Trends in Mortality at a Level II Rural Trauma Center

David L. McClure, PhD; Daniel C. Cullinane, MD; Ivan L. Maldonado, MD

ABSTRACT

Background: Most studies of deaths from traumatic injury are from urban trauma centers. In contrast, rural areas have higher incidence of traumatic fatal injuries than urban areas. The objective of this research was to describe trends of injuries and mortality from a trauma center serving a largely rural population and compare results with reports from the National Trauma Data Bank (NTDB).

Methods: We conducted a retrospective study of patients admitted to a rural Wisconsin level II trauma center from 2000 through 2018. Details on injuries and deaths prior to discharge were obtained from the trauma registry. Event counts and fatality ratios were described by year, sex, age, mechanism of injury, and injury severity score (ISS). Trends were analyzed across 2000-2005, 2006-2011, and 2012-2018 calendar year eras.

Results: During 2000-2018, there were 17,334 injury events among 16,495 patients included in the trauma registry. Across the 3 eras, the proportion of injuries related to falls increased (35.6%, 40.6%, and 51.5%, respectively), and the proportion from on-road motor vehicle events decreased (37.0 %, 32.8, and 22.5%, respectively), similar to the trends from 3 corresponding NTDB reports for 2004, 2010, and 2016. There was a statistically significant decreasing trend ($P<0.001$) in overall fatality ratios across the 3 eras, 5.3% (95% CI, 4.7%-6.0%), 4.1% (95% CI, 3.7%-4.6%), and 3.9 (95% CI, 3.4%-4.4%), respectively. The fatality ratios point estimates were similar to overall fatality ratios from the NTDB reports (4.7%, 4.0%, 4.3%, respectively). The median patient age increased significantly from 42, 45, and 55 years across the 3 eras (test for trend $P<0.0001$).

Conclusion: Long-term trends of traumatic injuries and mortality were generally similar to national trends, particularly in the shift to older patients and in the increasing proportion of injury events due to falls. Further research on traumatic injuries and deaths in rural populations is needed, particularly regarding immediate deaths at the scene and longer-term deaths after discharge.

• • •

Author Affiliations: Center for Clinical Epidemiology and Population Health, Marshfield Clinic Research Institute, Marshfield, Wisconsin (McClure, Cullinane); Trauma Center, Marshfield Medical Center, Marshfield, Wisconsin (Maldonado).

Corresponding Author: David L. McClure, PhD, Marshfield Clinic Research Institute, 1000 N Oak Ave, Marshfield, WI 54449; phone 715.389.3036; email mcclure.david@marshfieldclinic.org.

INTRODUCTION

Trauma registries are databases that contain clinical and demographic information on injured patients admitted and treated at trauma centers. Trauma registry data are used for performance improvement of patient care, accreditation and verification of trauma service status, injury prevention initiatives, research on epidemiology and treatments of injury, and uploads to state and national trauma databases.[1]

Most studies recently published have been based on national registry data[2] or registry data from densely populated urban trauma centers[3] or large regional areas.[4,5] However, from population-based studies, rural residents have higher age-adjusted incident rates of injury and higher mortality rates compared to urban populations.[6-11]

The Marshfield Clinic Health System (MCHS) serves the north-central Wisconsin area with over 3.5 million patient encounters annually. Injured patients may be seen at the trauma center in Marshfield, with level II designations for adult and pediatric trauma. Our objective was to describe trends of injuries and mortality from the Marshfield trauma center, which has long-term experience in treating patients from a rural and small metropolitan population.

METHODS

This was a retrospective study of injured patients at the MCHS level II trauma center in Marshfield, Wisconsin. The Marshfield Clinic Research Institute Institutional Review Board approved

this study as exempted research using data collected for nonresearch purposes. Details on injuries and deaths prior to discharge were obtained from the trauma registry. The registry, which began in 2000, was certified to provide data to the Wisconsin Trauma Registry[12] in 2005 and to the National Trauma Data Bank[13] (NTDB) in 2013. To avoid sparse data conditions and to provide more stable estimates of possible trends, the registry data were summed across 3 calendar year eras defined by the years of state and national certification: 2000-2005, 2006-2012, and 2013-2018. Patients of all ages were included from 2000 through 2018. Patients were excluded if they were transferred to a level I trauma center or did not have a recorded mechanism of injury or injury severity score (ISS). The outcome of interest was death due to injury prior to discharge and included patients dying during hospitalization, in the emergency department, or dead upon arrival. Deceased patients were identified in the trauma registry data by selection of "discharge to morgue" status. The fatality ratio was the outcome measure and defined as the count of deaths divided by the count of patient events.

Table 1. Distributions of Injury Event Counts (Percentages) at Marshfield Clinic Health System Trauma Center by Sex, Injury Severity Score, Mechanism of Injury, and Calendar Year Eras and Representative National Trauma Data Bank Reports

Characteristic	Marshfield Clinic Health System Trauma Center			National Trauma Data Base		
	2000–2005	2006–2012	2013–2018	2004	2010	2016
	Count (%) of Injury Events			% of Injury Events		
Overall	4548 (100)	6983 (100)	5803 (100)	100	100	100
Sex and age, years[a]						
Female, 0-14	208 (4.6)	321 (4.6)	321 (5.5)	4.2	4.4	4.0
Female, 15-44	509 (11.2)	730 (10.5)	416 (7.2)	14.4	10.9	9.6
Female, 45-64	267 (5.9)	448 (6.4)	450 (7.8)	6.2	7.4	7.7
Female, 65-74	144 (3.2)	261 (3.7)	287 (4.9)	2.7	3.4	5.0
Female, 75-84	243 (5.3)	417 (6.0)	385 (6.6)	4.2	5.2	6.3
Female, 85+	205 (4.5)	399 (5.7)	473 (8.2)	2.0	4.8	6.8
Male, 0-14	379 (8.3)	596 (8.5)	530 (9.1)	7.5	7.7	6.5
Male, 15-44	1387 (30.5)	1828 (26.2)	1065 (18.4)	39.8	31.6	26.3
Male, 45-64	651 (14.3)	1091 (15.6)	870 (15.0)	12.6	15.3	15.3
Male, 65-74	216 (4.7)	336 (4.8)	438 (7.5)	2.9	3.7	5.2
Male, 75-84	216 (4.7)	348 (5.0)	337 (5.8)	2.6	3.4	4.3
Male, 85+	123 (2.7)	208 (3.0)	231 (4.0)	0.8	2.1	3.1
Injury severity score[a]						
<9	1712 (37.6)	3096 (44.3)	2738 (47.2)	67.6[b]	53.0	45.5
9-15	1524 (33.5)	2227 (31.9)	1981 (34.1)	12.4[b]	26.5	32.8
16-24	669 (14.7)	933 (13.4)	702 (12.1)	11.2	15.2	13.9
>24	643 (14.1)	727 (10.4)	382 (6.6)	8.8	5.4	7.8
Mechanism of injury[a]						
Fall	1621 (35.6)	2833 (40.6)	2991 (51.5)	16.7	37.0	44.2
Firearm	51 (1.1)	49 (0.7)	51 (0.9)	5.4	4.7	4.2
Motor vehicle on-road	1684 (37.0)	2287 (32.8)	1306 (22.5)	48.5	30.0	26.0
Other mechanism	731 (16.1)	976 (14.0)	867 (14.9)	19.6	22.8	21.1
Other transport	461 (10.1)	838 (12.0)	588 (10.1)	9.8	5.5	4.6

[a]Chi-square P <0.00001.
[b]National Trauma Data Bank 2004 injury severity score categories 1-9, 10-15, 16-24, >24.

Event counts and fatality ratios were described by sex, age, mechanism of injury, and ISS across the 3 calendar year eras. Mechanism of injury was determined from injury memo text fields and International Classification of Diseases external causes of morbidity and mortality codes. Categories were "fall;" "firearm;" "motor vehicle on-road" of registered motor vehicle traffic crashes; "other transport," such as pedestrian, pedal, horse, or off-road motor vehicle; and "other mechanism," which included injuries due to blunt, cutting, or piercing objects. ISS ranged from 1 to 75 (death from injury) and was classified as low (<9), moderate (9-15), severe (16-24), and very severe (>24).

Fatality ratios were calculated as binomial proportions with exact Clopper-Pearson 95% confidence intervals. Trends in mortality were described across the 3 calendar year intervals: overall and by patient sex, age, mechanism of injury, and ISS. Trends were analyzed with Cochran-Armitage tests. Results were also compared to US trauma mortality data compiled from NTDB 2004, 2010, and 2016 reports. These 3 reports were selected to be at or near the midpoint of the 3 calendar year eras. Annual NTDB reports from 2004 through 2016 are publicly available,[13] with data stratified by rurality (urban, suburban, rural, wilderness) since 2009. Finally, patient age was described by sex, ISS, and mechanism of injury across the 3 eras. Since age was not normally distributed, trends were analyzed with nonparametric Jonckheere-Terpstra tests. All analyses were conducted using SAS software, version 9.4 (SAS Institute Inc, Cary, NC).

RESULTS

There were 17,556 total injury events during 2000-2018, and 17,334 events with ISS and injury mechanism among 16,495 patients. There were 261 excluded patients transferred to level I trauma centers: 77 in 2000-2005 (1.7%), 102 in 2006-2012 (1.4%), and 82 in 2013-2018 (1.4%).

There were highly statistically significant distributional differences for sex and age, ISS, and injury mechanism across the 3 eras (Table 1, chi-square P<0.00001 for all characteristics). Notably, there were shifts to lower injury severity, with the proportion of ISS <9 increasing (37.6%, 44.3%, 47.2%, respectively) across the 3 eras and the proportion of ISS >24 decreasing (14.1%, 10.4%, 6.6%, respectively). In contrast, there was not a clear trend in proportion of injuries with ISS >24 from NTDB reports (8.8% in 2004, 5.4% in 2010, and 7.8% in 2016).

Table 2. Fatality Ratios of Marshfield Clinic Health System Trauma Center by Sex, Injury Severity Score, Mechanism of Injury, Calendar Year Eras, and Representative National Trauma Data Bank Reports

Characteristic	Marshfield Clinic Health System Trauma Center			National Trauma Data Base		
	2000–2005	2006–2012	2013–2018	2004	2010	2016
	Fatality Ratio % (95% CI)			Fatality Ratio %		
Overall [a]	5.3 (4.7-6.0)	4.1 (3.7-4.6)	3.9 (3.4-4.4)	4.7	4.0	4.3
Female, 0-14	2.4 (0.8-5.5)	3.4 (1.7-6.1)	1.3 (0.3-3.2)	2.3	1.4	2.0
Female, 15-44	2.6 (1.4-4.3)	1.8 (1.0-3.0)	1.2 (0.4-2.8)	3.1	2.5	2.4
Female, 45-64	3.8 (1.8-6.8)	4.0(2.4-6.3)	2.0 (0.9-3.8)	3.7	2.8	2.8
Female, 65-74 [c]	7.6 (3.3-12.0)	3.8 (1.9-6.9)	2.8 (1.2-5.4)	5.4	3.6	3.3
Female, 75-84	8.6 (5.4-12.9)	5.5 (3.5-8.2)	5.7 (3.6-8.5)	6.4	4.7	4.8
Female, 85+	9.3 (5.7-14.1)	7.0 (4.7-10.0)	7.4 (5.2-10.1)	7.0	5.5	7.0
Male, 0-14	2.4 (1.1-4.5)	2.0 (1.0-3.5)	1.9 (0.9-3.4)	2.2	1.3	2.2
Male, 15-44 [c]	4.1 (3.1-5.3)	2.3 (1.7-3.1)	2.8 (1.9-4.0)	4.3	3.7	3.9
Male, 45-64 [b]	5.2 (3.6-7.2)	4.7 (3.5-6.1)	2.4 (1.5-3.7)	5.2	4.2	4.2
Male, 65-74	7.4 (4.3-11.8)	6.0 (3.7-9.0)	6.2 (4.1-8.8)	8.7	6.7	6.3
Male, 75-84	12.0 (8.0-17.1)	11.5 (8.3-15.3)	10.4 (7.3-14.2)	12.8	10.1	9.4
Male, 85+ [c]	17.1 (10.9-24.9)	10.1 (6.5-15.0)	9.1 (5.7-13.6)	15.0	12.1	12.2
Injury severity score						
< 9	11.0 (0.6-1.6)	1.0 (0.7-1.4)	1.0 (0.7-1.5)	1.0	0.9	1.2
9-15	3.0 (2.2-3.9)	1.8 (1.3-2.5)	2.0 (1.5-2.7)	1.9	2.4	2.7
16-24	5.5 (3.9-7.5)	3.3 (2.3-4.7)	6.6 (4.8-8.6)	6.2	6.6	5.5
> 24 [b]	22.2 (19.1-25.7)	25.6 (22.5-28.9)	29.6 (25.1-34.4)	33.0	30.2	27.6
Mechanism of injury						
Fall [b]	6.2 (5.1-7.5)	4.8 (4.0-5.7)	4.3 (3.6-5.1)	3.9	3.5	4.4
Firearm	27.5 (15.9-41.7)	20.4 (10.2-34.3)	27.5 (15.9-41.7)	16.5	15.8	15.3
Motor vehicle on-road [c]	5.4 (4.4-6.6)	4.4 (3.6-5.3)	3.8 (2.8-4.9)	4.8	4.5	4.6
Other mechanism	3.6 (2.3-5.2)	3.2 (2.2-4.5)	3.3 (2.3-4.8)	2.7	2.1	2.4
Other transport	2.4 (1.2-4.2)	1.4 (0.7-2.5)	1.2 (0.5-2.4)	3.2	2.0	2.3

Test for trend across calendar year era: [a] $P < 0.001$, [b] $P < 0.01$, [c] $P < .05$.

Generally, fatality ratios (FR) from 2004, 2010, and 2016 NTDB reports were within the confidence interval uncertainty of the MCHS fatality ratios across calendar year eras (Table 2). Notable exceptions were ISS > 24, with FR = 22.2% (95% CI, 19.1%-25.7%) in 2000-2005 vs NTDB 2004 FR = 33.0 or FR = 25.6% (95% CI, 22.5%-28.9%) in 2006-2012 vs NTDB 2010 FR = 30.2; and falls with FR = 6.2% (95% CI, 5.1%-7.5%) in 2000-2005 vs NTBD 2004 FR = 3.9% or FR = 4.8% (95% CI, 4.0%-5.7%) in 2006-2012 vs NTDB 2010 FR = 3.5%. While there was large uncertainty in the firearm fatality ratios, the MCHS point estimates (27.5%, 20.4%, and 27.5%) were consistently larger than those from NTDB reports (16.5%, 15.8%, and 15.3%, respectively).

From the NTDB 2010 and 2016 reports,[13] the rural fatality ratios were 3.8% and 4.2%, respectively, and urban fatality ratios were 4.1% and 4.8%, respectively. Both rural and urban fatality ratios were within overall MCHS fatality ratio confidence intervals for the corresponding 2006-2012 and 2013-2018 eras.

In terms of injury mechanisms, the proportion of injuries related to falls increased (35.6%, 40.6%, and 51.5%) and the proportion from on-road motor vehicle events decreased (37.0%, 32.8, and 22.5%) across the eras. The proportions of injury events due to other mechanisms were relatively stable, with few due to firearms (<1.1%). The increasing trend of falls and decreasing trend of on-road motor vehicle injuries were similar from the NTDB reports. In contrast to the MCHS data, the proportion of injuries from firearms was larger, with an apparent decreasing trend (5.4%, 4.7%, and 4.2%) from the NTDB 2004, 2010, and 2016 reports, respectively.

There was a statistically significant decreasing trend in overall fatality ratios across the 2000-2005, 2006-2012, and 2013-2018 intervals: 5.3% (95% CI, 4.7%-6.0%), 4.1% (95% CI, 3.7%-4.6%), and 3.9 (95% CI, 3.4%-4.4%), respectively (Cochran-Armitage exact test-for-trend, 2-sided $P < 0.001$). Injuries due to falls also had a significant decreasing trend in fatality ratios: 6.2%, 4.8%, and 4.3%, respectively (test-for-trend, $P < 0.01$). The highest fatality ratios were patients with ISS > 24 (22.2%, 25.6%, 29.6%, $P < 0.01$ test for trend across year eras) or patients with injuries caused by firearms (27.5%, 20.4, 27.5%, test-for-trend, $P = 1$) (Table 2).

The median patient age at admission increased significantly from 42 years in 2000-2005, to 45 years in 2006-2012, and 55 years in 2013-2018, respectively (Table 3, test for trend $P < 0.0001$). Age trends were consistently increasing for patient sex ($P < 0.0001$), ISS ($P < 0.05$) and fall ($P < 0.0001$) or on-road motor vehicle ($P < 0.01$) mechanisms. Patient ages were essentially the same across calendar year eras for other injury mechanisms.

DISCUSSION

For over 50 years, there has been an organized medical response to traumatic injuries among residents of rural north-central Wisconsin. Since 2000, there are reliable data on characteristics of traumatic injuries and associated deaths from the trauma registry maintained at the MCHS level II trauma center in Marshfield, Wisconsin. Long-term trends of traumatic injury and mortality at the MCHS trauma center were generally similar to national trends from NTDB reports,[13] particularly in increasing proportion of injury events from older patients and injuries due to falls. This is also consistent with population-based injury statistics. While motor vehicle death rates have steadily decreased, the age-adjusted death rate from unintentional falls has increased an average of 3% annually from 1997 to 2017.[10]

The overall fatality ratio at the MCHS trauma center was

essentially similar to national-based ratios overall or for ratios aggregated from rural or urban trauma centers. This suggests that standards of trauma care are similar across various trauma center levels and the areas they are located. This points to the success of continual improvements in modern trauma care systems in the US.

The proportions of injuries from firearms were low and the firearm-related fatality ratios were higher at the MCHS trauma center compared to the NTDB reports. Although this needs further investigation, it is possible that a majority of patients with firearm injuries were immediate deaths at the scene or were transferred to level I centers. Neither of these events would have been captured in the MCHS level II trauma registry. Rural Wisconsin firearm injuries are also more likely from high-powered rifles and shotguns compared to urban areas,[14] leading to a lower comparative survival.

The proportion of patients with the most severe injuries (ISS >24) declined from 14.1% in 2000-2005 to 6.6% in 2013-2018, but the fatality ratio increased from 22.2% to 29.6%, respectively. This is not reflected in national data. A variety of factors could contribute to this observation, including age and comorbidities of injured patients, as well as improvements in prehospital care that allow more patients with severe injury to survive long enough to be admitted to a trauma center.

This study has several limitations. It provides only a partial description of mortality because data were not available for patients who died at the scene of injury. Historically, most patients with severe injuries died at the scene.[15] With the development of modern emergency medical services, more patients can survive during the prehospital phase. However, according to a recent population-based study in California,[9] the majority of injured rural trauma patients die at the scene compared to a minority of urban trauma patients. An additional limitation is loss to follow-up after the recorded discharge date in trauma registries. Some trauma-related deaths can occur several months after discharge. These limitations are inherent in any study based only on trauma registry data.[16,17]

These limitations can be overcome by a future population-based analysis of injuries within the Marshfield Epidemiologic Study Area (MESA)[18,19] combined with death certificate information. This study, along with the present analysis of MCHS trauma registry data, could provide key insights in improving the outcomes of traumatic injury among rural and small-town residents.

CONCLUSION

Long-term trends of traumatic injuries and mortality were generally similar to national trends, particularly in the shift to older patients and in the increasing proportion of injury events due to falls. Further research on traumatic injuries and deaths in rural populations is needed, particularly regarding immediate deaths at the scene and longer-term deaths after discharge.

Table 3. Median Patient Age (Interquartile Range) in Years by Sex, Injury Severity Score, Mechanism of Injury, and Calendar Year Era at the Marshfield Clinic Health System Trauma Center

Characteristic	2000–2005	2006–2012	2013–2018
Overall [a]	42 (21–65)	45 (22–69)	55 (24–75)
Sex			
Female [a]	50 (21–78)	55 (24–80)	64 (30–83)
Male [a]	39 (21–57)	41 (21–60)	49 (22–68)
Injury severity score			
<9 [a]	39 (20–61)	40 (20–65)	48 (19–71)
9–15 [a]	44 (23–70)	50 (24–74)	61 (32–79)
16–24 [a]	43 (21–67)	48 (25–66)	57 (31–73)
>24 [c]	41 (21–61)	47 (24–64)	54 (28–72)
Mechanism of injury			
Fall [a]	66 (41–82)	68 (43–82)	71 (53–84)
Firearm	32 (21–52)	37 (23–47)	28 (18–49)
Motor vehicle on-road [b]	34 (21–51)	34 (21–53)	37 (22–58)
Other mechanism	32 (15–49)	33 (16–51)	28 (12–53)
Other transport [a]	27 (16–42)	30 (17–48)	37 (16–54)

Test for trend across calendar year era: [a] $P<0.001$, [b] $P<0.01$, [c] $P<.05$.

Acknowledgments: The authors would like to acknowledge the following individuals: Brian Hoerneman, MD, Marshfield Medical Center; Deborah Gojmerac, BSN, RN, CSTR, Trauma Center, Marshfield Medical Center; Judith Hase, Erik Kronholm, Jennifer King, MPH, Oluwatosin Olaiya, MBChB, MSc, Edward Belongia, MD, Center for Clinical Epidemiology Population Health, Marshfield Clinic Research Institute.

Financial Disclosures: None declared.

Funding/Support: Funding for this study was provided by contributors to the Marshfield Clinic Research Institute.

REFERENCES

1. Rotondo MF, Cribari C, Smith RS, eds. Trauma registry. In: Rotondo MF, Cribari C, Smith RS, eds. *Resources for Optimal Care of the Injured Patient. American College of Surgeons;* 2014:107-113. Accessed June 15, 2020. https://www.facs.org/-/media/files/quality-programs/trauma/vrc-resources/resources-for-optimal-care.ashx

2. Bardes JM, Inaba K, Schellenberg M, et al. The contemporary timing of trauma deaths. *J Trauma Acute Care Surg*. 2018;84(6):893-899. doi:10.1097/TA.0000000000001882

3. Oyeniyi BT, Fox EE, Scerbo M, Tomasek JS, Wade CE, Holcomb JB. Trends in 1029 trauma deaths at a level 1 trauma center: impact of a bleeding control bundle of care. *Injury*. 2017;48(1):5-12. doi:10.1016/j.injury.2016.10.037

4. Callcut RA, Kornblith LZ, Conroy AS, Robles AJ, et al. The why and how our trauma patients die: a prospective Multicenter Western Trauma Association study. *J Trauma Acute Care Surg.* 2019 May;86(5):864-870. doi: 10.1097/TA.0000000000002205

5. Khorgami Z, Fleischer WJ, Chen YA, Mushtaq N, et al. Ten-year trends in traumatic injury mechanisms and outcomes: a trauma registry analysis. *Am J Surg.* 2018;215(4):727-734. doi: 10.1016/j.amjsurg.2018.01.008

6. Rogers FB, Shackford SR, Hoyt DB, et al. Trauma deaths in a mature urban vs rural trauma system. A comparison. *Arch Surg.* 1997;132(4):376-382. doi:10.1001/archsurg.1997.014302800500077

7. Peek-Asa C, Zwerling C, Stallones L. Acute traumatic injuries in rural populations. *Am J Public Health.* 2004;94(10):1689-1693. doi:10.2105/ajph.94.10.1689

8. Jarman MP, Castillo RC, Carlini AR, Kodadek LM, Haider AH. Rural risk: geographic disparities in trauma mortality. *Surgery*. 2016;160(6):1551-1559. doi:10.1016/j.surg.2016.06.020

9. Newgard CD, Fu R, Bulger E, et al. Evaluation of rural vs urban trauma patients served by 9-1-1 emergency medical services. *JAMA Surg.* 2017;152(1):11-18. doi:10.1001/jamasurg.2016.3329

10. Olaisen RH, Rossen LM, Warner M, Anderson RN. Unintentional injury death rates in rural and urban areas: United States, 1999-2017. *NCHS Data Brief.* 2019 Jul;(343):1-8. Accessed June 15, 2020. https://www.cdc.gov/nchs/data/databriefs/db343-h.pdf

11. Farrington JD. Death in a ditch. 1967. *Bull Am Coll Surg*. 2013;98(6):44-53.

12. Wisconsin Department of Health Services. Wisconsin trauma care registry. Updated June 29, 2021. Accessed August 5, 2020. https://www.dhs.wisconsin.gov/trauma/registry.htm

13. American College of Surgeons. National trauma data bank. Updated July 2018 Accessed August 5, 2019. https://www.facs.org/quality-programs/trauma/tqp/center-programs/ntdb/docpub

14. Dodge GG, Cogbill TH, Miller GJ, Landercasper J, Strutt PJ. Gunshot wounds: 10-year experience of a rural, referral trauma center. *Am Surg*. 1994 Jun;60(6):401-404.

15. Sobrino J, Shafi S. Timing and causes of death after injuries. *Proc (Bayl Univ Med Cent)*. 2013;26(2):120-123. doi:10.1080/08998280.2013.11928934

16. Moore L, Clark DE. The value of trauma registries. *Injury*. 2008;39(6):686-695. doi:10.1016/j.injury.2008.02.023

17. Zehtabchi S, Nishijima DK, McKay MP, Mann NC. Trauma registries: history, logistics, limitations, and contributions to emergency medicine research. *Acad Emerg Med.* 2011;18(6):637-643. doi:10.1111/j.1553-2712.2011.01083.x

18. Greenlee RT. Measuring disease frequency in the Marshfield Epidemiologic Study Area (MESA). *Clin Med Res.* 2003;1(4):273-280. doi:10.3121/cmr.1.4.273

19. Kieke AL, Kieke BA Jr, Kopitzke SL, McClure DL, et al. Validation of health event capture in the Marshfield Epidemiologic Study Area. *Clin Med Res.* 2015 Dec;13(3-4):103-111. doi: 10.3121/cmr.2014.1246

advancing the art & science of medicine in the midwest

WMJ

WMJ (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

Visit www.wmjonline.org to learn more.