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Predicting work-related disability and medical cost outcomes: A comparison of injury severity scoring methods

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ABSTRACT

Introduction: Acute work-related trauma is a leading cause of death and disability among U.S. workers. Occupational health services researchers have described the pressing need to identify valid injury severity measures for purposes such as case-mix adjustment and the construction of appropriate comparison groups in programme evaluation, intervention, quality improvement, and outcome studies. The objective of this study was to compare the performance of several injury severity scores and scoring methods in the context of predicting work-related disability and medical cost outcomes.
Methods: Washington State Trauma Registry (WTR) records for injuries treated from 1998 to 2008 were linked with workers' compensation claims. Several Abbreviated Injury Scale (AIS)-based injury severity measures (ISS, New ISS, maximum AIS) were estimated directly from ICD-9-CM codes using two software packages: (1) ICDMAP-90, and (2) Stata's user-written ICDPIC programme (ICDPIC). ICDMAP-90 and ICDPIC scores were compared with existing WTR scores using the Akaike Information Criterion, amount of variance explained, and estimated effects on outcomes. Competing risks survival analysis was used to evaluate work disability outcomes. Adjusted total medical costs were modelled using linear regression.
Results: The linked sample contained 6052 work-related injury events. There was substantial agreement between WTR scores and those estimated by ICDMAP-90 (kappa = 0.73), and between WTR scores and those estimated by ICDPIC (kappa = 0.68). Work disability and medical costs increased monotonically with injury severity, and injury severity was a significant predictor of work disability and medical cost outcomes in all models. WTR and ICDMAP-90 scores performed better with regard to predicting outcomes than did ICDPIC scores, but effect estimates were similar. Of the three severity measures, maxAIS was usually weakest, except when predicting total permanent disability.
Conclusions: Injury severity was significantly associated with work disability and medical cost outcomes for work-related injuries. Injury severity can be estimated using either ICDMAP-90 or ICDPIC when ICD-9-CM codes are available. We observed little practical difference between severity measures or scoring methods. This study demonstrated that using existing software to estimate injury severity may be useful to enhance occupational injury surveillance and research.

Introduction

Acute work-related trauma is a leading cause of death and disability among U.S. workers. Every day, approximately 9000 workers are treated in emergency departments (EDs), 200 are hospitalized, and 15 die due to traumatic injuries.[1] Severe traumatic injury can lead to long-term pain and disability and is very costly for workers' compensation (WC) systems and society as a whole. The total cost of occupational injuries was recently estimated at $192 billion annually.[2]

Occupational health services researchers have described the pressing need to identify valid injury severity measures for purposes such as case-mix adjustment and the construction of appropriate comparison groups in programme evaluation, intervention, quality improvement, and outcome studies.[3] Trauma registries typically contain injury severity measures based on the Abbreviated Injury Scale (AIS),[4,5] and occupational injury researchers have begun to explore state trauma registries as a resource.[6–8] In contrast, administrative databases often used for occupational

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health services research, such as workers' compensation claims databases and hospital discharge datasets, do not contain injury severity measures but often do contain ICD-9-CM diagnosis codes. Our primary motivation was to compare various methods of estimating AIS-based injury severity from ICD-9-CM codes for potential use in studies involving common occupational health services outcomes such as the amount of compensated time lost from work, the total medical cost of a work-related injury, and permanent work disability.Two software packages that estimate injury severity directly from ICD-9-CM codes have been used for injury research: (1) ICDMAP-90 software (ICDMAP) developed by and available from the Johns Hopkins Bloomberg School of Public Health,[9] and (2) Stata's user-written ICDPIC suite of programmes (ICDPIC), developed using National Trauma Data Bank (NTDB) data to assign approximate injury severity scores by classifying injuries into general severity and body region categories.[10] ICDMAP is not current to the most recent ICD-9-CM and AIS changes and does not run on newer computers. ICDPIC is freely available and easily run by Stata users. ICDPIC-based scores are now included in some ED discharge files released by the Healthcare Cost and Utilization Project (HCUP). However, validation studies of ICD-9-CM-based scores have not produced uniformly reassuring results.[9,11–14]

AIS-based injury severity scores have been validated for prediction of mortality,[15–19] but there have been mixed findings regarding prediction of work-related outcomes. Many studies have found no association, but most such studies have been small-scale and focused on functional capacity or short-term work status rather than longer-term outcomes such as total lost work time, total costs, or total permanent disability. The few studies that have used a continuous measure of work disability along with survival analysis or regression methods have found a significant association between injury severity and work disability.[20–23] In a recent related study, we used ICDPIC-based injury severity scores (ISS) estimated from WC billing data to demonstrate that ISS was significantly associated with work disability and medical cost outcomes for work-related injuries.[23] However, we did not compare ICDPIC head-to-head with ICDMAP, nor have we been able to identify any such comparison in the literature. The current study expands on our previous work, comparing ICDPIC with ICDMAP and with trauma registry-based scores, as well as comparing other types of AIS-based injury severity measures with ISS.

Objective

The objective of this study was to compare the performance of several injury severity scores and scoring methods in the context of predicting work-related disability and medical cost outcomes. To accomplish this objective, we linked injury data from a state trauma registry with outcomes data from WC claims for a large sample of work-related injuries.

Methods

Study population and data sources

This retrospective cohort study linked data from: (1) the Washington State Trauma Registry (WTR), maintained by the Washington State Department of Health, and (2) WC claims data, maintained by the Washington State Department of Labor and Industries. The WTR contains traumatic injuries meeting specific inclusion criteria from all state-designated acute trauma care facilities, including at least one of the following: trauma resuscitation team activation, dead on arrival or death during hospital stay, interfacility transfer by Emergency Medical Services or ambulance, or inpatient admission of at least 48 hours. Washington State has a single payer WC system (State Fund) that covers approximately 70% of those workers covered by the Industrial Insurance Act.[24] Self-insured employers account for the remainder. All WTR cases and all compensable WC claims were requested for workers injured from 1998 to 2008, excluding those younger than 16 and injuries occurring outside Washington State. Records were linked and deduplicated using The Link King, a public domain software program developed in Washington State for deterministic and probabilistic linkage of administrative records.[25] Further details about the data sources and linkage procedures are described in previous related publications.[8,26] This study was approved by the Washington State Institutional Review Board.

Our sample included injuries that involved at least one ICD-9-CM diagnostic code for a traumatic injury as specified by the National Trauma Data Bank (800–904.9, 910–929.9, 950–957.9, 959–959.9).[27] Isolated burns were excluded because ICDPIC does not score burns. In addition, AIS-based injury severity scores do not reliably classify burns due to the importance of inhalation injuries (inhalation injuries are not scored by AIS). Proximate fatalities (e.g., before or during the initial hospitalization, or accepted fatal WC claims filed by survivors) were excluded as our population of interest was injured workers who might return to work; later deaths were treated as a competing risk/censoring mechanism. Self-insured claims that met the inclusion criteria were included only for scoring concordance assessments, due to unavailable outcomes data.

Samples and outcomes

We assessed the association of injury severity scores with outcome measures using two samples: (1) all injured workers, and (2) a subset of workers with traumatic brain injuries (TBI). We followed the CDC case definition for TBI: any ICD-9-CM code of 800.0–801.9, 803.0–804.9, 850.0–854.1, 950.1–950.3, or 959.01.[28] Outcomes data were extracted from WC claims data in December 2010, providing 2–13 years of follow-up.

The number of compensated lost work days was used as a proxy for length of work disability. The end of time loss compensation without total permanent disability (TPD) determination usually, but not always, means that the worker is able to or has returned to work. It should be noted that the end of time loss compensation, though a commonly-used proxy, has been found to underestimate the actual amount of time lost from work.[29] TPD is determined when medical and vocational evaluations indicate that the injury prevents the worker from ever becoming gainfully employed.

Total medical costs were based on paid-to-date facility, professional, and pharmacy costs for closed claims. Open claims were excluded from cost analyses. Total medical costs were adjusted to December 2008 using the Consumer Price Index, based on month and year of injury.

Injury severity

We focused on three recognized injury severity scores: (1) Injury Severity Score (ISS), which has been well-validated for the prediction of mortality[15] and remains the most common measure of injury severity used by trauma systems and in trauma research, (2) New Injury Severity Score (NISS), which has been found more predictive of injury mortality, particularly for penetrating injuries,[16,17] and (3) the overall maximum AIS (maxAIS), which performs as well as the ISS in at least some circumstances.[18,19] AIS ranges from 1 (minor) to 6 (non survivable). ISS is the sum of squares of the highest AIS scores from up to three different body regions. NISS is the sum of squares of the three highest AIS scores, regardless of body region. Both ISS and NISS have a range of 1–75, with 75 assigned whenever maxAIS is 6. For simplicity of