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Technical Report

Using Linked Data To Evaluate Hospital Charges for Motor Vehicle Crash Victims in Pennsylvania

Crash Outcome Data Evaluation System (CODES) Linked Data Demonstration Project

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Michael Allen, MPH, Harold Weiss, MPH, MS	

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Center for Violence and Injury Control Allegheny University for the Health Sciences 1 Allegheny Center, Suite 520 320 East North Avenue Pittsburgh, PA 15212	
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16. Abstract

This report uses police-reported crash data that have been linked to hospital discharge data to evaluate charges for hospital care provided to motor vehicle crash victims in Pennsylvania. Approximately 17,000 crash victims were hospitalized in Pennsylvania in 1994, and approximately $350 million in hospital charges were incurred for these crash victims. Average hospital charges were significantly higher for those not using safety belts, the elderly, alcohol-users and motorcyclists. Adolescents and young adults incurred the largest portion of total hospital charges.

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Data Highlights

- More than 17,000 people were hospitalized in 1994 in Pennsylvania due to motor vehicle crashes.
- Approximately $350 million was incurred in hospital charges in 1994.
- Males between the ages of 16 and 40 incurred the greatest total hospital charges.
- Commercial health and automobile insurance bore the brunt of the hospital charges. The data indicated that commercial insurance was the expected primary payer for about 65% of hospital charges associated with motor vehicle crashes.
- Pennsylvania's Medicaid program was expected to be the primary payer for about 10% of all hospitalized crash victims and about 14% of all hospital charges.
- Average hospital charges for Medicaid patients were about 50% higher than for all other patients. In about 40% of all cases over $100,000, Medicaid was indicated as the expected payer for care.
- Many of those with one risk factor for incurring higher hospital charges also exhibited other risk factors.

Executive Summary

Motor vehicle crashes represent one of the greatest risks to public health and safety in Pennsylvania, with more than 350,000 individuals involved in crashes in 1994. These crashes resulted in more than 1,400 deaths and many more serious and moderate injuries. In addition to the human suffering, motor vehicle crashes represent a significant economic cost to insurers, health care providers, and ultimately to society in general. Victims of motor vehicle crashes in Pennsylvania incurred approximately $350 million in hospital charges in 1994. This represents only a fraction of the true cost of motor vehicle crashes, ignoring property damage, other health care costs, and the direct and indirect costs of short and long term disability. The study presented in this document used linked crash data to examine how hospital charges for motor vehicle crashes are distributed among the motoring public and which payers are estimated to bear the direct cost of paying for hospital care for victims of motor vehicle crashes.

The research indicated that males, alcohol users, non-safety belt users, motorcyclists, the elderly, and front seat occupants were among those with hospital charges that were well above average. Males between the ages of 16 and 40 were one of the groups that incurred the greatest total hospital charges primarily because males made up a disproportionate share of crash victims and hospitalized crash victims, although males also had slightly higher average hospital charges than female. Among payers, commercial health and automobile insurance bore most of the hospital charges. Commercial insurance was the expected primary payer for about 65% of hospital charges associated with motor vehicle crashes. The data were not sufficiently detailed, however, to reliably indicate which portion of these charges could be assigned to health or automobile insurance. Pennsylvania's Medicaid program was the expected primary payer (i.e., expected by the hospital) for about 10% of all hospitalized crash victims and about 14% of all hospital charges or nearly $50 million. Average hospital charges (i.e., total charges divided by the number of patients) for Medicaid patients were about 50% higher than for all other patients. In about 40% of all cases over $100,000, Medicaid was indicated as the expected payer for care.

Many of those with one risk factor for incurring higher hospital charges also exhibited other risk factors as well. For example males were about four times as likely to be reported by the police to be under the influence of alcohol, while approximately 75% of reported alcohol users were reported as not using a safety belt.

The information developed in this study may be useful to payers and those concerned with public health and safety in developing targeted interventions to reduce the financial and human consequences of motor vehicle crashes.

Introduction

In 1994, motor vehicle crash victims incurred approximately $350 million dollars in hospital care charges. While hospital charges are not identical to actual payments received, they are a reasonable indicator of actual costs and offer a consistent way to compare differences in hospital costs. Using a conservative cost-to-charge ratio (i.e., the ratio of what is actually paid to what is charged) of 80% means that in 1994, more than $280 million dollars was spent to pay for hospital care alone for motor vehicle crash victims in Pennsylvania. These costs do not include physician and other outpatient care services, emergency department and ambulance services, long term nursing, rehabilitation, and home health care services, or the financial costs of lost wages and long term disability. Ultimately, of course, all these costs are borne by society in general, yet questions remain as to how these costs are proportionately shared among payers and who shares responsibility for incurring these costs.

Auto and health insurance companies, public agencies such as Medicare and Medicaid, private individuals, health care providers and others pay hospital costs for motor vehicle crash victims. This research uses linked crash data to examine the characteristics of those who incur these costs and which payers ultimately end up "footing the bill."

Purpose

The purpose of this research is to examine hospital charges associated with motor vehicle crashes and who ultimately ends up paying for these charges.

The two primary research questions addressed by this study are stated as follows:

1. Are there significant differences in motor vehicle-related hospital charges incurred by specific groups of individuals and how important are these differences?

2. Who directly pays for these costs and what are the direct economic consequences of motor vehicle crashes?

The results of this research are intended for use by policy and decision-makers within the fields of public health, highway and traffic safety, health care services, insurance regulation and related fields.

Approach

The research is based upon analysis of a linked crash data set available in Pennsylvania for 1994, as well as data representing all documented hospitalized motor vehicle crash victims in Pennsylvania for 1994. The study uses contingency table analysis to examine differences in average charges for specific groups of individuals such as seat belt users vs. non-users, or males vs. females. Linear regression is also applied to the data to control for confounding variables, in order to examine how hospital charges were independently related to the various factors under study.

The Data Set Used for Analysis

This research is based upon data collected during 1994 by the Pennsylvania Department of Transportation, the Pennsylvania Department of Health, and the Pennsylvania Health Care Cost Containment Council. Data from these three sources were linked together using probabilistic linkage. Each of the individual data sets and the linked data set are described in *Appendix I* to this document.

The overall 1994 crash data set included records for 350,492 crash victims involved in approximately 134,000 crashes. Approximately 52,000 of these crash records linked to an Emergency Medical Service "run report," while about 6,000 crash records were linked to a hospital discharge record. These linked records represent an estimated 42% of EMS patients involved in motor vehicle crashes and about one-third of all hospital patients hospitalized for crash-related injuries.

The records from the 1994 hospital discharge data set that did not link to crash records were also used for those analyses that did not require data elements from the crash or EMS data. This data set is compiled by the Pennsylvania Health Care Cost Containment Council and originally included discharge data for approximately 1.8 million patients who were hospitalized during 1994. Approximately 17,000 of these discharge records included External Cause of Injury Codes (E-codes) that indicated that a motor vehicle crash was the reason for hospitalization.

Method

Two principal statistical methods applied to the data were contingency table analysis and linear regression. Each of these methods is briefly described below.

Contingency Table Analysis

Contingency tables are tables that describe the differences in average and total hospital charges for a variety of groups of crash victims, such as belt users versus non-belt users, drivers versus passengers, and so forth. No attempt to control for contributing factors is made in this analysis, nor is the statistical significance of the results examined. For those categories with large numbers of observations, the results may indicate important differences between groups.

Linear Regression

Linear regression is a statistical technique used to calculate an equation that provides predicted values of an outcome variable (Y) for a given value of another variable (X) while controlling for other factors that may contribute to the value of the outcome variable. Generally the exact value of the outcome variable is not predicted, but instead an equation is produced that "best fits" the relationship between the two variables.

Case Selection

Two data sets were used in this research. The first data set consisted of all hospital discharges in 1994 for which an External Cause of Injury code (E-code) indicated that a motor vehicle crash was the cause of injury and reason for hospitalization (i.e., E-codes 810.xx through 819.xx). Among the 1.89 million hospital discharge records, 17,759 records, or approximately 1% of all hospital discharges in 1994, included an E-code within this range. More than 95% of these hospital discharge records represented a single patient, while approximately 4.5% (816 records) were for re-admissions or multiple admissions for the same patient.

The second data set was a linked crash-EMS-hospital discharge database that was created through probabilistic linkage. This data set included records for approximately 350,000 crash victims. Approximately 6,000 of the hospital records for these crash victims were linked from the hospital discharge database. The linked database was used in those analyses that required data elements from both the non-hospital data and the hospital discharge data.

Results

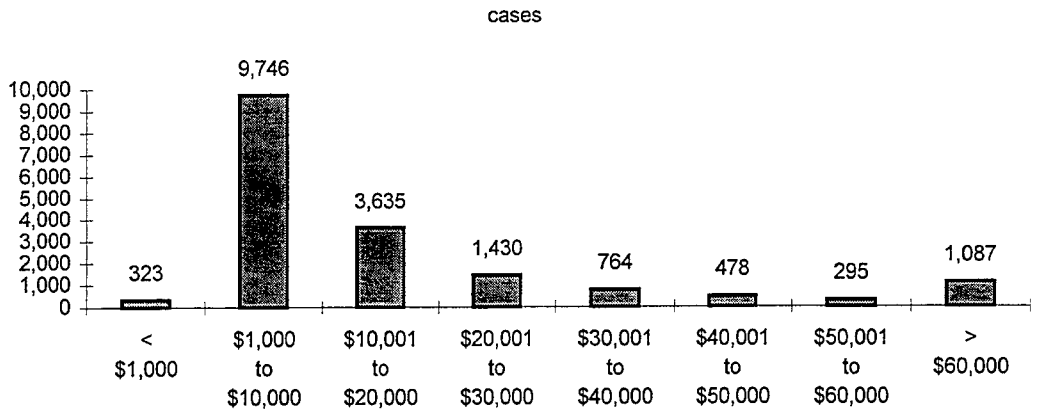
The contingency tables and linear regression analysis were applied to a wide variety of crash, person and injury specific characteristics. The statistical testing of the data yielded the results described below.

All Crash Victims

The hospital discharge data set included records for 17,759 patients with external cause of injury codes that indicated a motor vehicle crash was the reason for the hospitalization. The average hospital charge for these patients was $19,693 and the median charge as $8,613.

Figure 1. on the following page, depicts the distribution of the hospital charges for all hospitalized crash victims.

Figure 1. Distribution of Charges for Hospitalized Crash Victims, Pennsylvania, 1994.



Approximately 95% of all hospital charges were less than $69,800 and the highest hospital charge was $986,384. The distribution of charges was skewed to the right by the presence of a small number of very high charges. For example, while 95% of all cases were less than $69,800, the remaining 5% of cases accounted for about 40% of all hospital charges. Table 1 indicates that these high outlier charges accounted for a very disproportionate share of all hospital charges.

Table 1. Distribution of High Outlier Charges For Hospitalized Crash Victims, Pennsylvania, 1994.

Threshold	Cases	Total Charges	% All Cases	% Of All Hospital Charges
>$69,800	898	$137,162,127	5%	39%
>$112,700	452	$98,530,969	3%	28%
>$186,600	187	$60,318,220	1%	17%
>$447,000	28	$18,190,313	0.1%	5%

Hospital Charges by Sex

The hospital discharge data set includes information on patient gender and this information is available on more than 99.9% of the records. Males accounted for 60% of all hospitalized cases and about 63% of all hospital charges. The average charge for males was about 12.3% greater than it was for females or about $2,263 greater on average than it was for females.

As Table 2 indicates, males account for a greater share of total hospital charges because more males are hospitalized and they have a higher average hospital charge than females.

Table 2. Charges by Sex for Hospitalized Crash Victims, Pennsylvania, 1994.

Gender	Cases	Total Charges	Average Charges	% Of All Cases	% Of All Charges
male	10,653	$219,423,179	$20,597	60.0%	62.8%
female	7,099	$130,153,135	$18,334	40.0%	37.2%
all	17,752	$349,576,314	$19,692	100.0%	100.0%

In the police crash data, males account for approximately 60% of all crash victims, whose gender is identified, indicating that male crash victims are hospitalized at about the same rate as female crash victims.

Linear regression analysis was also applied to the linked data to examine how factors such as safety belt use, vehicle speed, seat position, age, or type of crash contributed to higher average hospital charges for males.

The linear regression analyses confirmed that the difference in average charges for males and females was statistically significant while controlling for seat position, age of the patient, and type of vehicle. These analyses indicated that hospital charges were about $2,177 dollars lower if the crash victim was a female.

Hospital Charges by Age of Crash Victim

The average age of all hospitalized crash victims was 38.4 years while the median age was 33 years. For all police-reported crash victims the average age was 32.8 and the median age was 29 years. This suggests that those victims who were hospitalized tended to be older than all crash victims.

Figure 2, on the following page, illustrates the age distribution of hospitalized crash victims superimposed upon the age distribution of all crash victims. The distribution of all crash victims is nearly normal while the distribution of hospitalized crash victims is weakly bi-modal, with the highest number of absolute of cases among teenagers and young adults. A slight increase in the number of cases over age 65 is evident.

Figure 2. Age Distribution of Hospitalized Crash Victims, Pennsylvania, 1994.

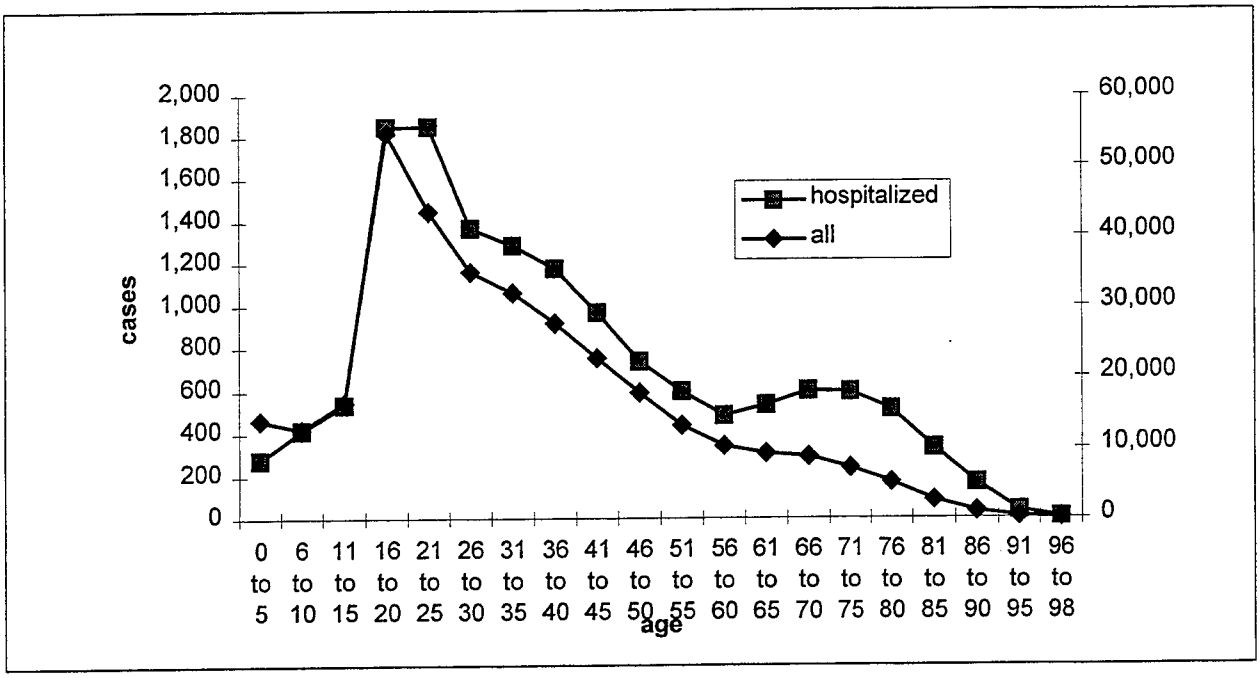
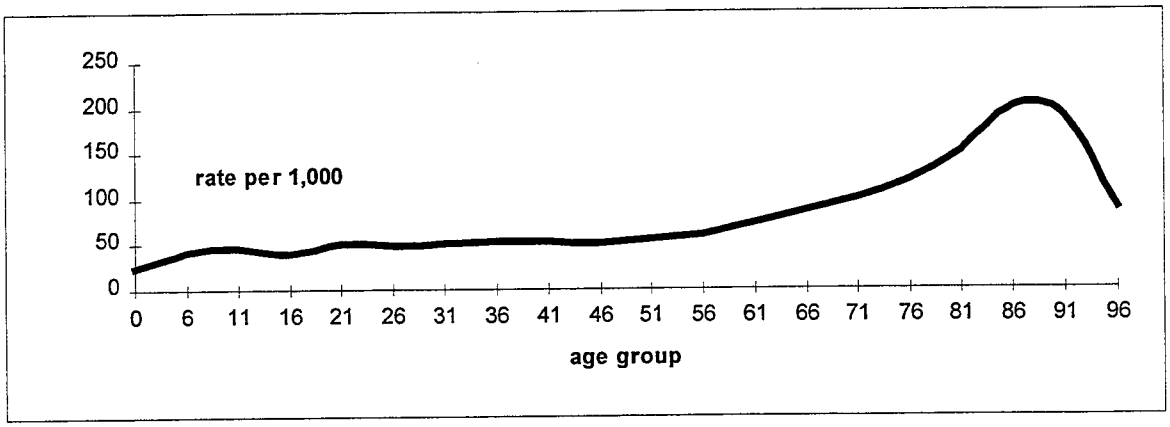


Figure 3 illustrates that hospitalization rates for crash victims appear to increase among older crash victims.

Figure 3. Hospitalization Rate by Age for Crash Victims, Pennsylvania, 1994.



Although the elderly have the highest *crash victim hospitalization rate* the absolute number of older crash and hospitalized crash victims is small as indicated in Table 3. The rate per population is probably low because of the low number of vehicle miles driven by the elderly. Elderly crash victims are more likely to be hospitalized than non-elderly crash victims, but the elderly are less likely to be crash victims.

Table 3. Totals and Hospitalization Rates for Crash Victims by Age Group, Pennsylvania, 1994.

Age Group	Number Of Crash Victims	Hospitalized Crash Victims	Rate Of Crash Victim Hospitalization
0 - 5	11,280	277	2.5%
6-10	10,079	416	4.1%
11-15	11,604	535	4.6%
16 - 20	45,320	1,849	4.1%
21 - 25	35,836	1,850	5.2%
26 - 30	27,806	1,370	4.9%
31 - 35	25,751	1,286	5.0%
36 - 40	22,332	1,177	5.3%
41 - 45	18,412	966	5.2%
46 - 50	14,548	736	5.1%
51 - 55	10,871	597	5.5%
56 - 60	8,241	484	5.9%
61 - 65	7,395	533	7.2%
66 - 70	7,006	599	8.5%
71 - 75	5,938	594	10.0%
76 - 80	4,257	512	12.0%
81 - 85	2,218	333	15.0%
86+	1,064	168	15.8%

Total hospital charges were greatest for teenagers and young adults, and then declined slowly with age of the crash victim. Average hospital charges on the other hand, increased slowly as a function of age. The increase in average hospital charges may reflect the occurrence of co-morbid conditions in older drivers. Figure 4 depicts total hospital charges by age group. Those between the ages of 16 and 25 incur approximately a quarter of all hospital charges for motor vehicle crash victims. This same age group however, only comprises about 13% of the population of Pennsylvania.

Figure 4. Total Hospital Charges by Age Group for Crash Victims, Pennsylvania, 1994.

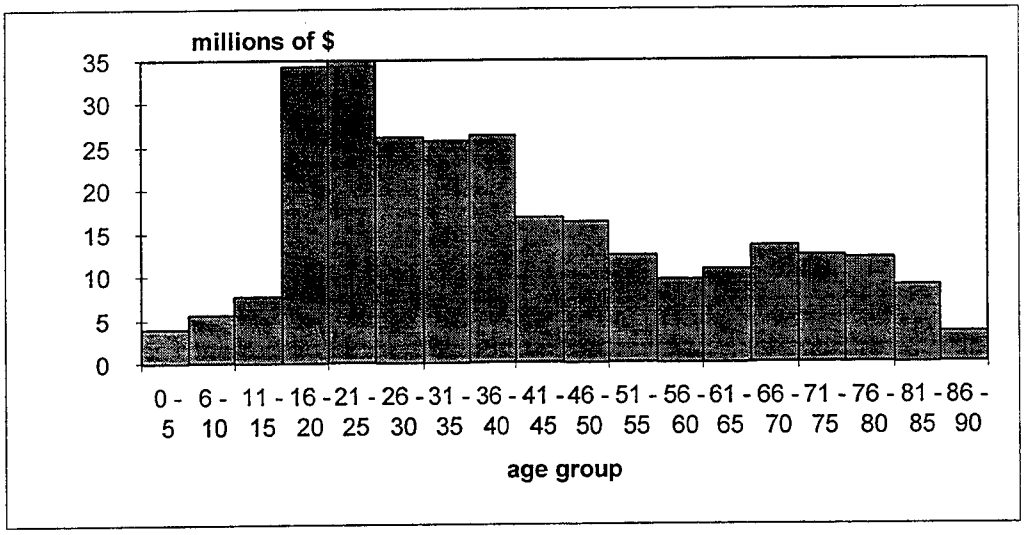


Table 4 indicates that those in the age groups between 16 and 50 incur the highest total hospital charges and incur about two thirds of all hospital charges for motor vehicle crashes.

Most of the age groups over age 65 tend to have the highest average hospital charges. With the exception of the extremely elderly (age 90+) all of those over age 65 have higher than average hospital charges. This higher average may reflect the presence of both injury and non-injury related co-morbid conditions or a greater vulnerability to injury.

Co-morbid conditions probably account for some of the differences in average charges for the elderly. A comparison of secondary diagnoses of those over age 65 with those under age 65 indicates that for all age cohorts, those over age 65, on average, have more secondary diagnoses reported. Table 5 compares the hospital records for those over age 65 with records for those under age 65 with regard to reported secondary diagnoses. As this table indicates, the elderly tend to have more secondary diagnoses than those under age 65.

Table 4. **Total Hospital Discharges and Charges, Average Charge by Age Group for Hospitalized Crash Victims, Pennsylvania, 1994.**

Age Group	Number Of Discharges	Total Charges (Millions Of $)	Average Charge
0 - 5	277	4	$14,728
6-10	416	5.6	$13,476
11-15	535	7.7	$14,409
all under age 16	***1,228***	***17.3***	***$14,088***
16 - 20	1,849	34.3	$18,585
21 - 25	1,850	34.9	$18,858
26 - 30	1,370	26.2	$19,111
young adults (age 16 to 30)	***5,069***	***95.4***	***$18,820***
31 - 35	1,286	25.7	$19,975
36 - 40	1,177	26.4	$22,422
41 - 45	966	16.8	$17,422
46 - 50	736	16.3	$22,222
51 - 55	597	12.4	$20,872
56 - 60	484	9.6	$19,858
61 - 65	533	10.8	$20,329
middle aged adults (age 31 to 65)	***5,779***	***118***	***$20,419***
66 - 70	599	13.6	$22,782
71 - 75	594	12.4	$20,914
76 - 80	512	12.1	$23,852
81 - 85	333	8.8	$26,375
86 - 90	168	3.6	$21,621
91 - 95	35	0.3	$9,924
96 - 100	3	0	$8,366
elderly (older than 65)	***2,244***	***50.8***	***$22,638***
all age groups*	***14,320***	***282***	***$19,658***

(not including unknown age)

Table 5. Comparison of Secondary Diagnoses for Elderly and Non-Elderly Crash Victims, Pennsylvania 1994.

Number Of Secondary Diagnoses Reported	% Of Records For Age 65+	% Of Records For Age < 65
1	96.9%	92.7%
2	85.4%	77.9%
3	77.3%	62.6%
4	65.7%	47.5%
5	52.9%	33.7%
6	41.2%	24.3%
7	33.8%	18.1%
8	24.7%	12.5%

Another reason why the elderly may tend to incur higher charges than the non-elderly may be that they are more vulnerable to serious injury. Examination of police reported injury data, which include virtually all of the motor vehicle-related deaths, reveals that the death rate for those over age 65 is more than three times the death rate for those under age 65. Also, those over age 65 have somewhat higher rates of injury for all categories of injury level reported by the police. Emergency medical service data confirm that older crash victims tend to have higher rates of "life threatening" injuries. Among the EMS records that linked to crash records, 4.7% of EMS patients age 65 and older had "life threatening" injuries, while only 3.2% of those under age 65 had injuries of a life threatening nature.

The linear regression analysis indicated that while controlling for safety belt use, and vehicle type, hospital charges increased on average about $147 for every five-year age increment.

A contingency table for age and sex indicated that although the elderly tend to incur the highest average hospital charges for motor vehicle crashes, young and middle aged males incur the highest total hospital charges. Table 6 compares the average and total hospital charges by age and sex.

Table 6a. Total Victims, Maximum, Total and Average Hospital Charges by Age for Female Crash Victims, Pennsylvania, 1994.

Age Group	N	Maximum	Sum	Average
Females				
0 to 5	112	$181,930	$1,449,810	$12,945
6 to 10	133	$128,347	$1,726,235	$12,979
11 to 15	190	$182,136	$2,851,009	$15,005
16 to 20	667	$667,532	$12,761,667	$19,133
21 to 25	575	$326,120	$9,868,918	$17,163
26 to 30	442	$522,446	$8,745,000	$19,785
31 to 35	480	$250,412	$7,952,113	$16,567
36 to 40	431	$392,215	$7,634,952	$17,715
41 to 45	397	$502,273	$7,471,575	$18,820
46 to 50	280	$447,064	$4,920,478	$17,573
51 to 55	279	$231,740	$4,675,752	$16,759
56 to 60	222	$144,768	$3,030,182	$13,649
61 to 65	244	$668,095	$4,603,639	$18,867
66 to 70	317	$986,385	$6,942,438	$21,900
71 to 75	330	$491,916	$7,231,796	$21,915
76 to 80	288	$285,041	$5,461,152	$18,962
81 to 85	182	$294,904	$3,788,950	$20,818
86 to 90	90	$394,790	$1,924,251	$21,381
91 to 95	22	$24,126	$204,764	$9,307
96 to 98	2	$9,013	$10,210	$5,105
unknown	1416	$920,507	$26,898,245	$18,996

Table 7b. **Total Victims, Maximum, Total and Average Hospital Charges by Age for Female Crash Victims, Pennsylvania, 1994.**

Age Group	N	Maximum	Sum	Average
Males				
0 to 5	164	$360,768	$2,619,108	$15,970
6 to 10	283	$164,783	$3,880,054	$13,710
11 to 15	345	$276,418	$4,858,274	$14,082
16 to 20	1182	$896,286	$21,603,322	$18,277
21 to 25	1275	$725,157	$25,020,112	$19,624
26 to 30	926	$379,341	$17,428,653	$18,821
31 to 35	806	$565,258	$17,735,987	$22,005
36 to 40	745	$896,124	$18,701,152	$25,102
41 to 45	569	$258,158	$9,358,401	$16,447
46 to 50	456	$960,322	$11,435,368	$25,078
51 to 55	318	$542,004	$7,758,060	$24,396
56 to 60	261	$547,892	$6,576,994	$25,199
61 to 65	289	$583,311	$6,231,957	$21,564
66 to 70	282	$444,763	$6,703,983	$23,773
71 to 75	264	$297,544	$5,191,615	$19,665
76 to 80	224	$428,514	$6,613,140	$29,523
81 to 85	151	$676,887	$4,994,241	$33,074
86 to 90	78	$161,203	$1,708,118	$21,899
91 to 95	13	$40,457	$142,577	$10,967
96 to 98	1	$14,888	$14,888	$14,888
unknown	2021	$889,874	$40,847,175	$20,211

Hospital Charges by Restraint Usage

The crash data include information on the types of active and passive passenger restraint systems available for each occupant of a crash vehicle, as well as whether or not the active restraint system (e.g., a safety belt) was in use and whether a passive restraint system (e.g., an airbag) was deployed.

However, questions arise as to the validity of the restraint usage data. Police reports of restraint usage are based upon observations and statements of crash victims. There may be an incentive for crash victims to tell police officers that they were wearing a safety belt, when in fact, they were not. In Pennsylvania, seat belt usage is mandatory for all front seat occupants and all occupants under age 18. Thus, seat belt use may be "over-reported" among crash victims. A second problem with the restraint usage data seems to be differences in how data are actually recorded. For example in about a quarter of the crash records, the police report records that an active restraint system such as a seat belt is available but its usage is "not applicable." The "not applicable" category should be applied only when no restraint is available.

As could be expected, among the hospital records that were linked to crash records the safety belt usage rate was lower than the rate among all crash victims. Those crash victims who were not using belts could be expected to be more seriously injured (i.e., enough to be hospitalized), than those crash victims who were using a safety belt.

Among all crash victims, whose belt usage was recorded, approximately 72% were reported to be using safety belts. Among hospitalized patients, only 60% of the linked records indicated that a belt was in use. Thus, crash victims who use seat belts are about 20% less likely to end up hospitalized as seat belt non-users.

The difference in average hospital costs between belt users and non-belt users is statistically significant. The average hospital charge for non-users was $21,610, while the average charge for belt-users was $15,575. Linear regression analysis indicated that average hospital charges were about $6,035 less for belt users than they were for non-users. Controlling for age and sex increased the average difference in charges to $7,280.

Hospital Charges and Alcohol Involvement

Alcohol use is widely recognized as a major contributor to death and injury due to motor vehicle crashes. Police crash reports include information on whether alcohol or drugs were a contributing factor to the crash, whether or not an alcohol test was administered and the results of the test if administered. However, police reports of alcohol involvement in crashes may significantly underestimate the problem. Drinking drivers obviously have an incentive to try to conceal their alcohol use and police generally only report for drivers or pedestrians who may have been drinking, not passengers.

Hospital data also include information in regard to alcohol use and abuse. Diagnostic codes are used to identify a range of alcohol-related conditions such as alcoholic psychosis, alcoholism, alcohol withdrawal syndrome, and acute alcohol intoxication.

The police crash data indicate that approximately 3.7% of all *persons* in reported crashes, were under the influence of alcohol. Approximately 5.6% of all *drivers* were reported by the police to be under the influence of alcohol. Almost all (98%) crash victims who were reported by the police to be under the influence were drivers. Pedestrians made up the rest of those who were reported by the police to be under the influence of alcohol.

The hospital data indicated that approximately 12% of all hospitalized crash victims and approximately 18% of all drivers who were hospitalized were reported by the police to have been under the influence of alcohol. Approximately 16% of hospitalized crash victims and 18% of hospitalized drivers included an alcohol related secondary diagnosis such as acute alcohol poisoning or alcoholic psychosis.

Those who were under the influence of alcohol according to police reports of alcohol usage incurred $18,839 in average hospital charges while those who were not reported by the police to be under the influence on average incurred $18,206 in hospital charges.

In examining the hospital discharge data, those patients whose records included an alcohol-related secondary diagnosis incurred approximately $21,192 in average hospital charges, while those who did not have an alcohol related secondary diagnosis incurred approximately $18,093 in average hospital charges.

Among the hospital records that linked to a crash record, approximately 12.2% were reported by the police to be under the influence, while only 3.9% within the entire crash data set were reported to be under the influence. This indicates that those who were under the influence were more likely to incur higher hospital charges, and were also more likely to be hospitalized due to a crash. A simple odds ratio calculation indicates that those crash victims who were under the influence were about three times as likely to be hospitalized as those who were not under the influence.

The linear regression analysis, controlling for seat belt use, age, and sex of the crash victim, indicated that much of the difference in average hospital charges for those who had an alcohol-related secondary diagnosis could be accounted for by differences in seat belt usage, age and sex. Those with an alcohol-related secondary diagnosis, only about 13.5% were reported to be using seat belts, while about 60% of all those without an alcohol-related secondary diagnosis were reported by the police to have a belt in use at the time of the crash.

In a similar manner, as shown in Table 7, police-reported alcohol involvement appeared to correlate with non-usage of a safety belt. In those cases where alcohol involvement and belt usage could be determined from the data, less than 30% of passenger car and light truck drivers with police-reported alcohol involvement were reported to be using safety belts, while 65% of without police-reported alcohol involvement were reported to be using belts. The lower rate of belt usage among those with alcohol involvement probably accounts for some of the higher average charges for those with alcohol-involvement, but those with alcohol involvement and using safety belts also had higher average charges than those using belts who were not reported to be using alcohol.

Alcohol use also appears to be a "repeat offense" among crash victims. Among those hospitalized crash victims with an alcohol-related secondary diagnosis, approximately 18% were reported to have at least one previous DUI conviction, while less than 5% of those without an alcohol-related diagnosis were reported to have had a previous DUI conviction. Those with more one or more previous DUI convictions had average hospital charges of approximately $20,000, while those without a previous DUI conviction had an average hospital charge of $18,500.

Table 8. Contingency Table of Average Hospital Charges for Police-Reported Belt Use and Alcohol Involvement by Passenger Car and Light Truck Drivers Involved in Crashes, Pennsylvania 1994.

Belt/Alcohol Use	Average Charge	Cases
safety belt in use, no alcohol involvement	$14,565	1,166
safety belt in use, alcohol involvement	$17,861	89
no safety belt in use, no alcohol involvement	$18,293	759
no safety belt in use, alcohol involvement	$17,006	208
belt use or alcohol involvement unknown	$19,963	3,180

Hospital Charges by Payer

Hospital charges for motor vehicle crash victims may be paid by a variety of payers including private health insurance, automobile insurance, Medicare or Medicaid or the crash victims themselves. The hospital discharge data include information in regard to the type of claims paying organization (e.g., commercial insurance, government, etc.) and the type of insurance product (e.g., HMO, auto insurance, etc.) that is expected to cover payment of the charges.

Approximately 85% of all discharge records identified the type of claims paying organization while only about 15% of discharge records include information about the specific type of insurance product. The information concerning the insurance product does not appear to be sufficiently detailed to draw any conclusions in regard to how hospital charges are distributed among various insurance products. Table 8, indicates the number of crash victims and average charges by estimated payer.

Table 8. Totals and Percent, Total and Average Hospital Charge by Payer for Hospitalized Crash Victims, Pennsylvania, 1994.

Payer	Cases	% Of All Crash Victims	% All Charges	Total Charges (Millions Of $)	Average Charge
commercial insurance	10,681	60%	57%	197.7	$18,507
Medicaid	1,698	10%	14%	50.2	$29,563
unknown	2,854	16%	12%	41.9	$14,684
Blue Cross	984	6%	7%	25.5	$25,894
Medicare	827	5%	6%	22.6	$27,373
self	591	3%	3%	8.9	$14,980
other government	91	1%	1%	2.0	$21,595
employer	33	0.2%	0.1%	0.5	$14,168
TOTAL	17,759	100%	100%	349.2	$19,693

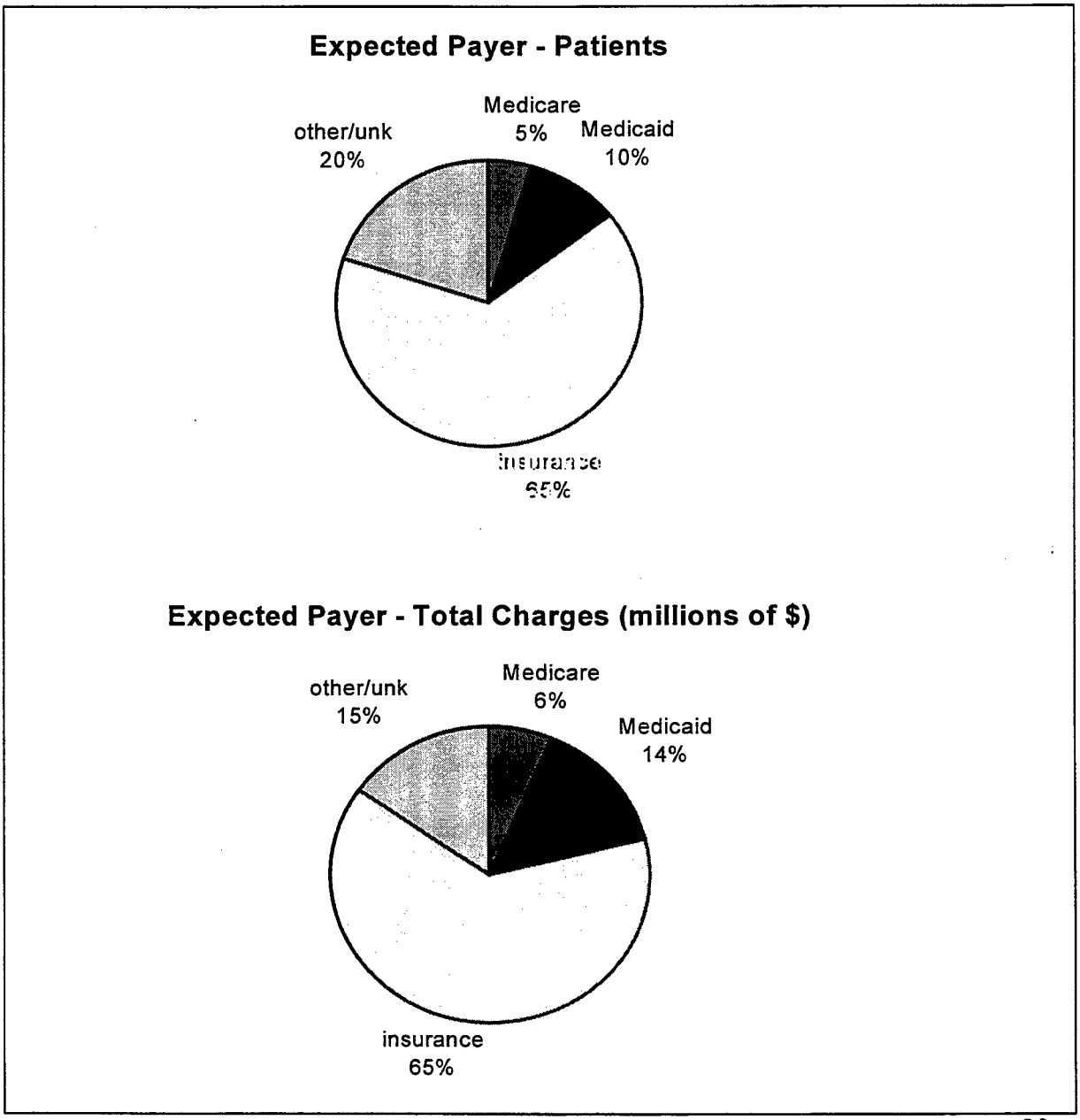
As Table 8 illustrates, commercial insurance pays for the majority of all hospital charges associated with motor vehicle crashes. Medicaid, Medicare and Blue Cross also account for a significant portion of payments to hospitals for motor vehicle crashes.

Linear regression performed upon hospital records that linked to crash records indicated that hospital charges were highly correlated, as expected, to the number of secondary procedures and diagnoses. While controlling for age, sex, seat position, and belt use, hospital charges on average increased by about $2,100 for every additional secondary diagnosis and about $6,200 for every additional procedure that was performed. However, additional linear regression indicated that not all of the differences in average hospital charges for Medicare and Medicaid patients could be explained by more secondary diagnoses or procedures performed. Controlling for the number of procedures and secondary diagnoses, as well as age, sex, and restraint usage, indicated that average hospital charges were about $11,000 higher for Medicaid patients than all patients and about $3,000 higher for Medicare patients. The higher costs for Medicaid patients may also be related to the fact that as the hospital charges increase, patients are more likely to end up using all of their health and auto insurance benefits and by default Medicaid becomes the payer of last resort for these high cost cases. While only about 9.7% of *all* hospital charges are expected to be paid by Medicaid, about 17.6% of those over $100,000 are charged to Medicaid and more than 40% of cases with costs over $400,000 indicate that Medicaid is the expected payer. Hospital care for individuals without health insurance or other insurance who are not eligible for public support such as Medicare or Medicaid, are considered to be "self-paying" individuals. Often a significant portion of self-pay care ends up being absorbed as bad debt or charity care on the part of the health care provider. In 1994, self pay patients incurred about $8.8 million in hospital charges due to motor vehicle crashes.

The crash data also include information in regard to the auto insurance status of the vehicle in which the crash victim was riding. These data indicated that approximately 4.5% of those who were hospitalized for motor vehicle crashes were not covered by automobile insurance.

Figure 5 illustrates the distribution of patients and total hospital charges among expected payers for hospital care. These graphs illustrate that Medicaid pays a disproportionate share of total hospital charges. While only about 10% of hospitalized crash victims are Medicaid patients, about 14% of total hospital charges are assigned to the Medicaid program.

Figure 5. Percent of Patients and Total Charges by Expected Payer for Hospitalized Crash Victims, Pennsylvania, 1994.

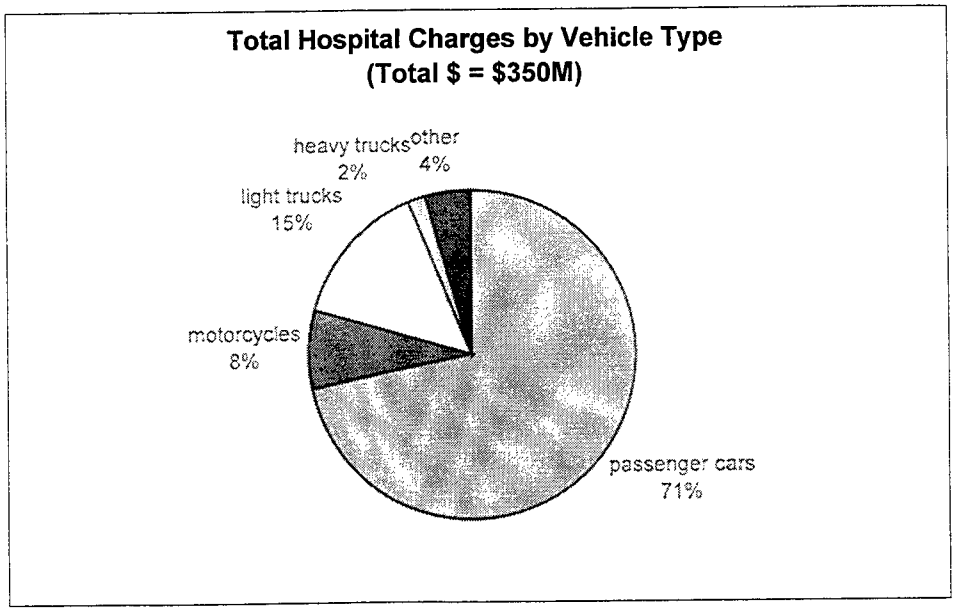


Bus crash victims had the highest average hospital charges but bus crash victims made up less than 3% of all crash victims and less than 1% of all crash victims whose hospital records linked to a crash record. Motorcycle and large truck crash victims also had average hospital charges well above average.

Not only do motorcyclists incur higher hospital charges; motorcycle crash victims are much more likely to be hospitalized than occupants of any other type of motor vehicle. Approximately 340,000 individuals were occupants of passenger cars, small or large trucks, or buses and approximately 13,400 of these crash victims were hospitalized resulting in a hospitalization rate of about 4%. On the other hand, approximately 1,300 of the approximate 3,200 motorcycle crash victims were hospitalized, resulting in a hospitalization rate for motorcycle crash victims of about 40%.

Linear regression analysis, controlling for age and sex of the crash victim, indicated that hospital charges were about $5,700 higher for motorcycle crash victims than for crash victims who were occupants of passenger cars or light trucks. Despite their higher average hospital charges however, motorcyclists incur about 8% of total hospital charge due to the relatively small number of motorcycle crash victims. Figure 6, below, depicts the distribution of total hospital charges by vehicle type.

Figure 6. Percent of Total Hospital Charges by Vehicle Type for Hospitalized Crash Victims, Pennsylvania, 1994.



Hospital Charges by Seat Position

The police crash data and the External Cause of Injury Codes (E-codes) in the hospital data indicate the seat position of each crash victim. The police reported data indicated that approximately 65% of all crash victims were drivers of the crash vehicle, while nearly 19% were front seat passengers. Back seat passengers accounted for about 9.5% of all reported crash victims. The hospital discharge data indicated that about 59% of all hospitalized motor vehicle crash victims were drivers, and about 22% were passengers in crash vehicles.

Pedestrians made up about 1.9% of all crash victims, but about 10% of all hospitalized motor vehicle crash victims.

For occupants of passenger cars only, average and total hospital charges were highest for drivers and front seat occupants incurred higher average charges than back seat occupants. Linear regression, controlling for age, sex and restraint use suggested that the difference in average charges for drivers may have been more attributable to differences in belt usage, gender and age rather than the seat position itself. The results obtained using linear regression, however, were not found to be statistically significant.

In a similar manner, hospital charges on average were about $5,600 higher for front seat passengers but when controlled for restraint usage, age and sex this difference was not statistically significant.

Hospital Charges by Type of Injury

The police crash data, EMS data and hospital discharge data include information on the type of injuries, injury site and injury severity. The hospital injury data, however, are the most detailed and probably the most reliable and valid injury data.

The injury data collected by EMS personnel are mostly concerned with the short-term patient survivability from the inflicted trauma. There appears to be some inconsistency in the way that EMS data are collected. For example, the Revised Trauma Score (RTS) is a standard way of measuring the severity of injury and is based on blood pressure, respiration, and the degree of consciousness (Glasgow Coma Score) of the patient. But an examination of the Revised Trauma Scores within the linked database indicated that approximately 33% of those transported by ambulance received a trauma score of "0" indicating that they were killed. It is likely that many records with missing scores are being confused with records with a real trauma score of "0." EMS data also include information on injury type and site.

Hospital-reported injuries are coded according to the International Classification of Diseases 9th Revision Clinical Modification (ICD-9-CM), a standardized and specific method of classifying diseases, injuries, and causes of injury. These data are used for classifying patients according to diagnosis-related groups upon which hospital reimbursement often depends and third party payers such as the government may audit these codes.

One of the difficulties in analyzing hospital charges by injury type is that many hospitalized patients suffer more than one type of injury and the data do not assign which injury contributed to which hospital charges that were incurred.

Three approaches were used to examine charges by injury site. The first step in this analysis was to use the primary diagnosis and each of the eight secondary diagnoses to classify injuries by the part of the body affected. Thus any patient with any diagnosis indicating that the lower limbs were injured (e.g., fractures, dislocations, superficial injuries) was classified as suffering a leg injury.

Injuries were first classified into four broad body regions: (1) head injuries, (2) upper limb injuries, (3) injuries to the trunk of the body, and (4) injuries to the lower limbs. Subcategories for injuries to the eyes, face, neck, back, spine, pelvis and abdomen were also created. Average hospital costs were then calculated for those patients who had injuries in only one body region. Average hospital costs were also calculated for patients who had injuries to *any* of the four body regions and finally average hospital costs were calculated based upon only the primary diagnostic code. The results of these analyses are indicated in Tables 9 and 10.

Table 9. Total Cases and Average Charge for Hospitalized Crash Victims With Only One Injury Site, Pennsylvania , 1994.

Injury Site	Cases	Average Charge
Trunk	2,572	$19,298
Head	2,856	$17,062
Lower limb(s)	525	$16,842
Upper limb(s)	1,651	$11,753

Table 10. Total and Average Charge for Hospitalized Crash Victims With Injury to Any Body Region, Pennsylvania, 1994.

Injury Site	Cases	Average Charge
Trunk	8,985	$22,906
Head	9,782	$21,574
Lower limb(s)	6,724	$21,370
Upper limb(s)	4,433	$18,406

Trunk, head and lower limb injuries appear to incur the highest charges while upper limb injuries tend to incur the lowest charges.

Tables 11 and 12 list the top ten average hospital charges and total hospital charges by primary diagnosis. As these tables indicate, the highest average hospital charges tend to be primarily for injuries to the head, neck, and trunk of the body. The highest *total* hospital charges tended to be mostly for injuries to the head, pelvis and lower limbs.

Table 11. Total and Average for Ten Most Frequent Primary Diagnoses for Hospitalized Crash Victims, Pennsylvania, 1994.

Primary Diagnosis	Cases	Total Charges	Average Charge
injury to blood vessels of thorax	35	$3,776,054	$107,887
multiple fractures involving skull or face	19	$1,995,748	$105,039
multiple open wound of upper limb	5	$408,373	$81,675
burn of trunk	7	$524,255	$74,894
fracture of vertebral column	162	$11,127,298	$68,687
Cerebral laceration	343	$17,632,094	$51,406
injury to pelvic organs	25	$1,226,891	$49,076
injury to other intrathoracic organs	40	$1,935,120	$48,378
spinal cord injury	94	$4,484,125	$47,703
Subarachnoid or subdural hemorrhage	302	$14,125,271	$46,772

Table 12. Ten Primary Diagnoses With Highest Total Hospital Charges for Hospitalized Crash Victims, Pennsylvania, 1994.

Primary Diagnosis	Cases	Total Charges	Average Charge
Intracranial injury	1,834	$30,930,080	$16,865
Fracture of tibia and fibula	773	$21,646,954	$28,004
Fracture of base of skull	417	$18,502,317	$44,370
Cerebral laceration	343	$17,632,094	$51,406
Fracture of pelvis	631	$15,322,627	$24,283
Fracture of femur	512	$15,313,302	$29,909
Subarachnoid/subdural hemorrhage	302	$14,125,271	$46,772
Fracture of vertebral column	609	$13,632,517	$22,385
Fracture of ribs/sternum	873	$12,186,134	$13,959
injury to spleen	313	$11,413,679	$36,465

In examining both the primary and secondary diagnoses reported in the hospital data, the most frequently reported injuries tend to be injuries to the head, face, and leg. Table 13 indicates the number of the ten most frequently reported primary and secondary diagnoses among hospitalized motor vehicle crash victims, and the percentage of all hospitalized crash victims with these injuries reported as primary or secondary diagnoses.

Table 13. Top 10 Most Frequent Primary and Secondary Diagnoses for Hospitalized Crash Victims, Pennsylvania 1994.

Injury	Cases	% Of All Patients
Open wound of head	5,563	32%
Concussion	2,290	13%
Contusion of lower limb	2,082	12%
Contusion of trunk	2,048	12%
Sprains and strains	1,037	6%
Other superficial injury	969	5%
Contusion of face	940	5%
Open wound of knee, leg and ankle	913	5%
Superficial injury of face	885	5%
Superficial injury of hip, thigh, leg and ankle	721	4%

The linear regression model confirmed that injuries to the trunk of the body tended to be the most costly. Controlling for the age and sex of the patient, the regression indicated that average hospital charges were approximately $7,600 greater if an injury to the trunk of the body was sustained and about $5,000 greater if the patient suffered a head injury. Average hospital charges were approximately $3,900 greater if an injury was incurred to the lower limbs and about $3,000 lower if the injury was to the upper limbs.

Hospital Charges by Type of Ambulance Transport

Among the 6,078 hospital discharge records that linked to a crash record, more than a third were also linked to an emergency medical service "trip ticket." Of the 2,076 hospital patients for whom an EMS record was identified, 309 were transported by helicopter ambulance.

The average hospital charge for those patients who were transported by ground ambulance was approximately $18,000. The average charge for those transported by helicopter was approximately $28,240.

Hospital Charges by County of Hospital

An analysis of the hospital discharge data indicated wide variability in average hospital charges for motor vehicle crash victims by the county of patient residence and the county of the hospital location. The highest average charges tended to be in the large urban counties around Pittsburgh and Philadelphia and in those counties in which large tertiary care hospitals were located. These higher charges probably reflect the higher cost of medical care in areas where there is a large concentration of specialized care and the fact that many of the most severely injured are often transferred to tertiary care facilities in these areas (see appendix III).

Discussion

The research described in this paper indicates that hospital charges for care rendered to victims of motor vehicle crashes vary significantly across demographic characteristics, crash characteristics and circumstances, type of injury, and payer for care.

While motor vehicle crash victims comprise less than 1% of all hospital discharges, they incur more than 1.5% of all hospital charges. Reductions of the number of hospitalizations due to motor vehicle crashes can result in considerable economic savings to insurers, providers, and ultimately to the motoring public.

An interesting feature of the payer information is the much higher average charges for Medicare and Medicaid patients. Some of these higher charges may be accounted for by differences in the patient populations. Medicare patients are mostly elderly, and thus can be expected to have more complicating co-morbid conditions, and may be more vulnerable to injury. The Medicaid population, which represents low-income individuals and families, in a similar manner may have poorer health in general associated with low income and thus incur higher average hospital charges. Another possibility is that these differences in average charges may be related to hospital billing practices. An analysis of the co-morbidity and secondary procedures performed upon hospitalized crash victims revealed that on average, all hospitalized crash victims had 3.8 secondary diagnoses and 1.2 secondary procedures performed while hospitalized. Medicare patients had on average slightly more secondary diagnoses than other patients (Medicare patients had an average of 4.0 secondary diagnoses) but actually had slightly lower average number of procedures performed. The Medicaid patients had the same average number of secondary diagnoses, as did the entire population of crash victims, but slightly more (1.4) secondary procedures performed.

The data also indicated that many crash victims have multiple risk factors for incurring higher charges. For example, males, alcohol users, non-belt users, drivers, and motorcyclists on average all incurred higher hospital charges. However, many more males were also alcohol-users, non-users of seat belts, and motorcyclists. In fact, less than 40% of males were using seat belts while about 60% of females used belts. About 15% of males were reported by police to be under the influence of alcohol while only about 4% of females were reported to be using alcohol. About 75% of alcohol users were not using seat belts, and about 95% of all motorcyclists were males.

Using the information developed in this study, payers for care, and those concerned with public health and safety should consider interventions that might target specific demographic groups, types of driving behaviors, or segments of the motoring public. For example, as the analysis of hospital charges by age and sex indicates, young males and the elderly represent high-risk groups. The elderly seem to be particularly at risk for incurring high hospital charges but represent only a small proportion of all crash victims. Young males, on the other hand, are less at risk for incurring high charges but much more likely to be involved in crashes that may result in hospitalization.

Using the information developed in this research it is possible to draw a risk profile for hospital charges. Table 14 summarizes the risk factors related to hospital charges.

Table 14. Summary of Average and Total Hospital Charges for Identified Risk Factors for Hospitalized Crash Victims, Pennsylvania, 1994.

Risk Factor	Average Hospital Charges	Total Hospital Charge
Sex	males somewhat higher than females	males much higher than females
age of crash victim	elderly much higher than non-elderly	elderly much lower than non-elderly
restraint usage	unbelted much higher	unbelted much higher, much more likely to be hospitalized
alcohol involvement	alcohol users somewhat higher	alcohol users much higher and more likely to be hospitalized
Payer	Medicaid much higher	Medicaid much higher
vehicle type	motorcyclists much higher	motorcyclists more likely to be hospitalized but represent a small proportion of all crash victims
seat position	much higher for drivers and front seat passengers	drivers are most likely to be hospitalized
site of injury	injuries to trunk and head	injuries to trunk and head
Ambulance transport	helicopter transport much higher	only a small % of patients arrive via air ambulance

Appendix I

Description of Data

The data used in this analysis was collected by the Pennsylvania Department of Transportation, the Pennsylvania Department of Health, and the Pennsylvania Health Care Cost Containment Council. Data for 1994 from these three sources were linked using probabilistic linkage technology. Each of the three separate databases are briefly described below as well as the linked crash data set that was created.

The Pennsylvania Accident Reporting System (ARS)

All motor vehicle crashes in Pennsylvania in which an individual is injured, a vehicle is towed from the scene or in which $1,000 in property damage has been incurred are reportable by law to the Pennsylvania Department of Transportation (PADOT). Accident reports are completed by the investigating police officer and forwarded to PADOT on paper where they are filtered for logic and validity and then entered into the Accident Reporting System database. The data collected include information in regard to the crash itself (e.g., date, time, location, harmful events, etc.), the vehicles involved (e.g., vehicle type, axles, VIN, body type etc.), the crash victims (e.g., age, sex, injury severity, restraint use, etc.), the crash location (e.g., intersection type, traffic control devices, speed limit, etc.), the sequence of events which occurred during the crash, contributing factors, road attributes, and extended description of the crash.

The 1994 ARS database included information on approximately 134,000 reported crashes and 350,498 crash victims.

EMS Data

The Pennsylvania Department of Health maintains a database of information collected by emergency medical service personnel for every EMS response in the Commonwealth. EMS personnel fill out a machine-readable form for every patient for whom there has been an EMS response. This form (or "trip ticket") includes information on the date and time of dispatch, the emergency interventions rendered, the type and location of the EMS incident, source of injury, injury severity, contributing factors and demographic information about the patient. This information is then forwarded to regional EMS Councils where it is filtered for logic and validity and then entered into a standardized database (EMSCAN). The data from the 16 regional councils are forwarded to the Pennsylvania Department of Health.

The 1994 EMSCAN database included data from 1.39 million EMS responses. Approximately 125,000 of these records indicated that the EMS call was in response to a motor vehicle crash.

Hospital Discharge Data

All Pennsylvania hospitals are required to submit discharge data on a quarterly basis to the Pennsylvania Health Care Cost Containment Council (PHC4). The data submitted include the standard administrative data from the Universal Billing Form 92 (UB 92) as well as severity adjustment information which is abstracted from clinical records. The data collected by PHC4 include information in regard to diagnoses, procedures, charges, length of hospital stay, patient demographic information, discharge status, physician services (i.e. the license numbers of attending, referring and operating physicians) and severity of illness.

The 1994 discharge database included information on approximately 1.8 million hospital discharges. Approximately, 18,900 of these records indicated that a motor vehicle crash was the reason for hospitalization.

The Linked Data Set

The three datasets described above were linked together using probabilistic linkage to create a data set, which is referred to as the CODES '94 database. This database contains a single record for each individual involved in a reported crash in Pennsylvania in 1994. All crash records include all information from the ARS database in regard to individual characteristics, the vehicle in which they were riding (if any), the crash circumstances, the events and crash location information. The records which linked to EMS records include information in regard to the emergency medical interventions rendered, the types and severity of injuries incurred, and contributing and extenuating factors that may have been involved in the patient outcome. Those records that linked to the hospital discharge data set include information in regard to diagnoses, procedures, hospital charges and length of hospital stay, discharge status, and external causes of injury.

The EMS database for 1994 contained records for approximately 1.3 million patients transported by ambulance. Of these 1.3 million records, approximately 132,000 were possibly a response to a motor vehicle crash (either reported as a crash, evidence of an injury, or the incident happening along a highway). Approximately 7,000 of these records linked to one another (i.e., they were responding to the same patient). These EMS records were internally linked leaving a total of approximately 125,000 EMS records. Of the 125,000 EMS potential responses to crashes, approximately 52,000 (42%) records linked to a crash record.

The hospital discharge database included records for approximately 1.8 million hospital discharges in 1994. Approximately 18,900 of these records had External Source of Injury Codes (E-codes) that indicated that a motor vehicle crash was the reason for the hospitalization. Another 111,000 hospital records also included trauma-related diagnostic codes. All primary and secondary diagnostic codes (ICD-9-CM), DRGs, and Major Diagnostic Categories were examined.

Any record which indicated the possibility of trauma was included in the hospital records that were matched to the crash/EMS file. Of the approximately 125,000 hospital discharges, which indicated trauma, about 6,000 high quality linked records were found. Thus for about one third of the estimated 18,500 hospitalized crash victims, a corresponding crash record was found.

About 2,500 of the 6,000 linked hospital records were also linked to an EMS record. The blocking and matching variables that seemed to be most effective in linking the hospital discharge records were age, sex, date of admission, time of admission, location (e.g., did the crash occur in the same county as the hospital), and the receiving facility identification number.

In comparing the crash records that linked with those that did not link, the principal differences between the linked and unlinked records was in those variables thought to be strongly associated with a higher likelihood of injury. For example, a higher portion of those individuals whose crash records linked to either EMS records or hospital discharge records were not wearing safety belts. This difference is belt usage rates between the linked and unlinked records is to be expected, however, as one would normally expect more non-belt users to be injured (and thus link to an EMS or hospital record) than non-belt users.

For those variables which one would not expect to be associated with likelihood of injury (e.g., date of crash, county of crash, insurance status of crash vehicle, license status of crash vehicle driver), the linked and unlinked records have nearly identical frequency distributions.

For those variables thought to have a weaker association with the likelihood of injury (e.g., age of crash victim, type of vehicle), the differences between the linked and unlinked crash records is less pronounced.

In comparing those EMS records which linked to crash records with those EMS records that did not link, the only significant differences between the linked and unlinked EMS records were the unlinked EMS records had a higher proportion of missing data elements such as the date of the crash, and the age and sex of the crash victim.

Appendix II

Description of Dependent

And

Independent Variables

The analyses described in this document were based upon statistical testing of linked crash data. In order to perform the analyses it was necessary to create variables in the data set that described the crash outcomes and the independent factors, which may have contributed to the outcome. These were created by transforming existing data within the linked database to a format appropriate for the particular type of statistical test being applied.

A brief description of key variables and how they were transformed follows.

Independent Factors

Simply examining the hospital charges ignores other factors such as seat belt use, age of the crash victim, or vehicle speed that may have affected the outcome of the crash and the hospital charges related to the crash. In order to control for these other factors, variables describing these possible contributing factors were created. Contingency tables were constructed with these variables and as a series of logistic regression models were performed to examine to what degree other independent factors may account for injury and crash outcome.

Previous research on injury outcomes of crashes indicates that a number of independent factors are related to the outcome of a motor vehicle crash. Among these factors are passenger restraint system usage, vehicle speed, seat position, vehicle size, and the age and sex of the crash victim. Logistic regression is a statistical method used to evaluate the inter-relation of multiple factors (i.e., independent) in contributing to a dichotomous outcome (or dependent) variable. A dichotomous outcome variable is one that can only have one of two possible values such as "killed" or "not killed."

Variables to describe these independent and dependent variables were created in the data set and logistic regressions were then performed using these independent and dependent variables.

The following independent variables were created in the data set.

Restraint Usage

Police reported crash information was examined to determine the types of active and passive restraint systems in place and whether or not these restraint systems were used or deployed for the crash victim. Five categories of restraint usage were established as follows:

1. safety belt only in use
2. safety belt in use and airbag deployed
3. airbag deployed without safety belt
4. no active or passive restraint system in use or deployed
5. unknown passenger restraint system

A series of four dichotomous variables based on this methods of classification were then created in the database as follows:

Variable name	Coding
Beltonly	1=safety belt only in use 0=no restraint system in use missing=other restraint combination
Bagonly	1=airbag only deployed 0=no restraint system in use missing=other restraint combination
Beltnbag	1=safety belt in use and airbag deployed 0=no restraint system in use missing=other restraint combination
Nobelt	1=no active or passive restraint 0=any other combination of active and passive restraint

Age

This independent variable was created from the age as recorded on the police crash report. Additional variables were created to identify those over the age of 65 and those under the age of six. These variables were coded as follows:

Variable Name	Coding
Age	age of crash victim as recorded on police crash report
Over65	1=individual age 65 or older 0=individual under 65 years old
Under6	1=child age 5 or younger 0=individual over the age of 5

Sex

Males represent a disproportionate share of all crash victims and this is reflected in the data for single vehicle fixed object crashes. Approximately 68% of all crash victims were male. A separate variable was created from information on the crash report to indicate whether the crash victim was male or not.

Crash Vehicle Speed

The crash data include data on the speed of the crash vehicle as estimated by the investigating police officer. This variable however was considered by the data-collecting agency to be high unreliable. The speed limit of highway of the crash vehicle was thought to be more reliably collected and probably would serve as a good indication of the speed of the crash vehicle. Speed limits are recorded in five mile per hour increments between 5 and 55 MPH in 1994. Additional variables were also created in the data set to indicate whether the crash occurred on a high-speed highway or not.

The linked EMS data also included a data field that indicated whether or not a speed change of 20 MPH or 40 MPH had occurred. Variables were created in the data set to indicate whether or not the crash had occurred on a high speed road or not and also whether or not a speed change of 20 MPH or 40 MPH had been incurred. The variables were coded as follows:

Variable Name	Coding
splim	speed limit on highway of crash (5 MPH increments)
speed35	1=speed limit 35 MPH or greater 0=speed limit less than 35 MPH
speed45	1=speed limit 45 MPH or greater 0=speed limit less than 45 MPH
speed55	1=speed limit 55 MPH or greater 0=speed limit less than 55 MPH
delta20	1=speed change of 20 MPH or greater 0=no speed change of 20 MPH or greater
delta40	1=speed change of 40 MPH or greater 0=no speed change of 40 MPH or greater

Seat Position

The crash data records information on the seat position of all crash victims. This information was recoded to indicate whether or not the individual was an occupant of the front or back seat, the driver or a passenger and whether or not they were sitting on the same side as the principal point of impact. The following variables were created in the data:

Variable Name	Coding
driver	1=driver 0=not driver
fseat	1=front seat occupant or driver 0=not front seat occupant or driver
bseat	1=back seat occupant 0=not back seat occupant
sameside	1=occupant of same side of vehicle as impact point 0=not on same side as impact point
oppside	1=occupant on opposite side of vehicle as impact point 0=not on opposite side of impact point

Crash Outcomes

A number of variables were created in the data set to describe the outcomes of the crash in terms of injury or death to the crash victim or damage to the crash vehicle. Data from the police crash report as well as from the linked EMS and hospital data were used to create this outcome descriptor. These outcome variables are described below.

Killed
This variable was created by examining police reports of injury severity as well as EMS data and hospital discharge data. This variable was coded as follows:

1=Killed
0=Not Killed

Major Injury or Worse
This variable was created by examining police reports of injury severity as well as EMS data. If police reported injury was either killed or major injury or if the EMS data reported the injuries to be "life-threatening" or if hospital discharge status indicated that the patient died, then this variable was coded as a "1." Otherwise it was coded as a "0."

Hospital Charges
The hospital discharge data include information on total hospital charges. This field was used as a proxy measure of injury severity. In these analyses, all observations for individuals who died were excluded from the analysis. In addition, those observations that were more than one standard deviation greater or less than average hospital charges were excluded to control for outlier charges.

Appendix III

Average Hospital Charges by County of Hospital

county	average hospital charge by county of hospital	county	average hospital charge by county of hospital
ADAMS	$6,082	LACKAWANNA	$10,739
ALLEGHENY	$17,742	LANCASTER	$10,235
ARMSTRONG	$6,567	LAWRENCE	$5,006
BEAVER	$15,348	LEBANON	$7,373
BEDFORD	$4,221	LEHIGH	$22,285
BERKS	$8,508	LUZERNE	$11,551
BLAIR	$6,429	LYCOMING	$5,172
BRADFORD	$12,448	MCKEAN	$6,113
BUCKS	$17,505	MERCER	$6,821
BUTLER	$10,103	MIFFLIN	$3,040
CAMBRIA	$20,302	MONROE	$6,414
CAMERON		MONTGOMERY	$17,174
CARBON	$11,132	MONTOUR	$26,196
CENTRE	$9,871	NORTHAMPTON	$12,341
CHESTER	$13,249	NORTHUMBERLAND	$5,349
CLARION	$3,977	PERRY	
CLEARFIELD	$5,876	PHILADELPHIA	$29,729
CLINTON	$3,952	PIKE	$8,762
COLUMBIA	$22,121	POTTER	$5,029
CRAWFORD	$7,304	SCHUYLKILL	$6,331
CUMBERLAND	$14,396	SNYDER	
DAUPHIN	$17,431	SOMERSET	$2,630
DELAWARE	$23,891	SULLIVAN	
ELK	$5,383	SUSQUEHANNA	$4,379
ERIE	$16,288	TIOGA	$9,668
FAYETTE	$7,200	UNION	$3,202
FOREST		VENANGO	$4,109
FRANKLIN	$7,668	WARREN	$21,364
FULTON	$1,611	WASHINGTON	$9,650
GREENE	$4,969	WAYNE	$8,142
HUNTINGDON	$7,834	WESTMORELAND	$21,437
INDIANA	$7,598	WYOMING	$6,135
JEFFERSON	$2,266	YORK	$15,940
JUNIATA			