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The value of a statistical life for transportation regulations: A test of the benefits transfer methodology

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Abstract Policy applications of the value of a statistical life (VSL) often make a benefits transfer assumption that the VSL from one market context is broadly applicable to other contexts. The U.S. Department of Transportation's estimate of $9.2 million is based on labor market estimates of VSL. This article examines whether there are any significant differences in labor market estimates of the VSL by the nature of the fatality, utilizing two different approaches that distinguish between fatalities resulting from transportation events and vehicle-related sources based on the Census of Fatal Occupational Injuries (CFOI) data. The labor market estimates of VSL generalize across transport and non-transport contexts so that it is appropriate to use labor market estimates of VSL to value the benefits of transport regulations. This result holds even after accounting for the level and composition of nonfatal job injuries.

Keywords Value of a statistical life · VSL · Benefits transfer · CFOI · Transportation · Fatality · Injury

JEL Classifications I18 · J17 · J30

The value of a statistical life (VSL) is the key parameter used in assessing the mortality risk reduction benefits of government policies. Since these benefits in turn comprise the largest benefit component for most risk and environmental regulations, choice of the VSL is the key determinant of whether a policy passes a benefit-cost test as well as the stringency of regulations. However, the VSL is not a universal constant. Its magnitude will differ across populations and, for any given population, may differ depending on

This paper used fatal injury data that were obtained with restricted access to the BLS Census of Fatal Occupational Injuries Research File.

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the cause of death. The valuation of reductions in fatality risks may vary by risk type because the associated morbidity effects may differ, as several studies have shown to be the case with respect to cancer risks.

Our focus in this article is on the VSL for assessing transportation safety policies. Transportation and environmental regulations comprise the dominant share of all regulatory costs. Some regulations are jointly enacted by the U.S. Department of Transportation (DOT) and the U.S. Environmental Protection Agency, such as those regarding fuel economy standards. The recent approach adopted by the U.S. Department of Transportation (2013, 2014) utilizes a benefits transfer methodology. To value transport-related fatalities, the agency uses an average VSL estimate based on recent labor market studies that have used the Census of Fatal Occupational Injuries (CFOI) data to construct measures of fatality risks to the worker. As of 2014, the DOT used a VSL of $9.2 million for its policy evaluations based on an average of nine VSL studies using CFOI data (Viscusi 2004; Kniesner and Viscusi 2005; Evans and Smith 2008; Viscusi and Hersch 2008; Evans and Schaur 2010; Hersch and Viscusi 2010; Kniesner et al. 2010; Scotton and Taylor 2011; Kniesner et al. 2012). The DOT also estimates the value of statistical injury (VSI) by multiplying the VSL estimate by a proportion reflecting the relative value of a nonfatal injury to a fatality (U.S. Department of Transportation 2014). The proportions vary by injury severity, resulting in five estimates of VSIs ranging from $27,600 to $5.5 million. Although the DOT uses the general job-related VSL to evaluate safety regulations for transportation and vehicular regulation, a transport-specific VSL would be a more pertinent measure for the department to use. The agency's current procedure involves a form of benefits transfer, in which the agency assumes that it is appropriate to apply valuations from the job risk context to transport risks. The statistical validity of this pivotal benefits transfer methodology has never been examined in any policy context.

The official policy evaluation guidance given to U.S. executive branch agencies highlights the potential importance of the benefits transfer issue but does not resolve it. The U.S. Office of Management and Budget (OMB) Circular A-4 (2003) expresses a preference, all else equal, for revealed preference figures such as labor market VSL estimates over stated preference figures. The Circular questions the appropriateness of using a common VSL for different regulatory regimes and discusses the value of a benefits transfer in which estimates from existing studies are transferred to new contexts. While acknowledging that the benefits transfer technique provides a low-cost, quick way to evaluate policy, the Circular suggests that a tailored study is preferable, if possible. In this article we undertake an analysis of the VSL associated with transport-specific fatality rates to formally test the validity of the benefits transfer assumption and to ascertain whether transport-specific VSL estimates from the labor market are consistent with the current approach of using average overall VSL estimates from the labor market.

Conversely, in the U.K., transport-specific VSL estimates have been used to approximate the general occupational risk VSL, again invoking the benefits transfer assumption. Numerous stated preference studies in the U.K. such as Jones-Lee et al. (1985), Jones-Lee (1989), Jones-Lee and Loomes (1995), Beattie et al. (1998), Carthy et al. (1998), Chilton et al. (2006), and Covey et al. (2010) have derived estimates of VSL in transport safety contexts. Unlike the U.S. empirical evidence, labor market estimates of VSL in the U.K. are very unstable (Viscusi and Aldy 2003), making the stated preference studies a potentially sounder benefit assessment approach for the U.K. Because such stated preference studies can be designed specifically for the transportation context, a benefits transfer issue can be avoided. However, if one wanted to generalize the stated preference results for transportation safety to other policy contexts, such as regulation of job safety, the same kinds of benefits transfer issues would arise.

At present, the U.K. recognizes both the importance of using VSL estimates as well as the existence of benefits transfer issues but does not have an explicit benefits transfer procedure. The U.K. H.M.S. Treasury provides guidance on the “value of a prevented fatality or prevented injury” (H.M.S. Treasury 2011). The U.K. Department for Transport estimates the specific value of transportation death at £1.145 million. The value of statistical injury ranges between £9,920 and £128,650 (year 2000 British pounds), depending on severity. The H.M.S. Treasury guidance acknowledges the challenge of benefits transfer in this context, noting that individuals are not indifferent to the cause of death or injury. The Treasury provides one example of an attempt to correct for this discrepancy: the Health and Safety Executive doubles the value of a prevented fatality to value asbestos risks, incorporating individual aversion to dying from cancer and medical costs. However, it is unclear how the transportation VSL generalizes to other risks or to total occupational risk.

The U.S. government benefit assessment guidelines express a preference for the use of revealed preference measures of benefits rather than stated preferences elicited through some type of survey (U.S. Office of Management and Budget (OMB) Circular A-4 2003). The large economics literature on the revealed preference approach to valuing risks of death, reviewed by Viscusi and Aldy (2003), consists primarily of hedonic studies of the labor market and, to a lesser extent, studies of product markets and housing markets. The canonical hedonic labor market model estimates yield average rates of tradeoff between risk and wages, which are used to construct the VSL. The tradeoff rates simultaneously reflect the marginal valuations of safety by workers as well as the marginal costs to firms of providing greater levels of safety. These labor market estimates are used throughout the U.S. federal government to value risks to life by all federal agencies including risks pertaining to motor vehicles, homeland security, occupations, the environment, consumer products, food and drug regulations, and many other hazards.[1] Apart from one exploratory regulatory analysis by the U.S. Environmental Protection Agency in which the agency used age-specific VSL levels to analyze the Clear Skies initiative, government agencies do not differentiate the VSL when policies affect different population groups.[2]

Although agencies generally use a single average VSL across different types of policies and affected population groups, there is considerably more heterogeneity in the levels of VSL that have been estimated in the academic literature. In large part due to the greater refinement in risk levels made possible by the availability of the CFOI data, labor market studies of VSL have estimated the heterogeneity of these values with respect to income levels, levels of job risk, age, immigrant status, race, gender, and

[1] Viscusi (2014) reviews the VSL estimates used in almost 100 U.S. regulatory analyses and finds substantial convergence in the VSL levels used. Viscusi (2009) provides more detail on the source of many of these VSL figures, which are based either entirely on labor market estimates of the VSL or based predominantly on these values in conjunction with a meta-analysis of stated preference estimates.

[2] Income elasticity adjustments for the VSL are used to account for rising income levels across time but not for income differences across population groups at any point in time.

other characteristics. Using these results, one can construct VSL estimates pertinent to the average worker's preferences or the valuations of quite different population groups. The estimates are not restricted to the average preferences of workers or the preferences of those who are willing to work at very high-risk jobs. The main omissions from the labor market studies are VSL estimates for children and for people who are outside the labor market, such as retirees. In each case, it is often feasible to use estimates of age variations in VSL and the value of a statistical life year to construct benefit estimates for those outside the labor force, but such extrapolations may not be ideal.

An alternative to making adjustments to the labor market estimates of VSL is to use stated preference values for VSL.[3] These stated preference estimates tend to be somewhat lower than the values implied by revealed preference studies,[4] but there is no apparent reason why this should be the case in terms of the populations whose preferences are being elicited. Stated preference studies are not restricted to workers, as these studies can potentially elicit values across the entire population except for children. In the case of children, stated preference studies can ascertain the altruistic value that parents place on risks to their children. The U.S. Environmental Protection Agency also has relied on stated preference studies as a general justification for placing a 50% premium on preventing cancer-related fatalities. But the 50% figure is a provisional number not based on any specific stated preference evidence, and the base VSL figure that serves as the foundation for this cancer benefit calculation is drawn principally from evidence in labor market studies. Other U.S. policy contexts where stated preference studies have played a greater role are the valuation of certain health risks, such as chronic bronchitis.

Measuring heterogeneous values of statistical life based on labor market studies is not new, but most studies have largely focused on dimensions such as those relating to worker characteristics rather than the nature of the injury. Studies have estimated VSLs by age (Aldy and Viscusi 2008; Aldy and Viscusi 2007; Kniesner et al. 2006; Evans and Smith 2006), race and immigrant status (Viscusi 2003; Leeth and Ruser 2003; Hersch and Viscusi 2010), gender (Leeth and Ruser 2003), and income (Kniesner et al. 2010; Evans and Schaur 2010). Accounting for the heterogeneity of VSL sometimes has generated controversy (Adler and Posner 2000) and in other instances has received support (Sunstein 1997; Posner and Sunstein 2005; Rowell 2012; White and Neeley 2013). Some observers question the VSL approach generally (Ackerman and Heinzerling 2005; Heinzerling 2000), despite the essential role of risk-money tradeoffs in setting government policy (Breyer 1993). The distinctions we draw here do not involve the threshold issue of whether VSL estimates should be used for policy assessment, as that issue has been resolved. Moreover, distinguishing the VSL for

[3] Lindhjem et al. (2011) provide a recent review of this literature. They find an average VSL level of $7.4 million and a median level of $2.4 million in 2005 dollars (in 2008 dollars, an $8.2 million mean and a $2.7 million median). Our estimates are comparable to their mean but are above their median values.

[4] The median VSL based on the U.S. studies reviewed in Viscusi and Aldy (2003) was $7 million in 2000 dollars, or $8.75 million in 2008 dollars, which is higher than the median for stated preference studies reported in Lindhjem et al. (2011).

accidents that are transportation-related does not involve any inherent social equity issues but instead represents an effort to tailor the VSL to the policy context, leading to more efficient policies.[5]

Many studies have derived transport-specific VSLs using stated preference approaches or hedonic price studies based on price premiums commanded by safer cars. Dionne and Lanoie (2004) report 28 estimates of VSL in the transportation sector, consisting of a mixture of consumer market and contingent valuation studies, and find a median VSL of $4.27 million (in year 2000 Canadian dollars). They note that labor market estimates tailored to transportation risks, especially focusing on individuals whose work-accident risks are predominantly traffic-accident risks, would be useful. Market-based evidence specifically related to valuation of automobile safety costs is principally derived from hedonic price studies of motor-vehicle characteristics, resulting in implied VSLs ranging from $0.84 million to $9.9 million (Viscusi and Aldy 2003, Table 3, year 2000 dollars).

The two wage-based studies of transport-related VSLs differentiate only between accidental and intentional fatality risks, and focus on very narrow classes of risks. Scotton and Taylor (2011) study heterogeneous VSLs using CFOI data from 1992–1997. They contrast the VSLs derived from violent assaults with the VSLs for other "traditional sources of death," of which transportation is merely a component. Scotton and Taylor find that risks of violent deaths are often associated with a significantly higher VSL than other traditional fatality risks. Kochi and Taylor (2011) use similar risk classifications to estimate the VSL for accidental death and homicide risks for occupational drivers only. They find that the fatality risk coefficient for risks of accidental death is not statistically significant for occupational drivers, while the fatality risk coefficient for violent deaths generally is significant. Their analysis isolated a particular, distinctive class of workers and focused on risk differences by locale within that occupational group rather than risk differences across occupations and industries.

In this paper, we analyze labor market VSLs separating transport-related fatalities from all other job-related fatalities. We do this for two reasons. First, fatality risks resulting from transport are both economically and practically significant. Transport-related deaths constitute the largest category of fatality types (either by source or event). Second, most jobs have transport-related elements, so this type of risk is very common to a wide variety of industries and occupations. We exploit the Bureau of Labor Statistics (BLS) characterizations of fatality type to explore transport-related risk preferences in two ways: by examining deaths involving transportation events as well as vehicle sources. These two definitions of transport deaths yield remarkably similar VSLs, providing evidence of the results' robustness. We find that transport-specific VSLs are not statistically different than the VSLs for non-transport-related deaths and that these VSLs are similar to the VSL currently used by the DOT. The benefits transfer assumption is thus well-founded in this instance.

Not all the results are necessarily supportive of current policy valuation approaches. While the level of VSL used in DOT analyses is appropriate, we find that the average

[5] There may, however, be transportation situations in which equity concerns are salient, as with the valuation of risks to passengers on airplanes who have higher income levels than the average person killed in traffic accidents. Viscusi (1993) examines these issues in a study prepared for the Federal Aviation Administration.

labor market estimates of VSI fall on the lower end of the current range of the DOT's estimated VSI amounts. A consistent assessment methodology based on the labor market valuations of transport risks would maintain the current levels of VSL. Further study is necessary to determine the correct level of VSI.

1 Compensating differentials for heterogeneous risks

To explore the willingness to accept different types of risk, we use a model that differentiates between types of risk. The standard semi-logarithmic hedonic wage model takes the following form:

$$ln(wage_i) = X_i\beta + \gamma_1 Fatality\ \ Risk_{jk} + \gamma_2 Nonfatal\ \ Risk_j + \varepsilon_i, \tag{1}$$

for worker i in industry j and occupation k, nonfatal risk level for the worker's industry j, and job fatality rate for the worker's industry j and occupation k. This formulation focuses on a general fatality rate including all types of death. In the estimates below, we will often break fatality rates into two mutually exclusive groups, which we will denote by *Transport Risk* and *Non-Transport Risk*. The division of fatality rates will be either by the accident event (i.e., transportation events versus all other events) or source (i.e., vehicle sources versus all other sources). The estimating equation then becomes

$$\begin{aligned}\ln(wage_i) = X_i\beta + \gamma_2 Nonfatal\ \ Risk_j + \gamma_3 Transport\ \ Risk_{jk} \\ + \gamma_4 Non{-}Transport\ \ Risk_{jk} + \varepsilon_i.\end{aligned} \tag{2}$$

We test for the benefits transfer assumption by testing whether $\gamma_3 = \gamma_4$.

The vector X includes worker-specific characteristics and job-specific characteristics to control for compensation unrelated to risk borne. It also includes a series of dummy variables for each state, thus controlling for state differences in workers' compensation programs and local labor market conditions. The nonfatal injury rate is also included in order to control for compensation for risks that are sufficiently severe to result in at least one lost day away from work but not a fatality.

Using Eq. 1, we provide an example of the procedure to calculate VSL. We construct the VSL, or $\frac{\partial wage}{\partial risk}$, for the fatality rate by

$$VSL = \hat{\gamma}_1 \times \overline{Wage} \times 2,000 \times 100,000, \tag{3}$$

based on a 2,000 hour work year and risks levels per 100,000 workers.

2 Data description

2.1 The employment sample

We estimate a hedonic wage model using log wages of workers in the 2008 National Bureau of Economic Research's Merged Outgoing Rotation Group (MORG) from the Current Population Survey (CPS) published by the U.S. Census Bureau. We restrict the sample for the wage equation estimation to employed workers, as the CPS defines those who are either working or with a job but not at work.[6] We drop workers who report working 35 hours or less a week to better isolate full-time workers. We limit our study to workers between the ages of 16–64, and exclude self-employed workers. We restrict our study to non-agricultural, non-military[7] workers with hourly wages above $2 and below $100, to limit outliers or wage rate miscodings.

Most of our empirical analyses focus on blue-collar workers, which we define as workers within the following occupations: (i) healthcare practitioner and technical occupations, and healthcare support occupations; (ii) protective service occupations; (iii) food preparation and serving related occupations; (iv) building and grounds cleaning and maintenance occupations; (v) personal care and service occupations; (vi) farming, fishery, and forestry, and construction and extraction occupations; (vii) installation, maintenance, and repair occupations; (viii) production occupations; and (ix) transportation and material moving occupations, from which we exclude aircraft pilots, flight engineers, air traffic controllers, and airfield operations specialists. This categorization is consistent with the procedure used in prior literature (Hersch and Viscusi 2010).

The hourly wage is calculated as the reported earnings per hour. If this value is missing, we replace it by the usual earnings per week divided by the usual hours per week. The independent variables include controls for sex, race (indicator variables for Black, Native American, Asian, Pacific Islander, multiracial, or reporting Hispanic ethnicity), marital status, government employment, union status,[8] whether paid on an hourly basis, years of education,[9] potential experience,[10] and controls for state, 9 blue-collar occupations, and Metropolitan Statistical Area (MSA) status. The equations also control for whether the worker classified herself as full-time.[11]

2.2 BLS risk measures

This article matches to each worker in the sample a risk measure constructed using CFOI data from 2003–2008. These data provide the most reliable measure of risk, as each reported death has been verified by two or more independent source documents or one source document and a follow-up questionnaire. Given the certification procedure the BLS uses to verify the deaths, the measure may not include all job-related fatalities as, for example, deaths from deferred health risks are undercounted.

[6] Examples of reasons people are with a job but not at work include illness, vacation, bad weather, child care problems, etc.

[7] For the CPS data, we dropped the census codes associated with military industries and occupations. For the CFOI data used to create fatality rates, workers within the North American Industry Classification System (NAICS) code 928110 and Standard Occupational Classification codes beginning with 55 are excluded.

[8] A worker is defined as having union status if she either reports being a member of a labor union or a similar employee association or reports being covered by a union or employee association contract.

[9] We also include an indicator variable indicating whether the worker received a doctorate or professional degree.

[10] Potential experience is constructed by using age and subtracting years of education and an additional 5 years in order to account for age upon entering school. A squared experience term is also included in the regressions.

[11] A worker is classified as reporting herself as full-time if she has a full-time schedule, is part-time for economic reasons but usually full-time, is not at work but usually full-time, or is part-time for non-economic reasons but usually full-time.

Not only do CFOI data allow for credible overall estimates of wage-risk tradeoffs, but the CFOI data provide detailed information on the source of death, the event by which death occurred, and the industry and occupation in which the death occurred. These data allow us to distinguish the differential market effects of heterogeneous risks, while controlling for industry- and occupation-specific unobservable characteristics that could confound the analysis.

A principal distinction used by the BLS and which will guide our analysis is between fatality events and fatality sources. A fatality "event" refers to the manner in which the fatality was inflicted, while the fatality "source" specifies what or who was involved in the death (U.S. Department of Labor 2007b). By utilizing both coding regimes, we expect to obtain different perspectives on the deaths stemming from a transportation event or a vehicle source.

The BLS codes fatality events through a hierarchical coding scheme. Assaults and violent acts take precedence over transportation accidents, transportation accidents take precedence over fires, and fires take precedence over explosions. Fatalities are labeled transportation "events" when "at least one vehicle (or mobile equipment) is in normal operation and the injury/illness was due to collision or other type of traffic accident, loss of control, or a sudden stop, start, or jolting of a vehicle regardless of the location where the event occurred." (U.S. Department of Labor 2007b, p. DE-11).

The BLS codes fatality source in a two-step process. The "primary" source of death involves "the object, substance, bodily motion, or exposure which directly produced or inflicted the previously identified injury or illness" (U.S. Department of Labor 2007b, p.77). The "secondary" source of death identifies the source that generated the source of injury or contributed to the fatal event. For the purposes of this paper, the primary source is of main interest, since it best encompasses deaths directly resulting from vehicles.

The interaction between source and event categorization is also instructive. A transportation event will be coded primarily as a vehicle source if the deceased was in—or, if the deceased was a pedestrian, was struck by—a vehicle or piece of mobile equipment. These categories, however, can be distinct. In a transportation event involving a collision, the "vehicle, machine, or object with which the source collided" is merely the secondary source (U.S. Department of Labor 2007b, p. 80). For example, a collision in which a piece of machinery holding an employee collides into an operating vehicle would be labeled a transportation-event death but not primarily a vehicle-source death. Conversely, a vehicle source will only be labeled a transportation event if at least one vehicle is in normal operation. An idle vehicle falling on an employee would be considered a vehicle-source death but not a transportation-event death.

Table 1 summarizes the fatality variable definitions, and Figure 1 shows the similarities of the two categorizations, as 85% of deaths involving either vehicle sources or transportation events included both a vehicle source and a transportation event. An additional 9% involved a vehicle source but not a transportation event, while 6% were classified as a transportation event but not a vehicle source.

Of the vehicle-source deaths that are not transportation-event fatalities (861 deaths), 715 of those deaths are from contact with objects and equipment. These deaths mostly capture incidents in which a vehicle crushes a worker when not in operation (e.g., when a vehicle rolls over a worker performing maintenance on its undercarriage or when a

Table 1 Fatality variable definitions

Event fatality variables	
Transportation	Total deaths per 100,000 workers from transportation.
Not transportation	Total deaths per 100,000 workers from contact with objects and equipment; falls; bodily reaction and exertion; exposure to harmful substances or environments; fires and explosions; suicides; assaults and violent acts; and other events or exposures.
Source fatality variables	
Vehicle	Total deaths per 100,000 workers from vehicles.
Not vehicle	Total deaths per 100,000 workers from chemicals and chemical products; containers; furniture and fixtures; machinery; parts and materials; persons, plants, animals, and minerals; structures and surfaces; tools, instruments, and equipment; and other sources.
Total fatality	Total deaths per 100,000 workers.

vehicle falls off a forklift and onto a worker attempting to perform maintenance). Transportation-event deaths, in contrast, only capture fatalities when a vehicle is being used as a vehicle at the time.

Between 2003 and 2008, 22,536 deaths occurred to nonagricultural, blue-collar victims between ages 16–64. As Table 2 shows, 9,160 (40.6%) of these deaths involved a transportation event and 9,403 (41.7%) were due to a vehicle source. Understandably, there seems to be substantial overlap between deaths from transportation events and deaths from vehicular sources.

Table 3 summarizes the number of deaths during the same period for the full employment sample including white-collar workers. Including deaths of white-collar workers only adds an additional 5,000 fatalities, which results in a lower overall average fatality rate per 100,000 workers than for just the blue-collar sample, with a rate of 3.50 versus 6.46.

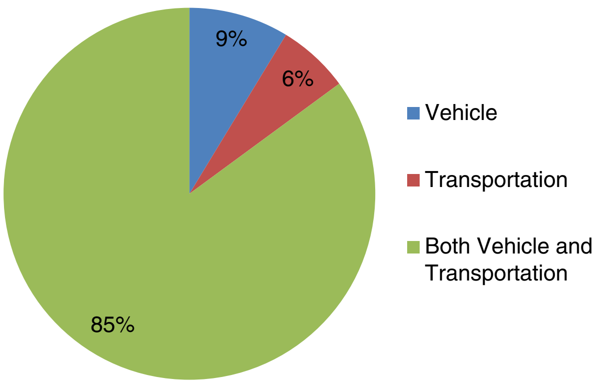

Fig. 1 Categorization of deaths classified as either transportation-event or vehicle-source deaths. *Note*: The number of fatalities classified as both vehicle sources and transportation events is 8,542. Eight hundred sixty-one fatalities were classified as just vehicle sources and 618 fatalities were classified as just transportation events. Fatal injury data were obtained with restricted access to the Census of Fatal Occupational Injuries research file. *Source*: U.S. Bureau of Labor Statistics

Table 2 Blue-collar worker fatalities by source and event type, 2003–2008

Event	Total fatalities	Percent	Rate[a]
Transportation accidents	9,160	0.406	2.627
Non-transportation deaths	13,376	0.594	3.837
- Contact with objects and equipment	4,277	0.190	1.227
- Falls	3,469	0.154	0.995
- Exposure to harmful substances or environments	2,353	0.104	0.675
- Assaults and violent acts	1,766	0.078	0.507
- Fires and explosions	814	0.036	0.233
- Suicides	628	0.028	0.180
- Bodily reaction and exertion	56	0.002	0.016
- Other sources	13	0.001	0.004
Source			
Vehicles	9,403	0.417	2.697
Non-vehicles	13,133	0.583	3.767
- Structures and surfaces	3,871	0.172	1.110
- Other sources	2,770	0.123	0.795
- Machinery	1,980	0.088	0.568
- Parts and materials	1,819	0.081	0.522
- Persons, plants, animals, and minerals	1,059	0.047	0.304
- Chemicals and chemical products	736	0.033	0.211
- Tools, instruments, and equipment	459	0.020	0.132
- Containers	350	0.016	0.100
- Furniture and fixtures	89	0.004	0.026
Total fatality count	22,536		6.464[b]

Fatal injury data were obtained with restricted access to the Census of Fatal Occupational Injuries research file. Source: U.S. Bureau of Labor Statistics

[a] The fatality rates reported in Table 2 are per 100,000 workers. The rates are constructed by dividing the total fatalities for non-agricultural blue-collar workers between 16 and 64 by the total blue-collar population working hours for 2003–2008 and multiplying by 2,000 hours per year and 100,000 workers

[b] This fatality rate is slightly higher than the total rate the BLS publishes because blue-collar workers experience more fatalities than white-collar workers. See Table 3 for a comparison to the full sample

As these data indicate, blue-collar workers have a greater mean risk level and a greater variation in risk than white-collar workers, thus facilitating estimation of wage premiums for risk. [12] Additionally, job risks play a more substantial role in blue-collar workers' compensation; in contrast, many unobservable characteristics of the worker and the worker's job, such as education quality and prestige, previous employment, interpersonal skills, and network connections are likely to influence white-collar workers' compensation.

[12] For example, the variation in vehicle fatality rates is 0.85 for white-collar workers and 4.78 for blue-collar workers.

Table 3 Full sample worker fatalities by source and event type, 2003–2008

	Total fatalities	Percent	Rate[a]
Event			
Transportation accidents	11,460	0.412	1.441
Non-transportation accidents	16,355	0.588	2.057
- Contact with objects and equipment	4,567	0.164	0.574
- Falls	3,903	0.140	0.491
- Exposure to harmful substances or environments	2,598	0.093	0.327
- Assaults and violent acts	3,238	0.116	0.407
- Fires and explosions	901	0.032	0.113
- Suicides	1,058	0.038	0.133
- Bodily reaction and exertion	74	0.003	0.009
- Other sources	16	0.001	0.002
Source			
Vehicles	11,746	0.422	1.477
Non-vehicles	16,069	0.578	2.021
- Structures and surfaces	4,372	0.157	0.550
- Other sources	4,373	0.157	0.550
- Machinery	2,091	0.075	0.263
- Parts and materials	2,027	0.073	0.255
- Persons, plants, animals, and minerals	1,222	0.044	0.154
- Chemicals and chemical products	861	0.031	0.108
- Tools, instruments, and equipment	628	0.023	0.079
- Containers	391	0.014	0.049
- Furniture and fixtures	104	0.004	0.013
Total	27,815		3.498

Fatal injury data were obtained with restricted access to the Census of Fatal Occupational Injuries research file. Source: U.S. Bureau of Labor Statistics

[a] The fatality rates reported in Table 3 are per 100,000 workers. The rates are constructed by dividing the total fatalities for non-agricultural workers between 16 and 64 by the total population working hours for 2003–2008 and multiplying by 2,000 hours per year and 100,000 workers

2.3 Fatality rate construction

This paper uses the new BLS method of calculating fatality risk rates by hours, rather than by employment. Other than the estimates in Viscusi (2013), which reports VSL estimates based on both approaches, all previous studies utilized the employment approach. The BLS moved to a solely hours-based fatality rate measure in 2008 (Northwood 2010). This measure allows for a more nuanced look at fatality risk per length of time exposure. An hours-based measure will be similar to the employment-based measure if the worker group includes mostly full-time workers. However, for worker groups with a large share of part-time workers, the rates will diverge. An hours-based measure discriminates between groups working different amounts of time and produces a measure with a baseline of 40 hours a week. Hours-based rates are more tailored to the length of the exposure to risk and thus are a more accurate reflection of the worker's risk.

The measure of employment-based fatality rates is constructed by dividing the number of fatalities in a given industry, occupation, and fatality type group by the number of employed workers within that industry and occupation, derived from the CPS MORG data for that employment year. Following standard practice, we multiply this number by 100,000 to reflect the fatality risk per 100,000 workers. The rate is

(i) $$(\mathrm{N}/\mathrm{W}) \times 100,000,$$

where

N = the number of fatal work injuries, and
W = the number of employed workers.

We construct the hours-based rates according to the new hours-weighted BLS method.[13] The hours-based approach divides the number of fatalities in a given industry, occupation, and fatality type group by the total average hours worked per year by all the employees within the industry and occupation, signified below by EH. For consistency with the employment rates, we multiply this number by 200,000,000 to reflect the fatality rate by 100,000 full-time workers, each working 40 hours per week, 50 weeks per year. The following equation formalizes this calculation:

(ii) $$(\mathrm{N}/\mathrm{EH}) \times 200,000,000,$$

where

N = number of fatal work injuries
EH = total hours worked by all employees during the calendar year, and
200,000,000 = base for 100,000 full-time employees (working 40 hours per week for 50 weeks a year).

In constructing the numerators for these calculations, fatalities are aggregated by worker groups over the 2003–2008 period. We exclude workers younger than 16 and older than 64, to capture active workers in the labor force.

We calculate the hours-based denominator by multiplying the number of employees by the average hours worked (usual hours per week multiplied by 50) in each industry-occupation-year category, to alleviate measurement error issues and missing value problems. Insofar as these worker groups vary by number of weeks worked, our rates do not reflect this. When we differentiate worker groups by fatality type, sometimes the groups are so small that no employees within a group report the usual hours worked per week. In these cases, we use the average hours of all worker groups, so as to preserve estimates for as many groups as possible.

[13] The procedure followed in the hours-based methodology is described in U.S. Department of Labor (2007a, footnote 2).

Our fatality risk measures are based on a 6 year average from 2003–2008 of fatality risks, by 50 industries and 9 blue-collar occupations.[14] Thus, we are able to match fatality rates to workers in specific industry-occupation combinations. This 6 year average smooths out irregularities in the fatality rates particularly for cells with small employment levels, which sometimes leads to reports of zero fatalities in any given year. The 6 year average risk divides the total fatalities from 2003–2008 in that industry-occupation cell by the total employment from 2003–2008 for each worker group.

2.4 Nonfatal injury rate construction

To isolate the effect of fatality risk on wages, we include a measure of the nonfatal injury rate. As in the case of fatality rates, we use two variations: a unitary nonfatal injury rate and a differentiated injury-specific rate. The unitary nonfatal injury rate, which is published by the BLS, is the incidence rate for injury cases that involve at least 1 day away from work. The rate is aggregated into 50 industry categories. The differentiated nonfatal injury rates separate the unitary nonfatal injury rate into transportation/non-transportation or vehicle/non-vehicle incidence rates. We construct these differentiated rates in the following way: the BLS publishes event- and source-specific nonfatal injury rates for 10 aggregated industry categories. To mitigate the aggregative nature of this measure, we calculate the proportions of transportation/non-transportation injuries and vehicle/non-vehicle injuries for each of the 10 categories.[15] We then apply these proportions to the corresponding industries within each of the 10 categories, multiplying the unitary rate for all injuries in the industry by each of the proportions. This procedure yields 50 differentiated transportation/non-transportation injury rate pairs. Using the same technique we also produce 50 differentiated vehicle/non-vehicle injury rate pairs. Both the unitary and differentiated nonfatal injury rates are used in the subsequent event- and source-specific regressions. To reduce the role of random year-to-year fluctuations in the nonfatal injury rate variables, we use a 3 year average nonfatal risk variable for the years 2006–2008.

3 Heterogeneous risk and compensating differentials: regression evidence from CPS

3.1 Results

The regression results consist of a series of log wage equations following the general structure of Eqs. (1) and (2) above. The regression estimates of unitary VSLs, which do

[14] The data before 2003 use the Standard Industrial Classification system, instead of the 2002 North American Industry Classification System. The 2009 data use the 2007 NAICS, so data from 2003–2008 were used for this project to have a consistent industry classification system. The BLS creates 52 aggregated industries, but we exclude workers within the agricultural and armed forces industries, leaving 50 industries. The full sample fatality rate measure is based on 50 industries and 10 occupations.

[15] The vehicle proportion is calculated by dividing the vehicle-specific incidence rate by the sum of all source incidence rates. The non-vehicle proportion is calculated by dividing the non-vehicle-specific incidence rate by the sum of all source incidence rates. The transportation/non-transportation proportions are constructed similarly.

not differentiate between fatality event or source, are displayed in Table 4 to provide a reference point. Standard errors are also clustered by industry, occupation, and state (Wooldridge 2003). Unobserved factors influencing wage should vary by industry and occupation pairs, which is the unit of construction of the fatality rate measure as all workers in a given industry-occupation cell are assigned the same fatality rate. Labor markets vary by geography due to costs of living and other unobservable variables. Clustering over states allows these errors to be correlated. To account for the fact that the worker wage used in calculating the VSL is a random variable, not a constant, the confidence intervals for the VSL estimates are constructed following the procedure in Goodman (1960).[16]

In Table 4, specifications (1)–(4) use the full sample, while specifications (5)–(8) use a blue-collar worker sample only. We present estimates of the VSLs in which the fatality rates are calculated according to both the old employment-based method and the new hours-based method. The results are similar between the two methods and between the two samples. The total VSL ranges from \$7.0 to \$9.3 million (\$2008) for blue-collar workers and from \$9.5 million to \$12.7 million for the full sample of workers. The differences in VSLs are driven in part by the fatality rate coefficient differences and in part by the difference in mean wages between the full sample and the blue-collar sample.[17] These results seem consistent with the previous literature and the DOT VSL figure of \$9.2 million.

Table 5 shows the event-specific results, using both the hours- and employment-based methods. Table 6 reports results for the VSLs associated with source-specific fatality rates, which are similar to the estimates for event-specific fatality rates, so we focus our discussion on the transportation-event results in Table 5. The transportation VSL has a range of \$6.9 to \$13.8 million, while the non-transportation VSL ranges from \$5.0 to \$8.2 million. Specifications (1)–(3) show the hours-based results for event-specific fatality risks. Without nonfatal injury rates, the hours-based transportation VSL is \$13.8 million while the non-transportation VSL is \$5.0 million. As indicated by the F tests for the equality of the coefficients of the transportation and non-transportation fatality rates, the gap between transportation and non-transportation VSLs is significant for specification (1).

However, for the results in which nonfatal injury rates are added, in specifications (2)–(3) and (5)–(6), the F tests indicate that the transportation- and non-transportation-event VSLs are not significantly different from each other. Specifications (2) and (5) include a unitary nonfatal injury rate which varies by 50 industries. The VSL values associated with the unitary nonfatal injury rate are similar to the VSL values derived by differentiating between transportation and non-transportation nonfatal injury rates (specifications (3) and (6)). The same pattern is seen in Table 6 for source-specific differentiation of nonfatal injury rates.

The VSL results using the earlier approach of employment-based fatality rates are reported in specifications (4)–(6). While the estimates are similar to those in the hours-based specifications, (1)–(3), there are a few notable differences. The hours-based measures produce somewhat higher transportation-event VSL values and lower non-

[16] Goodman (1960) derives the exact variance of the product of two random, independent variables. This allows us to construct the exact variance of the product $\hat{\gamma}_1 \times \overline{Wage} \times 2,000 \times 100,000$.

[17] The blue-collar mean wage is \$17.21, while the full sample mean wage is \$20.67.

Table 4 Log wage regression equations with total fatality rate

	Hours-based rate		Employment-based rate	
Full sample	(1)	(2)	(3)	(4)
Total fatality rate	0.0023	0.0027	0.0027	0.0031
	(0.0003)***	(0.0003)***	(0.0003)***	(0.0003)***
	[0.0006]***	[0.0006]***	[0.0005]***	[0.0005]***
Nonfatal injury rate		−0.0121		−0.0134
		(0.0023)***		(0.0023)***
		[0.0053]**		[0.0053]**
R-squared	0.44	0.44	0.44	0.44
VSL	9.5	11.3	11.2	12.7
	(6.9, 12.1)	(8.6, 14.0)	(9.0, 13.4)	(10.5, 15.0)
	[4.8, 14.3]	[6.4, 16.2]	[7.0, 15.3]	[8.4, 17.1]
Blue-collar workers	(5)	(6)	(7)	(8)
Total fatality rate	0.0027	0.0020	0.0027	0.0022
	(0.0003)***	(0.0003)***	(0.0003)***	(0.0003)***
	[0.0005]***	[0.0006]***	[0.0005]***	[0.0005]***
Nonfatal injury rate		0.0243		0.0224
		(0.0041)***		(0.0040)***
		[0.0053]***		[0.0052]***
R-squared	0.40	0.40	0.40	0.40
VSL	9.2	7.0	9.3	7.6
	(7.1, 11.3)	(4.8, 9.2)	(7.5, 11.1)	(5.7, 9.5)
	[5.7, 12.7]	[3.2, 10.9]	[6.2, 12.4]	[4.2, 11.0]

Standard errors are reported in parentheses. Standard errors clustered by industry, occupation, and state are reported in brackets. *$p<0.10$. **$p<0.05$. ***$p<0.01$. Additional variables included in all wage regressions but coefficients not reported are: a constant, sex, marital status, race, potential work experience, potential work experience squared, years of education, and indicator variables for whether the worker received a doctorate or professional degree, considers herself full-time, reports Hispanic ethnicity, is paid hourly, is part of a union or employee association, or has a government employer. Additional indicator variables are included for metropolitan status, state, and 9 blue-collar occupations. There are 131,842 observations in the full sample and 56,916 observations in the blue-collar sample. The 95% confidence interval is reported in parentheses and the 95% confidence interval using clustered standard errors in brackets

transportation-event VSL values than the employment-based measures. This systematic difference results in a significant gap between hours-based transportation and non-transportation estimates of VSL and an insignificant gap between the employment-based estimates of VSL, without including nonfatal injury rates.

Once nonfatal injury rates are included, in both the event-hours and event-employment regressions the transportation-event VSL declines while non-transportation-event VSL increases. After including nonfatal injury rates, the transportation VSL is smaller than the non-transportation VSL in the employment-based results, while the reverse is true in the hours-based results. Thus, the switch from employment-based measures to hours-based measures is not trivial.

Table 5 Log wage regression equations with fatality rates by transportation event

	Hours-based rate			Employment-based rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Transportation fatality rate	0.0040	0.0023	0.0023	0.0035	0.0020	0.0020
	(0.0006)***	(0.0007)***	(0.0008)***	(0.0006)***	(0.0007)***	(0.0007)***
	[0.0007]***	[0.0008]***	[0.0009]**	[0.0006]***	[0.0008]***	[0.0009]**
Non-transportation fatality rate	0.0015	0.0018	0.0018	0.0019	0.0024	0.0024
	(0.0006)**	(0.0006)***	(0.0006)***	(0.0006)***	(0.0006)***	(0.0006)***
	[0.0009]	[0.0009]**	[0.0009]**	[0.0008]**	[0.0008]***	[0.0008]***
Total nonfatal injury rate		0.0236			0.0229	
		(0.0043)***			(0.0043)***	
		[0.0054]***			[0.0054]***	
Transportation nonfatal injury rate			0.0290			0.0201
			(0.0686)			(0.0687)
			[0.0795]			[0.0797]
Non-transportation nonfatal injury rate			0.0234			0.0230
			(0.0054)***			(0.0054)***
			[0.0067]***			[0.0067]***
Transportation VSL	13.8	8.0	8.0	12.1	6.9	6.9
	(9.5, 18.1)	(3.3, 12.8)	(2.8, 13.2)	(8.1, 16.1)	(2.5, 11.3)	(2.1, 11.7)
	[8.9, 18.6]	[2.4, 13.7]	[1.6, 14.3]	[7.8, 16.5]	[1.8, 12.0]	[1.2, 12.7]
Non-transportation VSL	5.0	6.2	6.2	6.7	8.2	8.1
	(1.0, 9.1)	(2.2, 10.2)	(2.1, 10.3)	(2.9, 10.4)	(4.4, 12.0)	(4.3, 12.0)
	[−1.0, 11.1]	[0.1, 12.3]	[0.1, 12.3]	[1.0, 12.4]	[2.4, 13.9]	[2.4, 13.9]
Prob>F	0.018	0.636	0.673	0.120	0.731	0.756

Standard errors are reported in parentheses. Standard errors clustered by industry, occupation, and state are reported in brackets. *$p<0.10$. **$p<0.05$. ***$p<0.01$. All equations have an R-squared of 0.40. Additional variables included in all wage regressions but coefficients not reported are: a constant, sex, marital status, race, potential work experience, potential work experience squared, years of education, and indicator variables for whether the worker received a doctorate or professional degree, considers herself full-time, reports Hispanic ethnicity, is paid hourly, is part of a union or employee association, or has a government employer. Additional indicator variables are included for metropolitan status, state, and 9 blue-collar occupations. N=56,916. The F-statistics test the null hypothesis that Transportation VSL = Non-Transportation VSL. The 95% confidence interval is reported in parentheses and the 95% confidence interval using clustered standard errors in brackets

Table 7 summarizes these findings for estimates of the VSL. The employment- and hours-based VSL estimates are generally similar but vary in interesting ways. The hours-based rate tends to generate larger confidence intervals than the employment-based rates, and it also generates larger gaps between transportation and non-transportation (and vehicle and non-vehicle) VSL estimates. However, once nonfatal injury rates are introduced, the VSLs associated with transport and non-transport fatalities are no longer significantly different, even for the hours-based estimates. These results are robust to various specifications of the nonfatal injury rate.

Regardless of transport definition (source or event), both measures of the transport VSL seem more responsive to the inclusion of any nonfatal injury rate than the non-

Table 6 Log wage regression equations with fatality rates by vehicle source

	Hours-based rate			Employment-based rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Vehicle fatality rate	0.0039	0.0022	0.0019	0.0035	0.0020	0.0017
	(0.0006)***	(0.0007)***	(0.0007)**	(0.0005)***	(0.0006)***	(0.0007)**
	[0.0006]***	[0.0008]***	[0.0008]**	[0.0006]***	[0.0007]***	[0.0008]**
Non-vehicle fatality rate	0.0015	0.0019	0.0020	0.0020	0.0024	0.0025
	(0.0006)***	(0.0006)***	(0.0006)***	(0.0005)***	(0.0005)***	(0.0005)***
	[0.0009]*	[0.0009]**	[0.0009]**	[0.0008]**	[0.0008]***	[0.0008]***
Total nonfatal injury rate		0.0239			0.0231	
		(0.0043)***			(0.0044)***	
		[0.0054]***			[0.0054]***	
Vehicle nonfatal injury rate			0.0594			0.0481
			(0.0334)*			(0.0336)
			[0.0394]			[0.0394]
Non-vehicle nonfatal injury rate			0.0204			0.0207
			(0.0054)***			(0.0054)***
			[0.0070]***			[0.0068]***
Vehicle VSL	13.4	7.6	6.5	12.0	6.7	6.0
	(9.3, 17.5)	(3.0, 12.2)	(1.5, 11.5)	(8.3, 15.7)	(2.5, 10.9)	(1.4, 10.6)
	[9.0, 17.8]	[2.4, 12.8]	[0.8, 12.2]	[8.1, 15.9]	[2.1, 11.4]	[0.8, 11.2]
Non-vehicle VSL	5.3	6.6	6.9	6.7	8.3	8.5
	(1.4, 9.1)	(2.7, 10.5)	(2.9, 10.9)	(3.2, 10.3)	(4.7, 11.9)	(4.8, 12.2)
	[−0.8, 11.3]	[0.5, 12.6]	[0.8, 13.0]	[1.1, 12.4]	[2.6, 13.9]	[2.8, 14.2]
Prob > F	0.018	0.784	0.913	0.104	0.653	0.497

Standard errors are reported in parentheses. Standard errors clustered by industry, occupation, and state are reported in brackets. *$p<0.10$. **$p<0.05$. ***$p<0.01$. All equations have an R-squared of 0.40. Additional variables included in all wage regressions but coefficients not reported are: a constant, sex, marital status, race, potential work experience, potential work experience squared, years of education, and indicator variables for whether the worker received a doctorate or professional degree, considers herself full-time, reports Hispanic ethnicity, is paid hourly, is part of a union or employee association, or has a government employer. Additional indicator variables are included for metropolitan status, state, and 9 blue-collar occupations. N=56,916. The F-statistics test the null hypothesis that Vehicle VSL = Non-Vehicle VSL. The 95% confidence interval is reported in parentheses and the 95% confidence interval using clustered standard errors in brackets

transport VSL. Upon introduction of the differentiated nonfatal injury rates, the hours-based transportation-event VSL drops from $13.8 million to $8.0 million. In contrast, the non-transportation-event VSL only increases from $5.0 million to $6.2 million. Similarly, the hours-based vehicle-source VSL drops from $13.4 million to $6.5 million upon inclusion of differentiated nonfatal injury rates, while the non-vehicle-source VSL only increases from $5.3 million to $6.9 million. The same pattern can be observed for employment-based VSLs and for all estimates when only unitary nonfatal rates are included. These differing sensitivities to nonfatal injury rates emphasize the importance of distinguishing between fatal and nonfatal risks, since ignoring the distinction inflates transport VSLs more than

Table 7 Summary of estimates of the value of statistical life (in $ millions)

	Source		Event	
	Hours-based	Employment-based	Hours-based	Employment-based
Panel A: No nonfatal injury rate				
Transport VSL	13.4	12.0	13.8	12.1
	(9.3, 17.5)	(8.3, 15.7)	(9.5, 18.1)	(8.1, 16.1)
	[9.0, 17.8]	[8.1, 15.9]	[8.9, 18.6]	[7.8, 16.5]
Non-transport VSL	5.3	6.7	5.0	6.7
	(1.4, 9.1)	(3.2, 10.3)	(1.0, 9.1)	(2.9, 10.4)
	[−0.8, 11.3]	[1.1, 12.4]	[−1.0, 11.1]	[1.0, 12.4]
Prob > F	0.018	0.104	0.018	0.120
Panel B: Common nonfatal injury rate				
Transport VSL	7.6	6.7	8.0	6.9
	(3.0, 12.2)	(2.5, 10.9)	(3.3, 12.8)	(2.5, 11.3)
	[2.4, 12.8]	[2.1, 11.4]	[2.4, 13.7]	[1.8, 12.0]
Non-transport VSL	6.6	8.3	6.2	8.2
	(2.7, 10.5)	(4.7, 11.9)	(2.2, 10.2)	(4.4, 12.0)
	[0.5, 12.6]	[2.6, 13.9]	[0.1, 12.3]	[2.4, 13.9]
Prob > F	0.784	0.653	0.636	0.731
Panel C: Differentiated nonfatal injury rate				
Transport VSL	6.5	6.0	8.0	6.9
	(1.5, 11.5)	(1.4, 10.6)	(2.8, 13.2)	(2.1, 11.7)
	[0.8, 12.2]	[0.8, 11.2]	[1.6, 14.3]	[1.2, 12.7]
Non-transport VSL	6.9	8.5	6.2	8.1
	(2.9, 10.9)	(4.8, 12.2)	(2.1, 10.3)	(4.3, 12.0)
	[0.8, 13.0]	[2.8, 14.2]	[0.1, 12.3]	[2.4, 13.9]
Prob > F	0.913	0.497	0.673	0.756

The 95% confidence interval is reported in parentheses and the 95% confidence interval using clustered standard errors in brackets. The F-statistics test the null hypothesis that Transportation VSL = Non-Transportation VSL and Vehicle VSL = Non-Vehicle VSL

it deflates non-transport VSLs. The next section discusses nonfatal injury rates more fully.

3.2 Values of statistical injuries

The nonfatal injury counterpart to the VSL is the value of a statistical injury (VSI). Table 8 reports the values of statistical injuries inferred from Tables 4, 5, and 6. Rows 1–2 list the VSIs for undifferentiated risk equations from Table 4. The VSI for the full sample is negative while the blue-collar sample VSI is positive. The absolute values of the positive magnitudes range within $77,000 to $84,000, which is consistent with the previous literature (Viscusi and Aldy 2003).

Table 8 Summary of estimates of value of statistical injury (in $ thousands)

	Hours-based	Employment-based
Total fatality risk		
(1) Full sample, total nonfatality risk	−50.21	−55.21
	(−68.63, −31.79)	(−73.58, −36.85)
	[−92.86, −7.56]	[−97.78, −12.65]
(2) Blue-collar, total nonfatality risk	83.59	76.97
	(56.25, 110.92)	(49.69, 104.25)
	[47.94, 119.23]	[41.65, 112.29]
Event-specific fatality risks		
(3) Total nonfatality risk	81.35	78.70
	(52.50, 110.21)	(49.69, 107.71)
	[44.66, 118.04]	[42.30, 115.10]
(4) Transportation nonfatality risk	99.79	69.32
	(−362.72, 562.30)	(−394.13, 532.78)
	[−436.52, 636.10]	[−468.47, 607.12]
(5) Non-Transportation nonfatality risk	80.45	79.15
	(43.83, 117.07)	(42.52, 115.78)
	[35.02, 125.89]	[34.16, 124.15]
Prob (Transportation VSI = Non-Transportation VSI)	0.938	0.968
Source-specific fatality risk		
(6) Total nonfatality risk	82.15	79.46
	(52.96, 111.35)	(50.10, 108.83)
	[45.42, 118.88]	[43.04, 115.89]
(7) Vehicle nonfatality risk	204.55	165.58
	(−20.94, 430.05)	(−61.25, 392.41)
	[−61.05, 470.16]	[−100.48, 431.64]
(8) Non-vehicle nonfatality risk	70.14	71.16
	(33.63, 106.66)	(34.65, 107.67)
	[23.08, 117.21]	[25.21, 117.11]
Prob (Vehicle VSI = Non-Vehicle VSI)	0.283	0.453

The 95% confidence interval is reported in parentheses and the 95% confidence interval using clustered standard errors in brackets. The F-statistics test the null hypothesis that Transportation VSI = Non-Transportation VSI and Vehicle VSI = Non-Vehicle VSI. The VSI is calculated by $\beta_{injury} \times 2{,}000 \times 100 \times$ mean wage

For transport-specific regressions, VSIs are calculated both through unitary and differentiated transport/non-transport nonfatal injury rates. Rows 3 and 6 report the VSIs produced by the unitary nonfatal injury rates for the transportation-event and vehicle-source regressions. These estimates are all positive and fall between $70,000 and $85,000.

Rows 4–5 of Table 8 list the VSIs associated with the differentiated transportation/non–transportation injury rates and rows 7–8 list the VSIs associated with differentiated vehicle/non–vehicle injury rates. The overall incidence rate for vehicle-source injuries is consistently greater than the incidence rate of transportation-event accidents, as indicated in Appendix Table 9. This disparity is evident for every aggregated industry category. This difference could arise because there are many scenarios in which a car injures a worker through contact outside of a transportation setting (idle vehicles rolling over an employee's foot, etc.). However, situations in which an employee (not in a vehicle) crashes into an operating vehicle in a piece of machinery (and lives) might not be as frequent.

The VSIs for vehicle sources and for transportation events range between $70,000 and $210,000, which reflects the fairly substantial value assigned to nonfatal injuries for policy evaluation purposes in both the U.S. and the U.K. The vehicle-source VSI estimate falls within the transportation-event VSI's confidence interval, so we cannot conclude that these are significantly different. The non-transportation/non-vehicle VSIs range between $70,000 and $80,000. While the raw difference between transportation and non-transportation VSIs or vehicle and non-vehicle VSIs seems large, the errors are large and the F tests for differences between the VSIs for transportation and non-transportation events and for vehicle and non-vehicle source indicate that the differences are not statistically significant.

To explore why the point estimates for transport-related risks might be more highly valued, we next consider severity of the nonfatal risk. The high compensation for transport-related injuries may be explained if transport-related injuries are more severe than other types of injuries. We use BLS statistics from 2006 (U.S. Department of Labor 2006) on the length of absence each nonfatal event or source requires. We compare the percent of transport injuries resulting in a certain length of absence to the median of the percent of all non-transport injuries in the same category. The percent of transport and non-transport injuries resulting in different lengths of absences from work are generally similar: however, they diverge at extremely long and extremely short periods of absence. Consider first injuries classified by event type. A larger percent of transportation injuries require more than 31 days away from work than non-transportation injuries (31.1 vs. 25.9%). Slightly fewer transportation injuries require less than 2 days away from work than non-transportation injuries, (10.1 vs. 11.9%). Vehicle-source injuries follow the same pattern. Vehicle injuries are more likely to require more than 31 days away (28.5 vs. 22.1%), and are less likely to require less than 2 days away from work (11.4 vs. 14.2%) than non-vehicle injuries. This pattern suggests that transportation/vehicle injuries on average may be more severe than other types of injuries, which one would expect to lead to higher levels of compensation.

This difference in days away from work varies by industry. Figure 2 plots the median number of days away from work for transport and non-transport injuries by 10 industry categories for 2006–2008. Transport injuries have longer median absences in the following industries: construction; manufacturing; trade, transportation, and utilities; professional and business services; and leisure and hospitality. While non-transport injuries have a longer median absence in information, financial activities, educational and health services, and other services, these differences are often smaller.

The width of some of the confidence intervals for VSI often makes it infeasible to reject the entire current DOT range for VSI of $27,600 to $5.5 million. However, the point estimates of VSI correspond most closely with the DOT's valuation of "minor" injuries rather than the higher four levels of severity: moderate, serious, severe, or

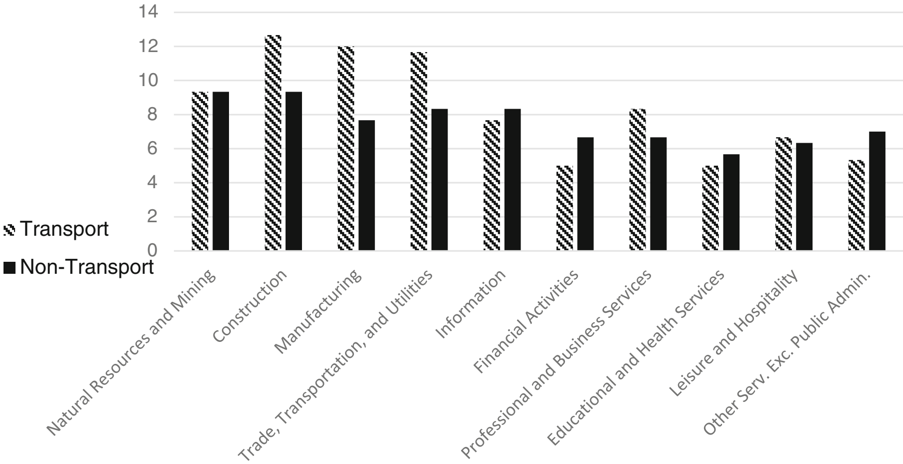

Fig. 2 Median days away from work for nonfatal injuries, by industry and fatality type. *Source*: U.S. Bureau of Labor Statistics. The median days are averaged for 2006–2008

critical.[18] This is true even for transport VSIs, even though transport injuries require more days away from work than non-transport injuries, as shown above. While this is not definitive, it does suggest that either the average nonfatal injury is more representative of minor injuries or that further examination of the DOT's higher severity ranges might be necessary. Our estimates are more in line with those used in the U.K. Further study of VSI stratified by the number of days away from work required by the injury would shed more light on the appropriateness of the upper values of the DOT's range.

The nonfatal injury rate variables have been included in the hedonic wage equation largely as controls so that the fatal injury rate coefficients will not also reflect differences in compensation for nonfatal job risks in transport and non-transport contexts. The main implication for our purposes is that controlling for these transport and non-transport nonfatal risks in the manner that is feasible with available data does not undermine the finding that the VSL estimates do not vary across these contexts. These separate sample estimates on the nonfatal injury rates are well-suited as controls in a VSL study but are not as well-suited to analyzing the VSI because the procedure used to separate transport and non-transport injury rates by industry involves the use of very aggregative factors to estimate the transport-related share of the industry rate. In contrast, the fatality rate measures are constructed by taking into account the specific nature of each individual fatality and assigning the fatality to the different transport-related industry-occupation groups. Given the broad confidence intervals for the VSI in transport and non-transport contexts, it is likely that policymakers would undertake a more focused analysis of the valuation of nonfatal injuries rather than rely on these estimates for benefit assessment. Such an alternative approach might, for example, focus on different types of injuries or injuries of different duration, but these are not the concerns of this article.

[18] The DOT calculates the VSI as a proportion of the VSL ($9.2 million), depending on the severity of the injury (U.S. Department of Transportation 2014). The following are the VSIs associated with each level, with the proportion of VSL in parentheses: The value of a minor injury is $27,600 (0.003), a moderate injury is $432,400 (0.047), a serious injury is $966,000 (0.105), a severe injury is $2.4 million (0.266), and a critical injury is $5.5 million (0.593).

While the magnitudes of the VSI estimates might be influenced by our aggregative industry measures, the qualitative result is interesting in its own right: transportation/vehicle VSIs are not significantly greater than non-transportation/non-vehicle VSIs. Most importantly, while more detailed nonfatal risk data will be necessary to precisely calculate risk-specific VSIs, our results show the source- and event-specific VSLs are robust with respect to the various injury measures included.

4 Conclusion

The DOT uses the benefits transfer technique to justify using the total VSL instead of a transport-specific VSL in their regulatory cost-benefit analyses. Such a benefits transfer would be problematic if the valuation of risks of death from vehicles or transportation accidents differs from the valuation of other fatality risk. Previous studies largely have not distinguished between the willingness-to-accept values for different types of occupational fatality risk. The few existing studies either use stated preference methods for assessing transport-specific VSLs or use very narrowly framed wage-based studies that do not focus on transport risks generally. In this paper, we distinguish transport-specific risks from all other risks and test the applicability of a benefits transfer assumption in the transportation context.

Our analysis utilizes the BLS's previous technique of using employment-based fatality rates as well as the new standard of using hours-based rates. We find that the BLS's shift from employment-based to hours-based rates is not trivial but also does not undermine the overall thrust of the previous literature. Hours-based rates produce slightly different VSLs, in ways that vary depending on type of fatality rate. The hours-based rates have the advantage of standardizing risk based on a uniform length of exposure, and this method results in higher transport VSLs and lower non-transport VSLs than the employment-based method.

We find that transport VSL is similar to the non-transport VSL, after controlling for nonfatal injury rates. This result is robust to two definitions of transport risks: by fatality source and fatality event. We also find that the current DOT VSL value of $9.2 million is appropriate for valuing transport-related fatalities. Both the transportation-event and vehicle-source VSLs are very similar to the VSL value the DOT uses in evaluating its regulations. These values are robust to various versions of nonfatal injury rates. However, the point estimates of VSIs correspond most closely to the lowest end of the DOT's estimated range, even for transport-related injuries, which require more time away from work. This disparity suggests that the appropriateness of the DOT's upper range of VSIs might require further study and reassessment.

Disentangling workers' responses to differential risks indicates possible differences in the benefits of preventing certain fatalities. However, instead of assuming that all risks are valued equally and that each regulatory measure can be assessed using a uniform VSL, agencies should consider the specific risk that their policies address. The benefits transfer assumption involving the VSL for occupational fatalities proves to be warranted in the case of transport-related risks. But for other hazards involving quite different morbidity risks and possibly exposed populations with different preferences, the valuations may differ depending on the nature of the risk.

Appendix

Table 9

Table 9 Descriptive statistics

	Mean	Standard deviation
Demographic variables		
Age	40.133	12.111
Usual hours worked per week	42.235	6.715
Hourly wage	17.207	9.625
Log of hourly wage	2.715	0.506
Male	0.669	0.470
Race, white = 1	0.816	0.388
Marital status, married = 1	0.559	0.496
Union status, union membership = 1	0.181	0.385
Years of education	12.668	2.612
Fatal injury rates		
Total fatality rate	6.291	7.546
Transportation fatality rate	2.555	4.412
Non-transportation fatality rate	3.736	4.396
Vehicle fatality rate	2.634	4.604
Non-vehicle fatality rate	3.657	4.463
Nonfatal injury rates		
Total nonfatal rate	1.498	0.500
Transportation nonfatal rate	0.071	0.044
Non-transportation nonfatal rate	1.427	0.469
Vehicle nonfatal rate	0.131	0.086
Non-vehicle nonfatal rate	1.367	0.445

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