Medical and Economic Cost of North Dakota Motor Vehicle Crashes

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ABSTRACT

Each year there are more than 16,000 motor vehicle crashes (MVCs) on North Dakota roadways, resulting in more than 2,900 injuries and 107 fatalities. Understanding the economic impacts of these MVCs is important in discerning impacts of road investments, behaviors, and policy changes that affect public safety. Total economic costs are estimated for MVCs in the state, with detail provided on medical costs borne by taxpayers. The present value of costs for MVC injuries incurred over a seven year period is estimated to better understand benefits, in terms of cost avoidance, for investment in traffic safety. Looking at the economic costs of MVCs and using a benefit/cost analysis of implementing a primary seatbelt law produces a savings from $90 million to $277 million over the seven-year period. The medical cost savings to Medicaid alone could be as little as $1 million and as high as $3 million, and the savings to all medical insurers ranges from $8.4 million to $25.3 million.

TABLE OF CONTENTS

ABSTRACT.. ii
1. INTRODUCTION 1
2. LITERATURE REVIEW 2
3. DATA MINING & FINAL SOURCES.. 3
4. TOTAL MEDICAL AND ECONOMIC COSTS.. 6
4.1 Medical Costs.. 6
4.2 Economic Costs 8
5. POTENTIAL BENEFITS FOR INVESTMENT TO REDUCING MVC INJURY 10
6. ESTIMATED SAVINGS AND BENEFIT 12
7. CONCLUSION.. 16
8. REFERENCES 17

LIST OF TABLES

Table 1. Case Definition for TBI 4
Table 2. Case Definition for SCI 4
Table 3. Case Definitions for Levels of SCI Severity 5
Table 4. Data Sources 7
Table 5. Estimated Medical Costs for All Payers in North Dakota 7
Table 6. Estimated Medical Costs for Medicaid in North Dakota 8
Table 7. Per Crash Cost Estimates by Crash Severity 8
Table 8. Motor Vehicle Crashes, 2006 -2009 9
Table 9. Estimated Injury Costs for Motor Vehicle Crashes in North Dakota 9
Table 10. Effectiveness of Seatbelts in Preventing Moderate to Critical Injuries in North Dakota 11
Table 11. Effectiveness of Seatbelts in Preventing Fatalities in North Dakota 11
Table 12. Savings by Medicaid with 5%, 10% and 15% Increases in Seatbelt Use 13
Table 13. Savings for All Payers in North Dakota with 5%, 10% and 15% Increases in Seatbelt Use Rates 14
Table 14. NPV Estimated Crash Prevention Benefit Over Seven Years, Based on Decreased Injury Severity Resulting from Implementation of a Primary Seatbelt Law 15

1. INTRODUCTION

Traffic safety is important in promoting North Dakota as a livable and mobile environment for residents, businesses, and tourists. Insight regarding the incidence and economic impact of motor vehicle crashes is important to resource and policy decisions that affect road safety. From 2002 to 2006, there were more than 16,000 motor vehicle crashes (MVCs) annually on North Dakota roadways. These include more than 2,900 crashes that result in injuries each year and in an average of 107 deaths annually (North Dakota Department of Transportation [NDDOT], 2008).

Costs associated with these crashes are substantial. Economic costs associated with MVCs have been quantified in a multitude of empirical studies (Viscusi and Aldy 2003; Viscusi 2004; Kochi et al. 2006). These costs range greatly by severity of the crash. They may be minor repairs to a vehicle in less severe crashes but, in the more severe crashes, the costs may include items such as initial medical care – emergency room and hospitalization, follow-up medical care, physical therapy, lost wages, legal costs, and lost productivity. This paper investigates the economic costs associated with crashes, with specific attention given to medical and taxpayer costs.

Based on National Highway Traffic Safety Administration (NHTSA) computations through Motor Vehicle Safety (MVS) software, crashes in North Dakota have an annual estimated economic cost of $298 million (NHTSA 2008). This amount is based on 2004 data adjusted for inflation to 2006 dollars, and it reflects costs for medical care of $37.5 million, along with costs for items such as emergency services, legal costs, and property damage. The estimate also incorporates costs for unreported crashes, which comprise a large part of the less-severe crashes – NHTSA estimates that about 23% of the minor injuries go unreported along with 48% of property damage only (PDO) crashes.

Based on these figures even a small reduction would result in substantial cost avoidance. These savings, however, would be realized by public and private entities inside and outside of North Dakota. To better understand the share attributable to North Dakota parties, data from medical services provided by North Dakota facilities was analyzed.

Some attention will also be given to estimating costs associated with MVCs using the Value of a Statistical Life (VSL) which Duvall (2008) puts at $5.8 million and based on estimates from the National Safety Council (2010) for incapacitating and non-incapacitating injuries. These estimates will be adjusted to reflect present value to estimate the cost and benefit under a variety of selected safety improvement scenarios.

2. LITERATURE REVIEW

The method commonly referenced in estimates of lifetime economic costs associated with MVCs and crash factors is the Blincoe, et al. study (2002). Here, the estimated lifetime economic costs of crashes in the United States in 2000 is $230.6 billion, with taxpayers directly paying for approximately 9% of the cost through public sources with 6% attributed to federal sources and 3% to states. Several subsequent studies have built on these methods to estimate state MVC costs and payee incidence as well as cost-avoidance associated with crash specific factors such as occupant behavior, vehicle safety systems, and road geometry and operations. Studies most relevant here include work by Chaudhary and Preusser (2004), Kirk et al. (2005), Farmer and Williams (2005), and Carpenter and Stehr (2007).

3. DATA MINING & FINAL SOURCES

The initial task in this study was to identify public and private sources containing medical cost and trauma injury information for MVCs in North Dakota. Work was focused on estimating costs for initial medical care of North Dakota residents involved in a crash that requires hospitalization. In addition, the follow-up costs associated with two costly diagnoses common in MVCs, traumatic brain injury (TBI) and spinal cord injury (SCI), are addressed. Initial and long-term care costs are well-documented in existing literature.

Unlike some states, North Dakota does not have a single repository for medical provider information for hospitals or emergency rooms. Initial attempts were made to utilize a sample of hospital-provided data and state trauma data to develop MVC injury incidence, medical diagnoses, and medical cost estimates. The ability to duplicate methods in the future would be easier if the study depended largely on public repository data. Efforts were unsuccessful because of issues involving diagnoses uncertainties within the trauma data and lack of detail regarding injury cause in claims studies in the hospital data. External cause codes (e-codes) used to categorize injuries are not consistently reported to insurers as a data element in the claims information.

Because North Dakota does not have a single source of data containing all payer information for hospital claims, several alternatives were explored. Initially, data from the North Dakota Department of Health (NDDH) trauma registry was linked to data from one of the larger medical facilities in the state in an attempt to ascertain the number of people involved in MVCs who had a medical stay and who suffered either a TBI or an SCI (MeritCare Hospital 2008; North Dakota Department of Health 2008). The linking between the two data sets was possible with probabilistic linking techniques (Cook et al. 2001; Dean et al. 2001). The diagnosis codes, however, contained some issues in the trauma data which made them unreliable for analysis. General diagnosis codes in hospital claims are used for billing purposes, which helps to ensure proper coding of these claims. Unfortunately, specific coding is needed to identify the TBI and SCI injuries. For this reason, the use of the trauma data was ruled out for identifying the injury types.

Another option explored obtaining the medical claims directly from the hospitals. This was ruled out for several reasons related to limited resources including: a lengthy process to satisfy Health Insurance Portability and Accountability Act (HIPAA) requirements for each hospital, uncertainties regarding compatibility among hospitals data systems, and time required for recruitment and coordination with potential participant hospitals.

It was decided to acquire claims from the organizations that provide the coverage. Although numerous insurance providers offer medical coverage to North Dakota residents, many of the providers have a very small market share and would not affect the estimates significantly. Therefore, efforts were concentrated on collecting information from the largest providers in the state. North Dakota's population was estimated to be 637,460 people in 2006 (U.S. Census Bureau 2007). Blue Cross Blue Shield of North Dakota (BCBSND) insures approximately 284,700 individuals or 44.7% of this population, while Medicare provides coverage to 103,654 individuals (16.2%) of the state's residents and Medicaid covers roughly an additional 10% of the residents (Blue Cross Blue Shield of North Dakota 2009; North Dakota State Data Center 2006; Henry J. Kasier Foundation 2009). Together these three entities provide coverage to 71% of the state's population. A reasonable assumption here is that they represent an equivalent share of MVC injury claims in North Dakota.

These providers were asked to provide data for all hospital admissions resulting from MVCs which are identified as those claims with an e-code between E810 and E819 and having a fourth digit of 0, 1, 8, or 9. Even though these e-codes are well-coded at the facilities, these same codes are seldom transmitted to the respective insurer. There are several possible explanations for why this happens. The most likely is that these e-codes are not required and do not affect reimbursement, and therefore are not transmitted with the rest of information. Because e-codes are reported sporadically, national estimates of the etiology for both TBIs and SCIs were applied to all cases of these conditions found in the claims data. Thus, the approach was modified to request all admissions for 2006 with a diagnosis code of TBI or SCI and then use national etiology figures to estimate the actual number of TBIs and SCIs that resulted from motor vehicle crashes.

Data requests to providers were for total cost figures which will be the basis for the cost avoidance calculations. Total costs are usually more than the actual amounts paid by the insurers for the hospitalizations, but represent a good proxy for the actual amount that the services cost the insurers. There is also the confounding issue that some costs are covered by the motor vehicle insurance companies under personal injury protection (PIP) coverage. North Dakota law requires motorists to carry PIP coverage, which covers medical costs up to $30,000 for each person in the motorist's vehicle. According to the North Dakota Insurance Department (2010) claims paid out under the PIP coverage in 2009 were just over $24 million. However, a breakdown of what these claims paid was unavailable. The amount that actually covers inpatient medical care varies by whether each person has health insurance, the type of health insurance they have, and how much of the PIP amount is used to cover emergency room and other costs, potentially leaving little or no coverage for the actual hospitalization costs. Because there is little information that addresses the portion of medical costs covered by the motorist's PIP coverage, the total costs and savings presented here represent a maximum amount. This total cost method also has the added benefit of being the standard for medical studies of this type, because it is readily available from data sets maintained in the medical community.

TBIs and SCIs are common injuries resulting from MVCs – both injuries are high-cost in terms of medical care. Therefore, the Centers for Disease Control and Prevention (CDC) developed detailed definitions for these conditions based on the World Health Organization's International Classification of Disease (ICD) systems (World Health Organization, 1977). These definitions have led to significant research on both diagnoses. In particular, the definitions used in this paper, formalized below in Table 3.1 and Table 3.2, are based on those used by Singleton, et al. in their similar research on the economic costs of low seat belt use in Kentucky (2005). They based their definitions on those published in the CDC's Central Nervous System Injury Surveillance Data Submission Standards – 2002 (Marr and Coronado 2004).

Table 3.1 Case Definition for TBI

ICD9- code(s)	Description
800.0-801.9	Fracture of the vault or base of the skull
803.0-804.9	Other and unqualified and multiple fractures of the skull
850.0-854.1	Intracranial injury, including concussion, contusion, laceration, and hemorrhage
950.1-950.3	Injury to the optic chiasm, optic pathways, and visual cortex
959.01	Head injury, unspecified

Table 3.2 Case Definition for SCI

ICD9- code(s)	Description
806.0-806.9	Fracture of the vertebral column with spinal cord injury
952.0-952.9	Spinal cord injury without evidence of spinal bone injury

In addition to the basic definition of an SCI, Singleton et al. also developed case definitions for the severity of SCIs to match the National Spinal Cord Injury Statistical Center's cost estimate research. These definitions are presented in Table 3.3.

Table 3.3 Case Definitions for Levels of SCI Severity

Injury Severity	**Definition**	**ICD9- code(s)**
High quadriplegia	Injury to C1-C4	806.00-806.04, 806.10-806.14, 952.00-952.04
Low quadriplegia	Injury to C5-C7	806.05-806.09, 806.15-806.19, 952.05-952.09
Paraplegia	Injury to T1-S5	806 (.2-.7), 952 (.1-.4)
Incomplete Motor Function at any level	-	806.8, 806.9, 952.8, 952.9

The cost estimates for crash survivors will be coupled with economic losses associated with MVC deaths. The U.S. Department of Transportation advises that the Value of Statistical Life (VSL) to be used in empirical research is $5.8 million (DuVall, 2007). The VSL is based on economic methods to determine willingness-to-pay for risk reduction for potential injury in stated and revealed preference studies. Estimates from the National Safety Council (2010) are used to estimate costs and savings for incapacitating and non-incapacitating injuries. Crash data from 2006 to 2009 was used to identify the number of fatalities, incapacitating injuries and non-incapacitating injuries resulting from MVCs in North Dakota where the vehicle type was passenger car or pickup/van/utility (NDDOT 2010).

4. TOTAL MEDICAL AND ECONOMIC COSTS

The net present value (NPV) of medical and total economic costs expected for MVCs over the next seven years is developed using a combination of state and national data sources. Cost figures derived from other sources are stated in actual values as reported in the underlying claims data and/or empirical research. The consumer price index (CPI) reported by the Bureau of Labor Statistics is used to adjust the figures for inflation (2008). The estimates are then standardized by adjusting the figures to reflect 2006 values using the NPV calculation. Future cost projections, which account for opportunity costs associated with these dollars, are based on a 7% rate of return (Duvall, 2007). NPV estimates the dollar value associated with costs of expected MVC injury and death.[1] The NPV is calculated as

Equation 1

$$NPV = I + \sum_{t=1}^{t=i} \frac{B_t}{(1+r)^t}$$

where,

I = initial investment
B = annual benefit (in terms of cost avoidance)
r = rate of return, based on opportunity cost of capital, and
t = years.

4.1 Medical Costs

Costs are categorized into three injury types and two time frames following the method used in previous studies (Blincoe 2000; Singleton et al. 2005). While some studies have used alternative categorization methods for injuries, the common thread is a distinction among the lesser injury, serious injury, and fatal injury (Chaudhary and Preusser 2004; Chaudhary and Tison 2008). A three-injury categorization was selected based on the detail available for categorizing the MVC injuries in North Dakota medical cost data. The injury types used are TBI, SCI, and other injuries suffered from an MVC. The two time frames include (1) a first-year cost and (2) subsequent years cost. First-year costs are broken down into initial hospital costs and post-discharge costs, which include charges such as office visits, physical therapy, and additional hospital stays.

Estimates for the two time frames for the SCI injuries were based on facts and figures published by the National Spinal Cord Injury Statistical Center (NSCISC). These reports indicate that there is great variability among the four categories of SCI, ranging from $218,504 to $741,425 for the first-year costs, and from $15,313 to $132,807 for the charges incurred after the first year (NSCISC 2006). The NSCISC also estimates that 43.3% of SCIs are caused by motor vehicle crashes (NSCISC 2006). This information will be used to adjust the total number of SCIs identified in the data.

Table 4.1 indicates which data source will be used to estimate the medical costs associated with each combination of injury type and timeframe. Cost estimates for the TBI injuries will be based on the charges from the North Dakota provider claims data for the initial hospital costs and national estimates

[1] Net present value considers an initial investment and the stream of benefits over time using a discount rate to account for the opportunity cost of capital during the investment life.

from the Craig Institute for the first-year post-discharge costs and subsequent years cost. First-year follow-up costs are $40,000, with costs for each subsequent year estimated to be $26,781 (Chaudhary 2004). As with the SCIs, the overall number of TBIs found in the data will be adjusted to account for only those TBIs with an etiology of MVC. According to the National Center for Injury Prevention and Control, MVCs cause 25.2% of all TBI hospital admissions (Langlois 2006).

Costs for the other admissions are based solely on the Medicaid claims data with only initial hospital costs estimated. Estimates for the post-discharge costs and the additional year costs of these admissions are beyond the scope of this paper. While the Maximum Abbreviated Injury Scale (MAIS) may offer some means for estimating other costs, work has not been done to define parameters or derive these calculations from the provider data available for this study and is outside the scope of work possible here (Blincoe2002).

Table 4.1 Data Sources

Injury Type	Initial Hospital Costs	First-Year Follow-up Costs	Costs after First Year
TBIs	Claims Data	Craig Institute Estimates	Craig Institute Estimates
SCIs	NSCISC Estimates	NSCISC Estimates	NSCISC Estimates
Other Admissions	Claims Data	Not Estimated	Not Estimated

Craig Institute research indicates that the percentage of TBI patients on Medicaid will double in the first year following injury and that 25.4% of all SCIs will eventually become Medicaid patients. Since the exact time frame that each patient ends up on Medicaid is not known and due to the severity of the injuries (i.e., most patients will spend a large percentage of their time rehabilitating and seeking additional medical care), the 25.4% of all SCIs was assumed to occur the first year after the accident.

The first-year follow-up costs are calculated only for those patients who do not die during the initial hospital admission. Because the data here comprises all TBIs and SCIs for North Dakota residents and not just those associated with MVCs, it is unclear whether the deceased cases were caused by an MVC or not. Also, there was very little mortality in the Medicaid population. Of the 57 cases found in the claims data, only two died during their hospital stay. If it is assumed the actual mortality was consistent across MVCs and non-MVCs, the estimates would change by less than 5%. Therefore, mortality was not factored in for the purposes of medical cost estimates so these may be slightly overstated.

As indicated in the figures in Table 4.2 the costs associated with MVCs are substantial. First year costs for MVCs are $26 million for the initial hospital costs plus the $7.3 million for first year follow-up costs. For every year after the first, an additional $7.6 million would be added to the costs of these crashes, plus the cost of the crashes that occur in each of those years.

Table 4.2 Estimated Medical Costs for All Payers in North Dakota

Injury Type	Estimated Admissions	Initial Hospital Costs	First-Year Post Discharge Costs	Annual Costs Incurred after the First Year
TBI	182	$4,730,944	$7,280,000	$4,890,522
SCI	34	$16,284,360	Included w/Initial Costs	$2,297,234
Other Admissions	559	$4,907,618	N/A	N/A
Total Costs	775	$25,922,922	$7,280,000	$7,187,756

The estimated costs borne by Medicaid are reflected in Table 4.3.The initial hospital costs borne by Medicaid are $1.9 million, with $520,000 in follow-up care during the first year following discharge. Annual costs after the first year post discharge total $1.4 million.

Table 4.3 Estimated Medical Costs for Medicaid in North Dakota

Injury Type	Estimated Admissions	Initial Hospital Costs	First-Year Post Discharge Costs	Annual Costs Incurred after the First Year
TBI	13	$392,776	$520,000	$698,646
SCI	3*	$1,041,168	Included w/Initial Costs	$667,637
Other Admissions	56	$491,640	N/A	N/A
Total Costs	72	$1,925,584	$520,000	$1,366,283

*Because the number of SCIs is small in the Medicaid population, fractional cases were used in estimating the costs and savings. This number has been rounded only for conformity.

The explicit costs considered in Tables 4.2 and 4.3 include only medical costs and are presented to investigate the direct costs to Medicaid and other insurers. Losses resulting from MVCs are not limited to medical insurers. They include lost productivity and wages, loss of life and property damage just to list a few. These costs will be broken down into three categories of injuries: fatalities, incapacitating, and non-incapacitating.

4.2 Economic Costs

In addition to the medical costs associated with serious injury crashes, a substantial economic loss is associated with MVC death and injury. Costs for fatalities are based on the VSL as reported by the U.S. Department of Transportation, (Duvall 2008) and does not include costs for medical expenses, property damages or other costs. The costs for both incapacitating and non-incapacitating injury include wage and productivity losses, medical expenses, administrative expenses, motor vehicle damage, and employers' uninsured costs (National Safety Council 2010). All three estimates are reported for 2008 in Table 4.4.

Table 4.4 Per Crash Cost Estimates by Crash Severity

1.	**Crash Severity**		
Year	**Fatal**	**Incapacitating Injury**	**Non-Incapacitating Injury**
2008	$5,800,000	$214,200	$54,700

Cost estimates can be used to interpolate cost savings associated with specific crash-related factors such as road departure and seat belt use. This cost and injury data is used in conjunction with NDDOT Crash Report Data which includes incident, vehicle, driver, and environmental data for the population of reported motor vehicle crashes to estimate factor-related savings. Crash data from 2006 to 2009 was used to identify the number of fatalities, incapacitating injuries and non-incapacitating injuries resulting from MVCs in North Dakota as reported in Table 4.5 (NDDOT, 2010). Testing this data, the number of fatalities, incapacitating injuries and non-incapacitating injuries are found to vary significantly from year to year (χ^2=20.5, p-value<0.003). Because there is a significant difference in the years, averages from the previous three years are used for the injury numbers for 2010-2012. To be consistent, costs and savings will be based on seven years, because it represents the lower end for the life expectancy of SCI and TBI cases (Langlois et al. 2006; Shavelle et al. 2007).

Table 4.5 Motor Vehicle Crashes, 2006 -2009

2.	**Crash Severity**			
Year	**Fatal**	**Incapacitating Injury**	**Non-Incapacitating Injury**	**Totals**
2006	98	353	1,241	1,692
2007	95	321	1,256	1,672
2008	87	258	1,167	1,512
2009	122	257	1,182	1,561
2010*	101	279	1,202	1,582
2011*	103	265	1,184	1,552
2012*	109	267	1,189	1,565
Totals	715	2,000	8,421	11,136

*Estimated based on previous three years.

Using the injury costs from Table 7, adjusted for inflation, and the numbers of injuries from Table 4.5, the total crash costs associated with MVCs in North Dakota were calculated for 2006 – 2012.

Table 4.6 shows the crash costs by injury type. Total costs for the seven years are $5 billion. More than 80% of the total costs are attributed to the costs associated with fatal injuries. These range from roughly $500 million to just over $700 million a year. The incapacitating injury and non-incapacitating injury costs annually range from $55 million -$71 million and $63 million - $65 million, respectively.

Table 4.6 Estimated Injury Costs for Motor Vehicle Crashes in North Dakota

3.	**Crash Severity**			
Year	**Fatal**	**Incapacitating Injury**	**Non-Incapacitating Injury**	**Totals**
2006	$534,296,000	$71,075,844	$63,809,738	$669,181,582
2007	$528,960,000	$66,007,872	$65,955,072	$660,922,944
2008	$504,600,000	$55,263,600	$63,834,900	$623,698,500
2009	$707,600,000	$55,049,400	$64,655,400	$827,304,800
2010*	$591,658,000	$60,359,418	$66,406,894	$718,424,312
2011*	$599,391,333	$56,952,210	$64,980,683	$721,324,226
2012*	$635,009,778	$57,445,584	$65,327,359	$757,782,721
Totals	$4,101,515,111	$422,153,928	$454,970,046	$4,978,639,085

*Estimated based on previous three years.

5. POTENTIAL BENEFITS FOR INVESTMENT TO REDUCING MVC INJURY

Currently, North Dakota has a secondary seat belt law. This level of enforcement means that a motorist can only be ticketed if they are stopped for a moving violation. North Dakota's statewide seatbelt use rate in 2007 was 82.2% (NHTSA 2009). While up from 79.0% in 2006, there is still room for improvement (NDDOT 2008). The NHTSA has shown that implementation of a primary seatbelt law increases seatbelt use rates by 10% to 15% (NHTSA 2000). In addition, the NHTSA has also demonstrated seatbelt effectiveness to be between 30% and 78% in preventing injuries and fatalities, depending upon the type of restraint used, the seat position the person occupies, and the type of vehicle (NHTSA 2000). Based on North Dakota crash data, seatbelts are estimated to be 56.1% effective in preventing injuries and 50.7% effective in preventing fatalities (NDDOT 2010).

Not all of the costs enumerated above will be saved because of a primary seatbelt law. Only a percentage will be realized by the move from a secondary seatbelt law to a primary enforcement law. The reduction in costs will depend on how much the overall seatbelt use is increased as well as how effective seatbelts are in reducing injury severity.

The NHTSA states that seatbelt use increases anywhere from 10% to 15% statewide after the passage of a primary seatbelt law (NHTSA 2000). According to the North Dakota Department of Transportation, seatbelt usage in North Dakota was 82.2% in 2008 (NDDOT 2008). This usage level would likely indicate the improvement that could be expected in North Dakota would be toward the lower end of the range reported by the NHTSA. To provide a more comprehensive understanding of the possible savings, the estimates used in the study will be based on several different scenarios of increased seatbelt use. Increases of 5%, 10%, and 15% will be used to calculate savings. These increases correspond to seatbelt usage rates of 87.2%, 92.2%, and 97.2%, respectively, which would rank it among the top in the nation.

The actual effectiveness of seatbelts depends on the type of vehicle, the type of restraint used, and the seating position of the occupant within the vehicle. For example, passengers in the front seat of a passenger car using only a lap belt have fatalities reduced by 35% compared to 60% for passengers riding in the front seat of a light truck using a lap and shoulder belt (NHTSA 2000). This reduction is similar to that of passengers riding in the rear seat of a light truck using a lap and shoulder belt who have their chance of becoming a fatality reduced by 73%. The same trends hold for the efficacy of seatbelts in preventing moderate to critical injuries (MAIS 2-5) injuries.

Because the efficacy of seatbelts partially depends on the type of vehicle and the seat position, it follows that the efficacy of the seatbelts will vary from state to state, because states like North Dakota tend to have more light truck traffic and the passengers in these vehicles use seatbelts at a much lower rate than passengers in cars. The statewide efficacy for North Dakota can be calculated by applying these well-documented methods to the state's motor vehicle crash report data. Table 5.1 and Table 5.2 report the effectiveness of seatbelts in preventing moderate to critical injuries and fatalities, respectively, for each of the combinations of restraint type, seat position, and type of vehicle as reported by the NHTSA (NHTSA 2000).

Table 5.1 Effectiveness of Seatbelts in Preventing Moderate to Critical Injuries in North Dakota

Vehicle Type	Seat Position	Lap Belts		Lap/Shoulder Belts	
		Effectiveness	Number of Occupants Hospitalized	Effectiveness	Number of Occupants Hospitalized
Passenger Car	Front Seat	30%	26	50%	1,954
Passenger Car	Rear Seat	37%	14	49%	108
Light Truck	Front Seat	55%	13	65%	1,262
Light Truck	Rear Seat	68%	18	78%	100
Total	All		71		3,424

Table 5.2 Effectiveness of Seatbelts in Preventing Fatalities in North Dakota

Vehicle Type	Seat Position	Lap Belts		Lap/Shoulder Belts	
		Effectiveness	Number of Occupant Fatalities	Effectiveness	Number of Occupant Fatalities
Passenger Car	Front Seat	35%	0	45%	71
Passenger Car	Rear Seat	32%	0	44%	1
Light Truck	Front Seat	50%	1	60%	42
Light Truck	Rear Seat	63%	0	73%	1
Total	All		1		115

The overall effectiveness is found by calculating the weighted average for each of the categories.

$$Effectiveness = \frac{1}{\sum O_{ijkl}} \sum E_{ijkl}\, O_{ijkl} \;,$$

where

E_{ijkl} = the effectiveness of seatbelt type *i* in vehicle type *j* at seat position *k* in preventing injury type *l*
O_{ijkl} = the number of occupants having injury type *l* who used seatbelt type *i* in vehicle type *j* at seat position *k*
i = the type of seatbelt used
j = the type of vehicle
k = seat position in the vehicle
l = injury type, either fatality or moderate to critical injury

So,

Effectiveness in preventing injuries = (.30*26 + .37*14 + … + .78*100) / (71 + 3424) = 56.1%

Effectiveness in preventing fatalities = (.35*0 + .32*0 + … + .73*1) / (1 + 115) = 50.7%

Using data from 2002 to 2006, seatbelts were estimated to be 56% effective in preventing moderate to critical injuries and 50% effective in preventing fatalities (NDDOT 2010). This shows that seatbelts in North Dakota could save one in two lives. As mentioned above, the seatbelt effectiveness will be combined with the increases in seatbelt use to calculate the estimated savings from implementing a primary seatbelt law.

6. ESTIMATED SAVINGS AND BENEFIT

To find the benefit that could be achieved by the implementation of a primary seatbelt law, the costs of implementing the primary seatbelt law are subtracted from the savings realized by the reduction in fatalities and injury severity, which are found by multiplying the current costs of MVCs by the expected increase in seatbelt use and the effectiveness of the seatbelts. The benefit will be estimated in 2006 dollars by applying the net present value calculations to the savings over the seven-year period, using a rate of return of 7%.

So,

Benefit = NPV(Initial Investment + Savings), using a rate of return of 7% and where

*Savings = ∑ (MVC Costs * Increase in Seatbelt Use * Seatbelt Effectiveness), over 7 years*

Since the implementation of a primary seatbelt law is a policy change, the initial investment is considered to be zero. Therefore, the benefit is equal to the net present value of the savings realized from the increase in seatbelt use associated with the primary seatbelt law implementation for the seven-year period after implementation. The MVC costs for each of the different breakdowns are located in Table 5, Table 6, and Table 9. Savings resulting from increases in seatbelt use rates of 5%, 10%, and 15% will be calculated to show the range of expected savings, because the exact increase is unknown. Seatbelt effectiveness is calculated in the previous section. The product of these figures gives us the estimated savings.

Using these formulas and calculations, the cost savings realized by Medicaid for the initial hospital costs would range from $54,000 ($1,925,584 * 5% * 56.1%) to just over $162,000 ($1,925,584 * 15% * 56.1%). The savings attributed to the post-discharge costs range from an additional $15,000 ($520,000 * 5% * 56.1%) to $44,000 ($520,000 * 15% * 56.1%). The total savings for the first year would be at least $69,000 and could be up to $206,000. For every additional year, the savings associated with the crashes that occurred in 2006 are estimated to be anywhere from $38,000 ($1,366,283* 5% * 56.1%) per year to $115,000 ($1,366,283 * 15% * 56.1%), based on a 5% to 15% increase in seatbelt use. Possible savings for Medicaid for each of the categories of injury and timeframe are displayed in Table 6.1.

Table 6.1 Savings by Medicaid with 5%, 10%, and 15% Increases in Seatbelt Use

Increase in Seatbelt Use	Injury Type	Savings of Initial Hospital Costs	Savings of First-Year Post-Discharge Costs	Savings of Costs Incurred after the First Year	NPV of Savings from First Seven Years
5% Increase	**TBI**	$11,017	$14,586	$19,597	
	SCI	$29,205	Included w/Initial Costs	$18,727	
	Other Admissions	$13,790	N/A	N/A	
	Total Savings	$54,012	$14,586	$38,324	$996,039
10% Increase	**TBI**	$22,035	$29,172	$39,194	
	SCI	$58,410	Included w/Initial Costs	$37,454	
	Other Admissions	$27,581	N/A	N/A	
	Total Savings	$108,026	$29,172	$76,648	$1,981,890
15% Increase	**TBI**	$33,052	$43,758	$58,791	
	SCI	$87,614	Included w/Initial Costs	$56,182	
	Other Admissions	$41,371	N/A	N/A	
	Total Savings	$162,037	$43,758	$114,973	$2,972,840

The power of the savings actually comes from the fact that savings continues long into the future. Studies show that the life expectancy, even for the most severe case of TBI and SCI, is anywhere from 7 to 27 years and 8 to 36 years, respectively (Langlois et al., 2006; Shavelle et al., 2007). In the less severe cases, the life expectancy is close to normal. Therefore, projecting the cost savings over a seven-year time period seems reasonable. For the MVCs in 2006 to 2012, the savings, adjusted for inflation, would range from $1.4 million to $4.1 million. Again, an initial investment is not required for the primary seatbelt law since it is a policy adjustment rather than resource allocation. Applying the net present value calculations to the savings over the seven years would result in a benefit, in 2006 dollars, of $1.0 million to $3.0 million.

Similarly, the savings for all payers, displayed in Table 6.2, indicate that the medical cost savings for initial hospital costs and first year post-discharge costs would range from just over $930,000 to just under $2.8 million, while the savings for each additional year would be between $200,000 and $600,000. Adjusting these savings for inflation and summing them over the seven-year period from 2006 to 2012, suggests that the medical savings from all MVCs could be as low as $11.4 million and up to $34.2 million. Present valuing these savings to 2006 results in a benefit, ranging from $8.4 million to $25.3 million.

Table 6.2 Savings for All Payers in North Dakota with 5%, 10%, and 15% Increases in Seatbelt Use Rates

Increase in Seatbelt Use	Injury Type	Savings of Initial Hospital Costs	Savings of First-Year Post-Discharge Costs	Savings of Costs Incurred after the First Year	NPV of Savings from First Seven Years
5% Increase	**TBI**	$132,703	$204,204	$137,179	
	SCI	$456,776	Included w/Initial Costs	$64,437	
	Other Admissions	$137,659	N/A	N/A	
	Total Savings	$727,138	$204,204	$201,616	$8,445,207
10% Increase	**TBI**	$265,406	$408,408	$274,358	
	SCI	$913,553	Included w/Initial Costs	$128,875	
	Other Admissions	$275,317	N/A	N/A	
	Total Savings	$1,454,276	$408,408	$403,233	$16,890,429
15% Increase	**TBI**	$398,109	$612,612	$411,537	
	SCI	$1,370,329	Included w/Initial Costs	$193,312	
	Other Admissions	$412,976	N/A	N/A	
	Total Savings	$2,181,414	$612,612	$604,849	$25,335,635

Focusing on the more inclusive set of costs included in Table 4.6, implementing a primary seatbelt law could reduce costs associated with MVCs from $5.0 billion dollars to $4.9 billion dollars with only a 5% increase seatbelt use or to $4.6 billion with a 15% increase in the use of seatbelts. Using the same 7% opportunity cost and calculating the NPV for the same seven years yields a benefit ranging from $91 million to $277 million. The majority of this savings comes from the VSL and the number of fatalities, which represent 85% of the savings. Benefits based on increases in seatbelt use rates of 5%, 10%, and 15% are displayed in Table 6.3.

Table 6.3 NPV Estimated Crash Prevention Benefit Over Seven Years, Based on Decreased Injury Severity Resulting from Implementation of a Primary Seatbelt Law

4.	**Crash Severity**			**Totals**
	Fatal	**Incapacitating Injury**	**Non-Incapacitating Injury**	
5% downward injury severity				
Estimated Injury Costs	$3,997,965,778	$414,145,228	$445,237,700	$4,857,348,706
Benefit	$77,707,726	$6,259,587	$7,459,739	$91,427,053
10%downward injury severity				
Estimated Injury Costs	$3,895,073,778	$406,139,622	$435,450,655	$4,736,664,054
Benefit	$157,319,746	$12,548,006	$14,964,130	$184,831,882
15% downward injury severity				
Estimated Injury Costs	$3,791,550,222	$398,345,836	$425,720,679	$4,615,616,738
Benefit	$236,133,999	$18,664,387	$22,433,165	$277,231,551

7. CONCLUSION

Passing a primary seatbelt law has been shown to increase seatbelt use by 10% to 15% statewide (NHTSA 2000). Using a range of seat belt use increases from 5% to 15% and the estimated effectiveness of seatbelts, the present valued benefit realized by North Dakota's Medicaid budget ranges from $1.0 million to $3.0 million for the first seven years after implementation. Life expectancy ranges for both TBI and SCI can range anywhere from a low of seven or eight years in the more severe cases to near normal in less severe cases, which means that the savings calculated represents a conservative figure for the expected savings.

These savings also extend to all medical insurance providers, not just Medicaid. The present value of the benefit to all providers, including Medicaid, over the same seven-year period would range from a low of $8.4 million for a 5% increase in seatbelt use and up to $25.3 million assuming a 15% increase in seatbelt use.

Currently, 30 states, the District of Columbia, American Samoa, Guam, the Northern Mariana Islands, Puerto Rico, and the Virgin Islands have successfully implemented primary seatbelt laws. Implementing a primary seatbelt law in North Dakota not only reduces the burden on medical payers, but on the state's budget, as well. Looking at the much broader definition of costs, data suggests that the total economic benefit, including the reduction in fatalities, could be as low as $91 million and as high as $277 million over seven years. Although these savings are greatly influenced by the VSL, the potential savings shared by state and federal agencies, insurance companies, employers, and families is substantial.

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