URBAN/RURAL DISPARITIES IN OREGON PEDIATRIC TRAUMATIC BRAIN INJURY FATALITY

By

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CERTIFICATE OF APPROVAL

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LIST OF ABBREVIATIONS

CDC	Center for Disease Control and Prevention
CI	Confidence Interval
E-code	External Cause of Injury Code
GCS	Glasgow Coma Scale
GEE	General Estimation Equations
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
ISS	Injury Severity Score
LOS	Length of Stay
MVC	Motor Vehicle Collision
NCHS	National Center for Health Statistics
OHA	Oregon Health Authority
OR	Odds Ratio
SES	Socioeconomic Status
TBI	Traumatic Brain Injury
US	United States

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ABSTRACT

BACKGROUND: Traumatic brain injury (TBI) greatly contributes to morbidity and mortality in the pediatric population. Outcomes of TBI may vary geographically. We examined potential urban/rural disparities in mortality amongst Oregon pediatric TBI patients treated in trauma hospitals.

METHODS: Oregon pediatric patients, ages 0-19, seen in trauma hospitals for TBI were identified from the Oregon Trauma Registry for years 2009-2012. Location of injury was classified using the National Center for Health Statistics (NCHS) Urban-Rural Classification Scheme. Severity of overall trauma was estimated using Injury Severity Scores (ISS) and type of TBI was categorized as blunt versus penetrating injury. Incidence rates were calculated using Census data for denominators. Associations between urban/rural injury location and mortality were assessed using multivariable logistic regression, controlling for potential confounders. Generalized estimating equations were used to help account for clustering of data within hospitals.

RESULTS: Of 2,794 pediatric TBI patients, 46.6% were injured in large metropolitan locations, 24.8% in medium/small metropolitan locations, and 28.6% in non-metropolitan locations. Children from non-metropolitan (rural) locations had the greatest annualized incidence rate of TBI, at 107/100,000 children per year, and also tended to have higher ISS scores than those from large metropolitan areas (71/100,000 per year). Without adjustment for other factors, non-metropolitan location of injury was associated with increased odds of mortality (odds ratio [OR]=2.51; 95% CI= 1.57-4.03). This association remained significant while adjusting for age, gender, race/ethnicity, insurance status, ISS, and TBI type (OR=1.91; 95% CI=1.11-3.30).

CONCLUSION: This study identified a greater incidence rate of TBI and a higher proportion of severe injury in rural areas compared to urban areas in Oregon. Rural children treated in the trauma system for TBI were more likely to die than urban children after controlling for overall trauma severity and other factors associated with urban/rural residence. Research is needed to examine treatment and care disparities between urban and rural children. Future work should also identify interventions that can reduce risk of TBI and TBI-related mortality among children, particularly those who live in rural areas.

BACKGROUND

Traumatic brain injury (TBI) is a major cause of morbidity and mortality in the United States (US) pediatric population.[1,2] TBI results in substantial health care costs and many survivors experience permanent disability.[3,4] People who live in urban areas have different physical and socioeconomic environments than those who live rurally; therefore, risk factors for injury and poor outcomes of injury are likely also very different.[5] These inherent differences between urban and rural location may lead to differences in the epidemiology and outcomes of TBI that have important implications for care and prevention.[6] Furthermore, differences in the provision of care can lead to outcomes disparities between children in urban versus rural locations.[7,8,9]

Among the few studies that include pediatric populations in the US, injury severity has consistently been reported to be higher in rural locations compared to urban locations.[3,6,10] In contrast, studies examining urban/rural differences in TBI mortality have reported mixed results.[6,10,11] Children in rural areas had a higher frequency of motor vehicle related mechanisms of injury than children in metropolitan locations. Furthermore, motor vehicle related mechanisms are known to be associated with increased injury severity compared to other mechanisms and suggested as a possible contributor to regional severity and mortality differences.[3,6,10] Similarly, firearm-related mechanisms were also implicated as a factor associated with severity and mortality, especially in cases of suicide.[3,6] Currently, TBI prevention programs tend to target risk factors determined as high priority for states as a whole.[12] Knowledge of urban/rural differences in risk factors for pediatric TBI may enhance effectiveness of these and other population-level prevention programs.

Studies also indicate that there may be treatment and care disparities between urban and rural children.[7,8,9] Pre-hospital, emergency department, and hospital care and treatment differences can lead to mortality disparities.[7] In addition to longer transport times, rural children are more likely to receive care from emergency personnel who have basic life support training rather than advanced life support training.[7,13,14] Furthermore, children in rural locations are more likely to present to non-trauma hospitals or Level III or IV trauma centers than children in urban locations.[16] The hospital to which patients present can affect mortality due to care differences and the lack of specialized care. For example, Levels I and II trauma centers have pediatric and TBI-specialized surgical staff, while Levels III and IV hospitals are not required to have these resources and non-trauma hospitals rarely have these resources.[15,17]

This study examined urban/rural differences in the incidence, severity, and outcomes (mortality) among Oregon pediatric TBI patients treated in trauma system hospitals using a multi-level urban/rural geographic classification scheme. This scheme was specially designed to capture health differences and is useful for identifying potential mortality disparities by location due to treatment and care disparities. Additionally, the scheme will aid in providing important information that will contribute to development of geography-specific injury prevention strategies.[18] We hypothesized that, after accounting for potential confounding factors, mortality among children with TBI sustained in Oregon would be greater among those in rural locations compared to those in urban locations.

METHODS

Study population

This retrospective analysis was based on data from the Oregon Trauma Registry maintained by the Oregon Health Authority (OHA).[19] The study was approved by the OHA Institutional Review Board with ceded oversight from Oregon Health & Science University. The registry was queried from 2009-2012 for pediatric TBI patients ages 0-19 years identified using International Classification of Diseases -9th Revision-Clinical Modification (ICD-9-CM) diagnosis codes specified in the Barell Injury Diagnosis Matrix.[20] We included ICD-9-CM 959.01 indicating a head injury not otherwise specified to prevent under-estimation of TBI as recommended by the US Centers for Disease Control and Prevention (CDC).[20,21,22] Patients who had transfers indicated but without final mortality outcomes available within the Oregon Trauma System were included in incidence calculations but excluded from subsequent analysis. Demographic data obtained from the registry included age, gender, race/ethnicity, insurance status, zip code/county of injury location, and zip code/county of residence. High agreement between location of injury and location of residence has been previously reported.[6] To capture TBI cases occurring in Oregon, regardless of state of residence, we included patients who had an in-state location of injury but excluded patients with an out-of-state location of injury.

Measures

County of injury location information was used to assign urban/rural categories using the National Center for Health Statistics (NCHS) urban-rural classification scheme.[18] To accommodate the relatively small number of outcome events, the scale was collapsed into three categories: large metropolitan, medium/small metropolitan, and non-metropolitan. Patients were assigned 2013 NCHS designations.[18,23] For the purposes of this analysis, non-metropolitan designations were considered rural.[18] Mortality information was obtained directly from the Trauma Registry database.[19] For those with multiple records due to transfer, the record from the final Oregon Trauma Registry hospital was used to assess mortality outcome.

Race/ethnicity categories were categorized as white, non-white, and missing/unknown.[23] Insurance categories were categorized as insured, including those with private insurance, public insurance, car insurance or workers compensation; uninsured, including those who self-paid or received charity; and missing/unknown. Public insurance included Medicare/Medicaid and other government insurance.[24] The CDC reports that those ages 0-4 and 15-19 years are at the greatest risk for TBI.[12,21] Thus, we categorized age as 0-4, 5-14, and 15-19 years.

Injury-related information included variables such as mechanism of injury and intent of injury (based on ICD-9-CM external cause of injury codes, or E-codes), Injury Severity Score (ISS), Glasgow Coma Scale (GCS), and TBI-type. Mechanism of injury was categorized as fall, struck by/against, motor vehicle collision (MVC), firearm, other/specified classifiable, other/specified not elsewhere classifiable, unspecified, and other.[21] Injury intent was defined as unintentional, suicide attempt, assault, and undetermined/other.[21] Injury Severity Score (ISS) is a system used to assess injuries of six body regions (Head, Face, Chest, Abdomen, Extremities, and External) for patients with multiple injuries.[25] ISS scores range from 0 to 75, with higher scores indicating greater severity. We categorized ISS as done in past research: mild ($\leq$8), moderate (9-15), and severe (>15).[25,26] However, due to small cell sizes, mild and moderate ISS categories were combined for analysis. The Glasgow Coma Scale measures the level of consciousness in head-injured patients. GCS scores were categorized as mild/moderate (scores= 9-15) versus severe injuries (3-8).[5] TBI-type was defined as either blunt or penetrating.

Transfer status to another trauma facility was coded as a dichotomous variable (yes/no). Hospital trauma system level was reported as a categorical variable corresponding to the four levels: Level I, II, III, and IV. Time from initial location of injury scene to the trauma center was classified in minute increments: <30, 30-60, and 60 plus.

Statistical Analysis

We used Census data for years 2009-2012 to calculate annual TBI incidence by urban-rural location.[27] We examined differences in demographic and injury variables by urban/rural location of injury using χ^2 tests. To account for clustering within individual hospitals, we used generalized estimating equations (GEEs) in all logistic regression analyses.[28] Univariate logistic regression analysis was performed to investigate the association between urban/rural location and mortality. We performed multivariable logistic regression to assess the association between urban/rural location and mortality while controlling for potentially confounding variables. An *a priori* causal model (Figure 1) and directed acyclic graphs were used to determine the most parsimonious set of available covariates to include in analyses.[29] These covariates included age, sex, race/ethnicity, insurance status, injury severity, and TBI-type. We explored multiple indicators of injury severity (Appendix Table 6) and determined that ISS would serve as the best proxy of severity for this analysis due to the low percentage of missing values (1.4%) compared to other potential variables and its common use in TBI literature.[3,6] We computed the adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of mortality for non-metropolitan and small/medium metropolitan areas compared with large metropolitan areas. We were unable to examine potential effect modification of the association between urban-rural location and mortality by transfer status or ISS due to small cell counts.

Posthoc Analyses

We were interested in exploring potential explanations for any observed differences in mortality by geographic location. Therefore, we further examined transfer information for children with severe traumatic injuries who initially presented to Level III and Level IV trauma centers. Triage criteria indicate that patients with severe TBI are to either be directly taken to the highest level of trauma care or be stabilized then transferred to the highest level trauma center.[17,30] We also examined transportation times from the injury scene to initial care by location. We entered transfer and transportation time into our final multivariable regression model to determine if these factors could account for mortality differences.

All analyses were performed using Stata/SE 13.1.[31]

RESULTS

TBI Incidence

There were 3,169 children ages 0-19 years treated for TBI in the Oregon Trauma system from 2009-2012. The average incidence of pediatric TBI in Oregon over the four year period was 87 per 100,000 children. The incidence rates of TBI among those with non-metropolitan locations of injury were greater than those of the large and medium/small metropolitan areas for all years examined (Table 2).

Patient Characteristics

After excluding patients without a reported location of injury (n=247) and patients for whom final disposition could not be assessed (n=128), the study population for assessing association between injury location and mortality included 2,794 patients. Race/ethnicity and gender were not statistically different between included and excluded children (Appendix Table 5). However, excluded children were more likely to be older, have injuries classified as severe, have a missing GCS score, and have an unknown/missing insurance status. Excluded children were also less likely to present to either a Level I or II trauma hospital. There were 1,303 patients injured in a large metropolitan location (46.6%), 692 in a medium/small metropolitan location (24.8%), and 799 in a non-metropolitan location (28.6%). There were 1,879 males (67.3%). Overall 2,007 patients were categorized as white (71.8%), 575 as non-white (20.6%), and 212 as unknown or missing race (7.6%). The causes of injury included MVC (32.7%), fall (33.6%), struck by/against (12.3%), firearms (0.5%) and other (20.9%).

The characteristics of children and their injuries varied by injury location. Children sustaining TBI in rural locations were more likely to be White and between the ages of 15-19 compared to children in large-metropolitan locations. Furthermore, rural children were more likely to be uninsured or classified as having unknown/missing insurance. Motor-vehicle collisions were the most common mechanism of injury among rural children (37%), while falls were the most common mechanism among urban children (39%). Over the four year period examined, a slightly higher percentage of injuries in rural locations were unintentional compared to those in large metropolitan areas, although the difference was statistically insignificant (95% vs. 92%).

Severity of injuries was also different by location (Table 2). Of the children with a rural location of injury 34% sustained severe traumatic injuries compared to 24% of children from large metropolitan locations. Children from rural locations had a higher percentage of missing GCS scores (18%) compared to children from large metropolitan areas (7.7%). Of the children with a recorded GCS score, there was no difference in the proportion of severe TBIs by location; 3.6% in rural locations were categorized as severe compared to 3.2% in large metropolitan locations.

Mortality

We observed a significant difference between location of injury and mortality outcome, with crude mortality of 1.8% for large-metropolitan location of injury, 2.3% for small/medium metropolitan location of injury, and 4.5% for non-metropolitan location of injury (Table 3). Patients injured in non-metropolitan (rural) locations were 2.5 times more likely to die compared to those in large metropolitan locations (OR=2.51; 95% CI=1.56-4.03) (Table 4). In contrast, there was no statistical difference in risk of mortality for patients injured in small/medium metropolitan locations compared to those in large metropolitan locations (OR=1.28; 95% CI=0.58-2.80). When controlling for potential confounders (age, race/ethnicity, gender, insurance, ISS, and TBI-type), the estimated adjusted odds of mortality among children injured in a non-metropolitan location, compared to those in large metropolitan locations, was 1.91 (95% CI=1.11-3.30).

Posthoc Analyses

We found that those injured in rural locations were more likely to initially present to Levels III and IV trauma centers than those injured in large metropolitan areas. Furthermore, 38.7% of patients presenting to Levels III and IV trauma centers had injuries classified as severe, compared to 29.4% of patients presenting to Levels I and II trauma centers. There were 481 total transfer patients but only 353 for which final mortality status could be determined. Of the 786 severely injured patients, 170 initially presented to Levels III and IV trauma centers of which 69.4% were transferred (Figure 2). Those with large metropolitan locations of injury were transferred 91% of the time, those in small/medium metropolitan areas were transferred 51% of the time and those with non-metropolitan locations of injury were transferred 75% of the time. There was a 16% difference in survival between those transferred and not-transferred (93% and 77% respectively). Of the patients who were not transferred and who died, nine expired in the emergency department and none were dead on arrival.

Entering transportation time into the final multivariable model attenuated the odds ratio, but did not account for the entire mortality difference between children with large metropolitan locations of injury and non-metropolitan locations of injury (OR=1.90; 95% CI=1.08-3.33). Entering transfer status into the model elevated the odds of mortality for children with non-metropolitan locations of injury versus large metropolitan locations of injury (OR=2.09; 95% CI=1.12-3.92).

DISCUSSION

This is the first study to use the NCHS Urban/Rural Classification Scheme to examine potential urban-rural disparities in TBI-related incidence, severity, and mortality among children using trauma system care. We found that there was a greater incidence rate of trauma system care for TBI among children in rural areas compared to large metropolitan areas. Our results indicated that rural children treated in the trauma system for TBI were more likely to die than urban children while controlling for injury severity and other factors associated with urban/rural residence. A greater proportion of children in non-metropolitan areas sustained severe overall trauma, as indicated by the ISS, when compared to those with TBI from large metropolitan locations. Frequencies of primary mechanism tended to differ between urban and rural locations, although intent of injury did not significantly differ between locations.

Our findings suggest that there are systematic differences in care and/or treatment leading to increased mortality in children sustaining TBIs in rural locations. Currently, longer transport times are thought to be associated with the increased risk of injury mortality in rural areas.[11,30] Studies have reported decreased chances of survival with transportation times from injury scene to initial care over 30 minutes.[7] A larger proportion of children injured in rural locations in our study population experienced transportation times greater than 30 minutes (20% versus 14.6% for large metropolitan locations). Treatment received during prehospital transportation may also contribute to mortality disparities. Rural locations are more likely to have volunteer emergency medical technicians (EMTs) with less experience due to low retention of workers.[7] Additionally, rural areas have fewer trained advanced life support responders (such as paramedics) compared to large metropolitan locations. Basic life support trained responders do not have the training necessary to intubate patients or provide intravenous medications or fluids.[7] Future research should focus on identifying disparities in prehospital treatment by urban versus rural location and assessing how these disparities influence mortality outcomes.

Our finding that roughly 70% of severely injured patients were transferred from Levels III or IV trauma centers in conjunction with a lower percentage of survival for non-transfers, suggests disparities in TBI treatment at the hospital level. Rural children are more likely to present to non-trauma hospitals or lower levels of trauma care. These facilities generally lack pediatric surgeons as well as neurotrauma specialists.[16] Studies should assess the relationship between triage compliance and TBI mortality as well as potential associations with other long-term outcomes such as disability.

Our findings are consistent with previous reports of differences in incidence and outcome of TBI based on location. Gabella et al. (1997) reported rates of 97.8 per 100,000 for most urban groups and 172.1 per 100,000 for most rural groups in Colorado.[6] Although our study suggested a similar trend in relative incidence, the incidence rates for our study are lower due to our focus on the pediatric population. Our overall average incidence of 87 per 100,000 children is similar to that reported by Reid et al. (2001) in their study of pediatric TBI in Minnesota (73.5 per 100,000 children).[3] Gabella et al. also reported increased TBI-related mortality in rural locations compared to urban locations.[6] Chapital et al. (2007) found no statistically significant differences in TBI mortality rates for all ages between urban and rural locations, although findings did suggest a higher rate in the rural population.[10] Further research focusing on the pediatric population should use meaningful urban-rural classification schemes, such as the NCHS Classification Scheme which is designed to identify health differences.

Similar to previous studies, falls and MVCs accounted for the highest proportions of TBI mechanisms in our population.[3,6] Our findings are consistent with previous reports that MVC is more commonly the primary mechanism of injury among those in non-metropolitan locations.[3,18] MVC has been shown to be significantly associated with greater TBI severity while falls were not.[3] This may partially explain the observed increased injury severity for children with rural locations of TBI. Transport times were also longer for children with TBI sustained in a rural location. Research into rural location-specific injury prevention strategies for MVCs and severity-reduction strategies for injuries sustained by MVCs should be conducted to guide development of prevention plans targeted towards rural children.

This retrospective analysis has several limitations. Due to the relatively small number of outcome events (mortality) in conjunction with a high number of missing variables for GCS scores, we used ISS to measure overall severity of children's injuries. Although ISS does not directly measure TBI severity, severe head injuries will be accounted for in the ISS score. Consequently, patients with severe levels of TBI should have a high ISS translating to a severe injury classification for our study. Also related to low cell counts, we were unable to assess effect modification of the association between urban/rural location of injury and mortality by either ISS or transfer status. We had wanted to assess a larger time period, but registry data quality issues and reporting differences between years prevented utilization of data prior to 2009. Our findings suggest that improvements could be made to the Oregon Trauma Registry to facilitate TBI-related research and development of prevention strategies. Future studies should be conducted in larger populations with more complete reporting to help disentangle associations between urban-rural location, TBI and overall injury severity, transfer status, and risk of mortality.

Another limitation is the potential for selection bias if there were systematic underreporting or overreporting by region. Cases that did not have an Oregon location of injury or where the location of injury was missing were excluded from location-specific incidence calculations and multivariable analysis. We found that those we excluded were more likely to be older, have injuries classified as severe, have a missing GCS score, and have an unknown/missing insurance status and were less likely to present to either a

Level I or II trauma hospital. These characteristics are consistent with characteristics of children in our analysis population with non-metropolitan and small/medium metropolitan locations of injury. Since children who had injuries classified as severe, who had missing GCS scores, and who presented to Level III or IV trauma centers had higher crude mortality in the analysis population, we could be missing deaths at a higher rate in the non-metropolitan and small/medium metropolitan locations in the excluded population. This would lead to falsely attenuated reported adjusted odds of mortality for non-metropolitan and small/medium metropolitan locations. If location was less likely to be reported for rural areas, this could lead to an under sampling of rural TBI cases causing an under-reporting primarily of rural TBI incidence. The registry does not capture pre-hospital mortality cases or patients admitted to non-trauma centers. In our population, transportation times were longer for rural locations of injury which could lead to higher rates of death prior to presentation at the emergency department. Rural patients may also be admitted to non-trauma centers at a higher rate and die prior to transfer. Studies among rural hospitals across Oregon and Washington have shown that over 10% of patients in non-trauma centers die in non-trauma center emergency departments awaiting transfer to trauma centers.[8] Thus, mortality cases in rural areas could be excluded at a greater rate than urban mortality cases, potentially resulting in falsely attenuated odds of mortality for those in rural areas. Future studies should use methods to enumerate children with TBI who may have died prior to receipt of care in the Trauma System.

SUMMARY AND CONCLUSIONS

Despite these limitations, our study found mortality disparities as well as difference in the epidemiology of TBI by urban vs. rural location. Children in rural areas had higher TBI incidence rates as well as greater odds of dying from their injuries. Our results suggest that disparities in treatment and care lead to a greater burden of TBI mortality among rural children, after adjusting for severity of injury. Further examination of specific treatment and care disparities are needed amongst pediatric patients who sustain TBIs. Low overall transfer rates as well as differences in the proportion transferred by location of injury for pediatric patients with severe TBI to higher trauma level hospitals suggests that further examination of triage and transfer criteria compliance in Oregon may be warranted. Additionally, differences in mechanisms and severity of injury suggest that location-specific TBI prevention programs may be warranted.

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Table 1. Annual Traumatic Brain Injury Incidence per 100,000 Oregon Children ≤19 Years of Age, by Urban/Rural Location

	Year				
Injury Location	2009	2010	2011	2012	Total
Large metropolitan	75	73	71	68	71
Small/medium metropolitan	66	64	59	48	59
Non-metropolitan	111	108	110	101	107
Missing Location	17	10	8	13	12
Combined incidence	96	87	83	80	87

Table 2. Characteristics of Pediatric Patients ≤19 Years of Age Admitted to Oregon Trauma Hospitals for Traumatic Brain Injury, 2009-2012, by Urban-Rural Location

	Large metropolitan (n=1,303)		Small/Medium Metropolitan (n=692)		Non-metropolitan (n=799)		Total (n=2,794)	*p*
	n	(%)	n	(%)	n	(%)	n	
Injury Severity Score								<0.0001
≤15 (mild/moderate)	984	(50)	477	(24)	507	(26)	1,968	
>15 (severe)	316	(40)	198	(25)	272	(35)	786	
Missing	3	(8)	17	(42)	20	(50)	40	
Glasgow Coma Scale								<0.0001
9-15 (mild/moderate)	1,161	(51)	496	(22)	626	(27)	2,283	

3-8 (severe)	42	(40)	34	(32)	29	(28)	105	
Missing	100	(25)	162	(40)	144	(35)	406	
Gender								0.97
Male	879	(45)	463	(25)	537	(30)	1,879	
Female	424	(45)	229	(25)	262	(30)	915	
Age (years)								0.02
0-4	325	(51)	163	(26)	149	(23)	637	
5-14	380	(46)	203	(25)	240	(29)	823	
15-19	598	(45)	326	(24)	410	(31)	1,334	
Race/ethnicity								<0.0001
White	891	(44)	538	(27)	578	(29)	2,007	

Non-white	348	(60)	136	(24)	91	(16)	575	
Missing/unknown	64	(30)	18	(9)	130	(61)	212	
Insurance Status								<0.0001
Insured	1,197	(50)	579	(24)	611	(26)	2,387	
Uninsured	84	(43)	52	(26)	62	(31)	198	
Other/unknown/missing	22	(11)	61	(29)	126	(60)	209	
Transfer Status								<0.0001
Yes	23	(7)	129	(37)	195	(56)	347	
No	1,280	(52)	563	(23)	604	(25)	2,447	
Mechanism of Injury								<0.0001
Fall	509	(54)	204	(22)	227	(24)	940	

Motor vehicle collision	367	(40)	250	(27)	298	(33)	915	
Struck by/against	188	(55)	80	(23)	75	(22)	343	
Firearm	7	(54)	3	(23)	3	(23)	13	
Other, specified classifiable	15	(31)	18	(38)	15	(31)	48	
Other, specified NEC	8	(80)	0	(0)	2	(20)	10	
Unspecified	19	(51)	10	(27)	8	(22)	37	
Other	190	(39)	127	(26)	171	(35)	488	
Hospital Level								<0.0001
I	1,251	(85)	76	(5)	149	(10)	1,476	
II	5	(1)	401	(65)	211	(34)	617	
III	1	(0)	129	(34)	249	(66)	379	

IV	46	(14)	86	(27)	190	(59)	322

Table 3. Characteristics of Pediatric Patients ≤19 Years of Age Admitted to Oregon Trauma Hospitals for Traumatic Brain Injury, 2009-2012, by Mortality Outcome

	Lived (n=2,718)		Died (n=76)		Total (n=2,794)	*p*
	n	(%)	n	(%)		
NCHS Urban/Rural Classification						0.001
Large metropolitan	1,279	(98)	24	(2)	1,303	
Medium/small metropolitan	676	(98)	16	(2)	692	
Non-metropolitan	763	(95)	36	(5)	799	
Injury Severity Score						<0.0001
≤15 (mild/moderate)	1,960	(100)	8	(0)	1,968	
>15 (severe)	720	(92)	66	(8)	786	
Missing	38	(95)	2	(5)	40	
Glasgow Coma Scale						<0.0001
9-15 (mild/moderate)	2,280	(100)	3	(0)	2,283	
3-8 (severe)	82	(78)	23	(22)	105	
Missing	356	(88)	50	(12)	406	

Gender						0.83
Male	1,827	(97)	52	(3)	1,879	
Female	891	(97)	24	(3)	915	
Age (years)						0.013
0-4	612	(96)	25	(4)	637	
5-14	811	(99)	12	(1)	823	
15-19	1,295	(97)	39	(3)	1,334	
Race/ethnicity						0.022
White	1,956	(97)	51	(3)	2,007	
Non-white	562	(98)	13	(2)	575	
Missing/unknown	200	(94)	12	(6)	212	
Insurance Status						0.01
Insured	2,332	(97)	55	(3)	2,387	
Uninsured	185	(96)	13	(4)	198	
Other/unknown/missing	201	(97)	8	(3)	209	
Transfer Status						0.209
Yes	334	(96)	13	(4)	347	

No	2,384	(97)	63	(3)	2,447	
Mechanism of Injury						<0.0001
Fall	928	(99)	12	(1)	940	
Motor vehicle collision	879	(96)	36	(4)	915	
Struck by/against	341	(99)	2	(1)	343	
Firearm	6	(46)	7	(54)	13	
Other, specified classifiable	41	(85)	7	(15)	48	
Other, specified NEC	8	(80)	2	(20)	10	
Unspecified	35	(95)	2	(5)	37	
Other	480	(98)	8	(2)	488	
Hospital Level						0.053
I	1,447	(98)	29	(2)	1,476	
II	596	(97)	21	(3)	617	
III	363	(96)	16	(4)	379	
IV	312	(97)	10	(3)	322	
Injury Type						<0.0001
Blunt	2,695	(98)	69	(2)	2,764	

Penetrating	13	(65)	7	(35)	20
Missing	10	(100)	0	(0)	10

Table 4. Odds of Mortality by Urban/Rural Location among Oregon Children ≤19 Years of Age with Traumatic Brain Injury

	Bivariate Association		**Multivariate Association***	
NCHS Classification	OR	95% CI	OR	95% CI
Large metropolitan	1.0	Ref	1.0	Ref
Small/medium metropolitan	1.28	(0.58, 2.80)	1.17	(0.50, 2.70)
Non-metropolitan	2.51	(1.58, 4.03)	1.91	(1.11, 3.30)

*Model includes age, gender, race/ethnicity, insurance, ISS, and injury type (blunt vs. penetrating

Figure 3. Causal Model Depicting Theorized Associations between Location of Injury and Mortality

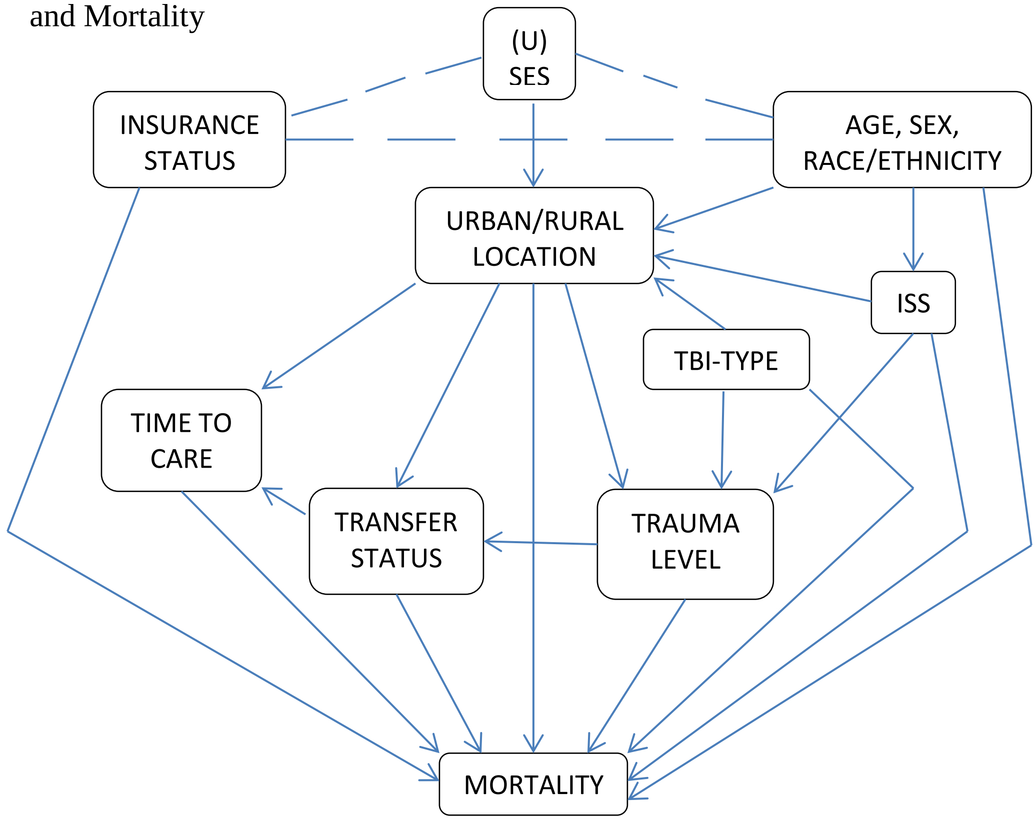
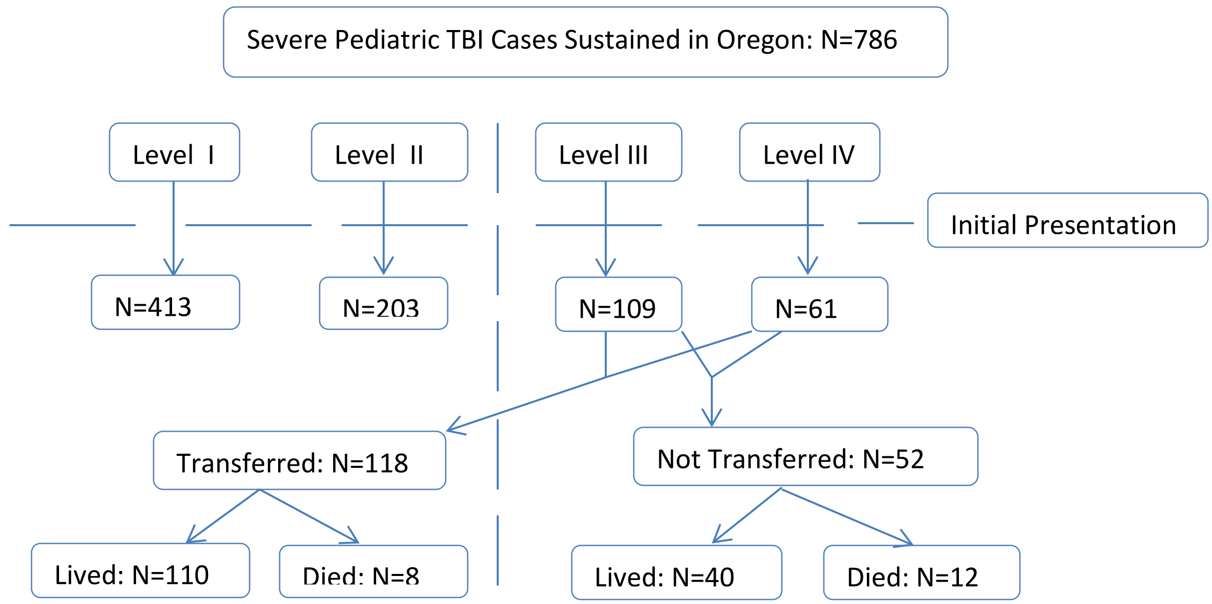


Figure 4. Patient Counts for Initial Presentation Trauma Level and Post Transfer Trauma Level and Mortality for Severe Pediatric Traumatic Brain Injuries Sustained in Oregon



APPENDIX

Table 5. Characteristics of Excluded Pediatric Patients ≤19 Years of Age Admitted to Oregon Trauma Hospitals for Traumatic Brain Injury, 2009-2012[*]

	Total (n=375)	*p***
Injury Severity Score		0.002
≤15 (mild/moderate)	231	
>15 (severe)	138	
Missing	6	
Glasgow Coma Scale		<0.0001
9-15 (mild/moderate)	228	
3-8 (severe)	19	
Missing	68	
Gender		0.08
Male	269	
Female	106	

Age (years)		0.03
0-4	96	
5-14	127	
15-19	152	
Race/ethnicity		0.32
White	272	
Non-white	68	
Missing/unknown	35	
Insurance Status		0.001
Insured	280	
Uninsured	31	
Other/unknown/missing	46	
Hospital Level		<0.0001
I	159	
II	54	
III	75	
IV	90	

*Includes patients excluded for missing location of injury (n=247) and patients excluded due to inability to determine final mortality outcome (n=128).

** Results of comparison to study population

Table 6. Severity Indicator Summary Statistics for Pediatric Patients ≤19 Years of Age Admitted to Oregon Trauma Hospitals for Traumatic Brain Injury, 2009-2012

Indicator of Severity	% missing	Range	Mean	SD	Median
ISS	1.4	1-59	11.0	8.7	9
GCS	14.5	3-15	14.1	2.3	15
Systolic Blood Pressure	4.4	0-246	125.5	22.3	126
Diastolic Blood Pressure	4.5	0-220	74.1	17.0	74
Pulse rate	1.6	0-226	102.4	30.0	98
Respiratory rate	10.3	0-98	21.5	22.3	20