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Crash costs in the United States by crash geometry

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Abstract

Main objectives: This study was conducted to estimate the costs per crash for three police-coded crash severity groupings within 16 selected crash geometry types and within two speed limit categories (≤45 and ≥50 mph).
Methods: We merged previously developed costs per victim by abbreviated injury scale (AIS) score into U.S. crash data files that scored injuries in both the AIS and police-coded severity scales to estimate injury costs, then aggregated the estimates into costs per crash by maximum injury severity.
Results: The most costly crashes were non-intersection fatal/disabling injury crashes on a road with a speed limit of 50 miles per hour or higher where multiple vehicles crashed head-on or a single vehicle struck a human (over $1.69 and $1.16 million per crash, respectively). The annual cost of police-reported run-off-road collisions, which include both rollovers and object impacts, represented 34% of total costs.
Conclusions: This paper provides cost estimates useful for evaluating roadway countermeasures and for designing vehicles to minimize crash harm. It gives unit costs of crashes by type in the coding system used by the police. The costs are in an appropriate form for economic analysis of countermeasures addressing locally defined problems identified by analyzing police crash reports.

Keywords: Crash; Cost; Geometry; KABCO; Speed limit; Signalized

1. Introduction

In State Highway Department evaluations of safety improvements in the U.S., the outcome measure is typically the frequency of police-reported crashes, often with separate estimates for different severity levels and crash types. However, some interventions may decrease some crash types but increase others. If these crash types are characterized by different average injury severities, then comparing crash frequencies will not provide the user with an accurate picture of intervention effectiveness. This problem led to the development of the crash cost estimates by crash type described in this paper.

A study of the red-light-camera (RLC) programs funded currently by Federal Highway Administration (FHwA) is a good example of this problem. Based on past literature, RLC programs can be expected to decrease angle-type crashes, but to increase rear-end crashes (Retting et al., 2002). The former tends to be more severe than the latter, but less frequent. For that reason, the present study not only examines crash effects by type, but also includes crash severity in the analysis by costing each crash based on unit costs by crash type and by police-reported severity, for crashes at urban signalized intersections.

Past studies have developed crash costs for the United States (e.g., Miller et al., 1997; Wang et al., 1999; Zaloshnja et al., 2004) and numerous other countries. Most U.S. studies estimate costs per person injured or vehicle damaged rather than cost per crash. Moreover, they often provide cost breakdowns by body region and, within that, by injury severity measured on the abbreviated injury scale (AIS). AIS is specified by trained medical data coders, usually within a hospital context. It is not recorded on police crash reports, making these cost estimates unusable in the majority of safety studies conducted.

Miller et al. (1997) successfully linked crash costs to police-reported crash profiles for a number of crash scenarios by using data files that contained both AIS and police-reported severity. That study provided aggregate costs, not unit cost estimates by police-reported maximum severity and crash type.

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It was intended to aid vehicle design that minimized overall harm. Wang et al. (1999) undertook a similar study, estimating unit costs by crash type and AIS for crashes that could be averted by intelligent transportation systems (ITS) technologies. Andreassen (1992) provided similar costs for Australia.

Differently from previous studies, this paper provides unit and total costs by crash type and severity, and both estimates of hard dollar consequences (what economists call "resource costs") and comprehensive costs, which add a value of the non-monetary losses to the hard dollar costs. Detailed estimates are provided for three police-reported crash maximum severity groupings within 16 critical crash types (e.g., pedestrian crash at signalized intersection; multi-vehicle cross-path crash at signalized intersection) and within two speed limit categories (≤45 mph and ≥50 mph) to account for possible differences in costs for a given police-reported maximum severity level between high-speed and low-speed crashes.

2. Methods

Modeling crash costs requires estimates of the number of people involved in a crash, the medical details of each person's injuries (ideally, body part injured, nature of the injury, and injury severity, e.g., skull fracture not resulting in loss of consciousness), and the costs of those injuries and associated vehicle damage and travel delay. The next section describes the methodology used to estimate the incidence and medical details of crash injuries for selected crash types and speed limits. The succeeding section explains how the costs of crashes were estimated.

2.1. Estimation of injury incidence and medical details

No data system that contains a nationally representative sample of recent U.S. incidence data on non-fatal crash injuries records both crash type and medical descriptions of the injuries. The National Highway Traffic Safety Administration's (NHTSA's) National Accident Sampling System (NASS; NHTSA, 1987) collected data containing medical descriptions of injuries for a representative sample of all police-reported U.S. motor vehicle injury victims in 1984–1986. In 1988, NASS was replaced by two ongoing sampling systems. The crashworthiness data system (CDS; NHTSA, 2002b) collects data similar to NASS but focuses on crashes involving automobiles and automobile derivatives, light trucks and vans with gross vehicle weight less than 10,000 pounds (4537 kg) that are towed due to damage, and excludes pedestrian and non-motorist records. The general estimates system (GES) collects data on a representative sample of all police-reported crashes, but the only injury description it gives is the severity that a police officer assigned in the police accident report.

GES, like the police reports, uses the KABCO severity scale (National Safety Council, 1990) to classify crash victims as K-killed, A-disabling injury, B-evident injury, C-possible injury, or O-no apparent injury. The codes are selected by police officers without medical training, typically without benefit of a hands-on examination. Some victims are transported from the scene before the police officer who completes the crash report even arrives. Thus, police reporting does not accurately describe injuries medically. Moreover, KABCO ratings are coarse and inconsistently coded between states and localities and over time (Miller et al., 1991; Blincoe and Faigin, 1992; O'Day, 1993). Viner and Conley (1994, working paper) found one cause of this variability was differing state definitions of A-injury. Miller et al. (1987) found police-reported injury counts by KABCO severity systematically varied between states because of differing state crash reporting thresholds (the rules governing which crashes should be reported to the police) and that state reporting thresholds often changed over time. GES verifies that all crash deaths are coded as K and all crash victims coded as K died.

NASS and CDS record both the KABCO codes assigned by police and medical descriptions of injury in the occupant injury coding system (OIC). OIC codes include detailed medical descriptions plus AIS threat to life severity scores. The NASS data were coded with the 1980 version of OIC/AIS, which differs slightly from the 1985 version; but NHTSA made most OIC/AIS-85 changes well before their formal adoption (Association for the Advancement of Automotive Medicine [AAAM], 1985). The 1999–2001 CDS data used in this paper were coded in AIS-90 (AAAM, 1990).

Starting with Miller et al. (1997), NHTSA's past costing studies and ours have met the challenge posed by the lack of an adequate data system by simulating the records that CDS would have collected if it had sampled the non-CDS strata (i.e., injuries to passenger vehicle occupants involved in non-tow-away crashes and to pedestrians, pedalcyclists, and heavy vehicle occupants). Combining the simulated data with the actual CDS data yields a synthesized, nationally representative sample of crashes with both crash types and medical descriptions of the injuries of all people involved in the crashes.

Our simulation used 1999–2001 GES data to reweight the 1984–1986 NASS data for the non-CDS strata so they represent the average annual estimated GES injury victim counts in non-CDS crashes. In applying the GES weights, we controlled for crash type (as defined by geometry), police-reported maximum injury severity, speed limit (≤45 miles per hour (mph) and ≥50 mph), and restraint use (see APPENDIX). Weighting the NASS data to GES restraint use levels updates the NASS injury profile to a profile reflecting contemporary belt use levels. This procedure assumes that particular crash types generate typical profiles of injury outcomes that are stable over time, an assumption that Australian research supports (Andreassen, 1986). Sample size considerations drove the decision to pool and average 3 years worth of GES data.

At the completion of the weighting process, we combined the CDS data with the synthesized NASS data on the non-CDS strata. This hybrid file was comprised of 1999–2001 CDS records for non-heavy vehicle, tow-away crashes and of reweighted 1984–86 NASS records for all other crashes. Finally, we adjusted the weights on fatal crashes in both CDS and non-CDS strata so that the weighted counts by strata, crash geometry and speed limit matched the fatal crash counts in NHTSA's Fatality Analysis Reporting System (FARS; NHTSA, 2002a). This adjusted file became our study's incidence file.