Curr Trauma Rep (2017) 3:1–7
DOI 10.1007/s40719-017-0073-3

GERIATRIC TRAUMA (F LUCHETTE, SECTION EDITOR)

Changing Epidemiology of Injury in the USA

Karen Brasel[1]

Published online: 19 January 2017

Abstract
Purpose of Review The aging population of the injured has had a profound effect on injury epidemiology.
Recent Findings A recent analysis demonstrates that outcomes in the geriatric population are improved in centers that treat a higher number of elderly trauma patients.
Summary To better prevent injuries and manage their population of patients, trauma care providers must concern themselves not only with understanding the overall rates of injury and admissions but also the likelihood that elderly patients will be admitted in greater numbers as well as make up a greater proportion of trauma admissions.

Keywords Epidemiology · Falls · Suicide · Trauma prevention

Introduction

The population of the USA is aging. In 2010, people aged 65 years and older comprised 13% of the population; that proportion reached 15% in 2015 and is estimated to reach 22% by 2020 and 25% by 2060 [1]. An increasing life expectancy with increasingly healthy elderly patients contributes to a greater number of injured elderly seen at trauma centers and nontrauma centers alike.

This article is part of the Topical Collection on *Geriatric Trauma*

✉ Karen Brasel
kbrasel83@gmail.com

[1] Division of Trauma, Critical Care & Acute Care Surgery, Oregon Health & Science University, 3181 S.W. Sam Jackson Park Road, Mail Code: L223, Portland, OR 97239, USA

This change in demographics has had a profound effect on injury epidemiology. We often think of epidemiology in terms of demographics, but the complete definition is that epidemiology is concerned with the incidence, distribution, and control of disease both in terms of prevention and mitigation. Thus, in order to better prevent and manage their population of patients, trauma care providers must concern themselves not only with understanding the overall rates of injury and admissions but also the likelihood that elderly patients will be admitted in greater absolute numbers as well as make up a greater proportion of trauma admissions.

Where Do the Data Come From?

In order to discuss epidemiologic phenomena, it is critical to understand the source of the epidemiologic data. This is a unique problem when discussing the injured elderly, as they are much more likely than younger patients to be treated at nontrauma centers. Recent data using the Nationwide Emergency Department Sample suggest that >50% of elderly patients with traumatic injury are not treated at trauma centers [2]. While that may have implications for care, it certainly has implications for understanding injury epidemiology, in that the majority of these patients are not described in the most common sources used by trauma practitioners and researchers.

One of the best sources of comparative epidemiologic data for hospitalized injured patients is the National Trauma Data Bank [3, 4]. This registry, operated by the American College of Surgeons, contains information from trauma centers throughout the USA. The number of centers contributing data has increased over time, from 405 in 2003 to 746 in 2014, and the annual number of submitted records has increased from 394,414 in 2003 to 860,964 in 2014. Although there has been

some change in the NTDB inclusion criteria as well as their methods of analysis, there is still good information available about the change in injury epidemiology that has occurred over the last 10 years. TQIP, the trauma quality improvement project based on data from the NTDB, provides risk-adjusted information to participating trauma centers which is used to improve their performance over time. It does not provide publically available epidemiologic information.

Another excellent source of injury information is WISQARS, the Centers for Disease Control's Web-based Injury Statistics Query and Reporting System [5•]. This website gives information about fatal and nonfatal injuries by mechanism, age, and region.

Change in Distribution and Mechanism of Injury

The NTDB data demonstrate the striking increase in the percentage of hospitalized elderly trauma patients >65 years of age, by decade (Table 1) [3, 4]. Data from WISQARS demonstrate the increase in the absolute number of both fatal and nonfatal injuries seen in the USA (Table 2) [5•].

Motor Vehicle Collisions

The increase in the geriatric population results in an increase in the number of licensed older drivers; in 2012, there were almost 36 million licensed older drivers, a 34% increase from 1999. Per mile traveled, fatal crash rates begin to increase starting at age 70 and are highest among drivers age 85 and older. Elderly drivers are more likely to use seatbelts, drive during the day, and are less likely to drive while impaired [6]. As a result, despite their higher crash fatality rate, due to overall improvements in driver safety, there has been steady overall improvement in the death rates per 100,000 older drivers since the mid-1990s (Fig. 4) [7].

Falls

In the USA, one in five people over the age of 65 will sustain a fall annually. Of these, about one quarter will be injured and another quarter will restrict their daily activities for fear of another fall. Falls account for nearly 60% of injury-related ED visits and approximately 80% of injury-related hospitalizations for persons age 65 years and older. One of the big changes in epidemiology related to falls over the last decade has been the increasing awareness of the importance of ground level falls. Once excluded from registry data, it is now understood that 86% of falls are ground-level, and it is patient age rather than fall height that is the determinant of outcome. Falls have overtaken all other causes of injury death in the entire population >65; the death rate for those >85 is over three times that for people age 75–84. As the number of people in the oldest age groups increases, the imperative for fall prevention programs becomes even greater. Despite the widespread acknowledgement of the problem of geriatric trauma, well-established fall prevention programs exist in a minority of communities [8•].

Table 1 Percentage of elderly patients in the National Trauma Data Bank by decade, 2004 compared to 2014

	2004	2014
65–74	5.62	9.78
75–84	6.88	10.30
>84	2.80	9.65

Table 2 Comparison of fatal and nonfatal injuries by age, 2004 vs 2014

	Fatal injuries		Nonfatal injuries	
	2004	2014	2004	2014
65–69	5308	8956	588,604	1,018,516
70–74	5697	7902	538,109	813,767
75–79	7310	8134	580,057	708,635
80–84	8694	9514	563,860	676,241
>84	14,431	22,904	695,886	1,135,292

Suicide

Suicide rates increase with age, peaking for men in the age group >85. For women who attempt suicide more often but are less successful than men, the peak age is 45–64. With the increasing population of elderly, the absolute number of successful and unsuccessful suicide attempts continues to increase. One of the issues in dealing with suicide prevention in the elderly is that risk factors present in younger patients who attempt suicide may not be present in the elderly, making standard screening tools much less effective [9]. Given the common interactions of elderly patients with the trauma system, this presents a unique opportunity to screen for this preventable disease.

Mortality

Injury continues to be an important cause of mortality for all ages, as the leading cause of death from age 1–44, and the 4th leading cause of death in all ages (Fig. 1) [10] (CDC ref). When considering death due to injury in those >65, the top three causes are falls, motor vehicle collisions, and suicide (Fig. 2). Compared to those younger than 65, the elderly have

10 Leading Causes of Death by Age Group, United States – 2014

	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	Total
1	Congenital Anomalies 4,746	Unintentional Injury 1,216	Unintentional Injury 730	Unintentional Injury 750	Unintentional Injury 11,836	Unintentional Injury 17,357	Unintentional Injury 16,048	Malignant Neoplasms 44,834	Malignant Neoplasms 115,282	Heart Disease 489,722	Heart Disease 614,348
2	Short Gestation 4,173	Congenital Anomalies 399	Malignant Neoplasms 436	Suicide 425	Suicide 5,079	Suicide 6,569	Malignant Neoplasms 11,267	Heart Disease 34,791	Heart Disease 74,473	Malignant Neoplasms 413,885	Malignant Neoplasms 591,699
3	Maternal Pregnancy Comp. 1,574	Homicide 364	Congenital Anomalies 192	Malignant Neoplasms 416	Homicide 4,144	Homicide 4,159	Heart Disease 10,368	Unintentional Injury 20,610	Unintentional Injury 18,030	Chronic Low. Respiratory Disease 124,693	Chronic Low. Respiratory Disease 147,101
4	SIDS 1,545	Malignant Neoplasms 321	Homicide 123	Congenital Anomalies 156	Malignant Neoplasms 1,569	Malignant Neoplasms 3,624	Suicide 6,706	Suicide 8,767	Chronic Low. Respiratory Disease 16,492	Cerebro-vascular 113,308	Unintentional Injury 136,053
5	Unintentional Injury 1,161	Heart Disease 149	Heart Disease 69	Homicide 156	Heart Disease 953	Heart Disease 3,341	Homicide 2,588	Liver Disease 8,627	Diabetes Mellitus 13,342	Alzheimer's Disease 92,604	Cerebro-vascular 133,103
6	Placenta Cord. Membranes 965	Influenza & Pneumonia 109	Chronic Low. Respiratory Disease 68	Heart Disease 122	Congenital Anomalies 377	Liver Disease 725	Liver Disease 2,582	Diabetes Mellitus 6,062	Liver Disease 12,792	Diabetes Mellitus 54,161	Alzheimer's Disease 93,541
7	Bacterial Sepsis 544	Chronic Low Respiratory Disease 53	Influenza & Pneumonia 57	Chronic Low Respiratory Disease 71	Influenza & Pneumonia 199	Diabetes Mellitus 709	Diabetes Mellitus 1,999	Cerebro-vascular 5,349	Cerebro-vascular 11,727	Unintentional Injury 48,295	Diabetes Mellitus 76,488
8	Respiratory Distress 460	Septicemia 53	Cerebro-vascular 45	Cerebro-vascular 43	Diabetes Mellitus 181	HIV 583	Cerebro-vascular 1,745	Chronic Low. Respiratory Disease 4,402	Suicide 7,527	Influenza & Pneumonia 44,836	Influenza & Pneumonia 55,227
9	Circulatory System Disease 444	Benign Neoplasms 38	Benign Neoplasms 36	Influenza & Pneumonia 41	Chronic Low Respiratory Disease 178	Cerebro-vascular 579	HIV 1,174	Influenza & Pneumonia 2,731	Septicemia 5,709	Nephritis 39,957	Nephritis 48,146
10	Neonatal Hemorrhage 441	Perinatal Period 38	Septicemia 33	Benign Neoplasms 38	Cerebro-vascular 177	Influenza & Pneumonia 549	Influenza & Pneumonia 1,125	Septicemia 2,514	Influenza & Pneumonia 5,390	Septicemia 29,124	Suicide 42,773

Data Source: National Vital Statistics System, National Center for Health Statistics, CDC.
Produced by: National Center for Injury Prevention and Control, CDC using WISQARS™.

Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

Fig. 1 Top ten leading causes of death by age 2014 (courtesy of CDC)

a higher case-fatality rate regardless of mechanism due to comorbid conditions, frailty, and undertriage [2].

Falls have overtaken all other causes of injury death in the entire population >65; the death rate for those >85 is over three times that for people age 75–84. Death rates due to falls are regional, with several neighboring states having disparate adjusted mortality rates (Fig. 3). There are several potential reasons for this, including data capture and statewide fall prevention programs.

One of the difficulties with mortality statistics is the definition of death (Fig. 4). Although this would seem to be fairly straightforward, different data sources define dead on arrival to the hospital differently. There is variability in the use and availability of palliative care and hospice, along with different contributions of hospice discharge to overall mortality statistics. For an individual patient, this is quite unimportant, but from an epidemiologic standpoint, it is important to have standard definitions. Standardizing these definitions in order to better understand mortality in the injured elderly is one of the top recommendations from the American Association for the Surgery of Trauma's Geriatric Trauma Committee [8•].

Understanding of Prognosis and Discharge Disposition

Discussion about prognosis is an important part of care for trauma patients of any age, but arguably of even greater importance in the elderly. There are several challenges inherent in these discussions, with one of the greatest being the lack of accurate prognostic tools. The NSQIP surgical risk calculator, which provides information for geriatric patients undergoing elective surgical operations, is of limited to no use in trauma. Phelan et al. have come up with a new tool, the Geriatric Trauma Outcomes Score (GTOS), which can be used to predict in-hospital mortality for injured elderly patients with variables that are available in the first 24 h [11•]. It is the hope that the availability of tools such as this can help inform prognostic discussions and provide goal-concordant care.

Mortality is one important aspect of prognosis, but of equal and perhaps greater importance to the elderly is discharge disposition. The increased emphasis on decreasing length of stay for all diagnoses has led to an increased reliance on non-home discharges, particularly in the elderly population.

Fig. 2 Top ten leading causes of injury death by age, 2014 (courtesy of CDC)

Davidson et al. have shown in a trauma population in the Washington State that discharge to a skilled nursing facility (SNF) was associated with a 1.5-fold increase in mortality. Over a 14-year period ending in 2009, in-hospital mortality improved from 8 to 4.9%, while long-term cumulative mortality increased from 4.7 to 7.4%. Importantly, those discharged to an inpatient rehabilitation facility (IRF) did not have the same increased mortality as those discharged to a skilled nursing facility [12•].

The GTOS can also be used to predict discharge disposition, although it does so with less accuracy than predicting in-hospital mortality. Unfortunately, it appears that elderly trauma patients are becoming less likely to be discharged to an inpatient rehabilitation facility and more likely to be discharged to a skilled nursing facility. In a retrospective cohort study of trauma admissions from the National Trauma Data Bank National Sample Program from 2003 to 2009, the proportion of patients discharged to an SNF increased from 30.7 to 40.8% but decreased for those discharged to an IRF (25.9 to 15.6%) [13•]. Where our elderly patients go after discharge is critical to improving both mortality, quality of life, and prognostic information we give our elderly patients and their families. Better understanding of whether determinants of discharge are patient or system related will help us understand how to best interpret these data.

Frailty

Age is an easy thing to measure and to capture in data reports with minimal data collection burden. However, it is becoming increasingly evident that it is not just age that contributes to injury patterns and outcomes, but frailty. Frailty is a syndrome of decreased physiological reserve and resistance to stressors and as such is extremely difficult to capture without significant data collection burden. Joseph et al. have developed a trauma-specific frailty score that is predictive of outcome and relatively easy to use, provided that the information required has already been captured. However, much of the information required (help with toileting, help managing money, health attitude) is not captured routinely and so the tool cannot be used unless the questions are asked routinely on admission

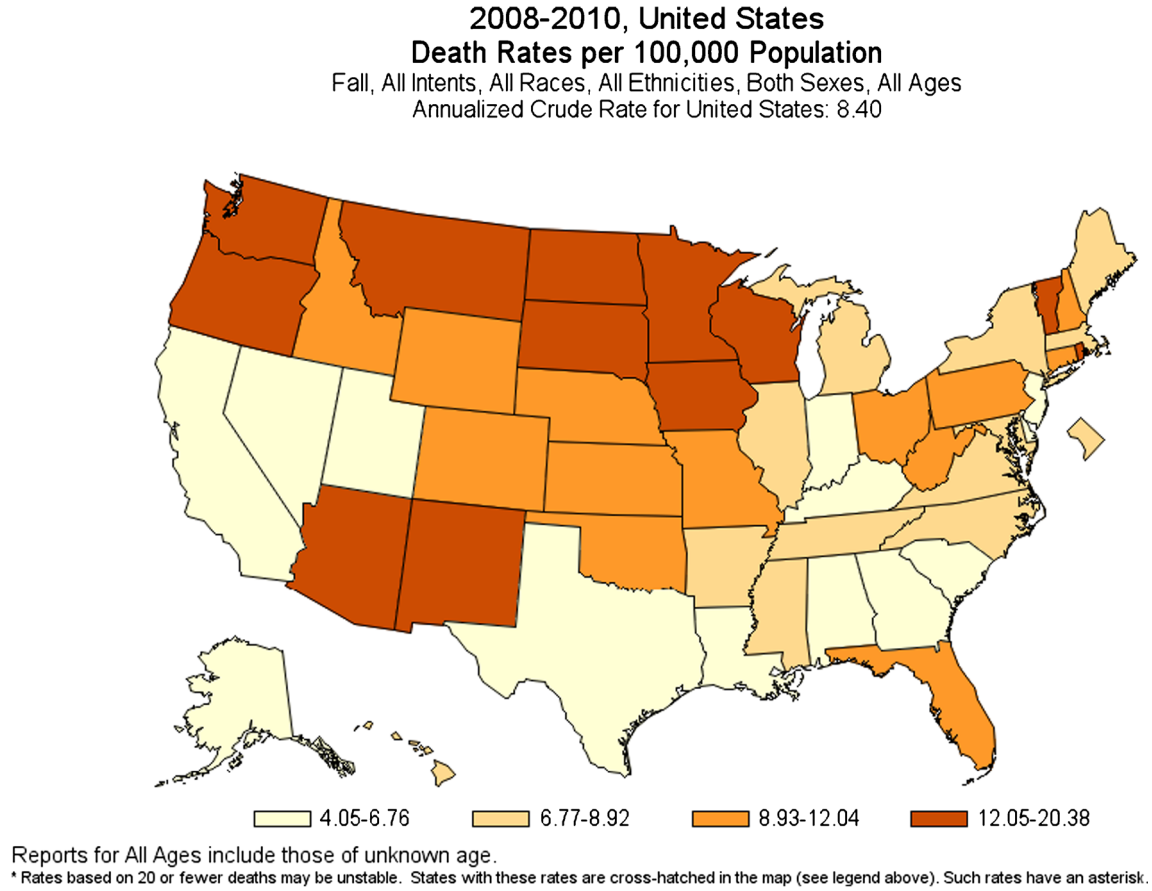

Fig. 3 Mortality rate due to falls by state, 2008–2010 (courtesy of CDC)

[14]. The tools used by Maxwell investigating frailty similarly require in-person questionnaires to be used [15].

Due to the difficulties in data collection, it is not likely that frailty will ever replace age in epidemiologic studies. That does not mean it is not important—epidemiologic information is information about populations of patients, and age can serve to provide information that is helpful for looking at trends over time, comparing broad age categories, and informing injury prevention programs. Frailty is much more likely to be helpful in determining an individual patient's prognosis and for investigating potential interventions that may be effective in altering the course of disease.

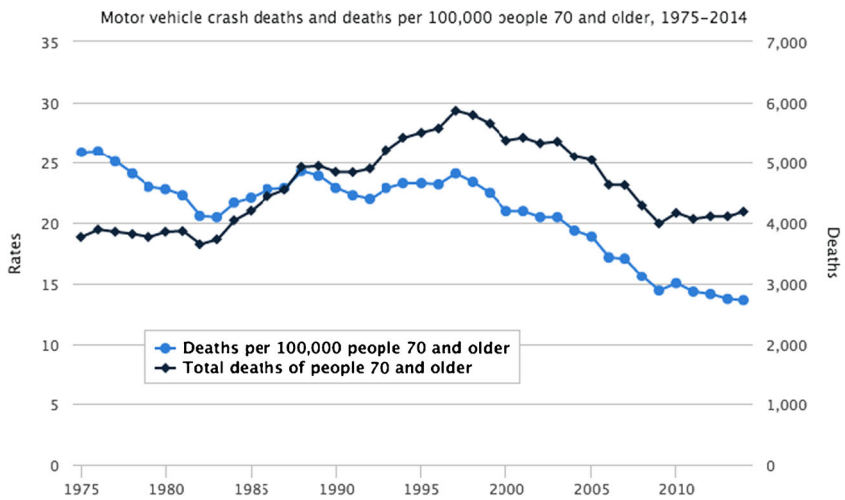

Fig. 4 Motor vehicle crash deaths and deaths per 100,000 people 70 and older, 1975–2014

Conclusion

Trauma surgeons clearly recognize the increasing problem of geriatric trauma [8•]. A better understanding of the impact of the problem and the specific epidemiologic patterns that exist at local, regional, and national levels should help drive trauma care practitioners to address the problem and improve outcome. Some of the suggestions include addressing geriatric triage criteria, using of geriatric-specific protocols and workforce, and working collaboratively to improve care post-discharge [8•]. Other suggestions include establishing centers of excellence for geriatric trauma care. Although the sheer volume of geriatric trauma makes this impractical as the sole solution, a recent analysis demonstrates that outcomes in the geriatric population are improved in centers that treat a higher number of elderly trauma patients. Interestingly, the majority of the centers in this NTDB-based analysis were level 2 centers, suggesting there may be best practices that can be learned from these higher-performing centers [16•].

Compliance with Ethical Standards

Conflict of Interest Dr. Brasel declares no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by the author.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance

1. U.S. Census Bureau. 2014 national population projections summary tables. Table 6: percent distribution of the projected population by sex and selected age groups for the U.S.: 2015 to 2060. Available at www.census.gov/population/projections/data/national/2014/summarytables.html. Accessed 31 Oct 2016.
2. Kodadek LM, Selvarajah S, Velopulos CG, Haut ER, Haider AH. Undertriage of older trauma patients: is this a national phenomenon? J Surg Res. 2015;199:220–9.
3. Fildes JJ. National Trauma Data Bank Report 2004. Accessed 16 Oct 2016.
4. Nance ML. National Trauma Data Bank Report 2014. Accessed 16 Oct 2016.
5.• Web-based injury statistics query and reporting system, injury center, centers for disease control. https://www.cdc.gov/injury/wisqars/ Accessed 1 Dec 2016. **An interactive website of all fatal and nonfatal injuries that reports a large amount of demographic information and can be sorted by age, mechanism of injury, year, and state. Output can be in customizable tables or regional maps. There is not a great level of detail, but it is the most complete population-based injury data available and is extremely easy to access and use**.
6. Injury prevention and control: motor vehicle safety, older adult drivers. http://www.cdc.gov/motorvehiclesafety/older_adult_drivers/ Accessed 1 Dec 2016.
7. Insurance institute for highway safety: older drivers. http://www.iihs.org/iihs/topics/t/older-drivers/fatalityfacts/older-people Accessed 1 Dec 2016.
8.• Kozar RA, Arbabi S, Stein DM, et al. Injury in the aged: geriatric trauma care at the crossroads. J Trauma Acute Care Surg. 2015;78:1197–209. **A white paper summary that presents data from two surveys administered by the American Association for the Surgery of Trauma's Geriatric Trauma Committee. The survey addressed the AAST members' definition of geriatric trauma, epidemiologic knowledge, geriatric trauma resources, clinical interest, and strategies for improving geriatric care. It highlights the gap in knowledge and practice, and the opportunities that exist for improving geriatric care. Several, including fall prevention initiatives, are remarkably uncomplicated and require the implementation of current programs that have been proven effective**.
9. Huh JT, Weaver CM, Martin JL, Caskey NH, O'Riley A, Kramer BJ. Effects of a late-life suicide risk—assessment training on multidisciplinary healthcare providers. J Am Geriatr Soc. 2012;60:775–80.
10. Top ten causes of injury. http://www.cdc.gov/injury/wisqars/leadingcauses.html. Accessed 1 Dec 2016.
11.• Cook AC, Joseph B, Inaba K, et al. Multicenter external validation of the geriatric trauma outcome score: a study by the Prognostic Assessment of Life and Limitations after Trauma in the Elderly (PALLIATE) consortium. J Trauma Acute Care Surg. 2016;80:204–9. **Validation of the Geriatric Trauma Outcomes score, the first tool that provides specific individual prognostic information for geriatric trauma patients. The tool incorporates age, ISS, and transfusions within the first 24 h using data from 4 level I trauma centers. This model predicts the likelihood of in-hospital mortality with a high degree of accuracy, AUC 0.86. This information can be used to guide prognostic discussions with elderly patients and their families**.
12.• Davidson GH, Hamlat CA, Rivara FP, Koepsell TD, Jurkovich GJ, Arbabi S. Long-term survival of adult trauma patients. JAMA. 2011;305(10):1001–7. **A retrospective cohort study of 124,421 injured adult patients during January 1995 to December 2008 using the Washington State Trauma Registry linked to death certificate data. Among adults admitted for trauma in the Washington State, 3-year cumulative mortality was 16% despite a decline in in-hospital deaths. Discharge to a skilled nursing facility at any age following trauma admission was associated with a higher risk of subsequent mortality, while discharge to an inpatient rehabilitation facility was not associated with an increased mortality risk**.
13.• Ayoung-Chee P, Rivara FP, Weiser T, Maier RV, Arbabi S. Beyond the hospital doors: improving long-term outcomes for elderly trauma patients. J Trauma Acute Care Surg. 2015;78:837–43. **An extremely interesting analysis of the National Trauma Data Bank's National Sample Project and the Nationwide Inpatient Sample, comparing discharge disposition and outcome of elderly trauma patients to elderly patients suffering a stroke. From the period 2003–2009, the proportion of trauma patients discharged to skilled nursing facilities increased from 31 to 41%, while the proportion discharged to inpatient rehabilitation centers decreased from 26 to 16%. Given the previous data from the same group (Davidson, et al, JAMA 2010 above) demonstrating an increased mortality for elderly trauma patients discharged to a skilled nursing facility, this is a disturbing trend**.
14. Joseph B, Pandit V, Zangbar B, et al. Superiority of frailty over age in predicting outcomes among geriatric trauma patients: a prospective analysis. JAMA Surg. 2014;149:769–72.

15. Maxwell CA, Mion LC, Mukherjee K, Dietrich MS, Minnick A, May A, et al. Preinjury physical frailty and cognitive impairment among geriatric trauma patients determine postinjury functional recovery and survival. J Trauma Acute Care Surg. 2016;80:195–203.

16.• Zafar SN, Obirieze A, Schneider EB, et al. Outcomes of trauma care at centers treating a higher proportion of older patients: the case for geriatric trauma centers. J Trauma Acute Care Surg. 2015;78: 852–9. **An NTDB analysis of level I and level II trauma centers treating 500 patients or more demonstrating an expected higher mortality in elderly patients (odds ratio 4.2, 95% CI 3.99–4.50) an a lower mortality in patients treated at centers with a higher volume of patients >65. Odds ratio for mortality at higher volume centers was 0.66, 95% CI 0.54–0.81. Interestingly and unexpectedly, these centers were more likely to be level II centers (odds ratio 1.15, 95% CI 1.05–1.25)**.