IDAHO TRANSPORTATION DEPARTMENT

TECHNICAL MEMORANDA

RP 241

Economic Cost of Crashes in Idaho

By

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Cambridge Systematics

Prepared for

Idaho Transportation Department

Office of Highway Safety Program

Division of Engineering Products and Plans

http://itd.idaho.gov/highways/research/

June 2016

1. Report No. FHWA-ID-16-241	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Economic Cost of Crashes in Idaho	June 2016
	6. Performing Organization Code

7. Author(s) (LIST ALL AUTHORS- erase this phrase before final)	8. Performing Organization Report No.
Elizabeth Wemple, P.E., Timothy Grose, and Isabel Victoria-Jaramillo	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Cambridge Systematics 555 12th St., Suite 1600 Oakland, CA 94607	11. Contract or Grant No. 50017SC15

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Idaho Transportation Department Office of Highway Safety, Division of Engineering Products and Plans PO Box 7129 Boise, ID 83707-7129	Final or Interim Report 06/12/2015- 06/11/2016
	14. Sponsoring Agency Code RP 241

15. Supplementary Notes

Project performed in cooperation with the Idaho Transportation Department and FHWA using Highway Safety "Flex" funds.

16. Abstract

The Idaho Transportation Department's Office of Highway Safety contracted with Cambridge Systematics (CS) for an assessment of the feasibility of calculating the Idaho-specific economic and comprehensive costs associated with vehicle crashes. Researchers produced two technical memoranda as part of the study. Technical Memorandum 1 reviews methods used to estimate crash costs nationally. The researchers describe "bottom-up" and "top-down" approaches that could potentially be used to estimate Idaho-specific costs. However, because a "bottom-up" approach would require extensive data collection, cleaning, and analysis, researchers recommend that ITD employ a "top- down" approach that relies on US Department of Transportation Value of Statistical Life (VSL) figures. Technical Memorandum 2 provides updated crash cost estimates for Idaho using the recommended "top down" approach. The researchers also examined how Idaho bears these crash costs from an economic perspective. This process involved estimating how costs split between monetary versus non-monetary outlays and between those involved in crashes versus Idahoans at large. Finally, the researchers characterized potential cost savings that might be achieved by safety investments and resulting crash reductions.
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17. Key Words	18. Distribution Statement
Highway Safety, Crashes, Costs, Economic Analysis	Copies available online at http://itd.idaho.gov/highways/research/

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	43	None

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4		mm
ft	feet	0.3048		m
yd	yards	0.914		m
mi	Miles (statute)	1.61		km
		AREA		
in^2	square inches	645.2	millimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.4046	hectares	ha
		MASS (weight)		
oz	Ounces (avdp)	28.35	grams	g
lb	Pounds (avdp)	0.454	kilograms	kg
T	Short tons (2000 lb)	0.907	megagrams	mg
		VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL
gal	Gallons (liq)	3.785	liters	liters
ft^3	cubic feet	0.0283	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3

Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
^oF	Fahrenheit temperature	5/9 (^oF-32)	Celsius temperature	^oC
		ILLUMINATION		
fc	Foot-candles	10.76	lux	lx
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2
		FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	Miles (statute)	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
km^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.471	acres	ac
		MASS (weight)		
g	grams	0.0353	Ounces (avdp)	oz
kg	kilograms	2.205	Pounds (avdp)	lb
mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces (US)	fl oz
liters	liters	0.264	Gallons (liq)	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
^oC	Celsius temperature	9/5 ^oC+32	Fahrenheit temperature	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

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Technical Memorandum 1

TO: Idaho Transportation Department

FROM: Cambridge Systematics

DATE: February 4, 2016

RE: Methods for Estimating the Cost of Motor Vehicle Crashes

Introduction

For Task 2 of the Economic Cost of Vehicle Crashes in Idaho project, this memorandum examines methods for estimating the cost of vehicle crashes in Idaho. It reviews existing methods for estimating these costs in Idaho and nationally and suggests how to apply these methods to Idaho. It considers data requirements for these methods. Metrics are addressed to a limited extent and will be given more consideration in later stages of the project, if needed.

The U.S. Department of Transportation National Highway Traffic Safety Administration (NHTSA) defines economic crash costs:

> The monetary impact of traffic crashes resulting from goods and services expended to respond to the crash, treat injuries, repair or replace damaged property, litigate restitution, administer insurance programs, and retrain or replace injured employees. Economic costs also include the health and environmental impacts that result from congestion, the value of workplace and household productivity that is lost due to death and injury, and the value of productivity and added travel time that is incurred by uninvolved motorists due to congestion from traffic crashes.[1]

Comprehensive crash costs include all of these economic costs plus a lost quality-of-life cost, which is "measured by society's willingness to pay to avoid risk".[2] This memorandum considers economic and comprehensive costs. In 2010, national economic crash costs were estimated to be $242 billion and comprehensive crash costs were estimated to be $836 billion.[3] In comparison, ITD estimated 2010 Idaho comprehensive crash costs to be $2.5 billion.[4]

[1] NHTSA 2015, p. 287
[2] NHTSA 2015, p. 287
[3] NHTSA 2015, p. 1
[4] ITD Office of Highway Safety 2010, p. 12

Well-regarded national and regional resources on crash costs were identified and reviewed for this memorandum.[5] This memo frequently references NHTSA's 2015 update to its report, *The Economic and Societal Impact of Motor Vehicle Crashes, 2010*.[6] The NHTSA report presents national comprehensive costs of crash estimates and thoroughly reviews relevant literature, including estimation methods. This report serves as the most prominent national resource regarding crash costs. This memorandum distills the NHTSA report's most relevant methodology information for Idaho. It identifies opportunities to use Idaho-specific data to obtain more accurate estimates for ITD. A range of methods are discussed; a final methodology will be chosen based on available data for Idaho.

The first section summarizes the general practices for estimating crash costs, briefly examines current practices in Idaho and other states, and then outlines different approaches for applying these best practices to Idaho. Subsequent sections discuss crash severity and the different categories of costs. The final section overviews next steps and data requirements for each cost category.

Methods Overview

General Practices

Since total comprehensive costs comprise many different cost types, an overall estimation methodology contains several different types of estimation methods. Economic costs are typically calculated for each category of cost (e.g., medical costs, lost productivity, legal costs, and property damage) by injury severity. Quality-of-life costs are also calculated. Generally, estimation methods involve developing unit cost estimates for each combination of severity rating and cost type. This paper examines both elements of these estimations and how these elements can be applied in Idaho.

Common metrics include total dollars, dollars per person, and dollars per damaged vehicle. Total dollars are used to convey the entire costs of crashes for a particular region. A unit cost, such as dollars per person or dollars per crash can be helpful for evaluating safety benefits of transportation investments or policies (i.e., each crash avoided results in a certain amount of savings). Dollars per person are used for crashes with injuries and dollars per vehicle are used for property-damage only crashes. Dollars per person is disaggregated further by severity rating. Also, metrics involving dollars are expressed in a common year dollar (e.g., 2015 dollars); temporal data from different datasets should be adjusted to these common year dollars.

Table 1 shows the NHTSA report's national unit cost estimates by severity and crash cost type in 2010 dollars. The table includes police-reported and unreported crashes and covers economic and comprehensive costs. MAIS0 through MAIS5 represent severity ratings based on the Abbreviated Injury Scale (AIS), an anatomically based global severity scoring system assigned by medical professionals. The ratings range from MAIS0, no injuries, to MAIS5, critical injuries. Maximum AIS (MAIS) refers to the maximum injury level within each AIS class. This system is

[5] The Bibliography contains a list of these sources.
[6] Referred to as "the NHTSA report" hereafter.

used to calculate economic crash costs based on severity (see next section for more detail). Property Damage Only and Fatal crashes are also included.

Table 1 NHTSA Report Summary of National Comprehensive Unit Costs and Police-Reported and Unreported Crashes, 2010 Dollars

Category	Property Damage Only	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical Care	$0	$0	$2,799	$11,453	$48,620	$136,317	$384,273	$11,317
Emergency Services	$28	$21	$89	$194	$416	$838	$855	$902
Market Productivity	$0	$0	$2,726	$19,359	$64,338	$140,816	$337,607	$933,262
Household Productivity	$60	$45	$862	$7,106	$22,688	$37,541	$95,407	$289,910
Insurance Administration	$191	$143	$3,298	$4,659	$15,371	$28,228	$72,525	$28,322
Workplace Costs	$62	$46	$341	$2,644	$5,776	$6,361	$11,091	$11,783
Legal Costs	$0	$0	$1,182	$3,351	$12,402	$26,668	$82,710	$106,488
Congestion	$1,077	$760	$1,109	$1,197	$1,434	$1,511	$1,529	$5,720
Property Damage	$2,444	$1,828	$5,404	$5,778	$10,882	$16,328	$15,092	$11,212
Total Economic Costs	$3,862	$2,843	$17,810	$55,741	$181,927	$394,608	$1,001,089	$1,398,916
Quality of Life	$0	$0	$23,241	$340,872	$805,697	$2,037,483	$4,578,525	$7,747,082
Total Comprehensive Costs	$3,862	$2,843	$41,051	$396,613	$987,624	$2,432,091	$5,579,614	$9,145,998

Note: Unit costs are expressed per-person for all injury levels and per-damaged-vehicle for property damage only crashes.

Source: NHTSA 2015, p.17. The NHTSA report's table states that costs are in 2010 dollars. But the table's total comprehensive fatality cost appear to reflect the 2012 dollars $9.1 million value, described in the NHTSA report text on p. 241, rather than the 2010 dollars value. The project team was unable to determine the reason for this discrepancy.

Based on this information, the total economic cost of a fatal crash is estimated at approximately $1.4 million per fatality. The same NHTSA report estimates the total comprehensive cost of a fatal crash to be $9.1 million per fatality in 2012 dollars, or $8.86 million in 2010 dollars.[7] Some studies[8] address costs to a particular party, such as state and local governments. The NHTSA report and this memorandum considers all economic costs, regardless of which party bears these costs. They do not distinguish between costs borne by public and private entities.

Idaho Current Practices

Currently, the ITD Office of Highway Safety uses the US DOT 2008 Value of Statistical Life (VSL) guidance, which recommends a $5.8 million comprehensive cost for each fatality, to report crash costs in its annual crash reports. ITD adjusts for inflation using the Gross Domestic

[7] NHTSA 2015, p. 241

[8] E.g., AASHTO SCOHTS 2011

Implicit Price Deflator from the US Bureau of Economic Analysis[9]. It uses the KABCO[10] severity scale for crashes. The US DOT 2008 VSL does not include costs of non-fatal crashes. To estimate these, ITD uses the ratios of different KABCO severity rating costs from Minnesota DOT. For each non-fatal severity rating, ITD multiplies the fatal cost times the ratio of that non-fatal severity rating's cost to fatal cost. The ITD Office of Highway Safety has yet to formally adopt more recent US DOT VSL guidance but will use this project's research and analysis to consider doing so, and to consider revising its severity cost estimation methodology.

The ITD Economics and Research Section uses TREDIS, a common economic impact analysis tool, to evaluate the potential safety benefits of transportation investments or policies. ITD uses the following TREDIS default values for crash costs (rounded to two significant figures): $6.3 million cost per fatality, $88,000 cost per personal injury, and $3,300 cost per collision. TREDIS obtained these values from 2012 guidance documentation for the Transportation Investment Generating Economic Recovery (TIGER) grant program. According to the individual at TREDIS who provided this information, TREDIS plans to update its default values to reflect the latest US DOT guidance.

Other State Practices

While the project team did not conduct a full literature review of other state cost estimation practices, a brief review of these practices suggests that many states tend to use national unit cost estimates rather than developing their own estimates[11]. The 2004 University of Iowa study, for instance, found that "the majority of DOTs use safety cost savings values recommended by the Federal Highway Administration (FHWA) either to prioritize or to qualify the potential value of proposed projects intended to improve safety".[12] The study's phone survey of state DOTs revealed that 26 of these agencies use FHWA VSL figures and adjust for inflation.[13] Some states use values from the National Safety Council.

A 2015 joint report from the Centers for Disease Control and Prevention (CDC) and NHTSA indicates that many states have their own 'data linkage systems' that relate crash reports to medical data. These states' systems exist independently from Crash Outcome Data Evaluation System (CODES), a national effort previously funded by NHTSA until 2011. The report mentions that in 2012, 14 states were known to have data linkage systems independent of CODES. It also indicates that 16 other states had data linkage systems tied to CODES.[14] The

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[9] The ITD Idaho Traffic Crashes reports used comprehensive costs per fatality of $6.1 million in 2010 and $6.3 million in 2012.

[10] KABCO is severity rating system assigned at the crash scene by law enforcement personnel rather than medically trained responders. KABCO is an acronym of its severity categories: Code K (fatal injury resulting in death), Code A (incapacitating injury), Code B (non-incapacitating evident injury), Code C (possible injury), and Code O (no injury – property damage only). The subsequent Crash Severity section explains this scale in more detail.

[11] I.e., most states use top-down rather than bottom-up approaches. The "Potential Approaches to Estimating Crash Costs in Idaho" section describes these approaches.

[12] Hanley, p. i.

[13] Hanley, p. 14.

[14] The report does not imply that these counts were comprehensive.

report found that state public health departments are most often the primary coordinating agency of linkage systems, followed by academic institutions and state transportation departments.[15] The most commonly listed challenges to linking crash and medical data were staffing, technical assistance, poor data quality, and lack of unique identifiers.[16]

Potential Approaches to Estimating Crash Costs in Idaho

This paper discusses two general approaches for estimating economic costs. The "bottom-up" approach entails gathering Idaho-specific crash cost data, aggregating these data, and building cost estimates for each cost type and crash severity rating. This approach requires substantial data collection and cleaning and depends heavily on data availability and completeness. But if crash cost data are sufficiently available, the approach allows practitioners to empirically impute Idaho-specific, per-crash costs.

Alternatively, the "top-down" approach leverages the substantial estimation efforts at the national level by taking national cost estimates (from the NHTSA report or other sources) for each cost type and severity rating and adjusting them to Idaho's cost levels. These cost adjustments can use the American Chamber of Commerce Research Association[17] (ACCRA) Cost of Living Index, similar indices, and/or state per-capita income differences.[18] While this approach does not examine Idaho cost data (e.g., medical cost records) directly, it requires much less effort and does not depend on completeness and quality of Idaho-specific datasets.

The estimation approaches do not have to be used exclusively; practitioners can use different approaches to estimate different cost types. Indeed, many methodologies use some combination of both approaches. If complete, clean datasets exist for a particular cost type, the bottom-up approach might be more thorough. But the top-down approach can be used for other cost types. Both approaches rely on having Idaho-specific crash severity data, which are available. The next section discusses how crash severity data can be rescaled for economic cost estimation.

Crash Severity

Generally, there are two main systems for classifying crash injury severity:

> **KABCO.** Police often employ this classification system. KABCO is an acronym of its categories, whose letters are vestiges of prior category names: Code K (fatal injury resulting in death), Code A (incapacitating injury), Code B (non-incapacitating evident injury), Code C (possible injury), and Code O (no injury – property damage only). The KABCO ratings are relatively broad and assigned at the crash scene by law enforcement personnel rather than medically trained responders.

[15] Milani, p. 12.
[16] Milani, p. 24.
[17] This organization is the Council for Community and Economic Research.
[18] NHTSA 2015, p. 141

AIS/MAIS. "The Abbreviated Injury Scale (AIS) is an anatomically based, consensus-derived global severity scoring system that classifies each injury by body region according to its relative importance on a 6-point ordinal scale (1=minor and 6=maximal)."[19] These severity ratings are assigned by medical professionals. The Maximum AIS (MAIS) refers to the maximum injury level within each AIS class. This system is used to calculate economic crash costs based on severity. Therefore, injuries originally classified using KABCO (see below) need to be reclassified to AIS or MAIS. The NHTSA report provides detailed MAIS unit costs for each cost type. In cases where individuals experience multiple injuries, individual crash costs were categorized with the MAIS value corresponding to the most severe injury.

Best practice entails converting crash injury data, which are often collected in KABCO, to MAIS. The NHTSA report examines several datasets with KABCO and MAIS ratings and more detailed injury descriptions. The report provides conversion tables that quantify the relationships between KABCO and MAIS, controlling for a variety of factors, including year, dataset[20], seatbelt use, and alcohol involvement.

The NHTSA report also provides KABCO unit cost (i.e., a certain dollar value per person or crash by KABCO code) tables that can be used when estimating economic costs directly from KABCO categories.[21] ITD's Idaho Traffic Crashes 2014, its most recent crash report, uses KABCO per person and per crash cost estimates directly.[22] These costs were taken from a previous FHWA document, published in 2008, and adjusted for inflation.

The NHTSA report estimates costs for unreported crashes as well as police reported crashes. Unreported crashes tend to involve less severe injuries, since crashes that require emergency services and medical assistance tend to be reported to police. Indeed, Idaho Code 49-1305 requires crashes involving injury, death, or property damage over $1,500 to be reported to the police. The NHTSA report analyzed prior studies and used its own phone survey to develop estimates of unreported crashes.[23] The survey included questions about participants' injuries and property damage that could be used to assign these injuries to MAIS severities probabilistically.[24]

Categorizing Idaho crashes by crash severity would likely involve one of three approaches.

1. The simplest method would be to simply use the KABCO unit costs that the ITD crash reports currently employ.

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[19] NHTSA 2015, p. 1

[20] The two major datasets include KABCO and MAIS ratings with detailed injury information: the Crashworthiness Data System (CDS), which includes injury information for tow-away passenger vehicle occupants, and the National Accident Sampling System (NASS), which is older but includes other injuries, such as those to bus and truck occupants (p. 22).

[21] NHTSA 2015, p. 251

[22] ITD Office of Highway Safety 2014, p. 12

[23] NHTSA 2015, p. 130

[24] NHTSA 2015, p. 141

2. A more thorough method would take the Idaho KABCO aggregate data (i.e., number of people by injury type) and use the NHTSA report conversion tables to assign MAIS values to these crashes. The analysis team should work with the ITD and Idaho police agencies to obtain and better understand and contextualize the current Idaho crash data and confirm that Idaho's ratings are consistent with standard KABCO ratings.[25] Converting KABCO ratings to MAIS will allow for easier incorporation of available Idaho-specific data into the NHTSA methodology.

3. The most involved (and potentially infeasible) method would identify, if available, Idaho-specific datasets with both KABCO codes and more detailed injury description from medical records. Then, these crash categories could be assigned to MAIS categories, if not already present in the dataset. A number of factors could complicate the process, including: the lack of such a dataset, privacy issues in obtaining datasets with medical descriptions, data existing on individual crashes that is not cleaned and aggregated into a single dataset, a dataset without enough records to be statistically valid, or relatively vague medical descriptions that are difficult to assign MAIS ratings.

Any Idaho-specific methodology should also account for unreported crashes. Although Idaho has a crash reporting requirement, the NHTSA report's research found that in other states, some percentage of crashes that exceed similar minimum reporting thresholds still go unreported. A bottom-up approach to understand unreported crashes in Idaho would conduct an Idaho household phone survey, similar to the one NHTSA conducted nationally, about reported versus unreported crashes and injury severities. A top-down approach would apply to Idaho crash injury data the NHTSA report's proportions of police-reported to unreported crashes and unreported crash severity profile.

Cost Types

This memorandum divides crash costs into categories similar to those used in the NHTSA report. Property damage only crash unit costs are expressed on a per-vehicle basis. All other crash unit costs are expressed on a per-person basis.

Medical Care

Medical care is the "cost of all medical treatment associated with motor vehicle injuries" and constitutes 10% of economic crash costs and 3% of comprehensive crash costs at the national level.[26]

Estimating bottom-up medical care costs is challenging given the breadth and nuance of possible injuries or combination of injuries in each crash, and datasets with varying degrees of compatibility and completeness. Medical costs from different datasets are often combined and adjusted for inflation to a common year's dollar (e.g., 2015 dollars) using the medical care

[25] The NHTSA report literature review finds that KABCO rating categories often vary between states and vary over time within the same state (p. 22).

[26] NHTSA 2015, p. 11, 16, 287

component of the Consumer Price Index.[27] Some datasets include useful information on mechanism of injury (e.g., motor vehicle crash), but others do not. Datasets without this information can still be helpful in estimating medical costs of motor vehicle crashes. Important datasets used in estimating national economic crash-related medical costs include:[28],[29],[30]

- National Hospital Discharge Survey (NHDS), which contains information on hospital stay duration, categorized diagnoses, and demographics.

- Healthcare Cost and Utilization Project – Nationwide Inpatient Survey (HCUP-NIS), which contains information on diagnoses and procedures, patient demographics (including median household income for zipcode), total charges, length of stay, and severity and comorbidity measures. The survey samples discharges from all participating hospitals; previously it sampled hospitals and included all known discharges from each sampled hospital.

- The similar State Inpatient Survey (HCUP-SIS) is used for analysis of state medical care cost trends. Idaho is one of only two states that do not participate in this survey. But the survey could still be useful in characterizing costs in states similar to Idaho.

- HCUP cost-to-charge ratios help translate hospitals' total billings (i.e., charges) to actual costs.

- HCUP Nationwide Emergency Department Sample (HCUP-NEDS) includes 100 data fields on emergency department stays, including detailed injury classifications, demographics, total hospital charges, and mechanism of injury (including motor vehicles).

- HCUP State Emergency Department Databases (HCUP-SEDD) and HCUP-SIS are used to sample the HCUP-NEDS. Idaho is not a SEDD participant.

- The National Vital Statistics System (NVSS) contains information about medical costs specific to motor vehicle related fatalities across different geographies and demographics.

Idaho-specific datasets with similar types of medical information (or subsets of Idaho-specific data from national datasets) could be gathered and used for medical care cost estimates. Several overlapping studies and reports, including the NHSTA report, AASHTO SCOHTS report, Zaloshnja et al (2004), Finkelstein et al (2006), and Miller et al (2006) use the above listed

[27] NHTSA 2015, p. 252
[28] AASHTO SCOHTS 2011, p. 10
[29] NHTSA 2015, p. 252
[30] Healthcare Cost and Utilization Project website.

and other datasets to estimate medical costs specific to motor vehicles. The NHTSA report also incorporates vocational rehabilitation[31] costs by severity ratings from previous studies.

Estimation methods often involve dividing medical costs into subcategories (see bulleted list below) and then calculating average costs per subcategory. Similarly, the datasets with both severity ratings and medical descriptions (e.g., CDS and NASS, as described in the Crash Severity section) are divided into the same subcategories, and average costs are calculated. Then costs are applied to crashes within each subcategory, and subcategory costs are weighted and aggregated back together to develop overall unit medical cost for each injury severity level. Sample sizes of and differences between existing datasets dictate which subcategories are chosen. Examples of these subcategories can include[32]:

- Fatal versus non-fatal crashes.
- Place of death for fatal crashes: on scene, dead on arrival at hospital, in emergency department, in hospital after admission, in nursing home, and in hospice.
- Non-fatal injuries requiring hospitalization versus those that do not require hospitalization.
- Components of non-fatal injuries requiring hospitalization: facilities component, non-facilities component, hospital readmissions, follow up costs for <18 months, follow up costs for 18 months to 7 years, follow up costs >7 years, hospital rehabilitation costs, nursing home costs, transport, and claims administration.
- Components of non-fatal, non-admitted injuries treated in emergency department: emergency department facilities payments, follow up visits and medications <18 months, follow up costs >18 months, emergency transport, and claims administration.
- Body region (e.g., upper extremity, trunk/abdomen) and/or body part (e.g., skull, brain, elbow, liver).
- Injuries caused by motor vehicle crashes and injuries caused by any mechanism. The latter category includes the former and can be used in datasets where mechanism of injury information does not exist. Medical cost datasets without mechanism information can have large sample sizes and detailed cost information for very specific subcategories (e.g., a particular body part with a particular injury severity). By understanding the ratio between costs for crash injuries and all injuries, practitioners can use larger sample sizes from datasets without mechanism information to fill gaps in smaller datasets with mechanism information.

In cases where Idaho-specific medical cost data are available, unit costs can be calculated bottom-up for some of these subcategories. This exercise might be beneficial given the absence

[31] "The cost of job or career retraining required as a result of disability caused by motor vehicle injuries" (p. 287).

[32] NHTSA 2015, p. 252

of Idaho from some key national medical cost datasets. The top-down approach can be used to impute missing values or to execute a simple standalone medical cost estimate with the ACCRA Cost of Living Index or similar measure.

Market and Household Productivity

The NHTSA report defines the market productivity costs as "the present discounted value…of the lost wages and benefits over the victim's remaining life span."[33] Similarly, household productivity costs are "the present value of lost productive household activity, valued at the market price for hiring a person to accomplish the same tasks." [34] Nationally, these categories represent 32% of economic crash costs and 9% of comprehensive crash costs.[35]

Typically, productivity costs are calculated separately for non-fatal and fatal injuries. Non-fatal injury market productivity costs can be calculated by multiplying average earnings and work years lost per crash by injury severity. This cost includes both short-term work loss and lost output due to longer term disability.[36] Finkelstein et al (2006) provides work loss duration estimates by injury severity. Likewise, household loss duration estimates can be multiplied by housekeeping costs to obtain household productivity.

For fatal injuries, average earnings for each age and sex can be multiplied by the probability of survival to each subsequent year for each for each sex. For example, market productivity for a crash that kills a 60-year-old would include the average earnings for a 61-year-old times the probability that a 60-year old survives to age 61; plus the average earnings for a 62-year-old times the probability that a 61-year old survives to age 62; etc. Calculations for partial years and adjustments for business cycles can also be applied. The same summations of subsequent year survival probabilities are multiplied by annual household productivity loss (calculated housekeeping costs as a proxy) to obtain overall household productivity loss.[37]

Costs of lost future productivity are converted to present value using a discount rate (e.g., 3%) or range of reasonable discount rates (e.g., 0-10%). Accompanying fringe benefits are also estimated in proportion to wage losses. Market growth rates are also factored into market productivity costs.[38]

It would likely be inefficient to collect and calculate bottom-up work loss duration estimates specific to Idaho. But Idaho earnings data could be coupled with medical cost records or general work loss estimates to calculate productivity costs using a more top-down approach.

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[33] NHTSA 2015, p. 287
[34] NHTSA 2015, p. 287
[35] NHTSA 2015, p. 11, 16
[36] NHTSA 2015, p. 261
[37] NHTSA 2015, p. 261
[38] NHTSA 2015, p. 262

Property Damage, Insurance, and Legal Costs

Property damage refers to the value of objects harmed in crashes. Insurance administration (i.e., insurance and legal costs) refers to the "administrative costs associated with processing insurance claims resulting from motor vehicle crashes and defense attorney costs."[39] Together, these categories constitute 44% of economic crash costs and 13% of comprehensive crash costs nationally.[40]

The NHTSA report describes purchasing and analyzing Insurance Services Office (ISO) aggregate data on earned exposure, earned premiums, incurred losses, and incurred claim counts for several policy types (e.g., property damage liability, collision, bodily injury liability).[41] Property damage per liability claim is calculated for the insured's vehicle and other vehicles. Basic assumptions are used to impute deductible amounts for these crashes. The method also adjusts for unreported claims using the ratio of single vehicle crashes to multi-vehicle crashes from crash data and claims data, and the ratio of collision (i.e., own vehicle) policies to property liability (i.e., other vehicle) policies. Crash severity rating multipliers from a previous study are used to disaggregate average property damage per vehicle by crash severity. Crash data on number of vehicles per crash are then used to convert these numbers to average property damage per crash estimates.

Roadside furniture damage is included within property damage but tends to constitute a small of this cost category. Roadside furniture includes signs, lampposts, guardrails, and other assets on or near roadways. The NHTSA report uses previously collected data on roadside furniture damage for non-injury, non-fatal injuries, and fatal crashes.[42] All non-fatal injury severity ratings are assumed to have the same roadside furniture damage cost.

The NHTSA method used insurance administration and legal costs with equations from a previous study, Blincoe et al (2000). Several of these equations' assumptions, such as percent of people with minor injuries compensated and policy limits, were updated to reflect more recent information. These administrative costs apply to property damage but also medical and work loss costs.[43]

A bottom-up approach would involve mimicking the NHTSA method but using Idaho-specific insurance data. It would probably be onerous to develop new Idaho-specific crash severity multipliers and insurance and legal cost equations, so the existing figures could be used. A top-down approach would adjust the NHTSA severity-specific costs using the ACCRA Cost of Living Index, per-capita income, or some weighted combination of these factors.

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39 NHTSA 2015, p. 287
40 NHTSA 2015, p. 11, 16
41 NHTSA 2015, p. 34
42 NHTSA 2015, p. 43
43 NHSTA 2015, p. 38

Emergency Services Costs

This category includes police and fire response costs and incident management costs. Emergency services represent a very limited portion – less than 1% nationally – of economic and comprehensive crash costs.

These costs are borne almost entirely by state and local governments, so these entities are most likely to have useful data on the costs. But obtaining this information at a breadth of jurisdictions has proved difficult.[44] ITD might be well-situated to coordinate with other agencies to obtain this emergency services data if a bottom-up approach is preferred.

Once data on emergency services costs is acquired, they must be aggregated into average costs per incident and then disaggregated by injury severity. The NHTSA report used a method from Miller, Viner, Rossman, et al (1991) to disaggregate by injury severity.[45]

Top-down estimates could apply ACCRA Cost of Living Index or similar metrics to the NHTSA emergency services costs for each severity level. The limited data used to develop the NHTSA figures might warrant a bottom-up approach, though this cost category's small portion of overall costs might warrant a more efficient top-down approach.

Congestion Costs

Congestion costs include "the value of travel delay, added fuel usage, greenhouse gas and criteria pollutants that result from congestion that results from motor vehicle crashes." [46] Nationally, they constitute 12% of economic crash costs and 3% of comprehensive crash costs.[47]

Estimating bottom-up congestion costs due to crashes is an involved process. The NHTSA report's method synthesizes information from prior studies and traffic simulations. It uses its own congestion model to quantify travel delay by crash. The Federal Motor Carrier Safety Administration (FMCSA) recently conducted an extensive study using micro simulations to quantify per-crash impacts from commercial vehicle crashes.[48] The NHTSA report's simpler model examines congestion data using assumptions for all vehicles and for commercial vehicles only. The NHTSA model's per-crash results for these two subsets were compared to develop conversions from commercial vehicles to all vehicles. These conversion factors were then applied to the FMSCA model's commercial vehicle crash delay results.

The NHTSA method addresses delays caused by lane closings, rubbernecking in lanes traveling both directions, traffic queue dispersal after crash clearings, and detours.[49] Different approaches are used to estimate each of these components. The travel delay estimation method

[44] NHTSA 2015, p. 44
[45] NHTSA 2014, p. 43
[46] NHTSA 2015, p. 287
[47] NHTSA 2015, p. 11, 16
[48] NHTSA 2015, p. 50
[49] NHTSA 2015, p. 51

considers many factors, including time of day, weekday versus weekend, roadway type[50], crash duration, probability of lane closures and lane configurations. Typically, the method uses the average annual hourly traffic that passes the crash site during the time affected by the crash (AAHT). AAHT and similar metrics are derived from the FHWA Highway Performance Monitoring System (HPMS) data on annual average daily traffic (AADT).

The average time of delay per crash, expressed in vehicle hours, is calculated for each roadway type. The times are multiplied by values of time to monetize the delay costs. The NHTSA report used FMCSA average values of time by roadway type, which were derived from U.S. Bureau of Labor Statistics Data.[51]

When crash-related delays occur, vehicles spend more time burning fuel and emitting pollutants due to either idling or taking detours. These represent additional congestion costs. Previous research was used to estimate fuel wasted per vehicle hour.[52] FMCSA research and the U.S. Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) were used to estimate pollutant volumes per vehicle hours. These include greenhouse gases and local pollutants, such as particulate matter, nitrous oxides, volatile organic compounds, and sulfur dioxide. The FMCSA report's dollars per short ton emissions costs were used to monetize these volumes.

In the NHTSA report, travel delay, excess fuel usage, and environmental costs are added together to produce total congestion costs per crash. Costs are also disaggregated by roadway type.

The NHTSA method assumes that "congestion costs are a function of crash circumstances rather than injury severity." Thus, congestion costs are equally distributed by crash severity. Other crash unit cost categories are expressed per-person rather than per-crash. To convert congestion costs from per-crash to per-person, crash data were examined to calculate number of persons per crash by severity. Finally, for each severity rating, these injuries per crash ratios were multiplied by the per-crash congestion costs.

Limited research exists on congestion costs for unreported crashes, but since they do not involve police and other emergency services, they are assumed to be minor. The NHTSA report makes some assumptions to calculate unreported crash congestion costs by roadway type. These unit costs constitute approximately 15-20% of reported crash congestion costs.

Implementing a full bottom-up, Idaho-specific crash congestion cost estimate would be difficult and time-consuming. The simplest top-down approach would adjust the final NHTSA congestion cost by crash severity type using Idaho per-capita incomes. But there are several opportunities to integrate Idaho-specific data into the congestion cost estimation while leveraging the work done on the national level (i.e., not having to develop a full bottom-up estimation). Idaho per-capita incomes could be used to adjust the national values of time used

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[50] Roadway types comprise: Urban Interstate/Expressway, Urban Arterial, Urban Other, Rural Interstate/Principal Arterial, and Rural Other.

[51] NHTSA 2015, p. 102

[52] NHTSA 2015, p. 91

to monetize delay. Fuel costs could be adjusted using Idaho price data. If ITD have crash data with locations, an Idaho-specific roadway type weighting could be used to aggregate congestion costs by roadway type. One would expect Idaho to experience more crashes on rural roads, and this method enables the congestion costs to reflect Idaho's crash locations.

Workplace Costs

Workplace costs refer to the "workplace disruption that is due to the loss or absence of an employee. This includes the cost of retraining new employees, overtime required to accomplish work of the injured employee, and the administrative costs of processing personnel changes." These costs represent a modest 2% share of economic crash costs and less than 1% share of comprehensive crash costs.[53]

Market productivity loss durations can be multiplied by the employment cost index from the Bureau of Labor Statistics to estimate workplace costs.[54] A bottom-up method for Idaho would likely not be worthwhile unless applicable datasets are readily available. Instead, Idaho per-capita incomes could be applied to adjust national workplace cost estimates, or, very similarly, an Idaho employment cost index could be used instead of the national employment cost index.

Lost Quality-of-Life Costs

Aside from the economic costs described in the previous sections, comprehensive costs include "the value of lost quality-of-life as measure by society's willingness to pay to avoid risk."[55] These less tangible cost estimates attempt to quantify the value of life quality and enjoyment that serious or fatal injuries take away from their victims. This category accounts for 71% of comprehensive crash costs.[56]

Researchers use willingness to pay (WTP) studies to examine differences in wage rates for jobs with different risks of occupational injury and fatality. Other WTP studies examine prices that consumers pay for products that reduce the risk of fatality.[57] Results from these numerous studies help estimate the value of a statistical life (VSL). These studies produce a wide range of VSL estimates. Meta-analyses of these studies produce VSL medians and ranges. Public agencies, including the US DOT, review this information and recommend VSL values for departmental use. The US DOT updates its recommendation periodically and provides a range of acceptable values for VSL. The US DOT 2013 update used estimates based exclusively on studies that employ the Census of Fatal Occupational Injuries, conducted by the Bureau of Labor Statistics, which the US DOT considers better quality than other data sources. The 2013 range is $5.2 million to $12.9 million in 2012 dollars. The 2015 NHTSA report uses the 2013 US

[53] NHTSA 2015, p. 11, 16
[54] NHTSA 2015, p. 44
[55] NHTSA 2015, p. 287
[56] NHTSA 2015, p. 16
[57] NHTSA 2015, p. 113

DOT-recommended VSL of $9.2 million in 2012 dollars, the equivalent of $8.86 million in 2010 dollars.[58]

WTP studies typically identify a monetary value for a single life year. Fatality costs can then be estimated by multiplying this monetary value times the number of years in a victim's expected remaining lifespan. Nonfatal crash costs are often estimated using a metric called a quality-adjusted life year (QALY). A QALY value of 1 corresponds to one year of perfect health and a value of 0 corresponds to death.[59] Duration and severity of injuries determine QALY loss. The medical industry uses QALY extensively, and the NHTSA report examines previous studies that incorporate relevant medical information, such as the Injury Impairment Index. The report uses this information and its own study to assign QALY values to each severity rating.

While QALY and similar measures do not include most economic costs, there is a small amount of overlap with economic costs. Thus, when QALY and economic costs are added together to determine comprehensive costs, some adjustments are made for double counting particular economic cost types, namely worker and household productivity, also covered by QALY.[60]

ITD would likely use a top-down approach in estimating quality-of-life costs, since conducting the WTP research and analysis involved with a bottom-up approach would be very resource intensive. Using updated national VSL figures would benefit ITD, since the data behind these more recent estimates are more highly regarded.

Conclusion and Recommendations

Estimating crash costs is a detailed, extensive process that incorporates a breadth of cost types. Developing bottom-up Idaho-specific crash costs would require a range of data sources and include substantial data collection, cleaning, and analysis. Table 2 lists potentially useful datasets types if ITD chooses an involved, bottom-up estimation process. Fortunately, significant work has been done to estimate national comprehensive crash costs. In particular, the NHTSA report synthesizes much of this work and serves as a cohesive resource.

Given the complexity involved with calculating bottom-up cost estimates, this report recommends that ITD employ a simple top-down approach. The ITD Office of Highway Safety can use the latest US DOT VSL guidance to estimate comprehensive fatal costs. To estimate non-fatal comprehensive costs, it can apply the NHTSA report's KABCO severity factors to the latest US DOT VSL guidance.[61]

The ITD Economics and Research Section can update the TREDIS fatality cost to reflect the latest VSL guidance too. TREDIS will likely update these values soon anyway, so ITD can either wait for this default adjustment or update the value manually. ITD can also adjust

[58] NHTSA 2015, p. 114

[59] NHTSA 2015, p. 115

[60] NHTSA 2015, p. 116

[61] The latest substantive change in US DOT VSL guidance was issued in 2013, and subsequent US DOT VSL guidances (2014 and 2015) have adjusted the 2013 estimate for inflation. It is recommended that ITD continue to use the most recent guidance as it is updated.

TREDIS default collision and personal injury costs to current dollars or wait until TREDIS adjusts them. Alternatively, ITD could explore using weighted average values for property damage and non-fatal injury from the NHTSA report.

ITD can also examine the possibility of applying cost of living adjustments to its crash cost estimates versus simply using the national figures. If ITD wishes to explore the applicability of the national estimates to Idaho further, it can select one cost type with a relatively high cost and available data, such as property damage. Then, it can collect relevant data and produce an Idaho-specific estimate for that cost type and compare it to NHTSA's national estimates.

Table 2 Potentially Useful Dataset Types by Category

Category	Dataset Types
Crashes/General	• Idaho crash database with KABCO codes, locations, number of vehicles per crash, number of people per crash, roadway type, and other descriptive information (including MAIS codes and detailed injury data, though most datasets that cover Idaho are unlikely to contain all of this information) • NHTSA KABCO unit costs and KABCO to MAIS conversion multipliers • NHTSA unreported crash severity profile and unreported to reported crash ratios • ACCRA Cost of Living Index or similar indices • Idaho per-capita income • Idaho inflation data
Medical Care	• Medical care costs by severity and other subcategory (e.g., body region) from prior studies • Idaho Consumer Price Index medical care component • Idaho medical care costs by injury type and severity (datasets with cost information and mechanism of injury (e.g., motor vehicle crash) would be particularly helpful but are less to likely to be available; general Idaho medical care cost datasets would also be helpful
Market and Household Productivity	• Work loss duration estimates by severity from prior study
Property Damage, Insurance Administration, and Legal Costs	• Aggregated Idaho auto insurance policy data (e.g., earned exposure, earned premiums, incurred losses, and incurred claim counts for different policy types) • Property damage estimates by severity from prior study • Idaho roadside furniture damage data, or damage information from prior studies (these are expected to be relatively minor costs) • Insurance administration and legal cost equations from prior study
Emergency Services	• Idaho police and fire responses costs for crashes • Idaho incident management costs for crashes • Emergency services cost estimates by crash severity from prior study
Congestion	• Congestion unit costs by roadway type and subcategory (i.e., delay, additional fuel, or environmental) from prior study • Idaho value of time information (or per-capita income, which is listed in the Crashes/General section) • Idaho fuel price data
Workplace Costs	• Market productivity by severity from prior study • Idaho employment cost index
Quality of Life Costs	• QALY by severity from prior studies

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Technical Memorandum 2

TO: Ned Parrish, Idaho Transportation Department

FROM: Cambridge Systematics

DATE: June 10, 2016

RE: Economic Cost of Vehicle Crashes – Crash Tax Estimation

Introduction

The project's previous memorandum, *Methods for Estimating the Cost of Motor Vehicle Crashes*, examined how Idaho Transportation Department can better estimate the comprehensive cost of motor vehicle crashes in Idaho. It recommended that ITD uses recent national guidance from the U.S. Department of Transportation National Highway Traffic Safety Administration (NHTSA) on unit cost estimates by cost category and severity and on the Value of a Statistical Life (VSL) rather than develop Idaho-specific estimates.

The project team applied this national guidance to the most recent available Idaho Traffic Crashes report from 2014 to estimate Idaho crash costs.[1] These substantial crash costs constitute what is essentially a "crash tax" on Idahoans. The team examined how Idaho bears this crash tax from an economic perspective. This process involved estimating how costs split between monetary versus non-monetary outlays and between those involved in crashes versus Idahoans at large. The team also characterized potential cost savings that might be achieved by safety investments and resulting crash reductions.

Updated Cost Estimates

Updating the Idaho crash cost estimates using more recent nationally recommended unit cost figures involved the following steps:

1. Obtain most recent (2014) Idaho crash counts broken out by KABCO severity level

2. Obtain national unit cost estimates by Abbreviated Injury Scale (AIS) severity and crash cost category (e.g., medical care, emergency services, market productivity, household productivity, insurance administration) from NHTSA's 2015 update to its report, *The Economic and Societal Impact of Motor Vehicle Crashes, 2010*[2]

[1] *Idaho Traffic Crashes 2014*. Idaho Transportation Department Office of Highway Safety, 2015.

[2] Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. *The economic and societal impact of motor vehicle crashes, 2010. (Revised)* (DOT HS 812 013). National Highway Traffic Safety Administration, 2015.

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3. Obtain most recent KABCO/AIS conversion factors from the US DOT Benefit-Cost Analysis (BCA) Resource Guide (updated in March 2016)[3]

4. Convert Idaho 2014 KABCO crash counts to AIS using the BCA Resource Guide conversion factors

5. Obtain most recent crash unit costs by AIS severity level from the 2016 BCA Resource Guide

6. Distribute updated AIS unit costs among crash cost categories

7. Multiply Idaho AIS crash counts by AIS unit costs by crash cost category

Appendix A details these steps and their calculations.

Table 1 shows the updated costs for the 2014 Idaho crashes. Values are in 2015 US dollars. The total comprehensive costs include both the total economic costs and the lost Quality of Life costs. The *Methods for Estimating the Cost of Motor Vehicle Crashes* memorandum describes these categories in greater detail.

The estimated total comprehensive crash cost for 2014 Idaho crashes was $3.37 billion. This estimate includes $679 million in economic costs. Fatal crashes are the most expensive in comprehensive ($1.79 billion) and economic ($273 million) terms.

Idaho's 2014 gross domestic product was $63.952 billion in current dollars, according to a 2015 Bureau of Economic Analysis news release.[4] Thus in 2014, Idaho faced comprehensive crash costs equivalent to approximately 5% of its gross domestic product.

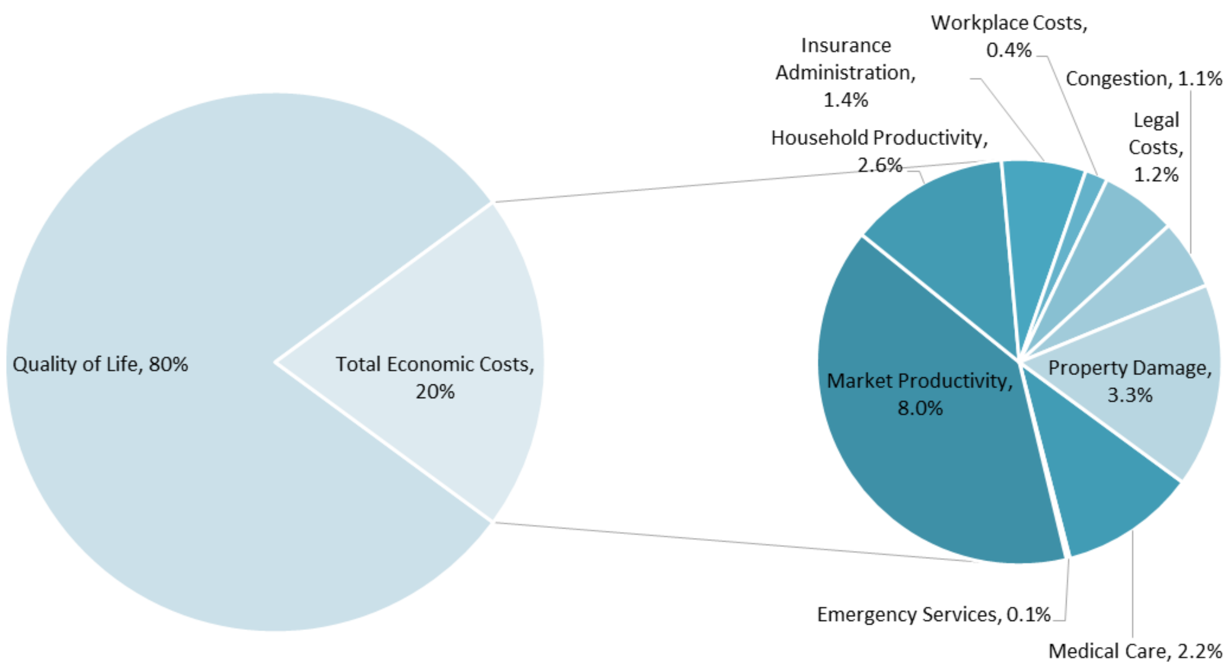
Figure 1 shows the percentage breakdown of comprehensive cost categories across severity levels. Quality of Life, the intangible cost of lost health or life, represents the largest category with 80%. The other categories are all economic costs. Of the economic costs, market productivity is the largest, accounting for 8% of comprehensive costs. Household productivity (3%), property damage (3%), and medical care (2%) are the next largest cost categories.

[3] *Benefit-Cost Analysis (BCA) Resource Guide*. U.S. Department of Transportation, 2016.
[4] *Broad Growth Across States in 2014; Advance 2014 and Revised 1997-2013 Statistics of GDP by State*. U.S. Department of Commerce Bureau of Economic Analysis, June 2015.

Table 1 Estimated 2014 Idaho Comprehensive Crash Costs with Updated Unit Costs, 2015 US Dollars

Category	Property Damage Only	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal	Total
Medical Care	$0	$16,167,147	$14,373,381	$18,578,453	$11,919,386	$10,706,701	$2,209,451	$73,954,519
Emergency Services	$731,941	$514,068	$243,468	$158,960	$73,274	$23,822	$176,100	$1,921,633
Market Productivity	$0	$15,745,496	$24,295,318	$24,584,544	$12,312,773	$9,406,482	$182,203,476	$268,548,089
Household Productivity	$1,568,445	$4,978,950	$8,917,947	$8,669,435	$3,282,537	$2,658,251	$56,599,979	$86,675,545
Insurance Administration	$4,992,885	$19,049,393	$5,846,990	$5,873,497	$2,468,221	$2,020,708	$5,529,387	$45,781,080
Workplace Costs	$1,620,727	$1,969,631	$3,318,189	$2,207,099	$556,198	$309,020	$2,300,430	$12,281,293
Legal Costs	$0	$6,827,284	$4,205,466	$4,738,996	$2,331,816	$2,304,485	$20,789,964	$41,198,011
Congestion	$28,153,595	$6,405,633	$1,502,221	$547,954	$132,120	$42,601	$1,116,732	$37,900,856
Property Damage	$63,888,010	$31,213,742	$7,251,322	$4,158,180	$1,427,700	$420,497	$2,188,952	$110,548,402
Total Economic Costs	***$100,955,603***	***$102,871,343***	***$69,954,303***	***$69,517,118***	***$34,504,024***	***$27,892,567***	***$273,114,471***	***$678,809,429***
Quality of Life	$0	$134,241,038	$427,790,370	$307,869,272	$178,154,933	$127,567,895	$1,512,485,529	$2,688,109,037
Total Comprehensive Costs	***$100,955,603***	***$237,112,381***	***$497,744,673***	***$377,386,390***	***$212,658,956***	***$155,460,463***	***$1,785,600,000***	***$3,366,918,466***

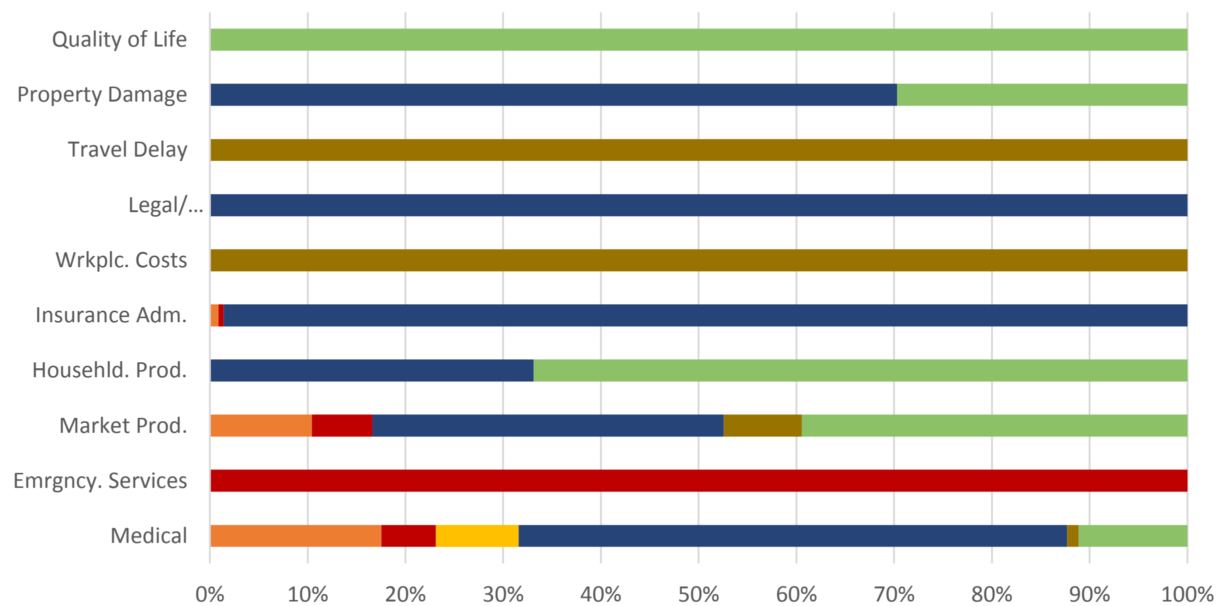
Figure 1 Estimated Percentage Breakdown of 2014 Idaho Comprehensive Crash Costs by Category (Economic Cost Categories shown at right)



Cost Breakdown

The project team examined who pays for these costs and how the costs are realized. The 2015 NHTSA report includes a chapter entitled Source of Payment, which reviews literature on how costs are borne by society. It summarizes results of this research in a table that breaks out payment sources by economic cost category. Payment sources include Federal government, State government, and other government programs; private insurers; individuals (i.e., those involved in crashes); and other sources, including non-government employers. Figure 2 shows that information with a row added for Quality of Life costs. The "Self" category represents the "individuals" payment source. The project team assumed that lost Quality of Life costs are borne entirely by individuals involved in crashes. Individuals involved in crashes also cover the majority of household productivity costs. Insurers bear the majority of the property damage, legal/court, insurance administration, and medical costs. Governments cover the cost of emergency services. Other parties cover workplace costs (employers) and travel delay costs (those in traffic caused by accidents).

Figure 2 NHTSA Report Distribution of Source of Payment for Economic Costs by Cost Category



	Medical	Emrgncy. Services	Market Prod.	Househld. Prod.	Insurance Adm.	Wrkplc. Costs	Legal/ Court	Travel Delay	Property Damage	Quality of Life
Federal Gov	18%	0%	10%	0%	1%	0%	0%	0%	0%	0%
State Gov	6%	100%	6%	0%	1%	0%	0%	0%	0%	0%
Other Gov	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Insurer	56%	0%	36%	33%	99%	0%	100%	0%	70%	0%
Other	1%	0%	8%	0%	0%	100%	0%	100%	0%	0%
Self	11%	0%	39%	67%	0%	0%	0%	0%	30%	100%

Notes: The project team appended the Quality of Life row to this table. Percentages are rounded.

Source: NHTSA 2015, p.238.

Table 2 shows the payment source percentages (Figure 2) multiplied by the 2014 Idaho comprehensive crash cost estimates (Table 1). Individuals involved in crashes represent the highest payment source (86%), followed by private insurers (10%), governments (2%), and other sources (2%).

Table 2 Estimated Idaho Source of Payment 2014 Crash Costs by Category

Category	Total Government	Insurer	Other	Self	Total
Medical	$23,369,628	$41,488,485	$887,454	$8,208,952	$73,954,519
Emergency Services	$1,921,633	$0	$0	$0	$1,921,633
Market Productivity	$44,632,692	$96,543,038	$21,430,138	$105,942,221	$268,548,089
Household Productivity	$0	$28,724,276	$0	$57,951,270	$86,675,545
Insurance Administration	$640,935	$45,140,145	$0	$0	$45,781,080
Workplace Costs	$0	$0	$12,281,293	$0	$12,281,293
Legal/Court	$0	$41,198,011	$0	$0	$41,198,011
Travel Delay	$0	$0	$37,900,856	$0	$37,900,856
Property Damage	$0	$77,726,582	$0	$32,821,821	$110,548,402
Total Economic Costs	***$70,564,888***	***$330,820,536***	***$72,499,741***	***$204,924,263***	***$678,809,429***
Economic % Breakdown	***10%***	***49%***	***11%***	***30%***	***100%***
Quality of Life	$0	$0	$0	$2,688,109,037	$2,688,109,037
Total Comprehensive Costs	***$70,564,888***	***$330,820,536***	***$72,499,741***	***$2,893,033,300***	***$3,366,918,466***
Comp. % Breakdown	***2%***	***10%***	***2%***	***86%***	***100%***

The crash costs are realized by different means. With the help of the 2015 NHTSA report's research, the project team examined how costs manifest themselves for each combination of cost category and payment source. Each was categorized as either monetary versus non-monetary, based on whether or not a cost has a value that is paid in currency or can easily be converted into a fixed amount of currency. Some combinations of cost categories and payment sources may include both monetary and non-monetary costs, but the project team chose one or the other based on what seemed to be more dominant. Table 3 describes the crash cost and payment source combinations and shows whether they were classified as monetary or non-monetary.

Table 3 Crash Cost and Payment Source Combinations with Descriptions and Payment Types

Category	Payment Source	Description	Monetary/ Non-monetary
Medical	Government	Medical bills covered by government programs such as Medicaid and Medicare	Monetary
Medical	Insurer	Increased health insurance payouts resulting in higher premiums	Monetary
Medical	Other	Unpaid medical bills covered by charities or healthcare providers	Monetary
Medical	Self	Out-of-pocket medical care	Monetary
Emergency Services	Government	Police and fire department response costs	Monetary
Market Productivity	Government	Tax income losses resulting from lost wages and benefits and employer costs for government employees (see Market Productivity, Other)	Monetary
Market Productivity	Insurer	Increased payouts from life and other insurance policies resulting in higher premiums	Monetary
Market Productivity	Other	Lost compensation covered by employers, such as workers compensation and sick leave	Monetary
Market Productivity	Self	Lost wages and benefits	Monetary
Household Productivity	Insurer	Increased payouts from life and other insurance policies resulting in higher premiums	Monetary
Household Productivity	Self	Uncompensated lost household productivity for housework, childcare, etc.	Non-monetary
Insurance Administration	Government	Increased administrative costs for governments associated with more claims, such as claim processing, defense attorneys, etc.	Monetary
Insurance Administration	Insurer	Increased administrative costs for insurers associated with more claims, such as claim processing, defense attorneys, etc.	Monetary
Workplace Costs	Other	Disruption to employers based on absence or loss of employees	Non-monetary
Legal/Court	Insurer	Legal fees and court costs of civil litigation for insurers	Monetary
Travel Delay	Other	Time spent by individuals in traffic congestion resulting from accidents	Non-monetary
Property Damage	Insurer	Increased property insurance payouts resulting in higher premiums	Monetary
Property Damage	Self	Out-of-pocket property repair or replacement	Monetary
Quality of Life	Self	Intangible cost of lost health/life due to crashes, measured by society's willingness to avoid risk	Non-monetary

Table 4 shows several cost measures based on these estimates.[5] Assuming a 2014 Idaho population of 1.634 million[6], the comprehensive crash cost per resident was $2,061. Based on the information in the

[5] Many Idaho crash costs, such as those borne by the Federal government, costs of crashes in Idaho are likely to be shared with residents and firms of other states, just as crash costs in other state are likely to be shared with residents and firms of Idaho. Given the complexity involved in quantifying how costs are

previous two tables, the project team estimated that 17% of the total crash costs are monetary and 14% of the total crash costs are borne by all Idahoans rather than the specific individuals involved in crashes. The project team calculated average annual costs per resident specifically involved in crashes of $1,771 and average annual cost per resident, regardless of their involvement in crashes, of $290. Of this $290, an estimated $259 are monetary costs. While Idahoans involved in motor vehicle crashes bear the majority of crash costs, even Idahoans who did not experience any crashes in 2014 still faced considerable monetary costs resulting from crashes – higher auto, medical, and life insurance premiums, higher taxes to cover medical costs and lost tax revenue from lower wages, traffic congestion, etc. Thus, virtually all Idahoans are economically impacted by the crash tax.

Table 4 Estimated 2014 Idaho Comprehensive Crash Costs with per Resident Costs

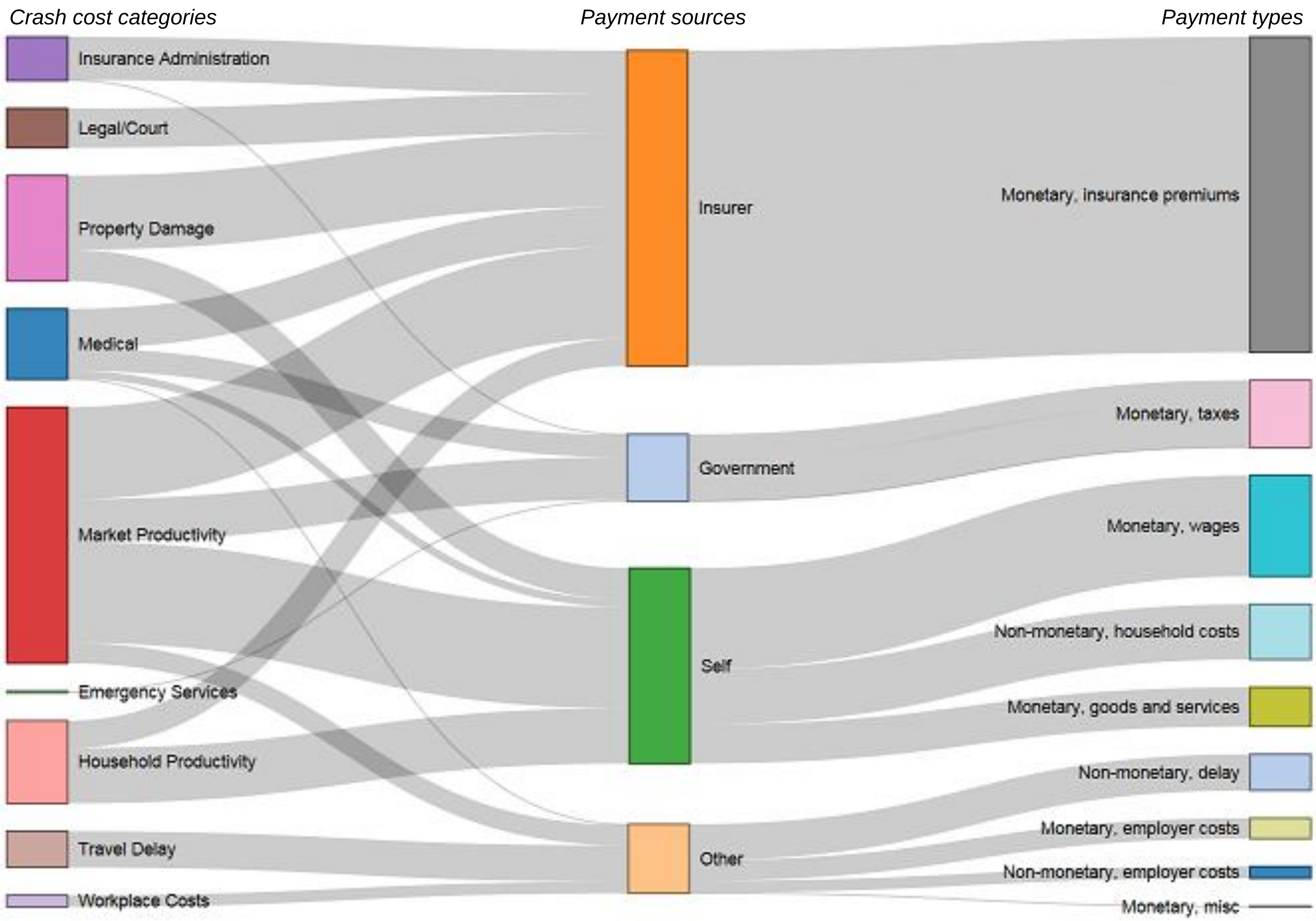
Measure	Estimate
Comprehensive crash costs	$3.37 billion
Total Average cost per resident	$2,061
Average cost per resident involved in crash	$1,771
Average cost per resident, regardless crash involvement	$290
Average monetary cost per resident, regardless crash involvement	$259

Figure 3 displays the proportion of economic crash costs by – from left to right – cost category, payment source, and payment type. The bands show cost payment sources by cost category (between left and middle columns) and payment types by payment sources (between middle and right columns). The payment types are simplified versions of the information found in the two rightmost columns in Table 3. The figure shows only economic costs and thus excludes lost Quality of Life, the largest comprehensive cost category.

imported and exported between jurisdictions, this assumes that Idahoans bear the full cost of Idaho crashes and none of the costs of other jurisdictions' crashes.

[6] *QuickFacts; Idaho*. United States Census Bureau website, 2016.

Figure 3 Economic Crash Cost Categories, Payment Sources, and Payment Types



Note: The figure shows only economic crash costs; thus, lost Quality of Life costs are excluded.

Crash Reduction Savings

The project team investigated how investments in safety might reduce the cost of motor vehicle crashes. The investigation did not conduct a full literature review of safety investments and their ability to reduce fatalities and injuries. Instead, it sought readily available tools that might be helpful for demonstration purposes.

The Centers for Disease Control and Prevention (CDC) developed a tool called Motor Vehicle Prioritizing Interventions and Cost Calculator for States (MV PICCS) that estimates the number and value of injuries and fatalities prevented by a set of 14 preselected safety interventions in any selected state.[7] The MV PICCS interventions are:

- Speed camera
- Increased seat belt fine
- Red light camera
- License plate impoundment
- Universal motorcycle helmet laws
- High visibility enforcement for seatbelts, child restraint and booster laws
- Primary enforcement of seatbelt law
- Alcohol interlocks
- Sobriety checkpoints
- Bicycle helmet laws for children
- In Person license renewal
- Saturation Patrols
- Vehicle Impoundment
- Limits on Diversion and Plea Agreements

The MV PICCS estimates implementation costs, revenues, and changes in fatalities and injuries associated with each treatment. Based on 2010 state-specific data, the tool applies the costs, revenues and benefits of treatments selected by the user to develop a prioritized list of treatments. The treatments are ranked by cost effectiveness and total budget available.

To develop an understanding of potential additional safety benefits and investment requirements to achieve these benefits, two hypothetical scenarios were developed and run using the MV PICCS tool and supporting information.

1. The first hypothetical was based on a research brief associated with MV PICCS, *How to Get the Biggest Impact from an Increase in Spending in Traffic Safety*.[8] A portion of the report examines

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[7] *Motor Vehicle Prioritizing Interventions and Cost Calculator for States (MV PICCS) 2.0*. Centers for Disease Control and Prevention website, 2016.

[8] Ecola, Liisa et al. *How to Get the Biggest Impact from an Increase in Spending in Traffic Safety*. RAND Corporation, 2015.

which interventions states could implement if they received a 10% increase in traffic safety funding. State-level information on existing crashes, traffic safety spending, and existing interventions is built into MV PICCS. In this report's method, increased funds are allocated toward intervention costs formulaically. The process looks at what interventions are already implemented, then chooses the next most effective intervention whose cost is less than the remaining funding. When no more interventions can be funded, the estimated fatality reduction from the new interventions are tallied and reported. According to Table 2 of the report, Idaho could implement 2 additional interventions with 8 lives saved under this scenario in 2010. Presumably, this funding process assumes that interventions do not generate revenue to cover their costs; MV PICCS provides a revenue generation option under which many interventions pay for themselves. The project team used this scenario and examined how crash costs would be affected. The report provides neither injury reduction numbers nor baseline injury counts, so the injury reduction rate was assumed to be 4% - the same as the fatality reduction rate compared to baseline fatalities.

2. The second hypothetical involved the project team creating its own scenario within MV PICCS. According to Table 5.6 in the MV PICCS documentation, Idaho already implements 2-4 of the tool's 14 interventions. At the time of the research, Idaho implemented motorcycle helmet laws and in person renewal. Authors of the research were unable to verify whether saturation patrols or seat belt enforcement campaigns were implemented for any of the states. The project team found evidence that saturation patrols and seat belt enforcement campaigns have been implemented recently in Idaho.[9,10] Thus assuming that these four interventions are currently implemented, the hypothetical looked at safety benefits of implementing the other ten interventions.[11] MV PICCS was run in portfolio mode, which accounts for interdependencies among interventions in efforts to avoid double counting benefits. Fine revenue was included in the scenario, and the total revenue from the ten-intervention portfolio more than offset the intervention costs. According to the MV PICCS tool, this scenario reduced fatalities by 51 and injuries by 4,374 in 2010. According to the project team's calculations, the fatality reduction rate was 27% compared to the baseline. The report does not provide baseline injury counts, so the injury reduction rates was assumed to be the same as the fatality reduction rate.

Table 5 summarizes how the two hypotheticals might reduce fatalities and injuries. The middle column shows the 10% spending increase in traffic safety scenario, and the right column shows the full ten-intervention portfolio. The 2010 injury reduction percentages calculated using MV PICCS results were applied to Idaho 2014 crash counts to estimate 2014 fatalities and injuries reduced.

[9] *Traffic Enforcement Mobilization Agreement; Highway Safety Programs.* Idaho Transportation Department website, 2016.

[10] Statewide Seat belt enforcement campaign set for May 16-30. Idaho Transportation Department News Release on website, 2016.

[11] The new interventions are: speed cameras, increased seat belt fines, red light cameras, license plate impoundment for DWI offenders, alcohol interlocks, primary enforcement seatbelt law, bicycle helmet laws for children, vehicle impoundment for DWI offenders, limits on diversion and plea agreements for DWI offenders, and seat belt enforcement campaigns.

Table 5 Hypothetical Fatality and Injury Reductions

Measure	Hypothetical 10% Safety Spending Increase	Hypothetical Intervention Portfolio
Fatalities reduced	7	46
Fatalities % reduction	4%	27%
Injuries reduced	457	2,913
Injuries % reduction	4%	27%

The project team used the updated unit costs (Table 1) and payment breakdown analysis (Tables 2 and 3, and Figure 3) to estimate how these injury and fatality reductions could affect crash costs. Table 6 presents results, showing the current cost in the left-middle column, the 10% safety spending increase in the right-middle column, and the intervention portfolio in the rightmost column. The rows unitalicized rows show cost figures for each metric. The italicized rows show cost savings in the two hypotheticals compared to the current numbers.

Table 6 Estimated 2014 Crash Costs in Hypothetical Scenarios

Measure	Current	Hypothetical 10% Safety Spending Increase	Hypothetical Intervention Portfolio
Comprehensive crash costs	$3.37 billion	$3.24 billion	$2.56 billion
Savings versus current: comprehensive crash costs	--	*$0.13 billion*	*$0.81 billion*
Total average cost per resident	$2,061	$1,982	$1,566
Savings versus current: total average cost per resident	--	*$78*	*$495*
Average cost per resident involved in crash	$1,771	$1,702	$1,335
Savings versus current: average cost per resident involved in crash	--	*$68*	*$435*
Average cost per resident regardless of crash involvement	$290	$281	$230
Savings versus current: average cost per resident, regardless of crash involvement	--	*$9*	*$60*
Average monetary cost per resident regardless of crash involvement	$259	$250	$203
Savings versus current: average monetary cost per resident, regardless of crash involvement	--	*$9*	*$56*

Both scenarios reduce crash costs substantially. The 10% safety spending increase reduces comprehensive crash costs by $0.13 billion, or $78 per resident. It reduces monetary cost per resident, regardless of involvement in crashes, by $9 ($14.68 million overall). The intervention portfolio reduces costs significantly more, with $0.81 billion in comprehensive costs saved, or $495 per resident. It saves $56 of monetary cost per resident, regardless of involvement in crashes ($92.23 million overall). The crash cost reductions in Table 6 do not account for implementation costs. As described previously, the first hypothetical assumes a 10% increase in traffic safety funding that would be used to cover implementation costs of the interventions. Under the second hypothetical, the intervention portfolio would generate more than enough revenue to offset its implementation costs.

While these are sketch-level analysis, these results demonstrate the significant potential benefits of safety investments in not only saving lives and reducing injuries, but in lowering the financial burden of crashes on Idahoans. The analysis provides the fiscal impetus for considering increased safety investment in Idaho.

Appendix A – Idaho Crash Cost Update Calculations

Appendix A presents the calculations involved for each step of the process described in the Update Cost Estimates section.

Table A1 shows the Idaho crash counts for 2014, the most recently published crash report at the time of analysis. The Methods for Estimating the Cost of Motor Vehicle Crashes memorandum describes how ITD develops the unit costs (i.e., Cost per Occurrence) by severity rating in its crash reports. The project team used these crash counts for this task but updated the unit the costs by converting from KABCO to the AIS scale, adjusting for recent inflation, and applying national guidance on unit costs.[12]

Table A1 2014 Idaho Traffic Crashes with ITD Crash Report Costs

Incident Description	KABCO	Total Occurrences	Cost per Occurrence	Cost per Category
Fatalities	K	186	$6,493,502	$1,207,791,372
Serious Injuries	A	1273	$323,382	$411,665,286
Visible Injuries	B	3,689	$90,577	$334,138,553
Possible Injuries	C	6806	$60,040	$408,632,240
Property Damage Only	--	13,742	$6,951	$95,520,642
Total		25,696		$2,457,748,093

Note: Property Damage Only occurrences refer to the number of incidents rather than number of vehicles.

Source: Idaho Traffic Crashes 2014, Table 4.

Table A2 shows national unit cost estimates by severity and crash cost type from NHTSA's 2015 update to its report, *The Economic and Societal Impact of Motor Vehicle Crashes, 2010*.[13] MAIS0 through MAIS5 represent severity ratings based on the AIS scale. The ratings range from MAIS0, no injuries, to MAIS5, critical injuries. Maximum AIS (MAIS) refers to the maximum injury level within each AIS class.

Because the NHTSA report's Property Damage Only (PDO) unit costs are provided per vehicle and the ITD PDO crash counts are provided per incident, the project team converted the ITD PDO counts to per vehicle. A conversion factor of 1.75 vehicles per incident. This ratio was based on the number of vehicles per police-reported PDO crash in Table 2-11 of the NHTSA report.

[12] This table does not include Unknown/Missing crashes or KABCO category O crashes that do not involve property damage. Thus, this memorandum might slightly underestimate the cost of crashes in Idaho.

[13] Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. *The economic and societal impact of motor vehicle crashes, 2010. (Revised)* (DOT HS 812 013). National Highway Traffic Safety Administration, 2015.

Table A2 NHTSA Report Summary of National Comprehensive Unit Costs and Police-Reported and Unreported Crashes

Category	Property Damage Only	MAIS0	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical Care	$0	$0	$2,799	$11,453	$48,620	$136,317	$384,273	$11,317
Emergency Services	$28	$21	$89	$194	$416	$838	$855	$902
Market Productivity	$0	$0	$2,726	$19,359	$64,338	$140,816	$337,607	$933,262
Household Productivity	$60	$45	$862	$7,106	$22,688	$37,541	$95,407	$289,910
Insurance Administration	$191	$143	$3,298	$4,659	$15,371	$28,228	$72,525	$28,322
Workplace Costs	$62	$46	$341	$2,644	$5,776	$6,361	$11,091	$11,783
Legal Costs	$0	$0	$1,182	$3,351	$12,402	$26,668	$82,710	$106,488
Congestion	$1,077	$760	$1,109	$1,197	$1,434	$1,511	$1,529	$5,720
Property Damage	$2,444	$1,828	$5,404	$5,778	$10,882	$16,328	$15,092	$11,212
Total Economic Costs	***$3,862***	***$2,843***	***$17,810***	***$55,741***	***$181,927***	***$394,608***	***$1,001,089***	***$1,398,916***
Quality of Life	$0	$0	$23,241	$340,872	$805,697	$2,037,483	$4,578,525	$7,747,082
Total Comprehensive Costs	***$3,862***	***$2,843***	***$41,051***	***$396,613***	***$987,624***	***$2,432,091***	***$5,579,614***	***$9,145,998***

Note: Unit costs are expressed per-person for all injury levels and per-damaged-vehicle for property damage only crashes.

Source: NHTSA 2015, p.17. The NHTSA report's table states that costs are in 2010 dollars. But the table's total comprehensive fatality cost appear to reflect the 2012 dollars $9.1 million value, described in the NHTSA report text on p. 241, rather than the 2010 dollars value. The project team was unable to determine the reason for this discrepancy. For the purposes of this analysis, the table is assumed to contain end-of-year 2012 dollars.

The project team translated the Idaho crash counts from KABCO to AIS using conversion factors. Table 3 shows the KABCO/AIS conversion factors from the US DOT Benefit-Cost Analysis (BCA) Resource Guide, was updated in March 2016.[14]

[14] *Benefit-Cost Analysis (BCA) Resource Guide*. U.S. Department of Transportation, 2016.

Table A3 US DOT KABCO/AIS Conversion Factors

MAIS	O	C	B	A	K
0	0.92534	0.23437	0.08347	0.03437	0
1	0.07257	0.68946	0.76843	0.55449	0
2	0.00198	0.06391	0.10898	0.20908	0
3	0.00008	0.01071	0.03191	0.14437	0
4	0	0.00142	0.0062	0.03986	0
5	0.00003	0.00013	0.00101	0.01783	0
Fatal	0	0	0	0	1
Total	1	1	1	1	1

Source: US DOT BCA Resource Guide 2016, Table 4.

Table A4 shows the Idaho estimated crash counts in AIS after multiplying the KABCO crash counts by the BCA Resource Guide conversion factors. Property Damage Only crashes did not require a conversion factor.

Table A4 Estimated 2014 Idaho Crash Counts Translated from KABCO to AIS

MAIS	PDO	C	B	A	K	Total
PDO	24,049	0	0	0	0	24,049
0	0	1,595	308	44	0	1,947
1	0	4,692	2,835	706	0	8,233
2	0	435	402	266	0	1,103
3	0	73	118	184	0	374
4	0	10	23	51	0	83
5	0	1	4	23	0	27
Fatal	0	0	0	0	186	186
Total	24,049	6,806	3,689	1,273	186	36,003

Note: The PDO figure is modified from the ITD crash report to reflect vehicle rather than incident counts.

To account for inflation, wage increases, and the most updated guidance on the Value of a Statistical Life (VSL), the project team used unit costs from the 2016 BCA Resource Guide for crashes by AIS severity level (see Table A5). The guide uses a VSL of $9.6 million.

Table A5 Recent US DOT Recommended Monetized Values for the Values of Statistical Life, Injuries, and Property Damage Only Crashes, 2015 US Dollars

Severity	Unit Value
PDO	$4,198
AIS 1	$28,800
AIS 2	$451,200
AIS 3	$1,008,000
AIS 4	$2,553,600
AIS 5	$5,692,800
AIS 6	$9,600,000

Source: US DOT BCA Resource Guide 2016, Table 1.

Table A6 displays the updated unit costs distributed among cost categories. The proportions of cost by category were assumed to remain the same within each severity level. The table does not show MAIS 0 costs, since the BCA Resource Guide lists these as $0.

Table A6 Estimated AIS Unit Costs by Cost Category, 2015 US Dollars.

Category	Property Damage Only	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical Care	$0	$1,964	$13,029	$49,623	$143,127	$392,068	$11,879
Emergency Services	$30	$62	$221	$425	$880	$872	$947
Market Productivity	$0	$1,912	$22,023	$65,665	$147,851	$344,456	$979,589
Household Productivity	$65	$605	$8,084	$23,156	$39,417	$97,342	$304,301
Insurance Administration	$208	$2,314	$5,300	$15,688	$29,638	$73,996	$29,728
Workplace Costs	$67	$239	$3,008	$5,895	$6,679	$11,316	$12,368
Legal Costs	$0	$829	$3,812	$12,658	$28,000	$84,388	$111,774
Congestion	$1,171	$778	$1,362	$1,464	$1,586	$1,560	$6,004
Property Damage	$2,657	$3,791	$6,573	$11,107	$17,144	$15,398	$11,769
Total Economic Costs	***$4,198***	***$12,495***	***$63,413***	***$185,680***	***$414,323***	***$1,021,397***	***$1,468,357***
Quality of Life	$0	$16,305	$387,787	$822,320	$2,139,277	$4,671,403	$8,131,643
Total Comprehensive Costs	***$4,198***	***$28,800***	***$451,200***	***$1,008,000***	***$2,553,600***	***$5,692,800***	***$9,600,000***

Table 1 in the main report shows the updated unit costs by cost category multiplied by the estimate 2014 Idaho AIS crash counts.