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Medical and Work Loss Cost Estimation Methods for the WISQARS Cost of Injury Module

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1. Introduction

This document describes the methods used to estimate costs of injury in the Center for Disease Control and Prevention's (CDC) Web-based Injury Statistics Query and Reporting System (WISQARSTM; CDC, Last updated Aug 2009) Cost of Injury module. The WISQARS database is an interactive query system that provides customized reports of injury-related data. It provides national and state statistics on the incidence and costs associated with unintentional and violence-related fatal and non-fatal injuries. The WISQARS Cost of Injury Module, which is available at (<http://www.cdc.gov/injury/wisqars>), provides cost estimates for injury deaths, hospitalizations, and emergency department (ED)-treated (i.e., treated in the ED but not hospitalized) cases by mechanism and intent of injury and by diagnosis and body region.

Part I of the WISQARS Cost of Injury Module uses fatal injury data from the National Vital Statistics System (NVSS; CDC/National Center for Health Statistics, Last updated Aug 2009)¹ and non-fatal data from the National Electronic Injury Surveillance System - All Injury Program (NEISS-AIP; US Consumer Product Safety Commission, Last updated Aug 2009). The NVSS provides data pertaining to causes of death that are classified and coded according to the International Classification of Diseases (ICD; CDC/National Center for Health Statistics, Last updated August 2009) (http://www.cdc.gov/nchs/nvss/about_nvss.htm). Since 1999, NVSS has

¹ The NVSS database is collected and disseminated by the National Center for Health Statistics (NCHS) division of CDC. It is one of the oldest and most successful examples of intergovernmental data sharing in public health. Its data are provided through contracts between NCHS and [vital registration systems operated in the various jurisdictions](#) legally responsible for the registration of vital events – births, deaths, marriages, divorces, and fetal deaths (source: http://www.cdc.gov/nchs/nvss/about_nvss.htm).

used ICD-10 (10th revision) as its basis of classifying and coding its data. The NEISS-AIP is an expansion of the National Electronic Injury Surveillance System (NEISS) operated by the U.S. Consumer Product Safety Commission (CPSC). The NEISS-AIP (Schroeder & Ault, 2001; CDC, 2001; <http://www.cdc.gov/ncipc/WISQARS/nonfatal/datasources.htm#5.3>) collects data on all types and external causes of non-fatal injuries and poisonings treated in U.S. hospital emergency departments (EDs), whether or not they subsequently are admitted to the hospital and whether or not they are associated with consumer products. NEISS-AIP is a collaborative effort between the National Center for Injury Prevention and Control (NCIPC) and CPSC.

Part II of the WISQARS Cost of Injury module allows users to input their own incidence data on deaths, nonfatal hospitalized injury cases, and ED-treated injury cases. For deaths, cost estimates are based on the ICD-10 diagnosis matrix (http://www.cdc.gov/nchs/injury/injury_tools.htm); CDC, Last updated August 2009) and the ICD-10 external cause of injury matrix (<http://www.cdc.gov/nchs/injury/ice/matrix10.htm>). For nonfatal hospitalized and ED-treated injury cases, cost estimates are based on the 9th Edition, Clinical Modification of the ICD (ICD-9-CM; <http://www.cdc.gov/nchs/icd.htm>) using the Barell Injury Diagnosis Matrix (http://www.cdc.gov/nchs/injury/injury_tools.htm) and the external-cause-of-injury code (E-code) matrix (http://www.cdc.gov/injury/wisqars/ecode_matrix.html).

The following sections describe how the total lifetime costs for fatal injuries, nonfatal hospitalized injuries and nonfatal ED-treated injuries, occurring in 2005, were estimated for use in the WISQARS Cost of Injury module. The process essentially entails estimating and aggregating the unit costs of medical treatment and work loss due to injuries.

1.1 Year of Dollars, Inflator Series, and Discount Rate

All costs used in the WISQARS Cost of Injury module are based on estimates in terms of 2005 dollars. Individual cost elements used in developing the cost module came from datasets belonging to different time periods and were inflated to 2005 dollars. Health care costs that were in prior year's dollars are inflated using the Consumer Price Index (CPI), Medical Care; work loss costs are inflated using the Employment Cost Index, Total Compensation, Total Private Industry. Work loss costs more than one year post-injury were discounted to present value using the 3% discount rate recommended by the Panel on Cost-Effectiveness in Health & Medicine (Gold, Siegel, Russell, & Weinstein, 1996) and by Haddix, Teutsch, and Corso (2003).

2. Background

Every year, injuries impose a significant financial burden on the U.S. health care system. For some injuries, medical treatment and corresponding costs may persist for years or even decades after the initial injury. Injuries can result in both temporary and permanent disability. When this occurs, injury victims may lose their ability to work or be restricted in their kinds of work they can do. Reduced or restricted ability to work due to injury may result in lost wages and accompanying fringe benefits, and the lost ability to perform one's normal household responsibilities. This document describes how these medical costs and work loss costs are quantified in the WISQARS Cost of Injury Module.

The cost estimates presented here cover three mutually exclusive categories that reflect the severity of injury: (1) injuries resulting in death, including deaths occurring within and outside a healthcare setting; (2) injuries resulting in hospitalization with survival to discharge;

and (3) injuries requiring an ED visit not resulting in hospitalization. Costs were not estimated for injuries treated only in doctor's offices or outpatient departments because WISQARS currently does not include those injuries. The cost analyses were computed from the societal perspective, which means they include all costs regardless of who paid for them.

The medical and work loss costs of each injury death were estimated using 2005 NVSS incidence data (http://www.cdc.gov/nchs/data/nvsr/nvsr56/nvsr56_10.pdf). The unit medical costs of non-fatal injuries primarily were built from databases of the Healthcare Cost and Utilization Project (HCUP) (<http://www.hcup-us.ahrq.gov/databases.jsp>): the 2005 HCUP Nationwide Inpatient Sample (HCUP-NIS) (<http://www.hcup-us.ahrq.gov/nisoverview.jsp>; HCUP Databases, last updated Aug 2009a) for hospital-admitted injuries and the 2003 HCUP State Emergency Department Databases (HCUP-SEDD) (<http://www.hcup-us.ahrq.gov/seddoverview.jsp>; HCUP Databases, last updated Aug 2009b) for non-admitted injuries treated in a hospital emergency department. The SEDD databases were accessed under a special agreement with AHRQ and its partner states. The treatment cost information from the HCUP databases were integrated with the injury incidence data from the NEISS-AIP dataset in order to assign costs at the case level classified by the NEISS diagnosis and body part codes.

The information on treatment costs from the HCUP databases were augmented with data from Finkelstein et al. (2006) including cost data on emergency transportation, physician fees, and rehabilitation to estimate the total lifetime medical and work loss costs by body region and nature of injury. All costs initially were classified by ICD-9-CM codes, then collapsed into costs by NEISS diagnosis code. The medical and work loss costs were summed to compute total costs.

ICD-9-CM uses a single numeric code to represent each medical condition. In contrast, NEISS uses two separate codes to represent each condition: a nature of injury code (e.g., burn,

fracture, laceration) and a body part code. As detailed in Appendix I, maps previously developed for CPSC (Lawrence, Miller, Jensen, Fisher, & Zamula, 2000) were used to collapse the unit costs into NEISS code categories.² The medical and work loss cost estimates from the HCUP databases were then merged at the case level by age, sex, and NEISS diagnosis, and body part codes to the 2005 NEISS-AIP dataset to yield total lifetime costs. (Note: NEISS routinely collects only the principal diagnosis and primary body part affected that are recorded in the medical record by the attending physician or other health care provider.)

3. Lifetime Medical Costs of Injuries

For some injuries, medical treatment and corresponding costs may persist for years or even decades after the initial injury. Due to data limitations, the medical costs presented in this study include costs associated with treatment for physical injuries only since data required to estimate costs for mental health and psychological treatment were not available.

3.1 Fatalities

Fatal medical costs were calculated using costs per case by place of death from Finkelstein et al. (2006). Costs were computed separately for five different places of death identified in the NVSS data:

- On-scene/at home.
- Dead on arrival at a hospital (DOA).
- In a hospital emergency department (ED).

² The reader is referred to the Appendix for additional details on the mapping procedure.

- In a hospital after inpatient admission.
- In a nursing home.

The medical costs incurred, depending on place of death, might include charges for coroner/medical examiner, medical transport, emergency department, inpatient hospital, and nursing home. Table 1 summarizes the costs included for each place of death.

Table 1. Data and Methods for Estimating Medical Costs of Fatal Injuries

Location of Fatality	Cost category	Description, Unit Cost (in 2005 US \$)	Source of Data
On scene/at home	Coroner/ME (C/ME)	\$657 (C/ME)	Edwards et al. (1981) (C/ME)
Dead on arrival (DOA) at hospital	Transport (T) + C/ME	\$263 (T) + \$657 (C/ ME)	1999 Medicare 5% Sample (T), Edwards et al. (1981) (C/ME)
In ED	T + C/ME + ED	\$263 (T) + \$657 (C/ME)+ Avg. Costs for fatalities in the ED by selected external cause and age groupings (ED)	1997 Nebraska, New Hampshire, and South Carolina ED discharge data (ED)
In hospital after admission	T + C/ME + Fatal Inpatient Total (FIT)	\$263 (T) + \$657 (C/ME)+ Avg. Costs for fatalities in the hospital by body region and nature of injury (FIT)	2000 HCUP-NIS for hospital facilities costs, 1996 and 1997 MarketScan® data for non-facility costs (FIT)
In nursing home	T+ C/ME + Non-fatal Inpatient Total (NIT) + Avg. Costs for fatalities in nursing homes (NH)	\$263 (T) + \$657 (C/ME)+ Avg. costs for non-fatal inpatient injuries by diagnosis (NIT)+ \$6872 (NH)	2000 HCUP-NIS for inpatient facilities costs (NIT), 1996 and 1997 MarketScan® data for non-facility costs (NIT), 1999 National Nursing Home Survey (NH)

All fatalities were assigned coroner/medical examiner costs of \$657 in 2005 dollars. The original estimate was based on a dated survey of these officials (Edwards et al., 1981). Although these data were old, no newer costs were available, and no evidence suggests these modest costs had changed except due to inflation. DOAs and all deaths in the hospital, whether in the ED or as an inpatient, also received the cost of a one-way transport, which was based on average ambulance transport costs for injured patients in the 1999 Medicare 5% sample.

For deaths in the ED, Finkelstein et al. (2006) added average costs for injury fatalities in the ED by external-cause-of-injury groupings (i.e., homicide, suicide, motor vehicle, other unintentional) and age groups (i.e., age 0-19 years, 20 years and older) computed from 363 injury deaths in Nebraska, New Hampshire, and South Carolina ED discharge data for 1997. (These were the only states where Finkelstein et al. (2006) could readily get data with ED charges and discharge destination.) These data, like most hospital data, contained the hospital's nominal charges, which typically exceed the actual costs of treatment. Because facility specific cost-to-charge ratios were not readily available for these data, average charges were adjusted to costs by multiplying them times the ratio of the cost per non-fatal ED injury visit (from the 1996-1999 Medical Expenditure Panel Survey – MEPS)) to the three-state average charge for a non-fatal ED injury discharge.

For deaths in the hospital, costs for an inpatient admission that resulted in a fatality were added to the transport and medical examiner/coroner costs. These inpatient costs were computed by body region and diagnosis, as per the Barell Injury Diagnosis Matrix (http://www.cdc.gov/nchs/injury/injury_tools.htm), from 10,889 unweighted cases in the 2000 HCUP-NIS file for those who died in the hospital. Then the estimated cost for non-facility services – such as professional services used while in the hospital, yet not included in the

admissions billing (e.g., surgeon, anesthesia, physical therapy) was added to the inpatient facility cost estimates from the HCUP-NIS. These non-facility costs were based on Medstat's 1996 and 1997 MarketScan® Commercial Claims and Encounters Database. This database contains an inpatient hospital admissions file, which summarizes each hospital admission, including total payments, facility payments, length of stay and detailed diagnosis data. After removing non-fee-for-service claims and claims without a diagnosis of injury, a file with 19,247 inpatient injury admissions was created. Using these records, the mean ratio of total medical costs during the inpatient stay to facilities costs was calculated by body region and nature of the injury as presented in the Barell injury-diagnosis matrix. The ratios of total costs to facilities costs ranged from 1.03 to 1.39, with an overall average of 1.26. The HCUP-NIS cost estimate for each admission was multiplied by the ratio in the corresponding Barell injury-diagnosis category to yield estimated total inpatient costs for each injury admission contained in the HCUP-NIS database. Costs were computed for non-fatal hospitalized injuries using this same approach (see below).

For deaths in a nursing home, the average cost of nursing home care (from 565 unweighted cases) computed from the 1999 National Nursing Home Survey was added to the inpatient, transport and coroner costs. Although it would have been desirable to use the average cost for only those who died in the nursing home, the small sample size prevented this analysis. Since an inpatient stay with live discharge likely preceded the nursing home stay, there was the potential for double-counting costs for both hospital and nursing home fatalities.

These costing methods were applied to the 2005 NVSS data at the case level using the place of death variable (i.e., specifying where the death occurred) to produce the fatal medical costs to be used in the WISQARS Cost of Injury module.

3.2 Hospitalized Injuries

The hospitalized injury costing methods in Finkelstein et al. (2006) were applied to 2005 acute care costs. An overview of the approach is presented in Table 2. The details are provided in the following sections.

Table 2. Data and Methods for Estimating Medical Costs of Non-Fatal Injuries Requiring Hospitalization

Cost category	Description, Unit Cost (in 2005 US \$)	Source/ Notes
Facilities Component of Inpatient Stay	Inpatient facility charges for the case multiplied by inpatient cost to charge ratio for the facility	2005 HCUP-NIS for charges, Cost to Charge ratios from Agency for Healthcare Research and Quality (AHRQ)
Non-facilities Component of Inpatient Stay	Estimated by comparing ratio of total costs to facilities costs by body region and diagnosis	1996 and 1997 MarketScan® data
Probability of Hospital Readmission During the First 6 Months Post-discharge	Probability of readmission by 3-digit ICD-9-CM codes	Estimated using 1997-98 MD, NJ, and VT hospital discharge data
Hospital Rehabilitation Costs	Estimated for 14 diagnosis groups and 6 mechanisms	Costs estimated using Prospective Payment System reimbursement amounts. All estimates reported in Miller et al. (2004)
Nursing Home (NH)	Costs added to 2005 HCUP/NIS discharges directly to NH. Specific costs estimated for hip-related fractures by age group. For all other injuries, average cost estimated	1999 National Nursing Home Survey

Cost category	Description, Unit Cost (in 2005 US \$)	Source/ Notes
Short- to Medium-Term Follow-Up Costs	Estimated as the ratio of all costs in months 1-18 after injury (on average) to total inpatient costs by select diagnosis groupings, excluding costs of readmission less than 6 months post-discharge	1996-1999 MEPS
Follow-Up Costs Beyond 18 Months and up to 7 Years	Estimated using ratios of total lifetime costs to 18 month costs by diagnosis/age group. Captures costs 7 years post injury	1979-1988 Detailed Claim Information (DCI) data from Worker's Compensation claims, Adjustment factor for youth from Miller et al. (2000)
Costs Beyond 7 Years Estimated for SCI and TBI	SCI: Ratio of lifetime costs to 7 year costs estimated from survey data TBI: 7+ year costs estimated at 75% of SCI costs	1986 survey data reported in Berkowitz et al. (1990)
Transport	50% of admissions assumed to have transport costs of \$263	Mean cost estimated using 1999 Medicare ambulance claims with an injury E-code

3.2.1 Total Inpatient Costs (Facility and Non-facility Costs)

The 2005 HCUP-NIS data on inpatient facilities charges were used to compute inpatient facilities costs. For each record in HCUP-NIS, inpatient facilities charges were, multiplied by the 2005 Medicare cost-to-charge ratios supplied by AHRQ. These ratios are hospital specific for 77% of the records in the 2005 HCUP-NIS file. For hospitals whose facility-specific ratio could not be calculated, a weighted group average ratio specific to the hospital's state, ownership, urban/rural location, and number of beds was used as recommended by AHRQ (Friedman, De La Mare, Andrews, & McKenzie, 2002). One exception was the state of Texas which accounted for 8.26% of total injury records. A weighted state average cost-to-charge ratio was used in this case because both hospital-specific and group ratios were unavailable.

When computing direct costs of inpatient care, 4.52% of the HCUP-NIS injury-related records were excluded because they lacked either charges or a diagnosis code.³ Another 0.1% of the records were excluded because the per diem charge fell in the extreme tails of the distribution (less than \$752 or greater than \$63,500 for the motor vehicle injury dataset; less than \$600 or greater than \$48,500 for the unintentional injuries dataset; less than \$395 or greater than \$46,625 for the residual injury dataset). Trimming the distribution eliminated obvious data entry errors (e.g., \$8/day for hospitalization charges) and produced robust means (Wainer, 1976). Following the approach described above for deaths in the hospital, Medstat's Marketscan® data were used to quantify non-facility fees incurred during an inpatient admission for non-fatal hospitalized injuries.

3.2.2 Inpatient Readmission and Rehabilitation Costs

Acute care readmission costs were computed for readmissions that occurred during the first six months after the injury. These were estimated by multiplying the diagnosis-specific probability of readmission from 1997-98 Maryland, New Jersey, and Vermont hospital discharge data times the average inpatient facilities cost plus non-facility fees (as described above) for the diagnosis.

Costs of inpatient rehabilitation were estimated using direct costs developed for 14 diagnosis groups in each of 6 mechanisms of injury groups by Miller et al. (2004). These diagnosis and mechanism of injury groups came from the Health Care Financing Administration (HCFA) (now the Center for Medicare and Medicaid Services, CMS) Prospective Payment System (PPS) reimbursement schedule that governs payments for all U.S. inpatient rehabilitation

³ A total of 6,292 cases (1.2%) had missing charges while another 238 cases (0.05%) reported charges that were deemed unreasonably high by AHRQ. An additional 17,087 (3.27%) cases had to be dropped because they lacked injury diagnosis codes.

including professional fees. Miller et al. (2004) used PPS data on lengths of stay and cost per day to develop direct cost estimates of rehabilitative treatment. They used data from California, Maryland, and Pennsylvania hospital discharge systems to compute the probability of rehabilitation for each PPS diagnosis and mechanism group. The product of the probability of rehabilitation and the direct cost estimate of rehabilitation developed by Miller et al. (2004) were added to the HCUP-NIS/Marketscan®-based cost estimates.

3.2.3 Nursing Home Costs

HCUP-NIS indicates injury admissions that were discharged directly to nursing homes. Finkelstein et al. (2006) quantified nursing home costs for these cases using the discharge file of the 1999 National Nursing Home Survey, a National Center for Health Statistics provider survey (<http://www.cdc.gov/nchs/nnhs.htm>). The discharge file included data on 540 nursing home discharges for injury. Each record included information on diagnoses, total length of stay from admission to discharge (some admissions occurred prior to 1999), and total payments. With a relatively small sample size, average nursing home costs were quantified for only two types of injuries – hip-related fractures and all other injuries. For hip-related fractures average costs were quantified separately for three age groups, 0-64 years, 65-74, and 75 and older. Costs were not differentiated by age for those with non-hip-related injuries. Nursing home costs were added to the HCUP-NIS/Marketscan® cost estimates by injury diagnosis.

3.2.4 Short- to Medium-Term Follow-Up Costs for Inpatient Admissions Not Discharged to a Nursing Home

To develop estimates of short- to medium-term costs for injuries requiring an inpatient admission but not discharged to a nursing home, Finkelstein et al. (2006) multiplied total

inpatient costs for each record in HCUP-NIS/MarketScan® (as derived above) by the ratio of all costs in the first 18 months after injury, on average, (including costs for inpatient services, ED visits, ambulatory care, prescription drugs, home health care, vision aids, dental visits, and medical devices) to the total inpatient costs (including admissions and readmissions) for injury by diagnosis and mechanism of injury. These ratios were derived from 1996-1999 MEPS data. MEPS is a nationally representative survey of the civilian non-institutionalized population that quantifies individuals' use of health services and corresponding medical expenditures for two consecutive years following enrollment. Because the MEPS analysis was limited to injuries of admitted patients with at least 12 months of follow-up and the MEPS data include costs for up to 24 months, the MEPS sample captures injuries with an average of 18 months of post-injury treatment.

Although MEPS is the best source of available data for capturing nationally representative injury costs across treatment settings (e.g., hospitals, physician's office, pharmacy), even after pooling four years of data the sample size for many injuries with low incidence rates was small. Therefore, to obtain robust direct cost estimates, injuries were collapsed into broad categories prior to quantifying average costs. Records were collapsed into ICD diagnosis groupings based on the following guidelines (in priority order):

1. Groupings must be comprehensive, covering all injury diagnoses (including those for which MEPS lacks cases).
2. Groupings need to balance the goals of diagnosis-level detail and reasonable cell sizes. In some instances, cell samples as small as 5 were accepted in order to avoid combining radically dissimilar diagnoses into a single group.

3. Groupings should be similar, either in nature of injury (e.g., sprain, fracture) or in body region, if not in both.
4. Total injury costs (or the ratio of total injury costs to hospitalization costs for admitted injuries) should be similar in magnitude across diagnoses within each grouping.

Using the MEPS data and the criteria detailed in the preceding paragraph, the average ratio of 18-month costs to total inpatient costs (including inpatient facility and non-facility fees) was calculated for 15 injury-specific diagnosis groups, ranging in size from 5 to 61 unweighted cases. The ratios ranged from 1.02 to 2.13, with an overall average of 1.35 (details in Appendix II). The ratios were then multiplied by the corresponding inpatient cost estimates detailed in the preceding section to arrive at 18-month costs for injuries requiring an inpatient admission.

3.2.5 Long-Term Follow-Up Costs

While short- to medium-term costs capture the majority of costs for most injuries, some injuries continue to require treatment and costs beyond 18 months. Rice et al. (1989) estimated long-term medical costs from costs in the first six months using multipliers derived from longitudinal 1979-1988 Detailed Claim Information (DCI) data on 463,174 Worker's Compensation claims spread across 16 states. The DCI file was unique: nothing similar in size, geographic spread, and duration has become available subsequently. Because occupational injury includes a full spectrum of external causes (e.g., motor vehicle crash, violence, fall), the DCI data by diagnosis presumably captured the medical spending pattern for an injury to a working-age adult reasonably accurately. Their applicability to childhood injuries was questionable. To address this concern, Miller, Romano, and Spicer (2000b) analyzed the 30-month cost patterns

(long-term costs were not available) of adult versus child injury using 1987-89 MarketScan data on private health insurance claims. They found that the ratios of 30-month costs to initial hospitalization costs for children's episodes by diagnosis did not differ significantly from the comparable ratios for adults. By diagnosis, the ratios for children ranged from 95% to 105% of the ratios for adults. Thus, it is reasonable to apply the DCI estimates to childhood injury cases.

Costs beyond 18 months were not inconsequential for some injuries. For lack of a better alternative, following Finkelstein et al. (2006), ratios computed from the DCI expenditure patterns were used to adjust estimates of costs in the first 18 months to arrive at estimates of the total medical costs (including long-term) associated with injuries. This method implicitly assumed that while treatment costs varied over time, the ratio of lifetime costs to 18-month costs had remained constant between the time the DCI data were reported and 2005.

For those injury/age groups identified in MEPS as having costs in months 7-18, the cost estimates for months 0-18 were multiplied by the ratio of lifetime costs to the costs in months 0-18 for the same injury/age group calculated using the DCI data. Although the DCI ratios varied by injury diagnosis, overall, they revealed that, using a 3% discount rate, 77% of the costs for admitted cases occurred in months 0-18 (Miller et al., 2000a). These ratios suggested an average multipliers of 1.30 for admitted cases.

3.2.6 Long-Term Costs of Spinal Cord Injuries (SCI) and Traumatic Brain Injuries (TBI)

WISQARS incorporates TBI and SCI medical cost estimates from Finkelstein et al. (2006). For several types of injuries, and especially for SCI and TBI, a substantial portion of the total medical costs occur beyond seven years of sustaining the injury. For SCI, because data are available beyond seven years, the ratio of lifetime costs to costs in years 1-7 was multiplied by

the estimates from the MEPS/DCI analysis to obtain total cost estimates (Finkelstein et al., 2006). This ratio was generated from data collected by Berkowitz, Harvey, Greene, and Wilson (1990), who surveyed a nationally representative sample of SCI survivors and their families in 1986 and collected data on 758 SCI victims, including those residing in institutions, those living at home, and those in independent living centers. The respondents (victims, families, or guardians) provided details of care payments during the past year, including payments for medical, hospital, prescription, vocational rehabilitation, durable medical equipment, environmental modification, personal assistant, and custodial care. The long-term cost estimates for SCI rely on the assumption that the now dated Berkowitz data on medical costs by year post-injury mirror the expected lifetime costs for recent SCI victims.

Quantifying long-term costs for TBI is more problematic. Most TBI programs do not have longitudinal data on TBI costs. However, Miller et al. (2004) estimated inpatient rehabilitation costs by diagnosis group, including SCI and TBI, finding that among patients receiving rehabilitation, the cost per case for TBI averaged 75% of the cost for SCI. TBI patients, however, were far less likely to receive inpatient rehabilitation (6% versus 31%). Finkelstein et al. (2006) assumed the TBI patients who received inpatient rehabilitation would follow the same cost pattern more than seven years post-injury as the SCI patients, but with costs equal to 75% of SCI levels. For very severe burns, amputations, and other non-SCI, non-TBI injuries requiring lifetime medical care, lack of available data will bias Finkelstein et al.'s (2006) lifetime cost estimates downwards.

3.2.7 Transport costs

None of the data sets and analyses of non-fatal hospitalized injuries described above include transportation costs. WISQARS incorporates transportation costs from Finkelstein et al. (2006). Finkelstein et al. (2006) estimated the half of non-fatal injuries requiring a hospital admission also required a one-way trip via ambulance to the hospital. For each injury, the costs include half of the one-way average emergency transport costs based on 1999 average transport costs for Medicare beneficiaries with an E-code on an ambulance claim. There were 15,579 Medicare ambulance claims (including air ambulance) that were E-coded, with an average cost of \$263 in 2005. The estimated 50% transport rate may be conservative. The National Pediatric Trauma Registry, which captures admitted serious injuries, showed that from 4/1/94 to 11/5/01, 58.4% of 48,288 pediatric patients arrived by ambulance (National Pediatric Trauma Registry, 2002).

3.3 Injuries Treated in an Emergency Department

Table 3 summarizes the approach for quantifying costs of non-fatal injuries treated in EDs and released without inpatient admission.

Table 3. Data and Methods for Estimating Medical Costs of Non-Fatal, Non-Admitted Injuries Treated in Emergency Departments

Cost category	Description, Unit Cost (in 2005 US \$)	Source/Notes
ED Visit	ED facility charges times facility-specific (or hospital stratum average) cost-to-charge ratios times national/state price adjusters	2003 HCUP-SEDD (CT, GA, MD, MN, NE, SC, TN, UT), cost-to-charge ratios from AHRQ, and national/state price adjusters from ACCRA
Follow-up Visits and Medication, Months 1-18	Estimated as the ratio of all costs in the first 18 months after injury to costs of the initial ED visit by diagnosis grouping	1996-1999 MEPS
Follow-Up Costs Beyond 18 Months	Estimated using ratios of total lifetime costs to 18 month costs by diagnosis/age group.	1979-1988 Detailed Claim Information (DCI) data from Worker's Compensation claims, Adjustment factor for youth from Miller et al. (2000)
Emergency Transport	50% of ED visits assumed to have transport costs of \$263	Mean cost estimated using 1999 Medicare ambulance claims with an injury E-code

The 2003 HCUP-SEDD data were used to quantify direct medical costs for ED-treated, non-admitted, non-fatal injuries. The HCUP-SEDD includes all patients treated in an ED who were not subsequently admitted as inpatients. AHRQ provided facility-specific cost-to-charge ratios for EDs in eight states (Connecticut, Georgia, Maryland, Minnesota, Nebraska, South Carolina, Tennessee, and Utah). These ratios were multiplied by the hospital charges in the HCUP-SEDD database to estimate the facility cost, similar to the methods described above using the HCUP-NIS data to estimate hospital-admitted costs.

Since these costs were at state price levels for a non-representative sample of states, we converted the costs to national price levels using state price indices based on the ACCRA Cost of Living Indices for health care services (<http://www.coli.org>). ACCRA publishes indices for large

metropolitan areas and the non-metropolitan remainders of states. The regional index values for medical care within each state were weighted using Census population estimates for 2003 to obtain a state-level index. For New York, separate indices were computed for New York City and the balance of the state and then combined using population weights.

As with costs for hospitalized injuries, the costs of the initial visit were factored up by 1996-99 MEPS-based ratios for 51 categories of non-admitted injuries, to account for follow-up visits and medication in the first 18 months post injury. The ratios ranged from 1.02 to 5.44, with an overall average of 1.78 (details in Appendix II). For those injury/age-groups identified in MEPS requiring follow ups longer than 18 months, average costs were estimated using ratios from DCI expenditure patterns and implicitly assuming that the ratio of lifetime costs to 18-month costs had remained constant between the time DCI data were reported and 2003. These long-term costs were calculated by multiplying the DCI ratios of lifetime costs to 0-18 month costs for the same injury/age-group using the 0-18 month costs from MEPS. Using a 3% discount rate, 88% of the costs for non-admitted cases occurred in months 0-18 and the average multiplier was 1.14 (Miller et al., 2000a). For age-groups not represented in DCI, the costs were adjusted using ratios from Miller et al.(2000b). As with hospital costs, half the patients were assumed to receive emergency transport so half of average one-way emergency transport costs of \$263 was added to the costs of all ED-treated injuries (see Transport Costs Section above).

3.4 Applying the Estimated Non-Fatal Costs to the 2005 NEISS-AIP

The medical costs were computed as described for all non-fatal injury cases in the 2005 HCUP-NIS and the 2003 HCUP-SEDD. The costs by admission status, age group, sex, and diagnosis were further differentiated by major cause using three cause groups: motor vehicle

traffic-related injuries, intentional injuries (i.e., assaults and self-harm), and all other injuries (including unintentional, non-motor-vehicle injuries and all injuries with missing cause codes or unknown intent). A few diagnosis categories not commonly found among intentional and motor vehicle injuries – notably burns – were not differentiated but were placed into the “all other injuries” category. All cases were assigned NEISS nature of injury and body part codes (which taken together constitute a NEISS diagnosis) using a procedure developed by Lawrence et al. (2000). Then average costs were computed by admission status, age group, sex, NEISS nature of injury, body part, and cause group. Sometimes age/sex/diagnosis cells were combined together using a set of decision rules developed for this purpose to obtain large enough cell counts (at least 10 unweighted cases and usually at least 30) for obtaining stable national estimates

4. Lifetime Work Losses Due to Injuries

Injuries can result in both temporary and permanent disability. When this occurs, injury victims may lose part or all of their productivity potential. Work losses due to injury may include lost wages and accompanying fringe benefits, and the lost ability to perform one’s normal household responsibilities. For non-fatal injuries, work losses represent the value of goods and services not produced because of injury-related illness and disability. To the degree that injuries prevent or deter individuals from producing goods and services in the marketplace, the public sector, or the household, the value of these losses is a cost borne by society.

Fatal work losses represent the value of goods and services never produced because of injury-related premature death. These work loss costs were estimated by applying expected lifetime earnings by age and sex to the 149,075 deaths from injury sustained in 2005, including an imputed value for lost household services.

Consistent with the human capital approach for quantifying the burden of injuries (Rice et al., 1989), estimates of non-fatal work losses involve applying average earnings to work-years lost and the value of housekeeping services to time lost in home production. Non-fatal injuries may result in both short-term work loss and in lifetime work losses. The latter includes the value of output lost by persons disabled in later years as a result of injury sustained in 2005.

The work loss estimates for the WISQARS Cost of Injury module were inflated from Finkelstein et al. (2006). Non-fatal work losses were stratified into two categories: short-term losses, which represent lost wages and accompanying fringe benefits and household services occurring in the first six months after an injury, and long-term losses, which represent the respective wage and household loss occurring after six months from the time of the injury. The decision to use six months as the transition point between short-term and long-term work losses was driven by the availability of data on duration of work loss.

Because men earn higher wages than women, even in the same job (Bureau of Labor Statistics, 2001) or for injuries with the same prevalence between men and women, the work loss estimates were greater for men. Finkelstein et al. (2006) view this as more of a shortcoming of the labor market than an inherent problem with the human capital approach. Regardless, this undervaluation of women's labor is reflected in the estimates.

4.1 Fatalities

For someone of a given sex and age who sustained a fatal injury, Finkelstein et al. (2006) summed the sex-specific probability of surviving to each subsequent year of age (Arias, 2002) times sex-specific expected earnings for someone of that age. We used this formula with earnings data by sex and year of age derived from the March Supplement of the Current

Population Survey, averaged across a full business cycle from 2002 through 2009. We inflated or deflated all earnings figures to 2005 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 2002-2009 from the national income accounts (*Economic Report of the President*, various years, Table B-28). Earnings, including salary and the value of fringe benefits, at future ages were adjusted upward to account for a historical 1% work growth rate (Haddix et al., 2003) and then discounted to present value using a 3% discount rate.

Parallel calculations valued lost household work. Estimates of the value of household work are also included in Haddix et al. (2003). Historically, productivity growth in household production has been negligible, so Finkelstein et al. (2006) did not adjust for it. In all cases, they assumed that the probability of surviving past the age of 102 is zero.

In equation form, lifetime earnings for someone of age a and sex b ($Earn_{a,b}$) is computed as

$$Earn_{a,b} = \sum_{k=a}^{102} \left\{ P_{a,b}(k) \times Y_{k,b} \times \left(\frac{1+g}{1.03} \right)^{k-a} \right\}$$

where $Earn$ = lifetime earnings, $P_{a,b}(k)$ = the probability that someone of age a and sex b will live until age k , $Y_{k,b}$ = the average value of annual wages (plus fringe benefits) or of annual household production at age k for someone of gender b , g = the productivity growth rate (0.01 for wages, 0.00 for household production), and .03 is the discount rate.

These costing methods were applied to the 2005 NVSS data at the case level to produce the fatal work loss costs to be used in WISQARS.

4.2 Non-fatal Injuries

For non-fatal injuries, work loss estimates included the sum of the value of wage and household work lost due to short-term disability in the acute recovery phase and of the value of wage and household work lost due to permanent or long-term disability for the subset of injuries that cause lasting impairments that restrict work choices or preclude return to work.

4.2.1 Short-term Work Losses

Finkelstein et al. (2006) quantified temporary or short-term work loss for non-fatal injuries using the approach presented in Lawrence et al. (2000). Lawrence et al. combined the probability of an injury resulting in lost workdays from 1987-1996 National Health Interview Survey (NHIS) data with the mean work days lost (conditional on having missed at least one day) per injury estimated from the 1993 Annual Survey of Occupational Injury and Illness reported by the Bureau of Labor Statistics (BLS). These data were sent to BLS by employers through a mandatory reporting system. Employers reported work loss from date of occupational injury to the end of the calendar year for a sample of approximately 600,000 injury victims. All cases reported involved at least one day of work loss beyond the date of the injury. Moreover, if a worker still was out of work at the time the employer report was due to BLS, the report would undercount work days lost. On average, BLS work-loss reports cover six months post injury. Lawrence et al. (2000) used a Weibull regression model to estimate the total duration of work loss for cases still open at the end of the survey reporting period. These results were combined with those of the closed cases to estimate average work loss, conditional on having missed at least one day of work. These BLS-based estimates were then combined with the pooled 1987-1996 NHIS data on probability of work loss to compute mean work loss including cases without

work loss. Although BLS uses a detailed two-column coding system (body part, nature of injury), Finkelstein et al. (2006) were able to map their codes to the ICD-9-CM codes. They assigned the average work loss across all BLS cases to cases with ICD-9-CM diagnosis codes of “Other Unspecified” or “Other Specified.” Averaged across all injuries, total estimated temporary work loss was 24.5 days per injury.

- Although the BLS data are limited to injuries that occur on the job, Finkelstein et al.’s (2006) separate analysis of 1996-99 MEPS data (based on a much smaller sample) found that the duration of work loss did not differ significantly by whether or not the injury occurred on the job. This suggested that the BLS-NHIS work loss estimates could credibly be applied to estimate work loss associated with non-work-related injuries.
- MEPS revealed that work-loss was roughly 5 times longer for hospitalized injuries than non-hospitalized injuries. Using this ratio, Finkelstein et al. (2006) computed work-loss durations for injuries separately for admitted and non-admitted cases. Averaged across all injuries (including those with no work loss), the estimated temporary work loss was 11.1 days per injury.
- To place a monetary value on temporary wage work loss, the estimated days of work lost were multiplied times average earnings per day of work, given the victim’s age and sex, from the Current Population Survey, as described above in section 4.1.⁴

Household workdays lost were estimated as 90% of wage workdays lost, based on findings from an unpublished nationally representative survey on household work losses following injury (S. Marquis, the Rand Corporation, personal communication, 1992). This ratio

⁴ Source: www.bls.census.gov/cps/cpsmain.htm

and the value of household work used in Haddix et al. (2003), were used to impute a value to household work lost.

The estimates in Haddix et al. (2003) value household production lost using replacement cost. They started with national survey data on the average amount and nature of housework that people do by age group and sex, for example the hours that a woman 30-34 years old spends on cooking and on cleaning. They valued the cost of replacing these hours using BLS data on average wage rate by occupation (e.g., for cooks and maids).

4.2.2 Long-term Work Losses

Finkelstein et al. (2006) considered permanent total disability and permanent partial disability separately. For permanent total disability, the present value of age-and-sex-specific lifetime earnings and household production from the fatality analysis were multiplied by the probability of permanent disability for each type of injury. For permanent partial disability, the earnings estimate times the probability of permanent partial disability was multiplied by an additional factor identifying the percentage of disability resulting from that type of injury. The results were then summed to compute the net work loss associated with permanent disability, including total and partial disability.

The probabilities of permanent partial disability by body part and nature of injury were from Miller, Pindus, Douglass, and Rossman (1995) and were based on pooled multi-state Workers' Compensation data from the 1979-1988 Detailed Claims Information (DCI) data base of the National Council on Compensation Insurance (NCCI). The percent disabled came from Lawrence et al. (2000) and was based on 1992-96 DCI data. DCI records the disability status for each sampled case. Following Rice et al. (1989), Finkelstein et al. (2006) assumed that these

probabilities are the same for injuries that do and do not occur on the job and that these probabilities have not changed significantly over time. This method also assumes that the probability that an injury (e.g., a skull fracture) will cause someone never to do wage or household work again is the same for children, adults, and the elderly (the years of work lost obviously will vary with the age of onset) and that people will experience the same percentage reduction in household work ability that they experience in wage work ability.

To verify that the DCI data produce reasonable estimates, Finkelstein et al. (2006) conducted a literature review to compare their estimates to estimates from other sources. Due to the paucity of data on this subject, they identified only a few sources with published disability estimates, and these were generally dated and limited to specific populations.

Based on the limited information available, the DCI data suggested similar probabilities of permanent disability to the other studies of long-term work loss. Although dated and restricted to occupational injury, the DCI data have several advantages that outweigh their disadvantages. As a result of their large sample, the DCI database can be used to compute probabilities for a far wider range of specific diagnoses than all the disability studies in the literature combined. Despite its restriction to occupational injury, the DCI sample also is more representative of the mix of injuries admitted to hospitals than the few studies in the literature, notably those which are restricted to patients triaged to trauma centers. The DCI data also are virtually the only source of information about permanent disability due to injuries not admitted to the hospital. The sample includes 318,885 medically treated, non-admitted patients with valid lost-work claims in Workers' Compensation. Averaged across all injuries, the estimated percentage of lifetime productivity potential lost due to permanent injury-related disability was 0.26% per injury.

4.2.3 Calculating Total Work Loss Costs

The work loss costs were computed as described for all non-fatal injury cases in the 2005 HCUP-NIS and the 2007 HCUP-NEDS. Short- and long-term costs were summed to compute total work loss costs. Similar to the procedure used for medical costs, average costs were computed by age, sex, and NEISS diagnosis within the three major cause categories, sometimes combining age/sex/diagnosis cells to ensure that estimates were produced for all cells.

5. Limitations of Methods for Medical and Work Loss Estimates

The WISQARS cost estimates are subject to several limitations. First, the estimates focus exclusively on medical costs and work loss costs. They do not account for non-health costs (e.g., criminal justice, educational impacts, property damage etc.), pain and suffering, quality of life loss, or injury costs borne by family and caretakers. Also excluded are costs due to mental health, psychological treatment, and medical claims processing.

Second, a major limitation was the requirement to use data from a multitude of sources. Although these were the best available data at the time of the analysis, some of the sources are old, others are based on non-representative samples, and all are subject to reporting and measurement error. These factors may have incorporated significant bias into the cost estimates. The costing approach was designed to minimize the potential bias. However, more current and nationally representative data would have been preferable but were not available.

Third, an additional limitation of having to use multiple data sets was the inability to generate standard errors around the cost estimates. These costs are associated with great

uncertainty, and users are cautioned that the actual costs for any given injury category could be substantially higher or lower than the WISQARS estimates.

The methods for estimating work loss costs had many additional limitations. Because women, the elderly, and children have lower average earnings, the human capital approach applied undervalued injuries to these groups. The approach also placed lower values on the work of full-time homemakers than the work of people participating in the labor market, which further depressed the value placed on women's losses relative to men's losses. It also undervalued disability among those of retirement age, and did not value temporary disability among children, as they had not yet entered the labor force. Discounting future work losses to present value meant that the loss of a lifetime of work by a 2-year-old was considered equivalent to loss of a lifetime of work by a 43-year-old. Although the child loses many more years of work, those years are far in the future and heavily discounted. The work loss cost calculations are also based on a year 2000 life table, which essentially assumes that life expectancy would have remained constant over each person's expected lifespan absent injury. Moreover, victims of serious and fatal injury may tend to be risk-takers (for example, thrill-seekers, heavy drinkers, or drug abusers) whose life expectancy may be shorter than for the average population, which would further bias the results. And, as noted above, some of the estimates are computed using fairly dated data that are based on a working population. Additionally, the estimates exclude the ability to work lost by people other than the injured person. These losses may include the time family, friends, and professionals spend caring for the injured, time spent investigating the injury, and worker retraining. All of these limitations suggest that the costs should be interpreted with caution.

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Appendix I

Mapping between ICD-9-CM Codes and NEISS Diagnosis and Body Part Codes

This Appendix describes the mapping technique between ICD-9-CM codes and NEISS diagnosis and body part codes developed by Lawrence et al. (2000) under contract for CPSC. In the HCUP datasets, diagnoses were coded using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), <http://www.cdc.gov/nchs/icd.htm> which uses a single numeric code to represent each medical condition. NEISS, like many other specialized systems for coding injury diagnoses, uses two separate codes to represent each condition: a nature of injury code (e.g., burn, fracture, laceration) and a body part code. Therefore, to estimate costs by NEISS diagnosis (nature of injury and body part), the ICD-9-CM primary injury diagnosis of each HCUP case had to be mapped into NEISS codes.

Mapping is not a straightforward process because there is not a one-to-one correspondence between codes in the two systems. In some instances, ICD-9-CM is more detailed, while in other instances, NEISS is more detailed. For example, NEISS lumps all poisonings into a single code, while ICD-9-CM has separate codes for more than 200 substances. In this instance, many ICD-9-CM diagnoses are mapped to a single NEISS diagnosis. When mapping from ICD-9-CM to NEISS, this is not a problem, as it results in a single NEISS diagnosis for each HCUP case. On the other hand, NEISS distinguishes between six different types of burns (electrical, scald, chemical, thermal, radiation, and unspecified), while ICD-9-CM has just one category for burns. In this instance, a single ICD-9-CM diagnosis must be mapped to six NEISS diagnoses. To handle this, the original HCUP burn case was transformed into six

cases, each with a different NEISS code. In order to maintain the original weighted case count when mapping, each new NEISS-coded case received one-sixth of the original case weight.

Using the NEISS-coded versions of the HCUP datasets, mean costs then were calculated by age group (0-19, 20-54, 55-69, 70+), sex (female, male), and NEISS diagnosis (31 two-digit nature of injury codes and 26 two-digit body part codes, which combine to make 500-plus four-digit diagnoses). In instances where cell counts were small, similar cells were combined, most often by combining adjacent age groups, but sometimes by combining male and female or by combining similar diagnoses. For a few nature of injury categories (e.g., amputation, crushing), the HCUP cell counts were too small to obtain hospital-admitted costs by age, sex, and four-digit diagnosis. For these cases, the hospital-admitted costs were computed using a two-step procedure. First, the mean cost for each four-digit diagnosis code and the cost differentials by age-sex for the entire nature of injury category (e.g. all burns) were estimated. Second, the age-sex differentials for each category were applied to the average cost of each four-digit diagnosis code to differentiate by age and sex.

In building the WISQARS costs, this process was applied using twelve datasets: two admission statuses (hospital-admitted, ED-treated) by three cause groups and by two types of costs (medical, work loss). The three cause groups were: motor vehicle traffic-related injuries, intentional injuries (i.e., assaults and self-harm), and all other injuries (including unintentional, non-motor-vehicle injuries and all injuries with missing cause codes or unknown intent). A few diagnosis categories not commonly found among intentional and motor vehicle injuries – notably burns – were not differentiated but were placed into the “all other injuries” category. The result was a file of costs by admission status, cause group, NEISS nature of injury and body part, sex, and age group. In order to test for completeness, the estimated costs were merged onto the 2005

NEISS-AIP data, revealing a number of cases with rare diagnoses without assigned costs. For these cases with rare diagnoses, costs were copied from similar diagnoses. For cases where the patient's sex or age was missing, average costs were estimated by age and NEISS diagnosis or by sex and NEISS diagnosis, respectively. Using this approach, all individual NEISS-AIP cases for the 2005 NEISS-AIP file were assigned medical and work loss costs.

Appendix II

Classification of Injury-Specific Diagnosis Groups by ICD-9-CM Codes and the Multipliers to Estimate Short-Term Follow-up Costs

A. Multipliers for Short-Term Follow-up Costs for Admitted Patients

The fifteen injury-specific diagnosis groups and associated multipliers that were used for estimating short-term follow up costs for admitted patients were as follows:

Group No.	ICD-9-CM Diagnosis Codes	Average Ratio of all costs in the first 18 months after injury to total inpatient costs
1	802, 830	1.02
2	800, 801,803, 804, 850-854	1.38
3	806, 952	2.13
4	805, 807-809, 839	1.12
5	810-819, 831-834	1.27
6	820, 835	1.38
7	821-829, 836-838	1.50
8	840-848	1.68
9	860-869	1.12
10	870-904	1.12
11	910-929	1.25
12	930-939, 950-958, 990-995	1.96
13	940-949	1.14
14	959	1.17
15	960-989	1.02
	All	1.35

B. Multipliers for Short-Term Follow-up Costs for ED-Treated Patients

The fifty one injury-specific diagnosis groups and associated multipliers that were used for estimating short-term follow up costs for injuries treated and released in emergency departments were as follows:

Group No.	ICD-9-CM Diagnosis Codes	Average Ratio of all costs in the first 18 months after injury to total ED visit costs	Group No.	ICD-9-CM Diagnosis Codes	Average Ratio of all costs in the first 18 months after injury to total ED visit costs
1	802, 830	2.47	27	851-854	1.38
2	800, 801, 803, 804	1.19	28	860-869	1.04
3	805-809	1.40	29	870-874	1.15
4	810-811	3.40	30	875-879	1.09
5	812	3.95	31	880-881	1.82
6	813	1.43	32	882	1.28
7	814	2.83	33	883	1.28
8	815-817	1.75	34	884-887	1.45
9	818-819	1.77	35	890-891, 894-897	1.35
10	820-822	2.01	36	892-893	1.18
11	823	2.31	37	900-904	2.73
12	824	2.19	38	910-919	1.29
13	825	1.77	39	920	1.02
14	826	1.69	40	921	1.33
15	827-829	1.38	41	922	1.32
16	831	2.44	42	923	1.28
17	832-833	3.96	43	924	1.49
18	834	1.36	44	925-929	1.53
19	835-839	1.27	45	930-934	1.11
20	840	5.44	46	935-939	1.74
21	841-842	1.22	47	940-949	1.93
22	843-844	2.25	48	950-958, 990-995	1.11
23	845	1.34	49	959	2.00
24	846-847	1.83	50	960-988	1.11
25	848	1.62	51	989	1.12
26	850	1.16		All	1.78