27.0)
South	120 700 (35.7)	22 136 (44.6)	142 836 (36.8)
West	65 993 (19.5)	5764 (11.6)	71 757 (18.5)
<i>Injury characteristic</i>			
Polytrauma at injury			
No	193 453 (57.2)	24 323 (49.0)	217 776 (56.2)
Yes	144 750 (42.8)	25 320 (51.0)	170 070 (43.9)
<i>Health history</i>			
Comorbid diagnosis in prior 180 d			
No	287 773 (85.1)	41 953 (84.5)	329 726 (85.0)
Yes	50 430 (14.9)	7690 (15.5)	58 120 (15.0)
<i>Health care costs</i>			
Total costs, 180 d before injury, \$			
Mean (SD)	1200 (7497)	1116 (6521)	1189 (7203)
Median (IQR)	345 (104-915)	278 (69-818)	337 (99-904)

Notes: Unless otherwise indicated, values indicate counts and percentages. Frequency counts may not sum to total because of missing responses or rounding.

IQR, interquartile range; SD, Standard deviation.

180 days after injury. The mean number of other outpatient office encounters among rural and urban children was 3.7 and 3.6, respectively. Unadjusted mean total health care costs in the 180 days after mTBI were \$2871 among rural children, compared to \$2479 among urban children.

3.2 | Adjusted health care utilization and costs by rurality

Zero-truncated negative binomial models with IPTW were used to compare utilization among rural and urban children with at least

one encounter for PT/OT, psychiatry/psychology, or other outpatient service. For speech therapy encounters, a zero-truncated Poisson model was conducted due to lack of convergence with zero-truncated negative binomial model. After adjusting for covariates, rural children were 15 percent more likely to have at least one PT/OT encounter than urban children (RR: 1.15, 95% CI: 1.04-1.28; Table 2). Among children who had at least one PT/OT encounter, rural children with mTBI utilized PT/OT services at a significantly greater rate compared to urban children and had 51 percent greater costs (Table 2). For all other utilization measures (ie, speech therapy, psychiatry/psychology, and other office visits), rural children had a significantly lower likelihood of having at least one encounter in the 180 days following mTBI, compared to urban children and holding covariates constant. Rural children with at least one psychiatry/psychology encounter utilized psychiatry/psychology services at a 20 percent lower rate than urban children. For outpatient office encounters other than PT/OT, speech, and psychiatry/psychology, the negative binomial model was optimal. There was a small but significant difference in the number of outpatient encounters in rural compared to urban children (adjusted IRR: 0.97, 95% CI: 0.96-0.98).

Box-Cox and modified Park tests specified log link and gamma family for cost models. Overall, total health care costs in the 180 days after mTBI were 11 percent greater among rural children than urban children (adjusted CR: 1.11, 95% CI: 1.06-1.16. Adjusted mean total health care costs in the 180 days after mTBI were \$2778 (95% CI: 2660-2897) among rural children, compared to \$2499 (95% CI: 2470-2528) among urban children. Interestingly, although costs for PT/OT were significantly higher among rural children than urban children, they were 26 percent lower for psychiatry/psychology services (Table 2).

4 | DISCUSSION

Among our sample of 387 846 children with mTBI, the overall cost in the 180 days after mTBI was significantly greater for children living in rural areas compared to urban areas. Despite higher health care costs associated with mTBI, children residing in rural areas had a significantly lower likelihood of utilizing speech therapy and mental health services than urban children. However, children in rural areas had a higher likelihood of utilizing PT/OT services. These findings advance the literature on health-related inequities that are influenced by geographic factors by highlighting that rural-urban mTBI treatment disparities include access and cost-related concerns.³⁶

Among children with at least one psychiatry/psychology encounter, rural children showed a significantly lower utilization rate than urban children. Consistent with the Aday-Andersen/Veddom-Cao framework, this finding may be indicative of access-to-care inequities stemming from limited availability of mental health services for youth in rural areas,³⁷ where mental health concerns may be managed by a primary care provider rather than a mental health specialist.³⁸ It is possible that outpatient psychiatry encounters may have been logged by insurance billers as generalist appointments

	At least one encounter		Rate of encounters ^a		Costs ^f
	IRR (95% CI)		IRR (95% CI)		CR (95% CI)
PT/OT	1.15 (1.04, 1.28) ^b ↑		1.73 (1.41, 2.14) ^c ↑		1.51 (1.30, 1.74) ↑
Speech therapy	0.52 (0.45, 0.61) ^b ↓		0.88 (0.75, 1.03) ^d		1.06 (0.88, 1.28)
Psychiatry/ psychology	0.63 (0.57, 0.69) ^b ↓		0.80 (0.72, 0.89) ^c ↓		0.74 (0.68, 0.81) ↓
Other outpatient service	0.96 (0.95, 0.97) ^b ↓		0.97 (0.96, 0.98) ^e ↓		—
Total (overall)	—		—		1.11 (1.06, 1.16) ↑

Notes: Reference group is urban children. All models adjust for patient age, sex, region, preexisting comorbidities, and evidence of polytrauma, and health care costs (total amount) or utilization (yes/no) in the 180 days before mTBI. Inverse probability of treatment weights (IPTW) were used in all models.

CI, confidence interval; CR, cost ratio; IRR, incidence rate ratio; PT/OT, physical therapy or occupational therapy.

^aAmong patients with at least one visit.

^bModified Poisson regression.

^cZero-truncated negative binomial regression estimated the difference in number of encounters among patients with at least one visit.

^dZero-truncated Poisson regression used as zero-truncated negative binomial regression failed to converge; among patients with at least one visit.

^eNegative binomial regression estimated the difference in number of encounters among all patients.

^fCosts refer to total reimbursed amounts for procedures and visits that occurred within 180 days following index mTBI.

TABLE 2 Multivariable analysis of health care utilization and costs following pediatric mild TBI among rural children as compared to urban children, 2007-2011

when they may have been mental health-related, thus resulting in an undercount in psychiatry/psychology encounters. It is not known whether such encounters are disproportionally logged as generalist encounters in rural areas; however, if this does occur, it may explain some of the variation in utilization between rural and urban settings. In addition, stigma regarding mental health may be more evident in rural communities than in urban areas, which may contribute to lower utilization of mental health care.³⁹ The lower rate of psychiatry/psychology service utilization among rural children following mTBI warrants further examination, particularly given that brain injury is associated with elevated impulsivity and that youth in rural areas complete suicide at a higher rate than urban children.⁴⁰ This points to the value of ensuring that services are accessible when needed, especially given potential changes in behavioral and affective regulation after TBI.

In contrast to psychiatry/psychology services, rural children were more likely to have at least one PT/OT encounter and utilized more services than urban children, an observation mirrored in the higher PT/OT costs among rural children. This finding is counterintuitive given prior studies that showed greater PT/OT utilization and costs among young children with developmental conditions in urban areas.⁴¹ Should access be a barrier to utilization of PT/OT services in rural areas, lower utilization and costs for rural children would have been expected. One possible explanation for this incongruous finding is that rural children experience more severe injuries than urban children^{17,36} and therefore may require more PT/OT services. This is consistent with our observation that rural children were more likely to present with polytrauma at

the time of index mTBI. Greater PT/OT service utilization among rural children in this study may therefore be related to residual confounding despite using propensity scores and adjusting for demographic characteristics, injury severity, and polytrauma. Alternatively, due to disparities in access health care services (including PT/OT) in rural areas, rural children may have had existing health conditions necessitating PT/OT but were undetected or undertreated until mTBI care was sought. Nonetheless, caregivers of rural children may have overcome barriers to access by traveling longer distances for PT/OT services. Additional research is needed to provide insight on this counterintuitive finding.

Access to services is a critical consideration in the provision of rural health care, and while certain barriers to care are fixed (eg, geography), others are modifiable (eg, supply of providers). The Aday-Andersen/Vedom-Cao framework suggests that innovations in policy and health care delivery have the potential to improve disparities in service utilization, such as those observed in this study. Obtaining care in rural areas is reliant on the existence of proximal services; therefore, reducing disparities must include increasing the rural health workforce or employing creative approaches to optimize access to services. Mental health services delivered via telehealth may be a viable means for addressing the scarcity of psychiatrists and psychologists in rural communities.^{42,43} Telemedicine has also been used to improve access to pediatric trauma and concussion care,⁴⁴⁻⁴⁶ and virtual visits are becoming increasingly common. In addition, incentives for rural providers through student loan reimbursement and other service and reimbursement incentives have been implemented.^{47,48}

Future research should investigate whether such innovations are associated with attenuated disparities in mTBI care over time.

Nearly all children in our sample had at least one other outpatient office encounter in the 180 days after mTBI. This point of contact with families of children with mTBI may present an opportunity to establish care for children who experience persistent symptoms and to provide appropriate referrals to ensure rehabilitation needs are met. Health care providers can help facilitate coordination between parents and schools to ensure that appropriate accommodations are available for students with mTBI symptoms, which may impact success in the classroom.⁴⁹ In addition, post-injury encounters provide an opportunity to conduct functional and mental health screening to ensure that concerns requiring specialized services are identified.

Previous studies of mTBI costs and health services utilization have generally been limited to patients who were hospitalized or treated in the emergency department for their index injury.⁷ The current study focused on children whose mTBI injuries were treated in an outpatient setting; children hospitalized for their index mTBI were excluded. The exclusion of children hospitalized for their index mTBI is a strength of this study as 80 percent of patients with medically treated mTBI receive care in outpatient settings rather than in hospital.⁵⁰ Hence, this study may provide a more accurate representation of the true population of children seeking care following mTBI.

This study has several limitations. First, we examined health care utilization among a population of children with commercial health insurance. The patterns identified in this study may differ for children who are not privately insured or who have fewer resources than the commercially insured children captured in the MarketScan[®] database. Given that a greater number of children living in rural areas have public insurance, replication of this study in claims databases that include publicly insured children may add credence to the findings reported herein. Second, the measurement of rurality in this study may crudely estimate the true geographic nature of a patient's residence or the resources available to a patient in their community. This is important, as long distances to rehabilitation services in rural areas may impact families' decisions and capacity to utilize the recommended services. Recently, more precise measures of rurality have been proposed, such as the index of relative rurality;⁵¹ however, the MarketScan[®] database lacks the variables required to employ these measures. Future research should integrate more refined measures of rurality and quality of care to determine whether the health inequities identified in this investigation hold true. Integrating more sophisticated measures of rurality will also enable future studies to test whether particular factors that are theorized to influence access to care, such as travel time to services,²⁰ do indeed predict disparities. Third, in order to avoid over-counting due to duplicate billing or multiple charges associated with a single visit, we defined encounters as one visit per type of encounter per day. This approach may have yielded underestimations in service utilization in cases where families planned more than one encounter per day (eg, PT appointment for post-injury pain and PT appointment for

balance/vestibular concerns). Underestimates of true utilization may have occurred if children received services through schools (eg, speech therapy) that were not billed to insurance. Fourth, in counting outpatient visits, we included outpatient preventive care visits in the analysis in order to capture full outpatient utilization pre- and post-injury. The effect of including these visits, if present, would be small, because children in our study would likely have only one visit per year,⁵² and we included a 180-day post-injury follow-up period. Further, we controlled for pre-mTBI utilization in all models, as well as income, which appears to influence utilization of preventive care visits beyond geography. Fifth, while this study controlled for comorbidities, injury characteristics, and utilized IPTW in models, it is conceivable that residual confounding by unmeasured variables might have occurred, thus contributing to bias in our findings. Inherent limitations of insurance claims data prohibit use of detailed patient or injury information. As a result, we were unable to control for clinical measures or evaluate clinical outcomes, such as duration of symptoms, in this study. Future research should examine the feasibility of combining insurance claims data and detailed patient clinical data to address this limitation. The zero-truncated Poisson model used to examine rural-urban differences in speech therapy encounters (chosen due to lack of convergence with zero-truncated negative binomial model) does not account for overdispersion, and results should be interpreted with caution. Finally, because this study focused solely on mTBI treated in outpatient settings, cases of mTBI that were admitted to the hospital (for observation or treatment of other injuries) were not identified and their utilization is not described in this study.

5 | HEALTH SERVICES IMPLICATIONS

Children in rural settings face unique obstacles post-injury, as evidenced in the disparities related to health service utilization and costs following mTBI that were observed in this study. Relative to urban youth, rural children have higher overall health care costs, as well as inequities in service utilization, particularly related to psychiatry/psychology. Rural children experience access-to-care burdens associated with long transportation distances, greater mental health stigma, and scarcity of locally based providers that may limit access to and utilization of health care services following mTBI. Future research is necessary to replicate findings from this study and to investigate the effectiveness of service delivery innovations in reducing health care inequities for rural children.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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