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Comparison of injury mortality risk in motor vehicle crash versus other etiologies

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ABSTRACT

The mortality risk ratio (MRR), a measure of the proportion of people who died that sustained a given injury, is reported to be among the most powerful discriminators of mortality following trauma. The primary aim was to determine whether mechanistic differences exist and are quantifiable when comparing MRR-based injury severity across two broadly defined etiologies (motor vehicle crash (MVC) versus non-MVC) for the clarification of important injury types that have some room for improvement by emergency treatment and vehicle design. All International Classification of Diseases, 9th revision (ICD-9) coded injuries in the National Trauma Data Bank (NTDB) database were stratified into MVC and non-MVC groups and the MRR for each injury was computed within each group. Injuries were classified as 11 different types for MRR comparison between etiologies. Overall, MRRs for specific injuries were 10–18% lower for MVC compared to non-MVC etiologies. MVCs however produced much higher mean MRRs for crushing injuries (0.184 versus 0.072) and internal injuries to the thorax, abdomen, and pelvis (0.200 versus 0.169). Non-MVCs produced much higher MRRs for intracranial injuries (0.199 versus 0.250). Analysis of the top 95% most frequent MVC injuries revealed higher MVC MRR values for 78% of the injuries with MRR ratios indicating an average 50% increase in a given injury's MRR when MVC was the etiology. Addressing the large differences in MRR in between etiologies for identical injuries could provide a reduction in fatalities and may be important to patient triage and vehicle safety design.

1. Introduction

After decades of research, the estimation of specific injury effects on mortality following trauma is well understood and quantifiable. Evidence-based scores are now available for injuries from different lexicons including the Abbreviated Injury Scale (AIS) and the International Classification of Diseases, 9th revision (ICD-9) (National Center for Health Statistics and Centers for Medicare & Medicaid Services 2001, Association for the Advancement of Automotive Medicine, 2008). The mortality associated with injuries can be measured using mortality risk ratios (MRRs), the probabilistic complement of survival risk ratios (SRR) first proposed by Osler et al. (1996). The MRR for an injury is both lexicon- and database-specific. MRRs/SRRs have been calculated for both major trauma coding systems (AIS and ICD-9), and several data sources including the National Trauma Data Bank (NTDB) (Osler et al., 1996, Meredith et al., 2002; Kilgo et al., 2003; Meredith et al., 2003; Weaver et al., 2013). An injury's MRR estimate is the quotient of the number of people who sustain the injury (the denominator) and the number of people with the injury who died (the numerator). MRR and MRR-based scores have consistently been reported to be among the most powerful discriminators of mortality following trauma (Sacco et al., 1999; Meredith et al., 2002).

These scores have been validated using diverse data sources including the NTDB, the Crash Injury Research and Engineering Network (CIREN), the National Automotive Sampling System (NASS), and others (American College of Surgeons, 2008; National Highway

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Traffic Safety Administration, 2011, 2012). Because trauma is unplanned and thus not "elective" or "controlled" in the manner of many other clinical arenas, injury estimation is very challenging, as are the risk adjustment methods required for inferences (Iezzoni, 2003).

One of these challenges concerns estimation across different mechanisms of injury. Despite injury scoring advancements, little research has focused on whether injury-specific estimates substantially vary across mechanisms of injury, though this was considered in the development of the Trauma and Injury Severity Score (TRISS) (Copes et al., 1990; Kilgo et al., 2006). Injury mechanisms can be generally classified as blunt or penetrating, with penetrating injuries known to have worse morbidity and mortality (Peek-Asa et al., 2001; Rhee et al., 2006; Gad et al., 2012). Additionally, investigations of injury mechanisms and thresholds have been studied in specific body regions, (Cox et al., 1999; Peek-Asa et al., 2001; Stitzel et al., 2004, 2008, 2010; Rhee et al., 2006; Kemper et al., 2009, 2011; Duma et al., 2011; Urban et al., 2012; Weaver et al., 2012a,b) as well as for pedestrians, motorcyclists, and MVC occupants (Mackay, 1992, Schneider et al., 2011).

The primary aim of this study was to determine whether mechanistic differences exist and are quantifiable when estimating MRR-based injury severity across two broadly defined etiologies (MVC versus non-MVC).

2. Materials and methods

2.1. Subjects and sample

The NTDB, a data registry sponsored and maintained by the American College of Surgeons (ACS) was examined for trauma cases with at least one ICD-9 code in the range from 800.0 to 959.9 that indicated an injury (National Center for Health Statistics and Centers for Medicare & Medicaid Services 2001). Patients who had late effects (905–909), foreign bodies (930–939), burns (940–949) and traumatic complications (958–959) were excluded from consideration. NTDB cases collected between 2002 and 2008 were subset for analysis.

The sample collected from the NTDB for this study is a convenience sample. In 2008, the NTDB collected trauma records from 567 different hospitals, including 186 Level I trauma centers, 192 Level II centers, and 146 Level III/IV centers. These represent 94%, 77% and 17% of all centers with these designations, respectively. Thus, the database is disproportionately represented by larger trauma centers and thus more severe injuries. The southern region of the United States observed nearly a third of the NTDB incidents in 2008 (34.9%) followed by the Midwest (26.8%), the West (22.4%), and the Northeast (16.0%). The large majority (90%) of hospitals included "dead on arrival" patients. Falls represented the most injury cases (34.7%) followed by MVCs (31.8%). The modal age class for MVCs was 25–34 years. The most commonly injured body region was the lower extremities (35.1% of patients) followed by the head (32.6%), upper extremities (27.5%), and face (24.8%). The region with the highest percentage of serious (AIS 3+) injuries was the head (17.4%) followed by the lower extremities (13.7%) and thorax (13.2%).

2.2. Measurements

The evidence basis for this mechanism comparison was injury measurements with ICD-9 codes in the range from 800.0 to 959.9. The primary classification variable was whether the patient was in a MVC. MVC cases were identified by ICD-9 external causes codes; a code between 810 and 819 with a post-decimal code of either 0 or 1 was designated as a MVC case. The majority of non-MVC cases were falls (59%).

Injury type was classified using broad ICD-9 code ranges similar, but not identical to the organization of the Barell matrix definitions (Barell et al., 2002; Clark and Ahmad, 2006). These classifications included fractures (800–829), dislocations (830–839), sprains and strains (840–848), intracranial injuries (850–854), internal injuries to the thorax, abdomen, and pelvis (860–869), open wounds (870–897), blood vessel injuries (900–904), superficial injuries (910–919), contusions (920–924), crushing injuries (925–929) and nerve/spinal cord injuries (950–957). This was done to better approximate the injury schema associated with MVC.

MRRs were calculated for each injury and etiology (MVC or non-MVC) combination. All diagnosed injuries of each patient were included in the MRR calculations. Within each ICD-9 code and etiology (MVC or non-MVC) combination, the MRR is calculated by dividing the number of people who died by the number of people who displayed the combination.

2.3. Analysis

To determine which injuries have different effects across etiologies, a variety of descriptive methods and regression analyses were employed. Summaries of MRRs and outcomes were made at the injury type level, the ICD-9 level, and the etiology level. Statistical significance was taken for granted because of large sample sizes and thus not assessed when comparing MRRs for etiologies across injury types. Statistical testing was not used to assess the differences in MRRs between etiologies for specific individual injuries as there were small sample sizes for some injuries (i.e. 30–40 patients). Descriptive statistics included proportion and mean comparisons to summarize differences across strata. Linear regression analyses and scatter plots were used to measure whether MRRs were more severe for MVC versus non-MVC etiologies. These analyses were repeated within injury type to establish whether MVC produced worse severity for specific types of injuries. The subset of injuries occurring most frequently in MVC was also analyzed. This subset was the top 95% of AIS 2+ injuries occurring in MVC that were computed using weighted injury data from the 2000–2011 NASS Crashworthiness Data System (CDS). An AIS to ICD-9 injury code mapping algorithm was used to map the 240 AIS codes in the top 95% list to an appropriate code on the ICD-9 scale for comparison in this study (Barnard et al., 2013).

3. Results

A total of 2,508,590 patients were eligible for analysis after all exclusion criteria were satisfied. Of these, 664,917 (26.5%) were classified as MVC patients while 1,843,673 (73.5%) were classified as non-MVC patients. MVC patients were on average younger (36 versus 40 years), disproportionately female (43% versus 32%), had higher ISS (11 versus 9), and presented with lower respiratory rate (34.8 versus 36.3 breaths per min) and higher systolic blood pressure (132 versus 129 mmHg) compared to non-MVC patients. Patient groups had similar levels of physiologic impairment as measured by the Glasgow Coma Scale (12.7 for both groups). MVC had a smaller proportion of deaths compared to non-MVC patients 3.9% versus 4.1%, respectively. Among hospital survivors, MVC patients had longer overall (5.6 versus 5.0 days) and intensive care (1.6 versus 0.7 days) lengths of stay.

In total, there were 5,471,548 eligible injuries studied, with an average of 2.2 injuries per patient. MVC patients averaged more injuries (2.8) than non-MVC patients (1.9). Fractures (800–829) were the most common injury, representing 42% of all injuries, including 44% of the injuries to non-MVC patients and 38% of