Costs of Alcohol-Involved Crashes, United States, 2010

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ABSTRACT – This paper estimates total and unit costs of alcohol-involved crashes in the U.S. in 2010. With methods from earlier studies, we estimated costs per crash survivor by MAIS, body part, and fracture/dislocation involvement. We multiplied them times 2010 crash incidence estimates from NHTSA data sets, with adjustments for underreporting of crashes and their alcohol involvement. The unit costs are lifetime costs discounted at 3%. To develop medical costs, we combined 2008 Health Care Utilization Program national data for hospitalizations and ED visits of crash survivors with prior estimates of post-discharge costs. Productivity losses drew on Current Population Survey and American Time Use Survey data. Quality of life losses came from a 2011 AAAM paper and property damage from insurance data. We built a hybrid incidence file comprised of 2008-2010 and 1984-86 NHTSA crash surveillance data, weighted with 2010 General Estimates System weights. Fatality data came from the 2010 FARS. An estimated 12% of 2010 crashes but only 0.9% of miles driven were alcohol-involved (BAC > .05). Alcohol-involved crashes cost an estimated $121 billion. That is 24% of the societal cost of all crashes. Alcohol-attributable crashes accounted for an estimated 22.5% of US auto liability insurance payments. Alcohol-involved crashes cost $0.84 per drink. Above the US BAC limit of .08, crash costs were $8.12 per mile driven; 1 in 788 trips resulted in a crash and 1 in 1,016 trips in an arrest. Unit costs for crash survivors by severity are higher for impaired driving than for other crashes. That suggests national aggregate impaired driving cost estimates in other countries are substantial underestimates if they are based on all-crash unit costs.

INTRODUCTION

Costs are useful in measuring, communicating, and comparing the size of societal problems. They also are essential when evaluating the return on investments in problem reduction.

The latest U.S. cost estimates for alcohol involved crashes (Zaloshnja & Miller, 2009) rely on inflated unit costs from Blincoe et al. (2002). They are hard to use credibly in advocacy because they are built from 1990s health care cost data and police underreporting of alcohol involvement in a single state.

This study is a major update on U.S. impaired driving incidence and costs. It draws on 2009 auto insurance data, nationally representative 2008 Health Care Utilization Program data for hospital costs, earnings data across the most recent business cycle, as well as recent studies of individual cost factors.

METHODS

Estimating alcohol-involved crash costs requires estimates of the number of people involved in alcohol-involved crashes, the severity of each person's injuries, and the costs of those injuries. We first describe the methods used to estimate incidence and severity of people injured in alcohol-involved crashes and then explain how the unit costs of injuries were estimated.

Incidence and Severity Estimation

NHTSA's General Estimates System (GES) provides a sample of U.S. crashes by police-reported severity for all crash types. GES records injury severity by person on the KABCO scale (National Safety Council, 1990) from police crash reports. Police reports in almost every state use KABCO to classify people injured in crashes as K–killed, A–disabling injury, B–evident injury, C–possible injury, or O–no apparent injury.

KABCO ratings are coarse and inconsistently coded between states and over time. The codes are selected by police officers without medical training, typically without benefit of a hands-on examination. Some of the injured are transported from the scene before the police officer who completes the crash report even arrives. Miller, Viner, et al. (1991) and Blincoe and Faigin (1992) documented great diversity in KABCO coding across cases. O'Day (1993) more carefully

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quantified variability in use of the A-injury code between states. Viner and Conley (1994) probed how differing state definitions of A-injury contributed to this variability. Miller, Whiting, et al. (1987) found police-reported injury counts by KABCO severity systematically varied between states because of differing state crash reporting thresholds (rules governing which crashes should be reported to the police). Miller and Blincoe (1994) found that state reporting thresholds often changed over time.

Thus police reports inaccurately describe injuries medically and crash databases inaccurately describe motor vehicle crash severity. We adopted a widely used method to refine crash and injury severity. Developed by Miller and Blincoe (1994), numerous studies have used this method, notably in impaired driving cost estimates in Blincoe (1996); Miller, Lestina, and Spicer (1998); Blincoe et al. (2002); and Zaloshnja and Miller (2009).

To minimize the effects of variability in severity definitions by state, reporting threshold, and police perception of injury severity, the method uses NHTSA data sets that include both police-reported KABCO and medical descriptions of injury in the Occupant Injury Coding system (OIC; AAAM, 1990, 1985). OIC codes include Abbreviated Injury Scale (AIS) severity score and body region, plus more detailed injury descriptors. We used both 2008–2010 Crashworthiness Data System (CDS) and 1984–1986 National Accident Sampling System (NASS; NHTSA, 1987) data. CDS describes injuries to passenger vehicle occupants involved in towaway crashes. The 1984–1986 NASS data provide the most recent medical description available of injuries to medium/heavy truck and bus occupants, non-occupants, and others in non-CDS crashes. The NASS data were coded with the 1980 version of AIS, which differs slightly from the 1985 version; but NHTSA made most AIS 85 changes well before their formal adoption. CDS data were coded in AIS 90/98 with coding shifting to AIS 2000 in 2011. We differentiated our analysis of the two versions of AIS because AIS 90/98 scores and OIC codes differ greatly from codes and scores in AIS 85, especially for brain and severe lower limb injury. Garthe et al. (1996) find that AIS scores shifted for roughly 25% of all OICs between AIS 85 and AIS 90/98.

We used 2008–2010 CDS and GES non-CDS weights to weight the CDS and NASS data, respectively, so that they represent estimated counts of people injured in motor vehicle crashes during 2008–2010. In applying the GES weights to old NASS, we controlled for police-reported injury severity, restraint use, alcohol involvement, and occupant type (CDS occupant, non-CDS occupant, and non-occupant). Weighting NASS data to GES restraint use and alcohol involvement levels updates the NASS injury profile to reflect contemporary belt use and alcohol-involvement levels, although it is imperfect in terms of its representation of airbag use in non-towaway crashes. At completion of the weighting process, we had a hybrid CDS/NASS casualty-level file—that is, we had an appropriately reweighted NASS record for each injured survivor in each non-CDS crash. Similarly, we reweighted the 2008–2010 CDS file to match GES counts in order to get appropriately weighted unit records for CDS sample strata.

We multiplied incidence by 1.107 to adjust for systematic undercounting in GES relative to police crash reports underlying it. Based on a NHTSA national probability survey, we then divided by estimated fractions reported to the police: 1.0 for people with critical to fatal injuries, 0.953 for people with MAIS-3 injuries, 0.794 for MAIS-2, 0.725 for MAIS-1, 0.469 for uninjured people in injury crashes, and 0.406 for crashes without injuries. For incidence purposes, we used only the 2010 portion of the reweighted hybrid CDS/NASS casualty-level file and the 2010 FARS file. For costing purposes (described below), we used the 2008-10 files.

Police underreport alcohol involvement in crashes (Blincoe, et al., 2002, Guo et al., 2007). Reasons include police priority on assuring safety at the crash site over determining driver alcohol involvement, expense of universal driver testing, challenges with testing seriously injured drivers and with evidentiary testing at crash scenes, and driver flight. Emergency departments (EDs) also often do not test or report alcohol involvement of injured drivers in crashes. Reasons include time and resource constraints in busy EDs; testing expense; and concerns that charting alcohol involvement would allow health insurers to deny coverage in states with uniform accident and sickness policy provision laws (UPPL), divert doctors from treating patients to testifying in criminal and liability cases, require alcohol interventions that attending physicians are uncomfortable delivering or perceive as lacking effectiveness, or raise patient confidentiality issues (Miller et al., 2012). UPPL repeals affect ED but not police reporting of alcohol.

We used multipliers from Miller et al. (2012) to adjust for underreporting of alcohol involvement (blood alcohol content (BAC) at or above .05, with .08 the U.S. legal limit) in crash reports. The multipliers were computed from 2006-2008 linked multi-state police and hospital data on crash-involved drivers treated at hospitals. These two linked, yet independent sources each assess alcohol involvement in crashes.

Unit Cost Estimates

We estimated or updated existing estimates of medical costs, work losses, monetized quality-adjusted life years, property damage, insurance claims processing, and legal costs. We adopted recent estimates of coroner, congestion, roadside furniture, and incident management costs, and inflated existing estimates of employer and police/fire services costs.

To generate injury costs per person by MAIS, body part, and whether a survivor suffered a fracture or dislocation, we created a 41-level body part descriptor based on information provided by the NASS/CDS variables describing the body region, system/organ, lesion, and aspect of each injury. Burns were classified as a separate category due to the lack of location information for burn injuries. The paragraphs that follow describe unit medical costs, work loss costs, monetized quality-adjusted life years, and selected ancillary costs.

Typically, motor vehicle crash patients suffer multiple injuries. When a crash survivor had two injuries of maximum AIS, we assigned the body part of the most costly injury. In merging costs onto the re-weighted NASS/CDS injury level file (NASS/CDS lists up to six injuries per person injured) we merged medical costs, work loss costs and monetized quality-adjusted life years (QALYs) separately. In each case, we assigned the cost for the injury with the highest cost for that cost component. Thus if a survivor's ruptured spleen had the highest medical cost and her broken leg had the highest work loss cost, this hybrid set of costs was assigned to the case. This yields conservative cost estimates since it assumes that secondary injury conditions do not increase costs.

Medical and work loss costs cover three mutually exclusive categories that reflect injury severity: (1) injuries resulting in death, including post-injury deaths in a healthcare setting; (2) injuries resulting in hospitalization with survival to discharge; and (3) injuries requiring an ED visit not resulting in hospitalization (ED-treated injuries). We estimated average medical and work-loss costs of injury deaths using 2008 data from the National Vital Statistics System (NVSS). Unit medical costs of non-fatal injuries were built primarily from the 2008 Nationwide Inpatient Sample (NIS) and the 2003 State Emergency Department Databases (SEDD), both from the Healthcare Cost and Utilization Project (HCUP), following methods from Finkelstein et al. (2006). For injuries treated only in doctor's offices or outpatient departments, we used prior estimates of unit costs (Finkelstein et al., 2006), properly inflated. Costs incurred beyond one year post-injury were discounted to present value using the 3% discount rate recommended by the Panel on Cost-Effectiveness in Health and Medicine (Gold, Siegel, Russell, & Weinstein, 1996) and Haddix, Teutsch, & Corso (2003). We did not link HCUP and NASS/CDS data, instead merging average HCUP costs by diagnosis group and place treated onto NASS/CDS data. Cost-to-charge ratios used to derive costs from NIS charges are computed with Federally regulated accounting rules and yield consistent estimates across facilities.

To estimate mean costs across all crash survivors, we added costs for cases treated only in physicians' offices or outpatient departments to the cost for cases treated in hospital emergency departments or admitted to hospitals. To do so, we multiplied unit costs for ED-treated injuries by body part and nature of injury (as per the Barell injury-diagnosis matrix) times ratios of ED-treated injuries vs. injuries treated only in doctor's offices or outpatient departments found in Finkelstein et al. (2006). We then took averages across treatment settings. We computed costs from a societal perspective, which means we included all costs regardless of who paid for them. We updated health insurance claims processing costs by payer with data from Woolhandler et al. (2003).

We used ICDMAP 90 software (Johns Hopkins University and Tri-Analytics Inc., 1997) to assign MAIS 90 scores to cases. We assigned AIS 85 scores with mappings developed by Miller et al. (1991). After assigning AIS scores to each injury, we determined the MAIS for each person.

We updated wage loss estimates with earnings data we tabulated from March Supplements of the Current Population Survey, averaged across a full business cycle from 2002 through 2009, and with household work estimates from Grosse et al. (2009). We inflated all earnings figures to 2010 dollars using the Employment Cost Index–Wages & Salaries, All Civilian. We added fringe benefits of 23.33% of wages based on the average ratio of wage supplements to wages for 2002–09 from the national income accounts (President of the United States, various years, Table B-28). We incorporated a 2008 life table (Arias 2012) into the lifetime work loss estimates.

We adopted coroner costs for crash fatalities from Miller et al. (2011). Their estimate builds on Hickman et al. (2007).

Updated estimates of average quality-adjusted life year (QALY) losses by MAIS, injury type, and body region injured from Spicer et al. (2011) were used to calculate monetized QALYs. Following methods described in Zaloshnja et al. (2004), we derived a monetized value per QALY from the value of $4.52 million per statistical life built into prior crash costs, with sensitivity analysis using the $8.86 million value for 2010 recently adopted by the US Department of Transportation (Trottenberg and Rivkin, 2013).

To analyze insurance-related costs and vehicle damage costs, we purchased data from the Insurance Services Office (ISO). ISO is a data-pooling organization that aggregates claims data from a large cross-section of auto insurers. The data detailed insurance premiums collected and claims paid by selected insurers in 2009. Combining those data with national insurance statistics and crash data, we analyzed (1) property damage costs per crash, (2) numbers of people receiving insurance claims payments due to crash injury, and (3) transaction costs of compensation through the insurance and legal systems.

We used national data on premiums written and loss ratios (Glenn, 2010) to estimate coverage and representativeness of ISO data and to factor up ISO data to national estimates. Unlike in 1998–1999, when Miller and Lawrence (2003) found losses in ISO data were typical of all auto policies, the loss ratios in 2009 ISO private passenger and commercial auto liability data were lower than the national averages. Loss ratios still were comparable to national averages for other coverages.

Blincoe et al. (2002) estimate that auto liability policy limits average $210,000 per person injured (inflated to 2010 dollars) and that 55% of those suffering moderate (MAIS 2) to fatal injuries make a claim. Based on that finding, we estimated the dollar amount of insurance compensation for medical and earnings/household production losses of people with MAIS 2+ injuries. The remaining compensation is for MAIS-1 injury costs; it compensates 55% of the cost of those injuries. We estimated insurance administration and legal costs from medical, work loss, and property damage costs using equations from Blincoe et al. (2002). We modified the equations to incorporate the estimate of people with MAIS-1 injuries compensated.

Estimated costs of roadside furniture damage by crash severity came from 1,462 crashes in 2008 tracked by the Missouri Claims Recovery Department (Miller et al., 2011). The data excluded costs not recovered from at-fault drivers and their insurers.

Public services costs are paid almost entirely by state and local government. Using the data underlying earlier crash cost estimates (Miller et al., 1991), we separated out EMS, police, fire, vocational rehabilitation, and court costs. We inflated these minor costs to 2010 dollars using the consumer price index-all items (Economic Report of the President 2012).

Missouri and Washington State provided average incident management costs (Miller et al., 2011). Estimated mean cost per crash attendance was $83 for 315 crashes in Missouri and $127 for 3,880 crashes in Washington (assuming the response rate to serious injury [A] crashes was 60% of the response rate to fatal [K] crashes). We adopted Washington State's estimate because the data were much more complete than the Missouri data. Using data on the percentage of crashes attended, we broke the estimate down by police-reported crash severity.

To break costs of incident management (and vehicle and roadside furniture damage) down into cost per person involved in a crash by injury severity, we followed the method used by Miller, Viner, Rossman, et al. (1991). We first cross-tabulated the number of people in a crash by the Abbreviated Injury Scale (AIS) severity of their maximum injury (MAIS) and by the maximum MAIS of anyone in the crash. Second, we used that cross-tabulation to iteratively estimate costs by MAIS. We first divided the cost for a property damage only (PDO) crash by the number of uninjured people involved in a PDO crash to get a cost per uninjured person. Next, we used that cost per uninjured person to compute the cost of an MAIS-1 crash net of the costs associated with uninjured people. Dividing by average number of MAIS-1 injury survivors per MAIS-1 crash then yields cost per MAIS-1 survivor. This process was repeated sequentially to compute costs for all MAIS levels.

Congestion costs came from ongoing U.S. Department of Transportation congestion modeling. The costs of workplace disruption due to the loss or absence of an employee were updated from Blincoe et al., 2002, inflating to 2010 dollars using the Employment Cost Index–Wages & Salaries, All Civilian. These costs pay for co-worker distraction, investigating and reporting on-the-clock crashes, juggling schedules, hiring and training replacement employees, and overtime to cover for the injured.

Denominator data include alcohol consumption (LaVallee and Yi, 2012), arrests for driving under the influence (Federal Bureau of Investigation, 2011), and miles driven (Federal Highway Administration (2012). We combined fractions of daytime and nighttime miles driven by BAC in 2007 (Lacey et al., 2009) in proportion to vehicle-miles driven during these two time periods (Santos et al., 2011), arriving at estimates of 0.47% of miles driven above .08 and 0.39% driven at .05-.079. We took relative risks of crashing by BAC from a case-control study (Blomberg et al., 2005); crash risks relative to driving sober were 17.99 at BAC >=.08 and 1.66 at BACs of .05-.079. Following Miller et al. (1999), we used an average impaired driving trip length of 9.7 miles.

RESULTS

In 2010, Americans drove an estimated 25.5 billion miles at BACs >= .05 including 13.9 billion above the .08 legal limit. An estimated 4 million people, 12% of people injured in U.S. traffic crashes, were in alcohol-involved crashes at BACs >= .05 (Table 1). However, police reported only 3.6% were in alcohol-involved crashes. As expected, underreporting is more severe for uninjured survivors and ones with minor injuries. Alcohol involvement was 37.7% in fatalities, followed by 35.5% in nonfatal MAIS 5 & 6 injuries. Estimated crashes at BAC >=.08 totaled 1,820,094, with 1 crash per 788 impaired driving trips. An estimated 139,215 crashes occurred at driver BACs of .05-.079. One in 1,016 trips above the legal limit resulted in arrest for driving under the influence including 1 in 1,324 that did not result in a crash.

Table 1. People injured in alcohol-involved crashes, BAC > .049, United States, 2010

Injury severity	Police-reported alcohol-involved	% of all crash victims	Adjusted for under-reporting	% of all crash victims	All crash victims
MAIS 0	1,011,502	3.4%	3,625,771	12.3%	29,359,750
MAIS 1	125,167	3.6%	272,959	7.9%	3,448,877
MAIS 2	27,005	7.8%	53,086	15.3%	347,175
MAIS 3	11,523	11.2%	23,563	22.9%	102,897
MAIS 4	1,962	11.8%	3,917	23.6%	16,619
MAIS 5&6	1,102	18.6%	2,108	35.5%	5,937
Fatal	12,290	37.2%	12,290	37.2%	32,999
Total	1,191,155	3.6%	3,993,694	12.0%	33,314,254

As expected, fatalities had the highest total societal cost per person, an estimated $5.37 million (Table A1). Lost QALYs (73%) and lost earnings (17.1%) dominated the fatality costs.

Although KABCO does not classify injuries as reproducibly as MAIS, many more data sets use it to code crash injury severity. Table A-2 shows unit costs for crash survivors in this coding system. It also shows total cost per survivor for all crashes. In each severity category, costs were much higher for alcohol-involved than all survivors.

Estimated societal cost of alcohol-involved crashes in 2010 totaled $121.5 billion including $113 billion at BACs >=.08. The total included costs detailed in Table A-3 plus $758 million in victim mental health treatment (Miller et al., 1996); $1,826 million in adjudication, sanctioning, and legal defense fees (Collins, 1996); and $149 million in perpetrator productivity loss while incarcerated that we were unable to allocate by crash severity. Of the remaining costs, 57.5% came from lost QALYs, 15.7% from lost earnings, 7.4% from vehicle damage, 5.2% from medical costs, 5.0% from household production loss, and 9.2% from the remaining cost categories. Fatality costs accounted for 55.7% of all costs followed by MAIS-2 and MAIS-3 injuries with 11.6% and 9.9%, respectively. With the higher QALY value that DoT just adopted, costs would total $208 billion. Crashes with only a non-occupant above .05 BAC accounted for 1,416 deaths and $7.6 billion of the costs.

Standard errors were a modest, 6% to 14% for medical costs, earnings loss, and household production loss. The widest uncertainty was for quality of life loss; in 2013, NHTSA virtually doubled its best estimate of cost per quality-adjusted life year lost. Consequently, the standard deviation of cost per crash (bootstrapped using the Crystal Ball@ add-in to Excel) was 19% of the mean.

The costs were $0.84 per drink (including deaths of non-occupants above .05 BAC), $8.12 per mile driven above the legal blood alcohol limit of 0.08, $0.73 per mile driven at BACs of .05-.079, and $.14 per mile driven alcohol-free ($0.20, $1.92, $0.16, and $.05 excluding quality of life and work loss). Of the costs, 94.4% above .08 BAC and 39.7% at .05-.079 were attributable to alcohol.

While only 12% of people involved in U.S. traffic crashes were in alcohol-involved crashes, their societal cost represented 24% of total societal costs of crashes. Moreover, 1.8 million of the 4 million people involved in these crashes were not drinking and driving. Injuries for these victims cost $62.6 billion (51.5% of total costs), including $35.7 billion in quality of life losses and $26.9 billion of more tangible costs.

Crash-involved people and their families absorbed all quality of life loss and paid about one third of tangible costs. Government paid an estimated $5.25 billion in alcohol-involved crash costs, with the Federal government paying 58% and state and local governments 42%. The estimated auto liability insurance bill was $11.3 billion, accounting for 22.5% of all auto liability insurance payments.

DISCUSSION

The finding that alcohol-involved crash survivors account for a much higher portion of costs than incidence means crashes without alcohol involvement are on average less severe. Our incidence estimate of alcohol-involvement (12% of all people in crashes) is higher than the 9.7% estimate reported in Blincoe et al. (2002). This increase represents a refinement in underreporting adjusters, not a shift in alcohol involvement. Adjusters in Blincoe et al. (2002) were based on 1997-99 data from Maryland. Computing 2010 incidence from the 60.5% police capture of alcohol involvement in Maryland in 2006-2008 (Miller et al., 2012) rather than the 43.8% average capture across six states including Maryland, estimated involvement would be 9.3%.

Enforcement seems to have improved since 1993. The probability of a non-crash trip above the legal BAC limit resulting in arrest rose from 0.0006 (Miller et al., 1999) to 0.00076 (1/1324).

Conversely, alcohol-impaired crash costs fell by 37% since 1993. In 2010 dollars and restricted to cost categories estimated in 1993, costs of crashes at driver or non-occupant BACs of .08 and above fell from $177 billion (Miller et al., 1998) to $110 billion.

A major limitation of the costs presented in this study is that some cost components are unavoidably quite old. In particular, no recent source exists for the percentage of lifetime medical costs incurred more than 18 months post-injury, probabilities of permanent disability by detailed diagnosis and whether hospital admitted, or the ratio of household work days lost to wage work days lost. In addition, we chose not to update some minor cost factors – police and vocational rehabilitation costs – that would have been expensive to update.

Although we included fatalities of pedestrians and pedalcyclists with BACs above .05 hit by alcohol-free drivers, NHTSA data sets do not capture similar counts for nonfatal injury. If the 14% nonoccupant alcohol involvement observed by one trauma center (Weber et al. 2002) applied nationwide, our cost estimate would rise by $1.2 billion.

The alcohol-involvement underreporting adjusters from Miller et al. (2012) have their own limitations. Notably, they cover only six states. Coding errors, missing data, and non-uniformity of administrative data sets may have affected them. Miller et al. (2012) reports that only South Carolina and Utah crash reports integrated BAC test results, and South Carolina alcohol coding relied exclusively on testing. Therefore, they may have removed a few alcohol-involved cases that police misreported as drug involved. Furthermore, the underlying data linkages were probabilistic. The occasional mismatch reduces reporting consistency and accuracy of the capture-recapture model used to estimate underreporting.

CONCLUSION

Unit costs per crash injury survivor by severity are higher for impaired driving than for other crashes in the U.S. That suggests national aggregate impaired driving cost estimates in different countries probably are substantial underestimates if they are based on all-crash unit costs. Our results should help policy makers and other stakeholders to better evaluate impaired driving policies and regulations.

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REFERENCES

Arias, E. (2012). United States life tables, 2008. National Vital Statistics Reports, 61(3). Hyattsville, MD: National Center for Health Statistics.

Association for the Advancement of Automotive Medicine. (1985). The abbreviated injury scale, 1985. Des Plaines IL: Association for the Advancement of Automotive Medicine.

Association for the Advancement of Automotive Medicine. (1990). The abbreviated injury scale, 1990. Des Plaines, IL: Association for the Advancement of Automotive Medicine.

Blincoe, L. (1996). The economic costs of motor vehicle crashes, 1994. Washington, DC: National Highway Traffic Safety Administration.

Blincoe, L., & Faigin, B.M. (1992). The economic cost of motor vehicle crashes 1990. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Blincoe, L.J., & Luchter, S. (1983). The economic cost of motor vehicle accidents. (DOT HS 806 342). Washington DC: National Highway Traffic Safety Administration.

Blincoe, L., Seay, A., Zaloshnja, E., Miller, T., Romano, E., Luchter, S., & Spicer, R. (2002). The economic impact of motor vehicle crashes, 2000. Washington, DC: National Highway Traffic Safety Administration.

Blomberg, R., Peck, R., Moskowitz, H., Burns, M., & Fiorentino, D. (2005). Crash risk of alcohol involved driving: A case-control study, Stamford CT: Dunlap and Associates Inc.

Bureau of Labor Statistics. (2001). Highlights of Women's Earnings in 2000. Washington, DC: Bureau of Labor Statistics.

Collins J. (1996, January 7). Drinking and driving is very, very expensive! Street Smarts, Orange County Register.

Corum, D. (2011). Recession marked by bump in uninsured motorists. Press Release. Insurance Research Council: Malvern, PA. Retrieved July, 2012, from http://www.insurance-research.org/sites/default/files/downloads/IRCUM2011_042111.pdf

Federal Bureau of Investigation. (2011). Crime in the United States 2010. Washington DC: US Department of Justice, http://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2010/crime-in-the-u.s.-2010/tables/10tbl29.xls, accessed June 6, 2013.

Federal Highway Administration (2012). Highway statistics 2011, Washington DC: US Department of Transportation, http://www.fhwa.dot.gov/policyinformation/statistics/2011/vm202.cfm, accessed June 6, 2013.

Finkelstein, E., Corso, P., Miller, T., Fiebelkorn, I., Zaloshnja, E., & Lawrence, B. (2006). Incidence and economic burden of injuries in the United States, 2000. New York: Oxford University Press.

Garthe, E., Ferguson, S., & Early, N. (1996). A method for converting injury severity in NASS93 (AIS90) to NASS88 (AIS 85). Annals of Advances of Automotive Medicine, 40, 477–494.

Glenn, D. (2010). U.S. property/casualty loss ratio improved in 2009. A.M. Best & Company, Best's Review, 91–94.

Gold, M., Siegel, J., Russell, L., & Weinstein, M. (Eds.). (1996). Cost-effectiveness in health and medicine: Report of the Panel on Cost-Effectiveness in Health and Medicine. New York, NY: Oxford University Press.

Grosse, S., Krueger, K., & Mvundura, M. (2009). Economic productivity by age and sex: 2007 estimates for the United States. Medical Care, 47:7, Supplement 1, S94-S103.

Guo, H., Eskridge, K., Christensen, D., Qu, M., & Safranek, T. (2007). Statistical adjustment for misclassification of seat belt and alcohol use in the analysis of motor vehicle accident data. Accident Analysis and Prevention, 39, 117–124.

Haddix, A., Teutsch, S., & Corso, P. (2003). Prevention effectiveness, A guide to decision analysis and economic evaluation (Second ed.). New York: Oxford University Press.

Hickman, M., Hughes, K., Strom, K., & Ropero-Miller, J. (2007). Medical examiners and coroners offices, 2004, Special Report: Bureau of Justice Statistics, U.S. Department of Justice.

Hoyert, D. (2011). Unpublished supplemental table accompanying The changing profile of autopsied deaths in the United States, 1972–2007. NCHS data brief, no 67. Hyattsville, MD: National Center for Health Statistics.

Johns Hopkins University, & Tri-Analytics Inc. (1997). ICDMAP 90 Software user's guide.

Lacey, J., Kelley-Baker, T., Furr-Holden, D., Voas, R., Romano, E., Torres, P., ... & Berning, A. (2009). 2007 national roadside survey of alcohol and drug use by drivers: Alcohol results (DOT HS 811 248). Washington, DC: National Highway Traffic Safety Administration.

LaVallee, R., & Yi, H. (2012). Surveillance report #95: Apparent per capita alcohol consumption: National, state, and regional trends, 1977–2010. Bethesda MD, National Institute on Alcohol Abuse and Alcoholism.

Miller, T., Whiting, B., Kragh, B., & Zegeer, C. (1987). Sensitivity of a highway safety resource allocation model to variations in benefit computation parameters. Transportation Research Record, 1124, 58–65.

Miller, T., Viner, J., Rossman, S., Pindus, N., Gellert, W., Douglass, J., Dillingham, A., & Blomquist, G. (1991). The costs of highway crashes. Washington DC: The Urban Institute.

Miller, T., & Blincoe, L. (1994). Incidence and cost of alcohol-involved crashes in the United States. Accident Analysis and Prevention, 26(5), 583–592.

Miller, T., Pindus, N., Douglass, J., & Rossman, S. (1995). Databook on nonfatal injury: Incidence, costs, and consequences. Washington, DC: The Urban Institute Press.

Miller, T., Cohen, M., & Wiersema, B. (1996). Victim costs and consequences—A new look. Washington, DC: National Institute of Justice.

Miller, T., Lestina, D., & Spicer, R. (1998). Highway crash costs in the United States by driver age, blood alcohol level, victim age, and restraint use. Accident Analysis and Prevention, 30(2), 137–150.

Miller, T., Spicer, R., & Levy, D. (1999). How intoxicated are drivers in the United States: Estimating the extent, risks, and costs per kilometer of driving by blood alcohol level. Accident Analysis and Prevention, 31(5), 515-523.

Miller, T., & Lawrence, B. (2003). Motor vehicle insurance in the United States: A 1998-1999 snapshot with emphasis on motorcycle coverage. Washington, DC: National Highway Traffic Safety Administration.

Miller, T., Langston, E., Lawrence, B., Becker, L., Snowden, C., Granger, C., Russell, C., Kreutzer, J., & Marwitz, J. (2004). Rehabilitation costs and long-term consequences of motor vehicle injury. Washington, DC: National Highway Traffic Safety Administration.

Miller, T., Bhattacharya, S., Zaloshnja, E., Taylor, D., Bahar, G., & David, I. (2011). Costs of crashes to government, United States, 2008, Annals of Advances in Automotive Medicine, 55, 347–356.

Miller T., Gibson, R. Zaloshnja, E., Blincoe, L., Kindelberger, J., Strashny, A., Thomas, A., Ho, S., Bauer, M., Sperry, S., Peng, J., Singleton, M., Smith, T., & Zhang, Y. (2012) Underreporting of driver alcohol involvement in United States police and hospital records: capture-recapture estimates. Annals of Advances in Automotive Medicine;56, 87-96.

National Highway Traffic Safety Administration. (1987). National automotive sampling system: Crashworthiness data system 1986. Washington, DC: National Highway Traffic Safety Administration.

National Safety Council. (1990). Manual on classification of motor vehicle traffic accidents, fifth edition (ANSI D-16.1-1989). Itasca, IL: National Safety Council.

O'Day, J (Ed.). (1993). Accident data quality: A synthesis of highway practice. National Cooperative Highway Research Program Synthesis 192,. Washington DC: Transportation Research Board, National Research Council, National Academy Press.

President of the United States. Economic Report of the President. U.S. Washington DC: U.S. Government Pinting Office, various years.

Santos, A., McGuckin, N., Nakamoto, H., Gray, D., & Liss, S. (2011). Summary of travel trends: 2009 National Household Travel Survey. FHWA-PL-ll-022, Washington DC: Federal Highway Administration.

Spicer, R., Miller, T., Hendrie, D., & Blincoe L. (2011). Quality-adjusted life years lost to road crash injury: updating the injury impairment index. Annals of Advances in Automotive Medicine. 55, 365-77.

Trottenberg, P, & Rivkin, R. (2013) Guidance on treatment of the economic value of a statistical life in U.S. Department of Transportation analyses. Washington DC: Office of the Secretary.

Viner, J., & Conley, C. (1994). Consistency of police reported "incapacitating injuries" between states. Federal Highway Administration, Virginia.

Weber, J., Maio, R., Blow, F., Hill, E., Barry, K., Waller, P. (2002). Alcohol and/or other drug use among adult non-occupant motor vehicle crash victims. Alcohol and Alcoholism, 37(5): 468-471.

Woolhandler, S., Campbell, T., & Himmelstein, D. (2003). Costs of health care administration in the United States and Canada. New England Journal of Medicine, 349(8), 768–775.

Zaloshnja, E., & Miller, T. (2009). Costs of Crashes Related to Road Conditions, United States, 2006, Annals of Advances in Automotive Medicine, 53, 141-153.

Zaloshnja, E., & Miller, T. (2012). How often do catastrophic injury victims become Medicaid recipients?, Medical Care, 50(6), 513–519.

Zaloshnja, E., Miller, T., Romano, E., & Spicer, R. (2004). Crash costs by body part injured, fracture involvement, and threat to life severity, United States, 2000. Accident Analysis and Prevention, 36(3), 415–427.

APPENDIX

Table A-1. Unit societal costs per person in an alcohol-involved crash, United States, 2010

Unit costs	MAIS							All alcohol involved crash victims
	0	1	2	3	4	5&6	Fatal	
Medical	0	4,128	26,032	74,860	201,258	450,424	11,317	1,540
Earnings loss	0	3,144	41,582	116,400	185,948	361,786	917,323	4,688
Household productivity	45	1,050	12,409	35,861	46,499	110,424	286,395	1,486
Insurance administration	107	4,106	10,879	25,396	111,415	174,882	111,859	1,223
Legal costs	0	1,063	8,317	21,609	39,252	83,260	94,898	689
Congestion	558	876	968	1,173	1,246	1,265	5,720	183
Vehicle damage	1,816	5,382	5,756	10,860	16,306	15,070	11,180	606
Roadside furniture	12	22	22	22	22	22	32	2,216
Incident management	1.6	0.6	0.3	81	81	78	112	13
Vocational rehabilitation	0	17	106	230	282	262	0	2
Workplace costs	46	341	2,644	5,776	6,361	11,091	11,783	4
Fire department	7	9	95	227	639	651	543	12
Police	12	79	99	108	118	126	247	19
Monetized QALYs	0	8,009	151,485	208,689	669,877	1,077,707	3,922,426	17,250
Total	2,605	28,226	260,394	501,291	1,279,305	2,287,049	5,373,835	29,933

QALYs = quality-adjusted life years, a measure of pain, suffering, and health-related quality of life lost. 1 QALY = $179,472.

Table A-2. Costs per crash-involved survivor by police-reported injury severity for alcohol-involved and all crashes (in 2010 dollars)

	O-uninjured	C-possible injury	B-evident injury	A-serious injury
Alcohol-Involved Crashes				
Medical	4,637	12,152	16,281	54,321
Earnings loss	3,942	14,137	21,218	62,715
Household productivity	1,282	4,333	6,453	18,457
Insurance administration	252	4,644	6,522	24,740
Legal costs	42	2,064	3,587	13,964
Congestion	979	1,026	1,026	1,457
Vehicle damage	2,132	4,538	5,569	7,840
Roadside furniture	13	19	21	22

Incident management	2	3	8	28
Vocational rehabilitation	2	24	47	117
Workplace costs	9	394	3309	8,806
Fire department	7	22	43	151
Police	18	61	76	94
Monetized QALYs, VSL=5.13M	10,885	38,336	54,914	170,872
Total	24,193	81,360	115,765	354,778
Monetized QALYs, VSL=7.86M	26,332	32,623	41,425	229,435
All Crashes				
Total	23,365	53,431	85,142	277,895

For K-fatal, see Fatal in Table A-1. QALY = quality-adjusted life years. VSL = value of statistical life.

Table A-3. Total societal costs of crashes, driver or non-occupant BAC>.049, United States, 2010* (in millions of U.S. dollars)

Total Costs	MAIS							All alcohol involved crash victims
	0	1	2	3	4	5&6	Fatal	
Medical	0	1,127	1,382	1,764	788	950	141	6,151
Earnings loss	0	858	2,207	2,743	728	763	11,425	18,725
Household productivity	163	287	659	845	182	233	3,567	5,936
Insurance administration	388	1,121	577	598	436	369	1,393	4,883
Legal costs	0	290	442	509	154	176	1,182	2,752
Congestion	2,023	239	51	28	5	3	71	2,420
Vehicle damage	6,584	1,469	306	256	64	32	139	8,850
Roadside furniture	43.5	6.0	1.2	0.5	0.1	0.0	0.4	51.7
Incident management	5.8	0.2	0.0	1.9	0.3	0.2	1.4	9.8
Vocational rehabilitation	0.0	4.6	5.6	5.4	1.1	0.6	0.0	17.3
Workplace costs	167	93	140	136	25	23	147	731
Fire department	25.4	2.5	5.0	5.3	2.5	1.4	6.8	48.9
Police	43.5	21.6	5.3	2.5	0.5	0.3	3.1	76.7
Monetized QALYs	0	2,186	8,042	4,917	2,624	2,272	48,854	68,895
Total	9,444	7,705	13,823	11,812	5,011	4,821	66,931	119,548

* Excludes $758 million in victim mental health treatment, $1,826 million in adjudication, sanctioning and legal defense fees, and $149 million in perpetrator productivity loss while incarcerated that could not be allocated by crash severity. QALYs = quality-adjusted life years. 1 QALY = $179,472.