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Town-level comparisons may be an effective alternative in comparing rural and urban differences: a look at accidental traumatic brain injuries in North Texas children

BD Robertson[1], CE McConnel[2]

[1]*Children's Medical Center Dallas, Dallas, Texas, USA*

[2]*UT Southwestern Medical Center, Dallas, Texas, USA*

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Robertson BD, McConnel CE

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ABSTRACT

Introduction: Rural areas in the USA are generally poorer, more isolated, less populated, have older populations, and also unique work dynamics that fundamentally set them apart from urban areas. Additionally, funding and resources are limited in rural areas; a problem that may be exacerbated when looking specifically at town-level resources. One of the key problems in comparing US rural and urban areas, particularly at the county level, is that the resources available to individual towns within a particular county may not accurately reflect the resources available to the county as a whole. This leads to questions about the validity of county-level comparisons between rural and urban areas because of differences in town sizes and the resources availability at this level. The authors of this study attempted to assess this difference by analyzing data previously collected for a study examining pediatric traumatic brain injury among four levels of rurality: urban city, large town, small town, and isolated town.

Methods: This study employed Rural and Urban Commuting Area 2 (RUCA2) codes to determine if significant differences exist between small and large towns for pediatric traumatic brain injury. Patients were included in this study if they presented to Children's Medical Center Dallas with severe traumatic brain injury, and comparisons of injury severity and outcome were compared between small and large towns. Patient zip (postal) codes were collected and designated as either small or large town based on the corresponding RUCA2 code.

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Results: A total of 444 patients were included in this study, with significant differences between large and small towns for Trauma Scores, Trauma Score and Injury Severity Score (TRISS) measures, and the total length of stay.
Conclusion: This study has numerous limitations, yet it demonstrates that comparisons based on the RUCA code designations of large and small towns can be an effective means for understanding the differences at the town level, and also to better establish prevention strategies geared toward these differences.

Key words: children, RUCA, small town, traumatic brain injury.

Introduction

Injuries are the leading cause of death for individuals under 45 years of age, and are a significant public health problem in the USA[1]. Specifically, traumatic brain injury accounts for almost one-third of all injury deaths[2]. This problem is even more pronounced when looking specifically at the pediatric population[3], where traumatic brain injury is the leading cause of morbidity and mortality[4-15] . Further, a myriad of problems exist when looking specifically at accessing the necessary medical care to treat traumatic brain injuries in rural-area children.

Access to healthcare services in rural areas is a well known problem, and includes limited availability of health services through the remote location, the isolation of rural areas as injury sites, difficulties with transportation, extended travel distances to healthcare facilities, lack of health insurance, and additional access problems associated with lower socioeconomic status[16]. This becomes even more problematic when looking at the pediatric populations in rural areas. With isolation and access to care already problematic for rural areas, rural children may be more isolated than their adult counterparts when considering the level of care needed to treat pediatric traumatic injuries. In interviews conducted by Robertson in 2009, Emergency Medical Service (EMS) providers indicated that while time and distance are known problems plaguing rural areas, children sustaining traumatic brain injury are generally best served at high-level trauma centers specializing in pediatric care[17]. Additionally, pediatric traumatic brain injuries require direct transport to these high-level trauma centers, receiving little to no benefit from being treated at local lower-level hospitals. Where adults can be treated for similar injuries at these lower-level hospitals, such centers are generally not equipped or staffed to effectively manage severe brain trauma in children[18,19]. While high-level pediatric trauma hospitals are better equipped to treat the severity and unique presentation of a pediatric injury, they are generally located in urban centers. As a result, fewer appropriately equipped hospitals are available to rural children who, because of this, may need to endure extended travel time to access an appropriate level of care.

While many health service studies examine differences at the rural and urban county levels, relatively few studies exist that compare resources and service provision according to town size. It stands to reason that larger towns will have better access to funds, are closer in proximity to the higher levels of health services found in the urban centers, and that individuals injured in such towns may benefit from these two factors. Henderson and Taylor posited that technological advances in healthcare delivery further divide the delivery of care between rural and urban areas due to resource differences at the town level[20].

This report is a follow-up to Robertson's 2009 study of severe traumatic brain injury in children admitted to the Children's Medical Center Dallas[17], one of several level I trauma centers in North Texas, and the only trauma center in the region specializing in children during the time of the data collection. Data collected and analyzed at the county level for a previous study were re-analyzed here to examine injury severity and outcome between town sizes and determine if significant differences can be established at this finer geo-

demographic level. Given that rural areas are more isolated, have limited funds, and limited resources, it is assumed that these problems are compounded at the town level. It is then hypothesized that comparisons between town sizes will yield more significant differences in injury severity and outcome than comparisons between county designations.

Methods

Following Institutional Review Board approval at both UT Southwestern Medical Center and the University of Texas at Dallas, data were collected on all patients seen at the Children's Medical Center Dallas for severe traumatic brain injury. The Children's Medical Center Dallas trauma census was utilized to collect data over a five-year period. Inclusion criteria were based on a previous study[17], using ICD-9 codes 800, 801, 802, 804, 850-854, and 959.01. Medical charts were reviewed to gather data on patient age, sex, county of injury, designation of the county as either rural or urban, the Rural-Urban Commuting Area 2 (RUCA 2) code for the patient's residence, the type of injury as accidental or non-accidental, whether the patient had a localized head injury or if the injury affected other body systems, the Glasgow Coma Scale (GCS) at the scene of injury, GCS on admission, Injury Severity Score (ISS) on admission, the Trauma Score and Injury Severity Score (TRISS), Trauma Score, length of hospital stay (LOS), and outcome mortality (defined as whether the patient recovered to discharge from the hospital or died during the hospital stay). Patients were excluded if they did not have an accidental injury, or were identified as any form of abuse, assault, or injury through other purposeful means.

The GCS is a clinical measure of neurological functioning ranging from 3 to 15 and is based on eye movement, motor movement, and verbal appropriateness[6]. Severe traumatic brain injury is associated with GCS scores of less than 8[4,8]. The ISS is another clinical measure of injury severity based on an examination of six different body systems[17,21], where higher ISS scores signal worse injuries. The TRISS is a third clinical measure predicting survivability of a particular injury[22,23], and Trauma Scores are the final clinical measure. Trauma Scores were collected and recorded by Trauma Services at Children's Medical Center Dallas. The calculation was reported previously[17], but is a summed value of scores ranging from -1 to +2 on 6 additional physiological variables (patient size, airway, level of consciousness, blood pressure, fractures, and cutaneous examination). These values were added to a revised GCS score where points were assigned to a specific GCS range, where four points were assigned to a GCS range of 13–15, three were assigned to a GCS range of 9–12, two points were assigned to a GCS range of 6–8, one point assigned to a GCS range of 4 or 5, and no points assigned to a GCS of 3. Lower Trauma Scores are associated with worse injuries.

Urban–rural differences are often analyzed using county-level data, typically out of either convenience afforded by readily available and widely used Department of Agriculture Urban Rural Continuum codes[24], the unambiguous boundaries that identify its spatial characteristics, or the abundant supply of socio-economic data that can be accessed and used in an analysis of the types of differences of interest. A major confounding factor in the use of counties, however, is the frequent existence of urban centers within officially designated rural counties and rural fringe in otherwise urbanized counties. As an alternative to a county-level analysis employing problematic urban/rural designations, this analysis adopts an alternative geographic coding system, also a product of the Department of Agriculture, the RUCA2[25], a coding system that allows the identification and codification of towns according to size and activity patterns. Using the stratification methods previously employed by Robertson[17], RUCA2 codes were broken down in the following manner to determine town sizes:

- Urban: 1, 1.2, 2.1, 3
- Large town: 4, 4.1, 4.2, 5, 5.2, 6, 6.1
- Small town: 7, 7.1, 7.3, 7.4, 8, 8.3, 9, 9.2
- Isolated town: 10, 10.2, 10.4, 10.5, 10.6.

Groups were then stratified by the size of the town into either small or large towns, and were compared for severity

and outcome for accidental injuries. Urban and large towns were designated 'Larger Towns', and small and isolated towns were classified as 'Smaller Towns'. Data were analyzed using χ^2 for nominal data, and *t*-tests for continuous variables. All statistical analyses were conducted using SPSS v15.0 (SPSS; Chicago, IL, USA; www.spss.com) with *p*-values <0.05 considered statistically significant.

Results

In all, 444 patients of the original sample of 545 met the 'accidental injury' inclusion criterion for patients admitted to the Children's Medical Center Dallas with severe traumatic brain injuries. A significant majority of the injuries occurred in Texas, but patients injured in Oklahoma and Arkansas were also seen at the Children's Medical Center Dallas and were included in the analysis. Demographic information by city size is presented (Table 1). Smaller-town patients accounted for 8.6% (n = 38) of the study sample, while larger-town patients accounted for 91.4% (n = 406). The average age at presentation was 5.67 years, with smaller-town patients presenting almost a full year older than larger-town patients. No statistical differences between town sizes were found for age, the type of injury, sex, or discharge status.

Severity comparisons are shown for smaller and larger towns (Table 2) and rural and urban counties (Table 3). As hypothesized, comparisons between town sizes for GCS on admission, ISS, and LOS become even greater compared with observed differences between urban and rural counties; however, only LOS showed statistically significant differences at the 0.05 *p*-value for these variables. Conversely, Trauma Scores, GCS on scene and TRISS scores become less diverse when comparing town sizes, rather than for county type comparisons. Interestingly, while TRISS and LOS comparisons between county designations have *p*-values of 0.055, the *p*-values for these measures drop below the 0.05 significance level when drawing comparisons between town sizes. The ISS, however, are not statistically significant despite expanding from a difference of 1.72 between rural and urban counties to an almost 3 point difference in town-size comparisons.

Discussion

Access to healthcare in rural populations is a serious public health problem in the USA. The authors report that while 20% of the American population currently resides in a rural area, only 10% of physicians practice in these areas[26]. Access to basic healthcare in rural areas is a problem, and several factors contribute to the actual use of these services, including convenience, cost, and time[27]. Additionally, rural environments differ from urban environments not only in location and socioeconomic status, but also in the nature of work dynamics and the environmental conditions found in rural areas. Rural areas typically have more labor-intensive jobs that expose individuals to environmental and chemical hazards[28-30] , and these problems often extend to children, particularly concerning agricultural work[31-33] . It is estimated that 100 childhood deaths, and 23 000 childhood injuries are related to agriculture annually[33]. Traumatic brain injury, accounts for almost 90% of all pediatric injury deaths[6].

Rural areas also have the added problem of lower levels of funding and available resources compared to more urbanized areas. This results in limited funds to training EMS personnel, fewer resources to treat traumatic injuries, and a heavier reliance on lower-trained emergency medical staff and volunteer emergency workers[34,35]. This is not to ignore the value of the contribution of volunteers in the rural health workforce, but as stated by Rogers et al[35], volunteers are by definition secondary EMS personnel. However, some authors dispute the benefit of being treated by a highly-trained paramedic due to delays in obtaining hospital care because of a paramedic's ability to treat emergencies and the subsequent increased time spent at the scene of the injury[36]. Despite these arguments, the limited availability of funds and resources in view of the pressing healthcare needs in rural areas cannot be ignored.

Table 1: Demographic information

Variable	Location		Total
	Smaller town	Larger town	
Number of patients	38 (9)	406 (91)	444
Sex			
Male	27	271	298
Female	11	135	146
Age at presentation	6.54 ± 4.07	5.60 ± 4.03	5.67 ± 4.0
Range	0.07–14.94	0.04–17.86	0.04–17.86
Type of Injury			
Localized	17 (45)	237 (58)	254 (57)
Multi-system	21 (55)	169 (42)	190 (43)
Discharge status			
Alive	37 (97)	367 (91)	404 (91)
Dead	1 (3)	39 (9)	40 (9)

Data given as *n* (%) or mean ± standard deviation.

Table 2: Severity measures' comparison of small and large towns

Measure	Location		Total
	Smaller town	Larger town	
Trauma score	7.78 ± 5.22*	9.98 ± 5.11	9.47 ± 5.1
GCS on scene	5.31 ± 3.16	5.25 ± 3.03	5.23 ± 3.2
GCS on arrival	3.7 ± 1.63	3.67 ± 1.45	3.70 ± 1.5
Injury Severity Score	17.95 ± 11.12	14.99 ± 11.04	16.04 ± 10.9
TRISS	0.76 ± 0.22*	0.87 ± 0.25	0.85 ± 0.3
Length of Stay (days)	9.05 ± 11.95*	4.7 ± 6.71	5.7 ± 8.4

GCS, Glasgow Coma Scale; TRISS, Trauma Score and Injury Severity Score.
Data given as mean ± standard deviation.
*$P < 0.05$.

Table 3: County severity measures according to rural and urban locationz[17]

Measure	Location		Total
	Rural	Urban	
N	79	365	444
Trauma score	5.18 ± 5.2*	10.47 ± 4.9	9.77 ± 5.2
GCS on scene	5.18 ± 3.0	5.27 ± 3.0	5.25 ± 3.0
GCS on admission	3.55 ± 1.4	3.69 ± 1.5	3.67 ± 1.5
Injury Severity Score	16.66 ± 10.9	14.94 ± 11.1	15.24 ± 11.1
TRISS	0.800 ± 0.3**	0.87 ± 0.2	0.86 ± 0.3
Length of Stay (days)	6.96 ± 10.1**	4.66 ± 6.6	5.07 ± 7.4

GCS, Glasgow Coma Scale; TRISS, Trauma Score and Injury Severity Score.
Data given as mean ± standard deviation.
*$P < 0.05$; **p 0.055.
Data source: reference 17.

Many existing studies compare rural and urban areas for injury severity, and many studies collect data on zip (postal) codes. However, few studies stratify the zip codes to draw direct comparisons between town sizes. One study compaing rural and urban differences collected zip code data for firearm deaths[37], but used county-level designations as the primary means of determining rurality. Additionally, some studies collected and compared zip codes directly for cases such as unintentional injuries[38], and violence associated with social deprivation[39]. Likewise, the RUCA codes have been used in a number of studies, often broken down into the four classes previously mentioned (urban, large town, small town, and isolated town). These RUCA code classes have been examined for rural hospital outcomes[16], nursing homes[40], EMS[41,42], and in comparing severity and outcome of pediatric traumatic brain injuries[17].

Similarly, some authors have used RUCA codes to identify and compare differences between rural and urban areas in terms of seat-belt usage[43], outcome of injury in Medicare patients[44], quality of life studies[45], healthcare utilization[46], and mental health[47]. Weeks et al went so far as to use RUCA codes to determine three levels of rurality: urban, suburban, and rural[45]. Despite the use of RUCA codes to define rural and urban areas or to compare among zip code levels, an extensive review of the literature indicates that this is the first study using RUCA2 codes to compare the severity of injury outcome between small and large towns for traumatic brain injury.

One of the problems with this study is the selection bias from looking at only one hospital system, and the limited number of patients living in small and isolated towns in the North Texas area. Whereas Robertson found 18% of the study population was injured in a rural county[17], this study finds only 9% of the study sample residing in small or isolated towns. While only having 9% of a study population fall into one comparison group leads to unequal groups, the key problem here may be related to the high number of urban counties in the Dallas area and the general size of the cities within those counties. For example, rural counties may contain large towns and urban cities, but urban counties rarely contain small or isolated towns. As Robertson noted, 59% of the patients residing in rural counties who suffered a severe traumatic brain injury lived in urban or large towns[17]. However, only 2% of the patients living in urban counties lived in rural or isolated towns, once again suggesting the problematic use of a simple urban–rural continuum. Additionally, the urban concentration of the Dallas area causes many of the towns anecdotally considered 'small' to be classified as larger towns, based solely on commutable distance to an urban center. More research using a larger sample size that encompasses more patients residing in small and isolated towns is necessary.

The urban makeup and spatial dimensions of the Dallas metropolitan area means that many of the patients from isolated or small towns must travel a substantial distance to high-level trauma centers should these emergencies arise. Additionally, because many local hospitals are not staffed or equipped to manage severe brain injuries in children, this equates to extended response times for EMS workers, longer traveling distances, and further isolation for the pediatric population[17]. As noted, while the severity of such injuries dictates that these patients are best served at specialized pediatric trauma centers, many of these patients may have difficulty reaching these hospitals, or may never reach them at all. Patients who need immediate emergency life-saving care, such as in the case of loss of airway or those who sustain cardiac arrest during transport, are immediately taken to the nearest hospital to preserve vital signs. Despite the injury or the ability to treat these injuries at lower-level trauma centers, these are two instances in which the patient's condition is best served at a the nearest medical center, as opposed to a Mobile Intensive Care Unit en route to a pediatric trauma center[17].

The retrospective study design of this research does not allow for cause-and-effect analysis or a greater direction on establishing any public health programs geared toward injury prevention. Additionally, the retrospective nature of the study limits the availability to obtain certain information.

Whereas Robertson drew comparisons between county of injury[17], the specific zip code of injury occurrence could not be identified in this study. Consequently, questions can be raised regarding the geographic location of where the injury was actually sustained in relation to residence. Given the differences in service availability and resources afforded to different town sizes, the exact zip code of injury may be highly valuable as injuries may not always be sustained in the same zip code as the person's residence. Resource differences at the town level are key constraints in the need for town-level comparisons, and the inability to determine the exact location of injury may inadvertently affect the outcome.

Conclusion

The results of this study indicate that town-size comparisons may be an effective means to define demographic groups because of the similarity and continuity between small and isolated towns. Rural counties may include large and urban towns, while small and isolated towns are rarely found in urban counties. Injury severity comparisons at the county level may be inadvertently affected by the size of the town because of the resources available at the town level. Research on the severity of rural-county injuries and patient outcomes may show improved outcomes due to those injuries being sustained in urban towns located in rural counties. Likewise, data on urban-county injury severities may appear worse because of the injuries sustained in those smaller and less-equipped towns found within urban counties. However, a larger sample size is needed to better gauge the efficacy of these comparisons, and more research is needed to better understand the differences in the actual services available to the individual towns, and the nature of injuries in smaller towns and rural counties, particularly in terms of mechanism and cause of injury.

When it comes to improving service delivery and reducing heath disparities in rural and underserved areas, understanding the differences between towns and counties can help practitioners better create effective public health programs and interventions geared toward reducing the health problems that plague certain concentrated areas. Specifically, this differentiation in geographic designation is required because with respect to rural/urban designations, congruence is not assured between town and county experiences in types or causes of injuries. Additionally, the resources available to individual towns may not reflect the resources available at the county level, and understanding these differences is necessary to improve the delivery of healthcare services in these areas.

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