

Work-Related Motor Vehicle Crashes: Reducing the Burden

RO1- OH03419-04A1

October 2001 – September 2005

Final Report

March 2006 (revised December 2007)

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Abstract

Motor vehicle crashes are the major occupational cause of death for American workers. A great deal has been learned about prevention of motor vehicle crashes for the general public; much less known about the underlying causes and effective prevention strategies for work-related motor vehicle crashes. In addition, few studies have focused on non-fatal motor vehicle injuries in the workplace and there is no comprehensive information on the true human and economic costs of work-related motor vehicle crashes. This project uses data collected from a single municipality (City of Philadelphia) to develop a database and prospective record linking system to capture comprehensive data on the number, magnitude, and economic impact of work-related injuries for the 28,000 employees of the City of Philadelphia. 20,357 employees are captured in these data along with 3,645 work-related motor vehicle accidents. We find that while most accidents occur during weekdays, the most expensive accidents tend to occur on weekends and they involve large trucks and younger drivers.

Work-Related Motor Vehicle Crashes: Reducing the Burden

Highlight/Significant Findings

1. Most regular drivers for the City of Philadelphia are male and under 50 years old. When they are involved in a work-related motor vehicle accident, they are generally not injured, the accidents occur in within the domain of normal transit (as opposed to parked cars or hit&runs) and they are not under the influence of alcohol. 80 percent of drivers involved in an accident over the 3 year study period were involved in only one accident with 16 percent involved in two accidents during the study period. Not surprisingly, length of employment at the City correlates with the probability of a driver being involved in a work-related motor vehicle accident.
2. The most common work-related motor vehicle accident setup is a two vehicle accident involving moving vehicles. Pedestrians are rarely involved in work-related accidents. Accidents are more common in the winter with January being the high accident month (11% of all accidents occur in January). There is no significant difference in the day of week for weekday accidents and the majority of accidents occur between the hours of 9am and 2pm. Most accidents do not involve a work zone and occur in the absence of reported adverse weather conditions. Dry and level road surfaces are the most common road condition.
3. Regression results show that accidents are most likely to involve drivers with longer employment with the City, drivers who are younger, male, and Black. Additionally, drivers in the departments of police and streets are more likely to be involved in an accident. This correlates with the fact that these two departments operate the most vehicles
4. Cost of injuries associated with work-related motor vehicle accidents account for a disproportionate share of all workers' compensation medical expenditures. For example, in 1999, 8.28 percent of all injuries requiring medical care in the City were related to motor vehicle accidents but those accidents accounted for 16 percent of all worker's compensation medical expenses for the City.
5. Analysis on the cost of injuries related motor vehicle accidents shows that (controlling for confounders) accidents that occur on the weekends, those involving multiple vehicles and those involving big vehicles (large trucks) are significantly more costly with respect to medical injuries.
6. The average medical cost of injuries from work-related motor vehicle accidents ranged from \$1,900 to \$2,500 per injury.
7. Accidents that occur on the weekends, involve big vehicles, younger drivers, and traffic control devices (e.g, flashing signals, traffic signals, stop signs) were significantly more costly in terms of medical expenditures for injuries.

Translation of Findings

The major findings of this study directly translate for workplace cost and safety improvement.

Motor vehicle safety will be improved with the adoption of programs that provide

1. Retraining for drivers. Drivers with more than 3 years of employment are significantly more likely to have an accident in a given year than others.
 - a. Refresher training for experienced, long-term employees is needed.
2. Accidents involving big/heavy vehicles produce significantly more expensive medical injuries.
 - a. Targeted training for drivers of large/heavy vehicles focused on the risk of severity of injury from these vehicles and explicit safe driving techniques for these vehicles.
3. Weekend accidents produce significantly more expensive medical injuries
 - a. Targeted training for drivers who work on weekends. This subgroup of drivers tends to be younger than those who work during the week.
4. Alcohol is NOT an important issue in accidents in this study.
 - a. Current alcohol training and policies appear to be effective and should be continued.
5. Most motor vehicle crashes in this study occurred during regular weekday hours, were most likely between 10-2pm, and occurred on dry and level pavement.
 - a. Generalized training messages focused on the need for drivers to need to remain diligent during routine driving conditions.

Outcomes/Relevance/Impact

There are three distinct areas of investigation in motor vehicle crashes: driver; vehicle; environment. In this study, all three are addressed in an integrated fashion. While this study focuses solely on a single large municipality, the results should translate readily to other municipal workers with identification of problem areas for municipal workers with respect to motor vehicle crashes.

Information for other studies and intervention designs:

This study points to the need to retrain drivers around 3 years into their tenure. For designs on studies using training interventions, this timing factor should be considered.

Weekend accidents produce more expensive medical injuries. This should be examined in future studies and considered in the design and implementation of driver training.

It's not surprising that big/heavy vehicles produce significantly more expensive medical injuries. This finding needs to inform future driver training programs.

The medical cost of injuries from motor vehicle accidents ranged from \$1900 to \$2500 per injured employee (in 2000 dollars). This finding helps provide a basis for evaluating the cost-benefit of driver training programs. Using this, a driver training program that costs \$1900 or less per reduced injury-producing accident would be budget neutral.

Scientific Report

Overview

The objective of this study was to create a comprehensive data of employees and their work-related motor vehicle crashes suitable for risk factor analysis using existing data on municipal workers in the City of Philadelphia, including a broad range of information on all City drivers and vehicles and to use the resulting database to explore predictors of work-related motor vehicle crashes, by examining risk factors related to driver characteristics, vehicle factors, and crash factors, using existing data on the City's workforce, vehicles, and motor vehicle crashes.

BACKGROUND

In the United States, motor vehicle injuries account for the majority of unintentional injury deaths (Rivera 1999) and are the leading cause of potential years of life lost before age 65 (NCHS 1997). MVCs also represent a major cause of work-related injury and death; from 1980 to 1992, MVCs were the leading cause of work related deaths among U.S. workers (NIOSH 1998b). During this 12-year period, it is estimated that motor vehicle crashes killed 15,830 workers in traffic related crashes and 1,997 workers in crashes not related to traffic on a public highway. These figures represent 20% of all fatal workplace injuries during that period; other sources have attributed up to 37% of occupational fatalities to MVCs (Baker 1992). NIOSH investigators carried out a more detailed analysis of national motor vehicle fatalities for the period 1990 through 1992 using the National Traumatic Occupational Fatalities (NTOF) surveillance system, a death certificate-based surveillance system for workers age 16 and older. Additional data were provided by the National Highway Traffic Safety Administration (NHTSA) Fatal Accident Reporting System (FARS). For the period 1990 - 1992, NIOSH identified 3,066 worker fatalities from traffic related motor vehicle crashes. The actual number of fatalities was probably significantly higher, since previous research has indicated that death certificates may capture only 60% to 83% of work related MVCs (Cone 1991, Karlson 1978, Paulson 1998, Russell 1991). The average annual fatality rate for work-related motor vehicle crashes during this period was 0.7 per 100,000 workers. .

Several other studies have attempted to characterize the nature and magnitude of work-related MVCs. A study of selected industries found that occupational motor vehicle death rates in the 1980s gradually decreased from 2 per 100,000 workers in 1980 to 1.4 per 100,000 in 1989 (Stout 1995). While motor vehicle injuries in the general population continue to decline, the magnitude of work-related crashes remains high. The fatality rate per 100 million vehicle miles of travel for the general public reached a new historic low of 1.6 in 1997 (US DOT 1998), yet the Bureau of Labor Statistics found that same year that job-related highway fatalities reached their highest level since the Bureau's fatality census began in 1992 (BLS 1998). Construction workers are at particular risk for fatalities from MVCs, with an annual mortality rate twice as high as other workers (Ore 1997). One study of municipal employees found that motor vehicles accounted for 16 percent of all injury costs, and that each year approximately one of every 50 workers

sustained motor vehicle-related injuries (Runyan 1988). An important limitation to the national statistical reports, common to virtually all studies of work-related MVCs, is the lack of reliable information on non-fatal injuries and on costs associated with crashes. Such data gaps result in a significant underestimation of the burden of occupational injury (Leigh 1997). The current proposal addresses this limitation by incorporating comprehensive data on non-fatal injuries, medical and indemnity costs, and costs related to vehicle damage as well as data on fatalities.

A NIOSH Alert issued in July, 1998 acknowledged the efforts expended in research to prevent injuries from MVCs in the public sector, while noting that much less little attention has been paid to preventing work-related MVCs (NIOSH 1998b). Observing that ACompanies with large fleets of motor vehicles can provide unique opportunities for researchers to study injury prevention strategies to begin answering the many remaining questions about risk factors and effective methods of injury prevention@, the authors identified a list of specific research needs. **This proposal addresses the need for Acollecting and analyzing detailed data on the causes of work-related motor vehicle crashes to target effectively the most appropriate areas for intervention efforts.@**

A formal scientific approach to injury prevention calls for interventions to be designed, evaluated, and then implemented based on a research-driven process of surveillance, hazard identification, risk assessment and analysis, intervention design and evaluation, and transfer of successful interventions into widespread practice (Bonnie 1999). Efforts to prevent and control occupational injuries, including job-related motor vehicle injuries, can use the same epidemiological approaches used to confront other public health problems (Veazie 1994, NIOSH 1992). Application of these approaches to the problem of motor vehicle injuries in the general population has resulted in significant improvements in highway safety. However, several factors limit their application to work-related MVCs. One impediment is the paucity of timely, systematic, and ongoing surveillance data, particularly for nonfatal injuries. A second limitation is the lack of information with sufficient specificity to the local environment and tasks of the local workforce. National or even statewide statistics on the risk factors associated with motor vehicle-related trauma are helpful, but often lack the specificity needed to design interventions at the local level. Murphy and colleagues compared six national databases which record occupational injury and illness and concluded that it was particularly important to understand the subtleties of data collection and reporting and the detailed characteristics of the data source and population characteristics (Murphy 1996). A third challenge is that important risk factor data, which may be available in many unrelated databases, are not consolidated into a single database suitable for use as a comprehensive injury surveillance system. Thus, the collection of injury surveillance data is often inefficient, with duplicative data collection and little ability to link or use crucial risk factor information. This proposal seeks to address these limitations by extending our analysis of a large, well-characterized workforce through creative linkages of diverse databases into a comprehensive MVC surveillance system suitable for risk factor analyses and development of predictive models.

As noted in a recent report by the NORA Traumatic Injury Team, *Traumatic Occupational Injury Research Needs and Priorities* , Asurveillance data should drive

prevention efforts by identifying worker groups with high frequency and risk of injury and...new methods for conducting occupational injury research must be pursued, including: exploring new sources of data, identifying ways to improve identification of work-related injuries in existing databases, linking data from various existing sources...and developing new and improved methods of assessing injury exposures (NIOSH 1998a). This proposal is designed to overcome many of these challenges and to respond to NIOSH's call for improved methods of occupational injury research. We will assemble a comprehensive database on motor vehicle-related injuries for a large municipal workforce, by identifying work-related injuries in existing databases, exploring new sources of data specific to the problem of MVCs and linking existing databases for the purposes of crash injury research. Because these data sources are common to many municipalities, this work can serve as a model for developing MVC surveillance systems across many municipalities.

The NORA Traumatic Injury Team (NIOSH 1998a) identified the following specific research needs, which will be addressed by this proposal:

- # **Surveillance**: ADevelop and increase emphasis of on-site or company-wide surveillance systems to identify emerging problems and capture exposure information for risk assessment. Develop hazard surveillance systems to identify and monitor injury hazards at the local level. Collect more detailed information on the circumstances of traumatic occupational injury incidents. In specific aim 1 of this proposal, we will develop a comprehensive MVC surveillance system. The resulting database will include information on driver, vehicle and crash characteristics, as well as medical and indemnity costs resulting from the crash.
- # **Exposure and Labor Force Data**: ADevelop and / or utilize exposure (denominator) data that can be used for calculating injury risk based on actual units of time of exposure to hazards or risk factors. To complement the MVC surveillance database developed in specific aim 1, we will capture driver-level data on actual time at work as well as miles and hours driven and information on average vehicle speed and hours of engine idle time. These data will be the most comprehensive driving exposure information to date for work-related crashes.
- # **Coordination and Integration of Surveillance System**: ACollect information that permits linkage (while maintaining confidentiality) to other relevant data systems and follow-back to the workers involved in the injury incident. Focus surveillance efforts on how to capture data as health care changes. The data sources used in specific aim 1 will be linked using a variety of unique identifiers. Data will then be stripped of identifiers (to ensure confidentiality) and transformed into a research-quality database. Because the data sources include comprehensive and detailed workers= compensation medical claims, actual morbidity following a work-related crash can be assessed.
- # **Increase Utility of Surveillance Data**: AImprove the timeliness of existing and newly-developing surveillance systems. Broaden and develop surveillance

systems to obtain information about minor injury. Where possible, further broaden data collection efforts to include system failures or property damage incidents in which no injuries occurred. Increase efforts to improve the accuracy and completeness of information on traumatic occupational injury incidents. @ The MVC surveillance database developed in specific aim 1 will capture MVC data as soon as the crash investigation paperwork is completed. The system will include information about all reported MVCs, including those with property damage but no injuries. Random sampling of data entry will be conducted to assure reliability of the data entry process.

- # **Quantify and Prioritize Risk Factors:** ADevelop economic indicators that can be used to help prioritize injury research issues and intervention efforts. @ The analyses included in specific aim 2 will quantify and prioritize identified risk factors using data on a variety of economic data, including costs related to medical care, indemnity (salary replacement) payments, lost work time, and vehicle damages..

We propose to employ the public health approach to injury prevention in the workplace. Central to this approach is establishing a MVC surveillance database capable of providing the information for risk assessment (Halperin 1996). Once this information has been collected, putative risk factors for injury and morbidity can be categorized based on a scheme first developed by William Haddon: (1) analysis of individual behavior; (2) analysis of products or agents of injury; (3) analysis of the physical environment; and (4) analysis of sociocultural and economic environment (Bonnie 1999, Haddon 1964). Recently, a third dimension has been added to Haddon=s matrix to facilitate its use for making decisions about which countermeasures to apply (Runyan 1998). Use of this matrix model, as well as the 10 general injury countermeasures developed by Haddon, provide the theoretic framework to guide the development of the predictive model for identifying determinates of MVCs and the development of future preventive interventions (Runyan 1998). It is from this analysis that demonstration projects could be developed, to begin the important process of evaluating the effectiveness of interventions (Schulte 1996). The merits of this sequential approach were cited by Burdorf and colleagues, who noted that little is known about the relative contribution of risk factors for specific occupational injuries and effective ways to prevent them (Burdorf 1997).

Over the past four years, funding from the National Institute of Occupational Safety and Health (NIOSH) has allowed us to establish a database and prospective record linking system for the approximately 29,000 employees of the City of Philadelphia. Working in collaboration with the City=s Division of Risk Management and the Office of Safety and Loss Prevention (OSLP), we have developed the capacity to capture prospectively comprehensive data on the number, magnitude, and economic impact of work related injuries throughout the City=s work force. We now propose to expand that database through additional record linking of existing data in order to analyze comprehensively the nature and causes of work-related MVCs by City vehicles. Building on the foundation of our current research and its associated data management capacity, we will expand the database to include information relevant to risk factor analysis of MVCs: police reports;

environmental conditions; medical claims and indemnity payments; and costs associated with repairing or retiring damaged vehicles. We will also include information on the driving and employment history of City drivers and detailed vehicle information. This type of exposure information is rarely, if ever, available to researchers. We will then utilize this database to test specific hypotheses and employ those results in the construction of a predictive model of factors primarily associated with MVCs, particularly those MVCs with high costs and with significant morbidity. Our current NIOSH funded project, Claims-based Surveillance to Identify Injury Precursors, is directed at developing predictive models for general workplace injuries. The experience gained from that project will be invaluable as we develop the predictive models for specific aim 2 of this proposal.

The Division of Risk Management, the Office of Safety and Loss Prevention (OSLP), and the City administration are committed to a long-term effort to decrease motor vehicle crashes involving city vehicles. This proposal will capitalize on that commitment and on the database development efforts and data analysis strategies developed under the recent project to establish a research program which will answer important questions regarding work-related MVCs and their possible prevention. In this partnership, the City will contribute significant support to assist in the identification and collection of relevant quantitative and qualitative data, as well as the necessary political support to address timely access and compliance issues. Without such support, a project of this magnitude and complexity would not be feasible. However, the City alone, like many other municipalities and employers, lacks the resources and expertise to develop the a comprehensive MVC surveillance database and data linkage mechanisms. It is the research team which contributes this expertise and the ability to perform sophisticated analyses which can answer the important research questions in occupational safety and health. For work-related MVCs, the important research issues include reliable data on morbidity as well as mortality, a comprehensive assessment of direct employer costs related to MVCs, a better understanding of factors which are associated with crashes, and an accurate estimate of the burden of those crashes in costs and morbidity. This comprehensive information on work-related crashes will ultimately be used to support the development of future safety interventions. The results of this research will be generalizable not only to other large municipalities, but to many other workforces which use motor vehicles in the course of employment.

Specific Aims:

The purpose of this project is to improve the lives of workers through research aimed at identifying risks associated with work-related motor vehicle crashes and their associated injury burden. We will pursue three highly focused specific aims. We propose to:

1. **Create a comprehensive database of employees and their work-related motor vehicle crashes suitable for risk factor analysis** using existing data on municipal workers in the City of Philadelphia, including a broad range of information on all City drivers and vehicles. The database will capture the

morbidity and economic impacts of crashes and provide the foundation for an ongoing crash surveillance system.

2. **Develop predictive models to define the determinants of work-related motor vehicle crashes**, by examining risk factors related to driver characteristics, vehicle factors, and crash factors, using existing data on the City=s workforce, vehicles, and motor vehicle crashes.

A number of hypotheses will be tested in conjunction with specific aim 2. These are not listed here, but detailed in three tables in the methods section.

3. **Validate predictive models of work-related motor vehicle crashes and run simulations to estimate the impact of defined changes in motor vehicle crash factors**, by using prospectively collected data on the City=s workforce and vehicles. We will also identify the important data elements needed for ongoing surveillance of MVCs.

Procedures, Methods, Results

This study required the collection of a large number of hard copy motor vehicle crash reports. These reports were then married to individual and department specific information supplied by the City of Philadelphia.

We developed a unified Access database to capture information in the Pennsylvania Accident Report (AA45). Over the study period, the State of Pennsylvania has revised and enhanced the AA45 making it longer and more complex. Because the project includes dates before and after the revision, we developed two intake forms for loading data into a single unified Access database we developed. The entry form for the original AA45 form is six pages long and includes 213 fields, while the revised AA45 form is nine pages long and includes 336 fields. Of the 3,268 original AA45 forms (the short version), data verification was done using a 5% random sample check as well as a 100% check on two fields. No entry errors were found. The remaining accidents are reported on the new longer AA45 report forms and required a new, custom-made Access database which links to the prior database. These data entries were quality checked with a 100% sample. Workers' compensation claims data were captured in December 2002 for the period 1999-2001. Several other databases complement the accident database. These include the City driver lists and a list of City-owned vehicles.

There are three levels of information in the project: drivers, vehicles, accidents. These will be described in turn below.

Drivers:

Based on data from the City of Philadelphia, there were 20,357 City employees designated by the City as City Drivers (i.e., their jobs required them to drive on a regular basis) during the period 1999-2001. Of these drivers, 11 percent (2,320/20,357) were

involved in at least one motor vehicle crash during the study period. Tables 1 through 6 describe characteristics of the City drivers.

Table 1: City Drivers' Involvement by type of Accident

	Number of Drivers	%
In Normal Transport	3,317	86.07
Not With vehicle at time of accident	463	12.01
Hit & run accident	62	1.61
Accident involving non-motorized object	12	.31
Total Drivers (not unique)	3,854	100.0

Table 2: Driver Condition as reported on Accident Form

Condition	Number of Drivers	%
Appeared Normal	3,002	77.89
Suspected Alcohol involvement	6	.16
Unknown	491	12.74
Missing (left blank on form)	355	9.21
Total	3,854	100.0

Table 3: Driver's Age (from personnel files)

Age Group (years)	Number of Drivers	%
~19	9	.26
20 ~29	685	19.98
30 ~ 39	985	28.73
40 ~ 49	931	27.15
50 ~ 59	597	17.41
60 ~ 69	91	2.65
70 ~ 79	9	.26
80 ~ 89	4	.12
Missing	118	3.44
Total	3,429	100.0

Table 4: Average Driver Age

	Min.	Max.	Mean	Std.
Age	18	88	39.63	10.84

Table 5: Driver's Sex (from personnel files)

	Number of Drivers	%
Female	549	16.01
Male	2,853	83.20
Missing	27	.79

Total	3,429	100.0
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Table 6: Driver Injury

	Drivers	%
Not Injured	3,099	90.38
Killed	1	.03
Major Injury	6	.17
Moderate Injury	68	1.98
Minor Injury	182	5.31
Missing	73	2.13
Total	3,429	100.0

Vehicles:

Based on data from the City of Philadelphia, 3,865 City-owned properties were involved in a reported accident from 1999-2001. After removing property not deemed a “vehicle” by study investigators (e.g., horses and fire hydrants), 3,842 vehicles (motorized and non-motorized) were included in the study. Tables 7 through 11 describe characteristics of the vehicles.

Table 7: City Vehicles

	Number
Total number of City Units Involved	3,865
Total number of City Motor Vehicle Involved	3,842

Table 8: Vehicles’ involvement in accident

	Number of accidents (%)	% of Total Vehicles in accidents (N=7,606)
Motor Vehicle in Transport	3,317 (86.07%)	43.61%
Hit & Run	62 (1.61%)	.82%
Illegally Parked	41(1.06%)	.54%
Legally Parked	422(10.95%)	5.55%
Non-Motorized	12(0.31%)	.16%
Total	3,854 (100.0%)	50.67%

Table 9: Types of City Vehicles involved in accidents

	Vehicles	%
Automobile	1,814	47.07
Motorcycle	16	.42
Bus	52	1.35
Small Truck	455	11.81
Large Trick	890	23.09
Van	385	9.99
Snowmobile	1	.03

Construction Equipment	25	.65
Other Type Special Vehicle	88	2.28
Unknown type Special Vehicle	14	.36
Unicycle, bicycle, or tricycle	7	.18
Other pedal cycle	1	.03
Horse & ride	4	.10
Trolley	2	.05
Other	63	1.63
Unknown	37	.96
Total	3,854	100.0

Table 10: Special Usages of City Vehicles involved in accidents

	Vehicles	%
Not Applicable	1,227	31.84
Fire Vehicle	250	6.49
Ambulance	75	1.95
Police Vehicle	1,674	43.44
Twin Trailer	1	.03
Other Emergency Vehicle	36	.93
Towing Passenger Vehicle	4	.10
Pupil Transport	14	.36
Commercial Passenger Carrier	41	1.06
Tow Truck	24	.62
Towing Utility Trailer	8	.21
Tractor Trailer	11	.29
Modified Vehicle	171	4.44
Unknown	304	7.89
Missing	14	.36
Total	3,854	100.0

Table 11: Ownership of vehicles involved in accidents

Vehicle's Ownership	Frequency	%
Private Vehicle Owned by Driver	30	.78
Private Vehicle Not Owned by Driver	94	2.44
Rented Vehicle	13	.34
Penn DOT Vehicle	12	.31
Other State Government Vehicle	3	.08
Municipal Police Vehicle	1,684	43.69
Other Municipal Government Vehicle	1,694	43.95
Federal Government Vehicle	10	.26
Commercial Vehicle	9	.23
Pupil Transport Carrier	5	.13
Other Commonwealth Vehicle	210	5.45

Other	26	.67
Unknown	47	1.22
Missing	17	.44
Total	3,854	100.0

Accidents:

3,645 unique motor vehicle accidents involving at least one City-owned vehicle were reported in 1999 - 2001. These accidents involved 7,114 vehicles. See Table 12.

Table 12: Accident information

General Information of Total Accidents	
Total number of accidents	3,645
Total number of motor vehicles involved	7,114
Total number of units injured	946
Total number of persons killed	5
Number of accidents that had used EMS agencies	434
Number of accidents that had pedestrians involved	83
Number of accidents that had parked vehicle involved	1,263
Number of accidents that had at least one vehicle in 'Hit & Run'	398
Number of accidents that had non-motor vehicles involved	56

After conducting our basic descriptive analysis of these data, we explore variables potentially associated with accidents.

Number of vehicles Involved in the Crash

# of vehicles	accidents	% of all accidents
1	5	.14
2	3,415	93.69
3	162	4.44
4	44	1.21
5	13	.36
6	2	.05
7	2	.05
8	1	.03
10	1	.03
Total	3,645	100.00

Vehicle condition	Number of accidents	% of accidents
Motor Vehicle in Transport	5,296	69.63
Hit & Run	399	5.25
Illegally Parked	171	2.25
Legally Parked	1248	16.41
Non-Motorized	56	.74
Pedestrian	87	1.14
Phantom Vehicle	1	.01

Object	338	4.44
Missing	10	.13
Total	7,606	100.00

Year	# of accidents	% of accidents
1998	2	.05
1999	1,273	34.92
2000	1,244	34.13
2001	1,118	30.67
Missing	8	.22
Total	3,645	100.00

Month of Accident

Month	# accidents	% accidents
January	417	11.44
February	357	9.79
March	322	8.83
April	313	8.59
May	335	9.19
June	333	9.14
July	284	7.79
August	296	8.12
September	287	7.87
October	253	6.94
November	207	5.68
December	233	6.39
Missing	8	.22
Total	3,645	100.00

Day of the Week of Accidents

Day of the week	# accidents	% of accidents
Monday	547	15.01
Tuesday	626	17.17
Wednesday	597	16.38
Thursday	580	15.91
Friday	601	16.49
Saturday	375	10.29
Sunday	319	8.75
Total	3,645	100.00

Hour of a Day of Accident

Hour of a Day	# accidents	% accidents
0	70	1.92
1	82	2.25
2	79	2.17

3	62	1.70
4	34	.93
5	24	.66
6	49	1.34
7	128	3.51
8	239	6.56
9	292	8.01
10	271	7.43
11	285	7.82
12	272	7.46
13	284	7.79
14	261	7.16
15	199	5.46
16	195	5.35
17	157	4.31
18	137	3.76
19	130	3.57
20	99	2.72
21	88	2.41
22	86	2.36
23	75	2.06
Missing	47	1.29
Total	3,645	100.00

Traffic Control Device

Control device	# accidents	% of accidents
Not Applicable	1,502	41.21
Flash Traffic Signal	13	.36
Traffic Signal	1,153	31.63
Stop Sign	429	11.77
Yield Sign	6	.16
Police Officer or Flagman	6	.16
Other	6	.16
Unknown	23	.63
Missing	507	13.91
Total	3,645	100.00

Type of Work Zone

Type	# accidents	% of accidents
Not Applicable	3,450	94.65
Construction Zone	44	1.21
Maintenance Zone	11	.30

Utility Company	8	.22
Unknown	32	.88
Missing	100	2.74
Total	3,645	100.00

Illumination

Type	# accidents	% of accidents
Daylight	2,641	72.46
Dark-No Street lights	35	.96
Dark-Street Lights	813	22.30
Dusk	52	1.43
Dawn	59	1.62
Other	3	.08
Missing	37	1.02
Unknown	5	.14
Total	3,645	100.00

Weather Conditions

Condition	# accidents	% accidents
No Adverse Condition	2,996	82.19
Rain	410	11.25
Sleet (Hail)	74	2.03
Snow	93	2.55
Fog	11	.30
Rain & Fog	14	.38
Other	3	.08
Unknown	9	.25
Missing	35	.96
Total	3,645	100.00

Road Surface Conditions

Condition	# accidents	% of accidents
Not Applicable	11	.30
Dry	2,794	76.65
Wet	544	14.92
Muddy	7	.19
Snow Covered	89	2.44
Ice	95	2.61
Ice Patched	45	1.23
Other	18	.49
Missing	37	1.02
Unknown	5	.14

Total	3,645	100.00
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Road Gradient		
	# accidents	% of accidents
Level roadway	3,520	91.33
Uphill	96	2.49
Downhill	187	4.85
Sag/Bottom of Hill	15	.39
Crest /Top of Hill	9	.23
Unknown	9	.23
Missing	18	.47
Total	3,854	100.0

Analysis of predictors of accidents.

As reported in the earlier analysis, there were 20,357 city assigned drivers in 1999-2001 in OLN data. Had these city drivers been involved in any accidents? By linking personnel data with Accident data, we obtain these:

City drivers	any accidents?	# of city drivers	% of drivers
Were assigned for 3 years (N=11,657)	Yes	1,461	7.18%
	No	10,196	50.09%
Were assigned for less than 3 years (N=8,700)	Yes	859	4.22%
	No	7,841	38.52%
Total		20,357	100.0%

From the table above, we know there are 2,320 city drivers in total who had involved in an accident from 1999- 2001. Among these city drivers, some had one accident, and some had multiple accidents. The distribution of the numbers of accidents for these city assigned driver is shown below:

With # of Accidents	# of Drivers	% of drivers
1	1,844	79.48%
2	370	15.95%
3	77	3.32%
4	19	0.82%
5	7	0.30%
6	1	0.04%
7	2	0.09%
Total	2,320	100.0%

In order to explore the association of accidents with other factors, we separated the city drivers into two groups: (1) no accidents, (2) any accident. Then we checked whether the distributions of selected variables were different between these two groups.

The results below show that the accidents are likely to be associated with the following driver characteristics: (1)Length being city driver during the 3 years, (2) Age, (3) Sex, (4) Race, (5) Department.

Average months being assigned *---the result shows that the drivers with accident had longer assigned time in general.

	No accident (N=18,037)	Any accidents (N=2,320)	Total (N=20,357)
Mean	30.44	32.00	30.67
Median	36.5	36.5	36.5
Std.	9.79	8.54	9.67
Minimum	0.07	0.47	0.07
Maximum	36.5	36.5	36.5

* The # of months is calculated by using the total assigned days divided by 30. That is why the Maximum months are 36.5, rather than 36 (for 3 years).

Two Groups Median Test ---Assigned Months as City drivers

Compared groups	Z Value	Df	P Value
No Accident Vs. Any Accident	5.9075	1	<.0001

---Percent of Full assignment

	Assigned for full of the time period (1999- 2001)	Assigned for partial of the time period (1999-2001)	Total
No Accident	10,196 (56.53%)	7,841 (43.47%)	18,037 (100.0%)
Any Accidents	1,461 (62.97%)	859 (37.03%)	2,320 (100.0%)
Total	11,657 (57.26%)	8,700 (42.74%)	20,357 (100.0%)

Chi-Square Test ---Full of assignment

Compared groups	Chi-Square Value	Df	P Value
No Accident Vs. Any Accidents	34.900	1	0.000

Age at June 30, 2000 (the mid point of 1999-2001) ---the results show that the drivers with accidents are younger than the drivers with no accidents

	No accident* (N=17,474)	Any accidents (N=2,276)**	Total*** (N=19,750)
Mean	41.58	39.34	41.32
Median	42	39	42
Std.	10.09	10.30	10.14
Minimum	17	19	17
Maximum	85	77	85

*563 persons with missing of Age; ** 44 persons with missing of Age;
***607 person with missing of Age.

T-Test ---Age at June 30, 2000

Compared groups	T Value	P Value
No Accident Vs. Any Accidents	-9.792	0.000

Sex---the result shows that male drivers are more likely to be involved in an accident.

	No accident* (N=17,811)	Any accidents (N=2,320)	Total* (N=20,131)
Female (%)	4,962 (27.9%)	375 (16.2%)	5,337 (26.5%)
Male (%)	12,849 (72.1%)	1,945 (83.8%)	14,794 (73.5%)
Total (%)	17,811 (100.0%)	2,320 (100.0%)	20,131 (100.0%)

*226 cases have a missing of Sex.

Chi-Square Test ---Sex

Compared groups	Chi-Square Value	Df	P Value
No Accident Vs. Any Accidents	144.108	1	0.000

Race ---the result shows that Black drivers are more likely to be involved in an accident.
The component part for Black drivers increases by the number of accidents.

(1)

	No accident* (N=17,807)	Any accidents (N=2,320)	Total* (N=20,127)
White	9,218 (51.8%)	956 (41.2%)	10,174 (50.5%)

Black	7,565 (42.5%)	1,236 (53.3%)	8,801 (43.7%)
Hispanic	757 (4.3%)	108 (4.7%)	865 (4.3%)
Asian	185 (1.0%)	13 (0.6%)	198 (1.0%)
Native American	28 (0.2%)	4 (0.2%)	32 (0.2%)
Other	54 (0.3)	3 (0.1%)	57 (0.3%)
Total	17,807 (100.0%)	2,320 (100.0%)	20,127 (100.0%)

*230 cases are with missing of Race

In order to increase the expected counts and make sure the chi-square test is valid, we merge the categories, Hispanic, Asian, Native American, and Others together as the new category, Others.

(2)

	No accident* (N=17,807)	Any accidents (N=2,320)	Total* (N=20,127)
White	9,218 (51.8%)	956 (41.2%)	10,174 (50.5%)
Black	7,565 (42.5%)	1,236 (53.3%)	8,801 (43.7%)
Other	1,024 (5.8)	128 (5.5%)	1,152 (5.7%)
Total	17,807 (100.0%)	2,320 (100.0%)	20,127 (100.0%)

*230 cases are with missing of Race

Chi-Square Test ---Race

Compared groups	Chi-Square Value	Df	P Value
No Accident Vs. Any Accident	131.063	3	0.000

Department (Top six of departments by numbers of accidents) ---the results show that the drivers in Police and Street departments are more likely to be involved in an accident.

(1)

	No accident*	Any accidents	Total* (N=20,343)

	(N=18,023)	(N=2,320)	
Police	6,903 (38.30%)	1,169 (50.39%)	8,072 (39.68%)
Fire	2,225 (12.35%)	269 (11.59%)	2,494 (12.26%)
Prison	1,976 (10.96%)	21 (0.91%)	1,997 (9.82%)
Water	1,680 (9.32%)	168 (7.24%)	1,848 (9.08%)
Street	1,111 (6.16%)	411 (17.72%)	1,522 (7.48%)
Public Welfare	958 (5.32%)	37 (1.59%)	995 (4.89%)
Others	3,170 (17.59%)	245 (10.56%)	3,415 (16.79%)
Total	18,023 (100.00%)	2,320 (100.00 %)	20,343 (100.00%)

* 14 persons with missing of Department

In order to increase the expected counts and make sure the chi-square test is valid, we merge the departments (except of Police and Street) together as one category, Others.

(2)

	No accident* (N=18,023)	Any accident (N=2,320)	Total* (N=20,343)
Police	6,903 (38.30%)	1,169 (50.39%)	8,072 (39.68%)
Street	1,111 (6.16%)	411 (17.72%)	1,522 (7.48%)
Other Departments	10,009 (55.53%)	740 (31.90%)	10,749 (52.84%)
Total	18,023 (100.0%)	2,320 (100.0%)	20,343 (100.0%)

* 14 persons with missing of Department

Chi-Square Test ---Department

Compared groups	Chi-Square Value	Df	P Value
No Accident Vs. Any Accident	659.598	2	0.000

Years of employment (from the earliest hired date to Dec. 31, 2001) ---the result shows that the driver with accident had less years of employment.

	No accident* (N=18,026)	Any accident (N=2,320)	Total* (N=20,346)
Mean	13.71	12.68	13.59
Median	12.00	11.00	12.00
Std.	10.13	9.27	10.04
Minimum	0	0	0
Maximum	54	48	54

* 11 persons with a missing of Date of Original Assignment.

Two Groups Median Test ---Years of employment

Compared groups	Z Value	P Value
No Accident Vs. Any Accident	-6.0130	<0.0001

Percentage of employment years less than ten years (includes ten years)

	No accident* (N=18,026)	Any accident (N=2,320)	Total* (N=20,346)
Employment years <=10	7,678 (42.59%)	1144 (49.31%)	8,822 (43.36%)
Employment Years >10	10,348 (57.41%)	1,176 (50.69%)	11,524 (56.64%)
Total	18,026 (100.0%)	2,320 (100.0%)	20,346 (100.0%)

11 cases with missing of the variable.

Chi-Square Test ---Department

Compared groups	Chi-Square Value	Df	P Value
No Accident Vs. Any Accident	37.754	1	0.000

Then we used logistic regression to determine the magnitude of the associations. We ran a logistic regression on whether or not a city driver has any accident while controlling for potential confounders identified in the previous analysis (length of being assigned as a city drivers during 1999-2001). A table below shows the result from the logistic

regression. **It indicates that a young, male, and black city driver is more likely to have an accident compared to older, female, and non-black city drivers respectively. Also, the city drivers in departments of Street and Police are more likely to have an accident than drivers in other departments.** The model is:

Dependent variable: MVC, 1 for drivers with any MVC in 1999-2001

Independent variables:

Black (Race), 1 for Black; 0 for Others

Police (Department), 1 for Police; 0 for Others

Street (Department), 1 for Street; 0 for Others

Age, Years old on June 30, 2000

Sex, 1 for Male; 0 for female

Length, Years of employment (from original assignment)

Month, Number of Months in which the person was assigned as city driver

The results are:

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I. for EXP(B)	
							Lower	Upper
Step 1 ^a								
BLACK	.544	.049	125.272	1	.000	1.723	1.566	1.895
POLICE	.737	.053	190.132	1	.000	2.090	1.882	2.320
STREET	1.446	.073	393.807	1	.000	4.247	3.681	4.899
AGE	-.024	.004	45.570	1	.000	.977	.970	.983
MONTH	.017	.003	34.753	1	.000	1.017	1.012	1.023
LENGTH	-.001	.004	.152	1	.696	.999	.991	1.006
SEX	.829	.063	172.469	1	.000	2.290	2.024	2.592
Constant	-3.000	.155	374.972	1	.000	.050		

a. Variable(s) entered on step 1: BLACK, POLICE, STREET, AGE, MONTH, LENGTH, SEX.

We then turn our attention to the cost of work-related accidents.

Risk analysis on medical cost for work related accident

First some general notes to guide this portion:

1. This analysis is based on our working drivers data file. Each record in the data file stands for a specific crash by driver. One driver may have multiple records because of multiple crashes.
2. The cost information is obtained from WC claims data (by linking the accident data with claims data, the common variables for the linkage are Payroll# and crash date). We assume that any cost for the work-related MVC should be reported in the WC claims data. So no cost report in the claims data will indicate the crashes had no cost.
3. There are 3,842 crash-drivers in total. Among them, 874 cases are excluded from analysis due to missing of 'Payroll', which results in an impossible to link the cost information in the claims data.

The following are a series of analysis looking at the cost of accidents.

Testing variable: Ln(Cost) (ttest of differences)

Grouping variable	Group1	Group2	T-value	P-value
Sex	Male	Female	-5.047	0.000
Race1	White	Others	-1.004	0.315
Race2	Black	Others	0.058	0.954
Department1	Police	Others	8.490	0.000
Department2	Street	Others	-4.289	0.000
Department3	Water	Others	-2.133	0.034
Department4	Fire	Others	-10.938	0.000
Vehicle's body type1	Small truck	Others	-2.729	0.007
Vehicle's body type2	Big vehicle (including: bus large truck, construction equip, snowmobile, other type of special vehicle, other unknown type special vehicle and trolley	Others	-9.935	0.000
Work zone	Construction zone, maintenance zone and utility company	Not applicable	0.130	0.896
Weather	rain, sleet, snow, fog, rain & fog, and other	No adverse conditions	-0.749	0.454
Illumination	dark-street light, dark-no street light, dusk, dawn and other	Day light	4.233	0.000
Road gradient	uphill or downhill, sag/bottom of	level	0.457	0.648

	hill, crest/top of hill			
Roadway surface	wet, muddy, snow covered, ice, ice patches and others	Dry	0.177	0.859
Day of week	Week end	Week days	4.373	0.000
Hour of day	Night time (7Pm -6Am)	Day Time (7Am – 6Pm)	4.233	0.000
Traffic control device	flashing signal, traffic signal, stop sign, yield sign, police officer/flagman, and other type TCD	Not applicable	3.744	0.000
# vehicles	Three or more vehicles involved in the crash	less than three vehicles involved in the crash	4.896	0.000

Linear regression --- according to the results of T-Test above, only the variables with a significantly associated with cost are selected as the independent variables in the regression analysis

Dependent variable: medical services cost

Independent variables: age, sex, police (department), street(department), fire (department) , water (department), small truck (vehicle’s body type), big vehicle (vehicle’s body type) , illumination, weekend, and TCD

Variable Codings:

Cost: $\ln(\text{cost}+1)$

Age: in years

Sex: 1 for male; 0 for female

Police: 1 for police department; 0 for other departments

Street: 1 for street department; 0 for other departments

Fire: 1 for fire department; 0 for others

Water: 1 for water department; 0 for other

Small truck: 1 for small truck of vehicle’s body type; 0 for others

Big vehicle: 1 for bus, large truck, construction equip, snowmobile, other type special vehicle or unknown type special vehicle in Vehicle’s body type; 0 for others

Illumination: 1 for dark-street light, dark-no street light, dusk, dawn and other; 0 for day light

Weekend: 1 for Saturday and Sunday; 0 for other week days

TCD: 1 for flashing signal, traffic signal, police officer/flagman, stop sign, yield sign, and other type of TCD; 0 for not applicable
 Night Time: 1 for night time (7Pm-6Am); 0 for day time (7Am-6Pm)
 # vehicles: the number of motor vehicles involved in the crash

Method: (1) Enter

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.226	.295		.765	.444
	SEX	-.411	.112	-.074	-3.661	.000
	age	-1.3E-02	.004	-.069	-2.997	.003
	Police	.165	.155	.040	1.064	.287
	Street	.340	.170	.065	2.007	.045
	water	.230	.203	.027	1.134	.257
	Fire	-.215	.190	-.033	-1.132	.258
	small truck	-.307	.152	-.048	-2.025	.043
	big vehicle	-.441	.147	-.094	-2.997	.003
	illumination	1.55E-02	.150	.003	.103	.918
	weekend	.297	.102	.059	2.905	.004
	Traffic control device	.194	.080	.047	2.412	.016
	Night time	.211	.154	.046	1.370	.171
	number of motor vehicles	.552	.074	.146	7.461	.000

a. Dependent Variable: $\ln(\text{cost}+1)$

(2) Stepwise (Entry=0.05, removal=0.10)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.325	.060		5.418	.000
	Police	.620	.082	.152	7.584	.000
2	(Constant)	-.812	.158		-5.156	.000
	Police	.631	.081	.154	7.807	.000
	number of motor vehicles	.581	.074	.154	7.795	.000
3	(Constant)	-.388	.186		-2.084	.037
	Police	.571	.082	.140	6.988	.000
	number of motor vehicles	.585	.074	.155	7.876	.000
	SEX	-.475	.112	-.085	-4.250	.000
4	(Constant)	-.426	.186		-2.286	.022
	Police	.529	.083	.130	6.394	.000
	number of motor vehicles	.579	.074	.154	7.815	.000
	SEX	-.465	.112	-.083	-4.165	.000
	weekend	.298	.100	.060	2.976	.003
5	(Constant)	8.22E-02	.264		.311	.756
	Police	.413	.093	.101	4.431	.000
	number of motor vehicles	.577	.074	.153	7.788	.000
	SEX	-.435	.112	-.078	-3.887	.000
	weekend	.281	.100	.056	2.806	.005
	age	-1.2E-02	.004	-.061	-2.705	.007
6	(Constant)	.297	.273		1.088	.277
	Police	.279	.103	.068	2.715	.007
	number of motor vehicles	.567	.074	.151	7.670	.000
	SEX	-.415	.112	-.074	-3.707	.000
	weekend	.323	.101	.065	3.203	.001
	age	-1.5E-02	.004	-.075	-3.250	.001
	Fire	-.447	.144	-.068	-3.109	.002
7	(Constant)	.200	.275		.727	.468
	Police	.271	.102	.066	2.648	.008
	number of motor vehicles	.555	.074	.147	7.491	.000
	SEX	-.415	.112	-.074	-3.709	.000
	weekend	.318	.101	.064	3.157	.002
	age	-1.4E-02	.004	-.073	-3.168	.002
	Fire	-.455	.143	-.069	-3.170	.002
	Traffic control device	.208	.080	.051	2.593	.010
8	(Constant)	.158	.275		.574	.566
	Police	.215	.105	.053	2.040	.041
	number of motor vehicles	.557	.074	.148	7.530	.000
	SEX	-.424	.112	-.076	-3.794	.000
	weekend	.283	.102	.057	2.783	.005
	age	-1.3E-02	.004	-.070	-3.016	.003
	Fire	-.496	.144	-.075	-3.435	.001
	Traffic control device	.209	.080	.051	2.597	.009
	Night time	.225	.096	.049	2.350	.019

a. Dependent Variable: ln(cost+ 1)

These analyses reinforce that young males are more likely to have motor vehicle accidents that result in high medical costs. Additional factors that predict accidents

with high medical costs are accidents that occur on the weekends, those involving multiple vehicles and those involving large vehicles.

Cost of Accident Injuries:

Using the workers compensation itemized claim data, we first describe all motor vehicle accident injuries resulting in medical costs. These are detailed below. **Motor vehicle accidents account for a large and disproportionate share of workers compensation medical spending.**

Year	# accident injuries	Medical \$ for accident injuries	# all injuries city-wide	Medical \$ for all city-wide injuries	% of all city injuries that are motor vehicle related	% of all medical \$ spent on motor vehicle accident injuries
1990	33	\$109,240.36	4871	\$880,836.38	0.68%	12.40%
1991	33	\$114,299.75	6056	\$1,060,299.53	0.54%	10.78%
1992	67	\$129,536.73	6428	\$1,237,201.54	1.04%	10.47%
1993	214	\$347,208.43	5390	\$2,383,128.73	3.97%	14.57%
1994	441	\$1,183,171.39	5471	\$4,897,209.96	8.06%	24.16%
1995	353	\$1,342,769.84	5036	\$4,998,521.32	7.01%	26.86%
1996	426	\$800,176.15	5265	\$4,441,382.04	8.09%	18.02%
1997	411	\$713,145.91	4877	\$4,223,162.63	8.43%	16.89%
1998	416	\$568,288.71	4915	\$3,826,674.19	8.46%	14.85%
1999	407	\$799,457.35	4916	\$4,986,677.90	8.28%	16.03%
2000	429	\$1,070,226.24	4748	\$7,152,841.80	9.04%	14.96%
2001	380	\$849,490.52	4801	\$5,154,575.05	7.92%	16.48%

Cost related risk analysis.

Using the cost data, we do a risk analysis on medical cost for work related motor accidents. First some basic notes on the analysis followed by the logical steps of the analyses.

This analysis is based on our working drivers data file. Each record in the data stands for a specific crash by driver. One driver may have multiple records because of multiple crashes.

The cost information is obtained from WC claims data (by linking the drivers' data with claims data, the common variables for the linkage are Payroll# and crash date). We assume that any cost for the work-related MVC should be reported in the WC claims data. So no cost report in the claims data will indicate the crashes had no cost.

There are 3,842 crash-drivers in total. Among them, 874 cases are excluded from analysis due to missing of 'Payroll', which results in the missing of 'Cost'.

T-Test of groups

Testing variable: Ln(Cost)

Grouping variable	Group1	Group2	T-value	P-value
Sex	Male	Female	-5.047	0.000
Race1	White	Others	-1.004	0.315
Race2	Black	Others	0.058	0.954
Department1	Police	Others	8.490	0.000
Department2	Street	Others	-4.289	0.000
Department3	Water	Others	-2.133	0.034
Department4	Fire	Others	-10.938	0.000
Vehicle's body type1	Small truck	Others	-2.729	0.007
Vehicle's body type2	Big vehicle (including: bus large truck, construction equip, snowmobile, other type of special vehicle, other unknown type special vehicle and trolley	Others	-9.935	0.000
Work zone	Construction zone, maintenance zone and utility company	Not applicable	0.130	0.896
Weather	rain, sleet, snow, fog, rain & fog, and other	No adverse conditions	-0.749	0.454
Illumination	dark-street light, dark-no street light, dusk, dawn and other	Day light	4.233	0.000
Road gradient	uphill or downhill, sag/bottom of hill, crest/top of hill	level	0.457	0.648

Roadway surface	wet, muddy, snow covered, ice, ice patches and others	Dry	0.177	0.859
Day of week	Week end	Week days	4.373	0.000
Traffic control device	flashing signal, traffic signal, stop sign, yield sign, police officer/flagman, and other type TCD	Not applicable	3.744	0.000

Linear regression --- according to the results of T-Test above, only the variables with a significantly associated with cost are selected as the independent variables in the regression analysis

Dependent variable: medical services cost

Independent variables: age, sex, police (department), street(department), fire (department) , water (department), small truck (vehicle's body type), big vehicle (vehicle's body type) , illumination, weekend, and TCD

Variable Codings:

Cost: $\ln(\text{cost}+1)$

Age: in years

Sex: 1 for male; 0 for female

Police: 1 for police department; 0 for other departments

Street: 1 for street department; 0 for other departments

Fire: 1 for fire department; 0 for others

Water: 1 for water department; 0 for other

Small truck: 1 for small truck of vehicle's body type; 0 for others

Big vehicle: 1 for bus, large truck, construction equip, snowmobile, other type special vehicle or unknown type special vehicle in Vehicle's body type; 0 for others

Illumination: 1 for dark-street light, dark-no street light, dusk, dawn and other; 0 for day light

Weekend: 1 for Saturday and Sunday; 0 for other week days

TCD: 1 for flashing signal, traffic signal, police officer/flagman, stop sign, yield sign, and other type of TCD; 0 for not applicable

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.314	.259		5.065	.000
	SEX1	-.412	.114	-.074	-3.633	.000
	age when the accident happened	-1.4E-02	.005	-.073	-3.123	.002
	Police	.171	.155	.042	1.104	.270
	Street	.366	.170	.070	2.149	.032
	water department	.240	.204	.028	1.180	.238
	Fire department	-.226	.191	-.034	-1.186	.236
	small truck	-.322	.153	-.050	-2.112	.035
	big vehicle 2	-.453	.148	-.097	-3.059	.002
	illumination1	.154	.094	.034	1.634	.102
	WEEKEND	.313	.103	.062	3.039	.002
	TCD	.246	.081	.060	3.035	.002

a. Dependent Variable: $\ln(\text{cost}+1)$

Follow this with method two of stepwise regression (Enter=0.05, removal=0.10)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.322	.060		5.386	.000
	Police	.629	.081	.154	7.724	.000
2	(Constant)	.759	.119		6.380	.000
	Police	.569	.082	.139	6.900	.000
	SEX1	-.480	.113	-.086	-4.244	.000
3	(Constant)	.620	.126		4.919	.000
	Police	.556	.082	.136	6.758	.000
	SEX1	-.478	.113	-.085	-4.237	.000
	TCD	.267	.081	.065	3.293	.001
4	(Constant)	.576	.127		4.545	.000
	Police	.515	.083	.126	6.173	.000
	SEX1	-.468	.113	-.083	-4.155	.000
	TCD	.260	.081	.064	3.213	.001
	WEEKEND	.297	.101	.059	2.941	.003
5	(Constant)	.650	.129		5.030	.000
	Police	.416	.090	.102	4.619	.000
	SEX1	-.456	.113	-.081	-4.050	.000
	TCD	.267	.081	.065	3.301	.001
	WEEKEND	.338	.102	.067	3.318	.001
	Fire department	-.405	.142	-.061	-2.849	.004
6	(Constant)	1.292	.235		5.487	.000
	Police	.252	.103	.062	2.438	.015
	SEX1	-.417	.113	-.074	-3.686	.000
	TCD	.258	.081	.063	3.187	.001
	WEEKEND	.326	.102	.065	3.202	.001
	Fire department	-.494	.144	-.075	-3.418	.001
	age when the accident happened	-1.5E-02	.005	-.076	-3.261	.001

a. Dependent Variable: $\ln(\text{cost} + 1)$

Excluded Variables^a

Model	Beta In	t	Sig.	Partial Correlation	Collinear it y Statistics	
					Tolerance	
1	SEX1	-.075 ^a	-4.025	.000	-.075	.973
	age when the accident happened	-.072 ^a	-3.413	.001	-.063	.749
	White	-.047 ^a	-2.552	.011	-.047	.977
	Black	.036 ^a	1.939	.053	.036	.964
	Street	.022 ^a	1.025	.306	.019	.730
	water department	.007 ^a	.354	.723	.007	.926
	Fire department	-.044 ^a	-2.243	.025	-.042	.896
	Uphill and Downhill	-.003 ^a	-.190	.849	-.004	.999
	S_TRUCK	-.003 ^a	-.158	.875	-.003	.932
	BIG_V1	-.073 ^a	-3.232	.001	-.060	.659
2	age when the accident happened	-.064 ^b	-3.032	.002	-.056	.742
	White	-.038 ^b	-2.054	.040	-.038	.961
	Black	.028 ^b	1.501	.134	.028	.952
	Street	.025 ^b	1.184	.236	.022	.729
	water department	.009 ^b	.458	.647	.009	.926
	Fire department	-.041 ^b	-2.100	.036	-.039	.895
	Uphill and Downhill	-.004 ^b	-.195	.846	-.004	.999
	S_TRUCK	-.002 ^b	-.099	.921	-.002	.932
	BIG_V1	-.066 ^b	-2.924	.003	-.054	.655
	3	White	-.041 ^c	-2.182	.029	-.041
Black		.031 ^c	1.654	.098	.031	.949
Street		.035 ^c	1.603	.109	.030	.716
water department		.008 ^c	.417	.677	.008	.926
Fire department		-.054 ^c	-2.725	.006	-.051	.863
Uphill and Downhill		-.002 ^c	-.122	.903	-.002	.999
S_TRUCK		-.002 ^c	-.080	.936	-.001	.932
BIG_V1		-.066 ^c	-2.938	.003	-.055	.655
4	White	-.046 ^d	-2.474	.013	-.046	.951
	Black	.037 ^d	1.961	.050	.037	.940
	Street	.063 ^d	2.756	.006	.051	.635
	water department	-.002 ^d	-.117	.907	-.002	.895
	Fire department	-.046 ^d	-2.295	.022	-.043	.842
	Uphill and Downhill	-.001 ^d	-.069	.945	-.001	.998
	S_TRUCK	-.038 ^d	-1.751	.080	-.033	.707
5	White	-.036 ^e	-1.856	.064	-.035	.894
	Black	.026 ^e	1.329	.184	.025	.884
	water department	.016 ^e	.799	.425	.015	.805
	Fire department	-.024 ^e	-1.057	.291	-.020	.630
	Uphill and Downhill	-.001 ^e	-.071	.943	-.001	.998
	S_TRUCK	-.044 ^e	-2.037	.042	-.038	.700
6	White	-.037 ^f	-1.909	.056	-.036	.893
	Black	.027 ^f	1.408	.159	.026	.882
	water department	.019 ^f	.947	.344	.018	.801
	Fire department	-.023 ^f	-1.021	.308	-.019	.630
	Uphill and Downhill	-.001 ^f	-.079	.937	-.001	.998

a. Predictors in the Model: (Constant), Police

b. Predictors in the Model: (Constant), Police, SEX1

c. Predictors in the Model: (Constant), Police, SEX1, age when the accident happened

d. Predictors in the Model: (Constant), Police, SEX1, age when the accident happened, BIG_V1

e. Predictors in the Model: (Constant), Police, SEX1, age when the accident happened, BIG_V1, Street

f. Predictors in the Model: (Constant), Police, SEX1, age when the accident happened, BIG_V1, Street, S_TRUCK

g. Dependent Variable: ln(cost+1)

Descriptions of workers' compensation medical expenditures for accident-related injuries

Year	# of accident injuries requiring medical care	\$ Medical Expenditure for accidents	Avg \$ per injury
1990	33	\$109,240.36	\$3,310
1991	33	\$114,299.75	\$3,464
1992	67	\$129,536.73	\$1,933
1993	214	\$347,208.43	\$1,622
1994	441	\$1,183,171.39	\$2,683
1995	353	\$1,342,769.84	\$3,804
1996	426	\$800,176.15	\$1,878
1997	411	\$713,145.91	\$1,735
1998	416	\$568,288.71	\$1,366
1999	407	\$799,457.35	\$1,964
2000	429	\$1,070,226.24	\$2,495
2001	380	\$849,490.52	\$2,236

Lost work days from work-related motor vehicle accidents

Year	# of accident injuries requiring medical care	# Lost-work-days for MVC	Avg lost work days per injury
1990	33	40662	1232.2
1991	33	15386	466.2
1992	67	35496	529.8
1993	214	39576	184.9
1994	441	28562	64.8
1995	353	41459	117.4
1996	426	24600	57.7
1997	411	9617	23.4
1998	416	10163	24.4
1999	407	8510	20.9
2000	429	11087	25.8
2001	380	3554	9.4

Discussion and Conclusion

Creation of a database of employees and their motor vehicle crashes was accomplished using a relational database that contain separate but linked tables for driver information, vehicle information, and accident information. This allowed easy access to data for analysis, depending on the unit of analysis desired (primary focus was the driver or the vehicle or the accident itself). This database also provided a simple capture method for ongoing surveillance of crashes.

Many hypotheses were proposed to examine risk factors related to drivers, vehicles, and accident factors. These, along with their results, are detailed in the tables below.

Hypotheses related to drivers: Factors expected to increase likelihood of a crash.

Driver Factors	Hypothesized to increase likelihood of MVC	Found to be significant?	Driver Factors	Hypothesized to increase likelihood of MVC	Measure type
Driver age	young drivers	Yes	Driving exposure	Full time assignment	True
Department assignment	Police Fire	Yes	driving history	many previous violations points against license	
Job type	example, clerk, detective	False	sex	male	True
Job tenure	low tenure	False	education	low levels of education	
Marital status	unmarried	Untested, data not reliable	Race	Non-white	True

Hypotheses related to vehicles: Factors expected to increase likelihood of a crash.

Vehicle Factors	Hypothesized to increase likelihood of MVC	Measure type	Vehicle Factors	Hypothesized to increase likelihood of MVC	Measure type
Vehicle age	older vehicles	Untested, data not reliable	engine to weight ratio	high ratio	Untested, data not reliable
Vehicle mileage	high mileage	False	braking system	no anti-lock brakes	Untested, data not reliable
Vehicle type	truck	True			

Hypotheses related to accidents: Factors expected to increase likelihood of a crash.

Crash Factors	Hypothesized to increase MVC severity	Measure type	MVC Factors	Hypothesized to increase MVC severity	Measure type
Vehicle type	low vehicle weight	False	Weather conditions	fog; rain; snow; sleet/freezing rain	False
Safety equipment	seat belt not in use roll bar not installed	Untested. No variation in data	Time of day	Nighttime	True
Driver training	driver with no job-related training	Untested, data unavailable	Number of vehicles involved	multiple vehicles involved	True
Road conditions	wet /icy pavement MVC in intersection	False	Department	Fire Police	True

In addition to the hypotheses proposed, some additional hypotheses were tested and are as follows:

1. Crashes are significantly more likely to occur when associated with a traffic control device (flashing signal, stop sign, flag person)
2. Crashes are significantly more likely to occur on weekends.
3. Crashes associated with injuries and high medical costs are significantly more likely to occur on weekends.
4. Crashes associated with injuries and high medical costs are significantly more likely to occur when large vehicles are involved.
5. Crashes associated with injuries and high medical costs are significantly more likely to involve three or more vehicles.
6. Small trucks are significantly more likely to be associated with crashes that have injuries and high medical costs.
7. Crashes that occur at night are significantly more likely to be associated with injuries and high medical costs.

The need for retraining for employees around the 3rd year of driving is apparent along with the need to address targeted training for weekend drivers. The high correlation between traffic control devices (such as stop signs, traffic lights) points to the need for targeted safety training related to driving safety at intersections. The correlate between medical costs and bib/heavy vehicles also leads to a suggestion for specialty safe driving training for drivers of these vehicles. They are not more likely to have an accident, but notably more likely to result in costly medical injuries when involved in an accident.

The fact that road conditions are not a predictor of either the likelihood of a crash or the costs of medical injuries from a crash speaks well to the adequacy of current training.

Publications

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