Using CODES Linked Data to Evaluate Motorcycle Crashes in Maine

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Abstract

Using a database of police crash reports linked to statewide medical data, injury outcomes for Maine motorcycle drivers were evaluated for 1995 and 1996. The study consisted of 806 motorcyclists involved in crashes.

Young drivers had significantly higher rates of involvement and injury than older drivers. Excessive speed, inexperience, and alcohol, contributed to motorcyclist-only crashes while the other motorist failure to yield or making a left turn contributed to multi-vehicle crashes.

Based on the linked data, of the 806 Maine licensed motorcyclists involved in crashes, 326 required EMS (Emergency Medical Service) transport, were hospitalized or died. Riders who were not wearing a helmet were 3 times more likely to have a head injury requiring EMS transport, hospitalization, or resulting in death than motorcyclists wearing a helmet.

Introduction

The purpose of this study was to provide information on motorcycle crashes in Maine using a linked database.

The Crash Outcome Data Evaluation System (CODES) evolved from a congressional mandate through which the National Highway Traffic Safety Administration funded states to link statewide police crash data to medical injury data bases[1,2]. Maine has linked police crash records to statewide EMS (Emergency Medical Service), hospital inpatient, and death certificate records in order to identify the medical and financial outcomes from motor vehicle crashes.

The National Highway Traffic Safety Administration (NHTSA) reports that during 1998, 2,284 motorcyclists were killed and an additional 49,000 were injured in traffic crashes in the United States[3]. Using management reports developed by the Maine CODES project, we identified that the burden of injury and cost for motorcyclists in Maine was significant. For example, during 1996 motorcyclists in Maine crashes accounted for less than 1% of the persons involved in crashes but contributed 11% to total motor vehicle crash-related hospital inpatient charges[4].

Maine has a population of 1.2 million, 870,000 licensed drivers, and 27,000 registered motorcycles.

Methods

The Maine CODES linked data base for 1995 and 1996 was utilized for this analysis. Source data included the State of Maine Traffic Accident Reports. Police are required to complete a report for any crash with more than $500 combined damage or personal injury or death. These reports contain driver information and crash characteristics for over 90,000 persons (drivers and occupants) involved in crashes each year in Maine.

Other source files included computerized EMS records, hospital inpatient discharge records, and death certificate records. The medical databases were all statewide data collected by state agencies and contain detailed medical information on the types of injuries and treatments provided to those injured. The medical records were linked to the person level data from the police crash reports using software provided to all CODES states by NHTSA. Combined, the medical information provide a more detailed picture of the nature and severity of injuries than the police are trained to evaluate.

To improve statistical validity 1995 and 1996 linked data were combined for this study. A total of 1,094 motorcycle riders in crashes were available for analysis. We removed 133 riders that were not Maine licensed, 113 riders who were passengers on the motorcycle, and 42 with invalid or missing data. After these exclusions the resulting study population was 806 Maine licensed motorcycle drivers. No significant differences were found between the riders studied and those excluded.

We evaluated a number of independent variables in our analysis. These included demographic (motorcyclist age and gender), crash type, location, time of day, speed limit, motorcycle driver's behavior (helmet use, inexperience, alcohol, speeding), and for multi-vehicle crashes the behavior of the other motorist (failure to yield and making a left turn). We considered including driver licensing status. Of the 806 riders, police reported no license (1%), permit (2%), suspended (5%), motorcycle endorsement (63%). Since we could not validate if the remaining 29 percent did not have a motorcycle endorsement or the field was not completed by the police, we did not evaluate license status further. No data was available to evaluate type of motorcycle helmet used (e.g. DOT/Snell approved).

Four injury outcome measures were used in the analysis:

1. INJURED = Police reported fatal, incapacitating, non-incapacitating injury OR linked to any medical record.
2. EMSALL = Any EMS transport to a hospital, hospitalized or died.
3. EMSHEAD = EMS transport to a hospital, hospitalized or died AND had a medical record indicating a head injury.
4. BRAIN = Persons hospitalized or died with an ICD-9 (International Classification of Disease-9th edition) code 800.1-801.99, 803.1-804.99, 850.2-850.89, 851.0-854.99.

The analysis consisted of simple bivariate tables for the variables of interest and calculation of odds ratios (OR) and 95 percent confidence (CI) intervals for the outcome measures. Multivariate techniques to control for other crash variables were also used - logistic regression

is the method of choice when assessing a dichotomous outcome measure (injured vs. not injured), a variable of interest (e.g. helmet use), and the other factors that may influence the relationship between the outcome and the variable of interest[5].

Results

The study included 806 Maine licensed motorcyclist drivers involved in crashes on Maine roads during 1995 and 1996. Of these 575 were injured, 326 required EMS transport to a hospital, were hospitalized or died. Of the 326, 94 had a head injury and 25 died. The total years of potential life lost for the 25 who died was 1,122. For those linked to a hospital inpatient record, the hospital's inpatient charges totaled $2.8 million.

The rate of injury was 104.2 per 10,000 Maine registered motorcyclists (Table 1). The highest rates were for youngest riders age 19 and under (825.5) and age 20-24 (400.8). The lowest rate was for age 55-59 (31.6). While riders age 24 and under accounted for 8 percent of the registered motorcyclists, they represented 33 percent of the motorcyclists transported by EMS, hospitalized or dying in motorcycle crashes and 44 percent of the inpatient hospital charges.

Over 17 percent of the motorcyclists were speeding and the police reported rider inexperience in 8 percent of crashes (Table 2). Alcohol was a factor in almost 10 percent of crashes and 51 percent were not wearing a helmet according to police. Rates of speeding were highest for riders age 19 and under (28%) and declined with increasing age. Inexperience was also highest in riders age 19 and under (17%). Alcohol use was highest for middle-aged riders, age 35-39 (20%) and lowest for riders age 19 and under (2%). Middle-aged riders between 25-39 were also more likely to not wear a helmet. Riders age 30-34 were most likely to not be wearing a helmet (67%) and riders age 19 and under were least likely to not wear a helmet (34%) according to the police crash reports. Of the 78 riders with alcohol reported, 60 (77%) were not wearing a helmet.

Table 3 provides additional information on the characteristics of motorcyclists involved in Maine crashes. Forty-five percent of these crashes took place on rural roads and the likelihood of injury was higher in the rural crashes.

Collisions with another vehicle accounted for 449 (56%) of the crashes while 357 (44%) were motorcyclist-only crashes. For multi-vehicle crashes, 321 took place at an intersection or driveway while a curved road was the location for 149 of the motorcycle only crashes. The behavior of the other driver in multi-vehicle crashes was evaluated - 131 (16%) of the crashes involved the other motorist making a left turn and failure to yield by the other motorist was a factor in 93 (12%). The likelihood of injury was higher in motorcyclist-only crashes on a curve. Higher speed also increased the likelihood of injury – 306 (38%) of the riders were traveling on roads with speed limits of 40 mph or more and they accounted for 154 (47%) of those transported by EMS, hospitalized, or dying.

Behavioral differences were found between multi-vehicle and motorcyclist-only crashes. Of the 78 crashes where the motorcyclist

use of alcohol was a factor, 61 (78%) were motorcyclist-only. Of the 140 crashes where the motorcyclist was speeding, 107 (76%) were motorcyclist-only. Of the 65 crashes where police reported driver inexperience, 54 (83%) were motorcyclist-only.

In rural areas, collisions with animals are often a problem. In this data set 44 riders collided with an animal – accounting for 12 percent of the motorcycle-only crashes. However, the risk of EMS transport, hospitalization, or death was actually lower than for the other motorcyclist crashes. Thirty-eight riders hit a tree or utility pole which increased the risk of injury.

Results of a study of helmet use and injury outcomes are presented in Tables 4-6. Using any injury as the outcome measure the effect of no helmet increased the risk by 27 percent (OR=1.273, 95% CI=0.937,1,729) and was not statistically significant (Table 4). However, when EMS transport, hospitalization or death with a head injury (OR=3.037, 95% CI=1.878,4.911) or hospitalization or death with a brain injury (OR=5.406, 95% CI=2.376, 12.297) were used as the outcome measure results were highly significant.

The multivariate analysis (Table 5) controlling for other variables yielded a similar result for the effect of helmet use on head injury (OR=3.406, 95% CI=1.994, 5.819). Other variables with statistical significance in this model included increasing speed limit, speeding, hitting a tree or utility pole, and motorcyclist gender (only 39 of the drivers were female and they had a higher risk of injury).

The multivariate analysis was also run for the other outcome measures (data not shown). When any injury was used as the dependent variable alcohol (OR=5.464), rider inexperience (OR=3.040), speeding (OR=2.021), other driver making left turn (OR=2.013), curved road (OR=1.882), and a 10 mph increase in speed limit (OR=1.283) were statistically significant. When hospitalization or death with a brain injury was used as a dependent variable, the reported effect of no helmet was slightly higher than that reported in the bivariate analysis (OR=6.364).

Of the 806 study motorcycle drivers, 118 were admitted to the hospital and incurred $2.8 million in hospital charges (Table 6). The average charge for those with a head injury ($28,242) was higher than for those without ($20,401). For the 47 with a head injury, those without a helmet had higher average length of stay (9.3 days vs. 4.2 days) and charges ($33,443 vs. $14,639) than those with helmet. Thirty of those hospitalized had no insurance, 20 with a public payer (Medicaid or Medicare), and 68 with commercial, Blue Cross, HMO or other insurance.

Discussion

Using a data base of police crash reports linked to statewide medical data sources (CODES), the medical outcomes for Maine motorcyclists involved in crashes during 1995 and 1996 were assessed.

During crashes Maine motorcyclists were vulnerable to injury – their likelihood of injury was similar to that of pedestrians and bicyclists involved in Maine motor vehicle crashes[4].

Our population-based rates demonstrate that a motorcyclist's age is a key factor in determining involvement in crashes – riders age 24 and under accounted for one third of those transported by EMS, hospitalized or died. Speed and inexperience were more likely to be factors for the younger riders while alcohol and failure to use a helmet had higher rates in middle-aged riders.

Fifty-six percent of crashes involved another vehicle – the other driver making a left turn or failing to yield were the most common contributing factors in these crashes. When another vehicle was not involved, crashes were more likely to take place on rural, curved roads and involve alcohol use, speeding, or inexperience on the part of the rider.

Although Maine has not conducted a formal observation study of helmet use, the repeal of Maine's helmet law in 1967 makes it likely that a significant proportion of riders were not wearing helmets. This enhances the ability to statistically evaluate the differential impact of helmet use on injury outcomes in a crash. Our assessment of head and brain injury indicated a significant effect. Riders without helmets were 3 times more likely to be transported by EMS, hospitalized or die with a head injury and were more than 5 times more likely to be hospitalized or die with a brain injury. Hospital charges were higher for those with head injuries and also higher for those with a head injury and not wearing a helmet.

There are some limitations to the results reported here. Since some medical records cannot be linked due to the limitations of the data itself, the medical records used here will underestimate the true injury burden. The hospital inpatient data consisted of inpatient hospital bills only and thus the charge information reported here also underestimates the total medical costs. It is possible that the reporting of helmet use overestimates the actual use rates during crashes. If those not injured were more likely to report helmet use when they actually were not using a helmet, then the effect of this would be to overestimate the true benefit from helmets. Since no observational study was available, this could not be adjusted for.

Our analysis of Maine CODES data indicate that motorcyclist were at high risk for injury resulting in EMS transport, hospitalization, or death. Young riders were more likely to be involved in a crash than older riders. In motorcyclist-only crashes, alcohol, speeding, and inexperience were all factors and most often occurred in rural areas at a curve in the road. In multi-vehicle crashes, the other driver making a left turn was an important factor. Head and brain injuries account for a large proportion of the most serious and costly of the injuries sustained and helmets reduced the likelihood and cost of these injuries.

References

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Table 1
Age and Driver and Injury Outcomes
Maine Motorcyclists in 1995 and 1996 Crashes

Driver Age	1995 and 1996 Drivers Involved*	Registered Motorcycles	Injured**	Annual Injury Rate***	EMS Transported, Hospitalized or Died
19 and under	97	424	70	825.5	40
20-24	214	1,809	145	400.8	68
25-29	111	2,539	75	147.7	42
30-34	89	3,367	69	102.5	42
35-39	75	4,409	57	64.6	32
40-44	64	4,605	42	45.6	26
45-49	72	3,700	54	73.0	41
50-54	26	3,048	23	37.7	14
55-59	20	1,581	10	31.6	3
60-64	14	955	9	47.1	6
65-69	12	559	11	98.4	6
70 and over	12	601	10	83.2	6
Total	806	27,597	575	104.2	326

* Excludes 133 non-Maine drivers, 113 motorcycle passengers, and 42 drivers excluded from the study due to missing or invalid data.
** Police Reported Death, Incapacitating, Non-Incapacitating or Linked to an EMS, hospital inpatient, or death certificate record.
*** Annual rate per 10,000 registered Maine motorcycles.

Table 2
Age and Driver Behavior
Maine Motorcyclists in 1995 and 1996 Crashes

Driver Age	Drivers Involved	Speeding %	Inexperience %	Alcohol %	No Helmet %
19 and under	97	27.8	16.5	2.1	34.0
20-24	214	20.6	9.8	7.5	45.8
25-29	111	19.8	7.2	10.8	46.9
30-34	89	19.1	6.7	16.9	67.4
35-39	75	10.7	6.7	20.0	65.3
40-44	64	10.9	3.1	6.3	60.9
45-49	72	8.3	4.2	8.3	54.2
50-54	26	15.4	3.9	7.7	42.3
55-59	20	0.0	10.0	5.0	55.0
60-64	14	14.3	7.1	7.1	28.6
65-69	12	8.3	0.0	8.3	33.3
70 and over	12	16.7	0.0	25.0	66.7
Total	806	17.4	8.1	9.7	50.6

Table 3
Crash Type and Driver Behavior
Maine Motorcyclists in 1995 and 1996 Crashes

Study Characteristic	Motorcyclists Involved (% of Total)	EMS Transported, Hospitalized or Died (% of Total)
Totals	806 (100%)	326 (100%)
Location		
Urban area	441 (54.7%)	149 (45.7%)
Rural area	365 (45.3%)	177 (54.3%)
Type of Crash		
Motorcyclist-Only, Straight Road	115 (14.3%)	52 (16.0%)
Motorcyclist-Only, Curved Road	149 (18.5%)	87 (26.7%)
Motorcyclist-Only, Intersection*	93 (11.5%)	32 (9.8%)
Multi-vehicle, Straight Road	95 (11.8%)	29 (8.9%)
Multi-vehicle, Curved Road	33 (4.1%)	17 (5.2%)
Multi-vehicle, Intersection*	321 (39.8%)	109 (33.4%)
Speed Limit		
Missing or invalid	33 (4.1%)	15 (4.6%)
20-35 miles per hour	467 (57.9%)	157 (48.2%)
40-45 miles per hour	218 (27.0%)	110 (33.7%)
50-65 miles per hour	88 (10.9%)	44 (13.5%)
Time of Day		
4 AM to 11:59 PM	126 (15.6%)	52 (16.0%)
12 PM to 7:59 PM	530 (65.8%)	204 (62.6%)
8 PM to 3:59 AM	150 (18.6%)	44 (21.5%)
Other Driver Behavior **		
Making Left Turn	131 (16.3%)	57 (17.5%)
Failed to Yield	93 (11.5%)	35 (10.7%)
Motorcyclist Behavior **		
Alcohol	78 (9.7%)	55 (16.9%)
Speeding	140 (17.4%)	81 (24.8%)
Inexperience	65 (8.1%)	35 (10.7%)
Motorcyclist Helmet		
Used	398 (49.4%)	146 (44.8%)
Not Used	408 (50.6%)	180 (55.2%)

* Intersection includes driveways.
** Sub-categories are not mutually exclusive.

Table 4
Helmet Use and Injury Outcomes
Maine Motorcyclists in 1995 and 1996 Crashes
(N=806)

Injury Outcome Level	Number with Outcome	Odds Ratio of Outcome without Helmet Use (95% confidence intervals)
INJURED: Police reported fatal, incapacitating, non-incapacitating injury OR linked to any medical record	575	1.273 (0.937, 1.729)
EMSALL: Any EMS transport, hospitalization or death for any type of injury	326	1.363 (1.027, 1.807)
EMSHEAD: EMS transport, hospitalization or death with a head injury indicated in the medical record	94	3.037 (1.878, 4.911)
BRAIN: Hospitalized or died with a brain injury indicated in the medical record	43	5.406 (2.376, 12.297)

Table 5
Results of Multivariate Logistic Regression Model: Dependent Variable is EMS Transport, Hospitalization, or Death with a Head Injury
Maine Motorcyclists in 1995 and 1996 Crashes

Variable	Odds Ratio (95% confidence intervals)	p-value
Intercept		0.0001
Rural	1.218 (0.664, 2.236)	0.5242
Multi-Vehicle	0.726 (0.381, 1.383)	0.3296
Intersection	1.445 (0.764, 2.732)	0.2571
Curved Road	1.535 (0.788, 2.991)	0.2076
Speed Limit *	1.398 (1.040, 1.879)	0.0262
Night (8PM to 3:59 AM)	0.763 (0.397, 1.464)	0.4151
Hit Tree or Utility Pole	3.063 (1.325, 7.081)	0.0088
Other Driver Failed to Yield	0.521 (0.182, 1.492)	0.2244
Other Driver Made Left Turn	1.428 (0.640, 3.186)	0.3845
Motorcyclist Age **	1.158 (0.966, 1.389)	0.1128
Motorcyclist Gender (Male)	0.404 (0.163, 0.999)	0.0497
Motorcyclist – Alcohol	1.440 (0.701, 2.958)	0.3201
Motorcyclist – Speeding	2.179 (1.182, 4.016)	0.0125
Motorcyclist - Inexperience	1.301 (0.519, 3.264)	0.5751
No Helmet	3.406 (1.994, 5.819)	0.0001

Hosmer and Lemeshow Goodness of Fit Test Statistic = 10.713 with 8 DF (p=0.2185)

* The odds ratio for speed limit was converted to an odds per 10 mile increase in speed limit.
** The odds ratio for motorcyclist's age was converted to an odds per 10 year increase in age.

Table 6
Hospital's Inpatient Charges by Payer, Head Injury, and Helmet Use
Maine Motorcyclists in 1995 and 1996 Crashes

	Motorcyclists Hospitalized	Hospital's Inpatient Charges*	Average Charge
Total	118	$2,775,809	$23,524
Public (Medicare/Medicaid)	20	$464,103	$23,205
No Insurance	30	$766,566	$25,552
Commercial, HMO, Blue Cross	68	$1,545,140	$22,722
No Head Injury	71	$1,448,453	$20,401
Head Injury	47	$1,327,356	$28,242
With Helmet	13	$190,306	$14,639
Without Helmet	34	$1,137,050	$33,443

* Hospital inpatient charges are limited to the hospital's bill for an inpatient admission. They do not include physician professional fees or any medical costs occurring in the outpatient setting associated with the rider's injuries.