

Evaluation of the Repeal of the All-Rider Motorcycle Helmet Law in Florida

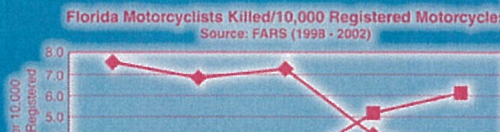
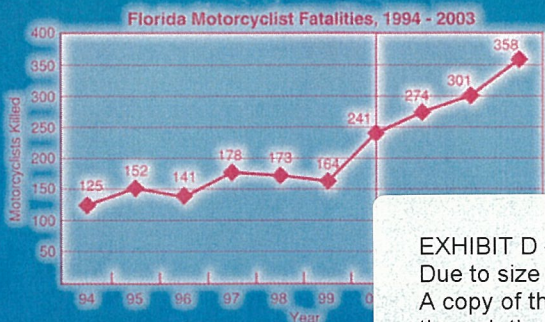
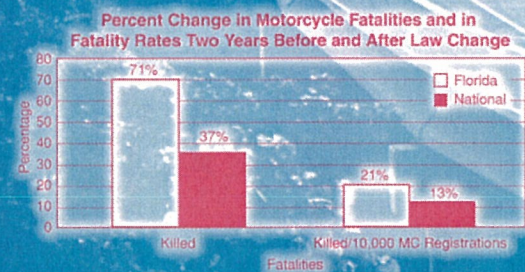


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16. Abstract Effective July 1, 2000, Florida eliminated the legal requirement that all motorcycle riders wear helmets. State law now requires helmet use only by riders under the age of 21, or older riders who do not carry at least \$10,000 of medical insurance. Observational surveys and crash reports indicated that helmet use dropped substantially following the law change. Motorcyclist fatalities increased by 81 percent comparing 2001-2003 to 1997-1999, compared to +48 percent nationally. Non-fatal serious injuries began increasing in the first six months of 2000, increased by 32 percent in the first year following law repeal. There was a 40 percent increase in the number of injured motorcyclists who were admitted to hospitals. Admissions for head injuries increased by 82 percent. The average head injury treatment cost increased by almost \$10,000, to \$45,602. In 1998 and 1999, the acute care hospital charges for head-brain-skull principal injury cases per 10,000 registered motorcycles were \$311,549 and \$428,347 respectively. The comparable figures for 2001 and 2002 were \$605,854 and \$610,386, adjusted for inflation. Time series analysis showed a statistically significant increase in fatalities while controlling for changes in motorcycle registrations. Similar analyses also showed significant increases for Kentucky, Louisiana and Texas. Florida crash reports also indicated that helmet use declined markedly among riders under age 21, who were still covered by the law. Fatalities in this age group nearly tripled in the three years after the law change. Comparing the 30 months before and after the law change, there was an increase of 55 percent in the average annual number of motorcyclists killed (181 to 280, respectively). Registrations increased an average 33.7 percent in this time period. Some of the increases in fatalities and other injuries in Florida were probably due to this increased ridership. The expected number of motorcycle fatalities as a result of the increase in registrations was 242. The actual number who died in 2002 was 301, 56 (+24 percent) more motorcycle fatalities than expected as a result of increased registrations alone. Nationally in 2001 and 2002, motorcycle miles of travel declined compared to earlier years. Given the large registration increase in Florida, it is unlikely that this national pattern held in the State.					
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On July 1, 2000, Florida repealed the legal requirement that all motorcyclists wear protective helmets. Instead, state law now requires helmet use only by riders under the age of 21, or by older riders who do not have a minimum of \$10,000 medical insurance coverage

The Florida Motorcycle Helmet Law Change

Helmet Use -- Observational Surveys

A Florida helmet use observation survey carried out in 1998 before the helmet law change showed that virtually all observed riders were wearing helmets. However, only 59 percent of the observed sample wore compliant helmets (headgear that meets FMVSS No. 218) while 40 percent were wearing noncompliant helmets (headgear that does not meet FMVSS No. 218). These figures compare to 84 percent compliant and 15 percent noncompliant observed in a 1993 survey suggesting that noncompliant helmet use was increasing over time. Following weighting, the 1998 survey results yielded estimated statewide helmet use of 65 percent compliant helmets and 35 percent noncompliant helmets.

A post law change survey, done in 2002, found 47 percent compliant helmet use, 6 percent noncompliant helmet use and 47 percent no helmet use. These results indicate that use of compliant helmets has declined following the law change, while wearing noncompliant helmets has largely been abandoned.

Helmet Use -- Crash Reports

Among the 515 motorcyclists killed in Florida in traffic crashes in the three years prior to the helmet law change (1997-1999), 9 percent were recorded in FARS as not wearing a helmet. In the three years following the law change (2001-2003), 61 percent of the 933 fatally injured motorcyclists were reported being unhelmeted. In 1997-1999, there were 35 motorcyclists under the age of 21 killed in Florida. Of these, 26 percent

were not helmeted. In 2001-2003, 101 motorcyclists under age 21 were killed, with 45 percent of them being unhelmeted.

Excluding cases where helmet use was not recorded (less than 7 percent of the cases), 27 percent of all motorcyclists involved in crashes in 1999, of all degrees of severity, were recorded in the Florida crash database as being unhelmeted. In 2001, the figure was 51 percent. Among motorcyclists who sustained incapacitating injury, 21 percent of those involved in 1999 crashes were unhelmeted while 50 percent of those involved in year 2001 crashes were not wearing helmets.

Among riders under the age of 21, 40 percent of those involved in crashes in 1999 were unhelmeted. In 2001, the figure was 49 percent. For those sustaining incapacitating injury, 35 percent of those in 1999 crashes were not helmeted, while in 2001 49 percent were not helmeted.

Motorcyclist Fatalities

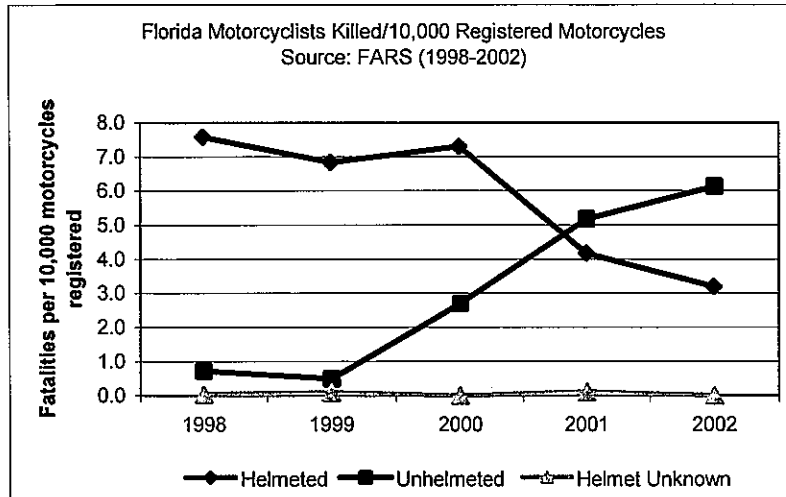
While Florida's all-rider helmet law was repealed in July 2000, there was a substantial increase in motorcyclists killed in Florida beginning in the first 6 months of the year, before the effective date of the law. Fatalities in the two years following the law change (2001-2002, N=575) were 71 percent greater than the 337 fatalities that occurred in 1998-1999, compared to an increase of 37 percent for the nation as a whole (4,560 to 6,227). Fatalities in Florida per 10,000 registered motorcycles increased 21 percent compared to 13 percent nationally for the two years before and after the law change. There was an annual average of 181 motorcyclists killed in Florida in the 30 months before the law change, and an annual average of 280 in the 30 months after the law change; a 55 percent increase. Registrations increased an average 33.7 percent (219,486 to 293,393) in this time period.

The expected average annual number of motorcycle fatalities as a result of the increase in registrations was 242 ($181 \times 1.337 = 242$). The actual number who died was 301 in 2002, 59 more motorcycle fatalities than expected as a result of increased registrations alone (a 24 percent increase).

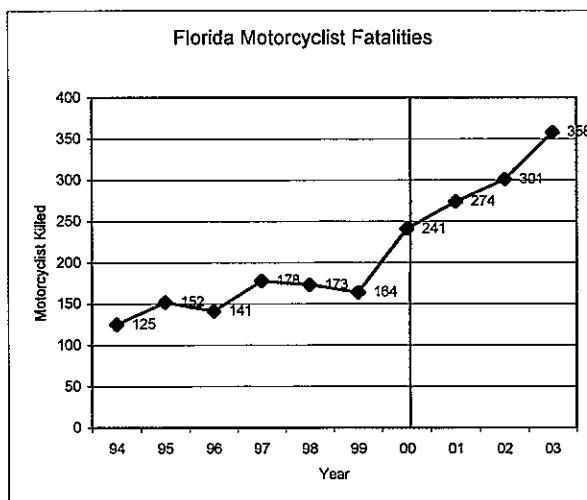
Motorcyclist fatalities in Florida have continued to increase. In the three years after the law change (2001-2003), 933 motorcyclists were killed, 81 percent more than the 515 motorcyclists who were killed in 1997-1999. The actual number who died in 2003 was 358.

While the reduction in helmet use observed after the law was repealed would be expected to result in more non-helmeted fatalities, the actual increase was above what would be expected based solely on the decrease in helmet use. Non-helmeted motorcyclists who were killed in Florida increased from 15 (9 percent) in 1998, when observed helmet use was close to 100 percent, to 198 (66 percent) of the total motorcycle fatalities in 2002, an increase of over thirteen times. When the increase in motorcycle registrations after the law was changed is taken into account, the non-helmeted fatality

rate per 10,000 registered motorcycles increased from 0.7 fatalities in 1998 to 6.1 in 2002. Helmeted motorcyclist fatalities, on the other hand, fell from 7.6 per 10,000 registered motorcycles in 1998 to 3.2 in 2002.



Autoregressive Integrated Moving Average (ARIMA) models were used to examine the relationship between the change in Florida's motorcycle helmet law and motorcyclist fatalities. The date of the law change was used as an intervention point in the time series. Data on motorcyclist fatalities in Georgia were employed as a comparison. Georgia was selected based on proximity to Florida and the fact that it had an all-rider helmet law in effect for the entire time period.



Monthly fatalities in Florida and Georgia, before and after the intervention point (July 2000), were modeled in the presence of the annual number of motorcycle registrations in each State. This was done to control for the extent to which changes in fatalities were associated with changes in motorcycle registrations.

The Florida intervention was statistically significant such that there was an average 9.1 increase in the number of monthly

motorcyclist fatalities following the law change ($p < .001$). The specified final ARIMA parameters were also significant. There was no statistically significant change in the fatality rate following the same intervention date for Georgia. Change in annual motorcycle registrations was not a statistically significant parameter in the final time series model. At the time of this analysis, motorcycle registration data were available

through the year 2002, making December 2002 the last point in the time series examined. In 2003, 358 motorcyclists were killed in Florida suggesting that the upward trend has continued.

Based on the available evidence the increase in motorcycle fatalities that occurred after the Florida motorcycle helmet law was repealed is due in part to the reduced use of helmets. Our analysis shows that is the case despite the pre-existing trend of increasing fatalities, the increase in fatalities associated with increased exposure (measured by registrations), the increase in fatalities that occurred in the first six months of 2000 (before the helmet law repeal became effective), and of a demographic shift in motorcycle ridership.

Motorcyclist Injuries

The Florida Department of Highway Safety and Motor Vehicles produces an annual database of information taken from police motor vehicle crash reports. The following table shows the number of statewide crashes involving motorcyclists, the number of seriously injured motorcyclists (A-injury), the number of motorcyclists sustaining lesser injuries (B & C injuries), and the injury rate per 10,000 registered motorcycles.

All Motorcycle Crashes and Non-Fatal Injuries, 1994-2001

Year	Crashes Involving Motorcycles	Motorcyclists A Injuries	Motorcyclist B&C Injuries	Injuries per 10,000 Registered Motorcycles
1994	5,055	1,507	3,488	281.6
1995	4,887	1,487	3,257	257.1
1996	4,829	1,479	3,442	259.6
1997	4,712	1,432	3,050	230.0
1998	4,536	1,406	2,951	210.1
1999	4,662	1,428	3,037	202.1
2000	5,334	1,576	3,487	210.2
2001	6,069	1,890	3,886	199.3

A-Incapacitating Injury, B-Evident Injury, C-Possible Injury

In the first full year following the law change (2001), there were 1,890 motorcyclists who sustained incapacitating injury and 3,886 who sustained lesser injury. These figures are 32 percent and 28 percent higher, respectively, than the comparable figures in 1999, but less when the increase in registrations is taken into account. Injuries per 10,000 registered motorcycles increased in 2000, but decreased in 2001. Some of the motorcyclists coded "C—Possible Injury" by the police officer may not have sought medical treatment. Although the injury rate per registered motorcycle in 2001 is less than

the rate in 1999, the previous downward trend of non-fatal injuries per registered motorcycle appears to have slowed following the law change period.

Hospital Discharge Data

The Hospital Discharge database maintained by the Florida Agency for Health Care Administration shows that in the 30 months immediately following the helmet law change, there were 4,986 motorcyclists admitted to hospitals for treatment, a figure 40 percent greater than the 3,567 admissions during the 30 months just before the law change. Head injury admissions increased by more than 80 percent.

Total gross costs charged to hospital admitted motorcyclists with head, brain or skull injury more than doubled from \$21 million to \$50 million; the average case cost rose by almost \$10,000; the median patient cost increased by almost \$4,000; and the range of costs also increased. Adjusted for inflation, total acute care hospital costs rose from \$21 million to \$44 million and the average cost per case rose from \$34,518 to \$39,877 in the 30 months after the law change. In the post law change period, 25 percent of the head, brain, skull injured admitted motorcyclists were charged approximately \$12,000 or less, while the remaining 75 percent of patients were charged more than this amount. That is, less than one-quarter of the injured would be covered by the \$10,000 medical insurance requirement for those who chose not to use helmets. The hospital discharge data indicate that in the post law change period, approximately 63 percent of admitted motorcyclists were covered by commercial insurance (\$31 million), 16 percent were classified as “self pay” because they were under insured or uninsured (\$8 million), while the remaining 21 percent had their costs (\$10.5 million) billed to charitable and public sources (e.g., Medicaid).

In the 30 months before the helmet law change, 52 motorcyclists with head-brain-skull principal injury died *after* admission to an acute care hospital. The average treatment cost for these cases was \$48,126. In the 30 months after the law change, 115 motorcyclists died following admission. Inflation adjusted costs for these cases averaged \$52,450.

In 1998 and 1999, the hospital charges for head-brain-skull principal injury cases per 10,000 registered motorcycles were \$311,549 and \$428,347 respectively. The comparable figures for 2001 and 2002 were \$605,854 and \$610,386, adjusted for inflation.

The effect of the motorcycle helmet law repeal on injuries is somewhat less clear than the situation for fatalities. Two sources of data were available: police motor vehicle crash reports, which show an increase in injuries, but a small decline in injury rates per 10,000 registrations; and hospital discharge data that show large increases in hospital admissions and admissions for head injuries. The weight of the evidence indicates that

the repeal of the helmet law was associated with a slowing of the existing downward trend in injury rates, with an increase in head injuries. The cost data show that total acute care cost more than doubled. As with fatalities, increased exposure (registrations) cannot account for these changes.

The Arkansas, Kentucky, Louisiana, and Texas Law Changes

Arkansas and Texas repealed all-rider helmet laws in 1997 while Kentucky did so in 1998 and Louisiana in 1999. Comparing motorcyclist fatalities in the three full years after the law changes indicates that fatalities increased by 130 percent in Louisiana, by 99 percent in Kentucky, by 52 percent in Texas, and by 23 percent in Arkansas.

Time Series Analyses

ARIMA modeling was conducted for these States. As with Florida, analyses explored monthly fatalities over a nine- year period (1994-2002), controlling for the annual number of motorcycles registered in each State. The intervention effects were statistically significant for Kentucky, Louisiana, and Texas, but not Arkansas.

For Kentucky, there was a statistically significant effect of the intervention on fatalities such that there was an average increase of 1.3 motorcycle fatalities per month ($p = .001$). Registrations did not enter the model as a statistically significant parameter.

Louisiana also showed a significant effect of intervention. For this State, the repeal of the law raised motorcycle fatalities by an average of 2.6 per month ($p < .001$). There was no statistically significant effect of registrations on fatalities.

The results in Texas demonstrated statistically significant effects of both intervention (fatalities increasing an average of 3.7 per month; $p = .001$) and registrations (fatalities increasing by 1 as registrations increase by 10,000, $p < .001$) on the number of motorcycle fatalities. That is, while there was an effect of registrations on a change in the rate of fatalities, there was also a separate effect of the law repeal.

Limitations of the Study

National data suggest that as motorcycle registrations increase, motorcyclists' deaths and injuries increase. Conversely, when registrations decline, fatalities and injuries decline. In Florida, motorcycle registrations increased substantially following repeal of the all-rider helmet law, an outcome similar to that seen in the other States that repealed helmet laws in recent years. It is likely that some of the increases in motorcyclist fatalities were due to increased ridership. However, the analyses just described show that increases in motorcycle registrations alone do not account for the magnitude of the increases in fatalities. Other factors than the decrease in helmet use that may have contributed to the fatality increase are alcohol use, speed, and a demographic shift in motorcycle ridership. Unfortunately, the available data do not allow for a precise

determination of the extent to which these various factors contributed to the increase in fatalities.

Nationally, motorcycle vehicle miles of travel (VMT) increased gradually throughout the 1990s, but decreased in 2001 and 2002. The VMT measure, provided by the Federal Highway Administration, is regarded as a good indicator of trends year to year, but cannot be broken down reliably to the individual State level for motorcycles. Nationally between 1998 and 2002, motorcycle registrations increased by approximately 29 percent. In 1998, the average motorcycle traveled 2,645 miles, while in 2002 this figure had declined to 1,909 miles. The extent to which this effect occurs at the individual State level is not knowable from existing data sources.

Summary

The effects of Florida's repeal of its all-rider motorcycle helmet use law are similar to those seen in the other States that have repealed such laws in recent years. Based on these findings, it is reasonable to conclude that the following are likely outcomes in a State considering elimination of an all-rider helmet law:

- Helmet use will decline markedly, from virtually full daytime compliance to voluntary use by about 50 percent of riders;
- Helmet use likely will decline among all riders regardless of restrictions remaining in the law (use required by young riders, those without insurance) because of enforceability factors.
- Motorcycle registrations will increase. This, in turn, will contribute to an increase in motorcycle crashes of all degrees of severity.
- Motorcyclist fatalities will increase significantly, typically by 50 to 100 percent comparing the years following the law change with the years immediately before repeal. The fatality rate per registered motorcycle will also increase.

The Florida results also showed that non-fatal serious injuries increase more than lesser injuries following law repeal. Injured motorcyclists' hospital admissions increased by 40 percent following the law change. Admissions for head-brain-skull injuries increased by more than 80 percent following the law change. Total gross treatment costs for these cases more than doubled and the cost per case also increased substantially. Fewer than 25 percent of hospital admitted motorcyclists for head-brain-skull injuries had treatment costs under \$10,000, indicating that the law's medical insurance provision is largely inadequate to cover the costs incurred. Only about two-thirds of admitted motorcyclists have medical insurance.

The Florida law continues to require helmet use by riders under the age of 21. The data indicate that this provision is not being observed. The number of under age 21 motorcyclists killed in Florida in the two years after the law change nearly tripled, compared to the two years before the change. Almost one-half of the post law change victims were not helmeted compared to about 26 percent before the law change, an increase of 188 percent. The number of young motorcyclists involved in crashes of lesser severity increased by about 47 percent.

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I. INTRODUCTION

The first state laws requiring motorcyclists to wear protective helmets began to appear in 1967 following the inclusion of mandatory helmet use in the highway safety program standards issued by the Secretary of Transportation. In 1967, 22 States adopted helmet use laws applicable to all riders and 14 more States added such laws in 1968. By 1975, almost all States and the District of Columbia had enacted all-rider helmet use laws.

Mandatory helmet use laws were not well received by segments of the motorcycling community. Organizations such as ABATE (A Brotherhood Against Totalitarian Enactments; now more commonly, American Bikers Aimed Toward Education) formed and lobbied against helmet use laws. In the nearly four decades since the original helmet laws, States have variously enacted and repealed all-rider motorcycle helmet laws, with the presence or absence of congressional transportation funding incentives and disincentives often facilitating state legislative actions. In recent years, allocations of Federal highway funds to the States have not been linked to whether the State had or did not have a motorcycle helmet law applicable to all riders.

Effective July 1, 2000, Florida eliminated the legal requirement that all motorcycle riders wear helmets. Instead, state law now requires helmet use only by riders under the age of 21. The Florida law change follows similar actions by Arkansas and Texas in 1997, by Kentucky in 1998, and by Louisiana in 1999. At the end of 2003, there were 19 States and the District of Columbia with laws requiring helmet use by all motorcycle riders, 28 States that require helmet use only by riders under a specified age, and 3 States with no law regarding helmet use.

The present report examines the highway safety effects of Florida's law change. Following this introduction, the report is organized as follows:

- Chapter II, Background, reviews recent literature on the effects of helmet use and helmet use laws.
- Chapter III presents national data on trends in motorcycle registrations, travel, and casualties.
- Chapter IV, Effects of the Law Change in Florida, describes the effect of Florida's law change on helmet use, fatalities, injuries, and casualty rates.
- Chapter V, Effects of the Other Law Changes, updates earlier analyses of the effects of law changes in Arkansas, Kentucky, Louisiana, and Texas.
- Chapter VI, Discussion, discusses the findings of the study.

II. BACKGROUND

This and the following chapter provide context for the examination of the effects of Florida's motorcycle helmet law change. This chapter briefly describes the history of motorcycle helmet laws in the United States and reviews the literature regarding helmet use and law changes. Chapter III describes recent trends in motorcycle ridership and crashes. The material is an update of that originally presented by Preusser et al., (2000).

Legislative History

The history of motorcycle helmet laws in the United States can be summarized as follows:

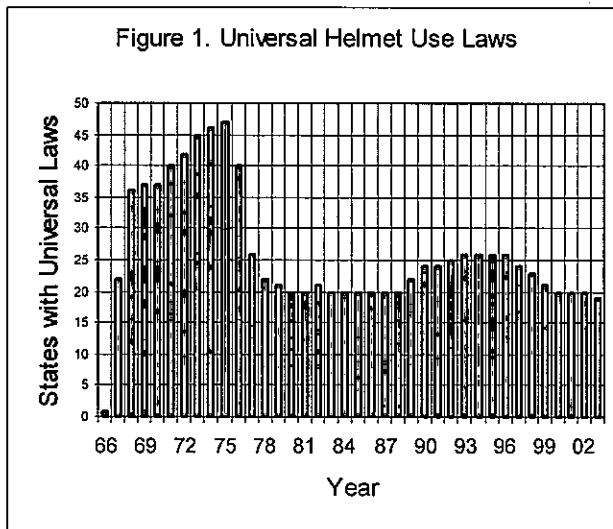
- 1966-1975: Most States Enact All-Rider Helmet Use Laws in Response to Federal Highway Safety Standards;
- 1976-1980: Half the States Repeal or Amend their All-Rider Helmet Use Laws after Congress Eliminates Sanctions;
- 1981-1988: Period of Stability;
- 1989-1994: Gradual Re-enactment and Congressional Encouragement; 6 States Adopt All-Rider Laws;
- 1995-2003: Congress Again Eliminates Sanctions; 6 States Drop All-Rider Helmet Laws.

The status of motorcycle helmet laws can be found at:
www.nhtsa.dot.gov/people/injury/new-fact-sheet03/index.htm.

Also, see Preusser et al., (2000), for a more complete description of the history of motorcycle helmet laws. Figure 1 shows the number of states with universal helmet laws in effect at the end of each year, beginning in 1966. Figure 2 shows the percentage of registered motorcycles covered by all-rider laws.

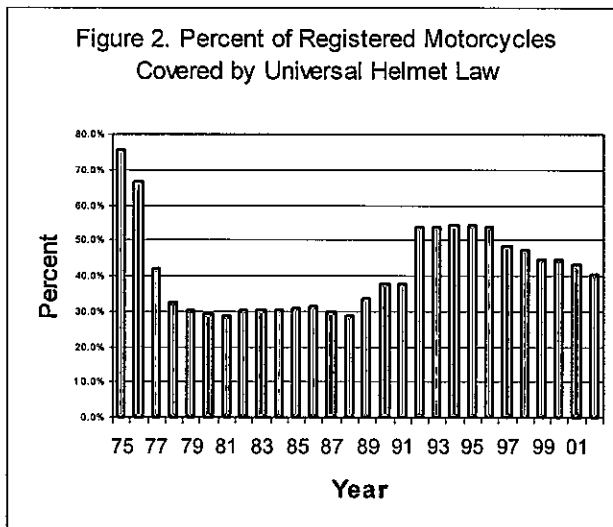
Studies of Helmet Use Law Effects

The General Accounting Office (GAO, 1991), now called the General Accountability Office, conducted a broad search for studies as of 1990 and found 46 that were: published between 1975 and 1990; used data from the United States; and contained original data or original analyses and met minimum criteria for methodological soundness.



GAO found 9 studies that included data on helmet use in States with and without universal laws. These studies:

“reported that helmet use under universal laws ranged from 92 to 100 percent, while without a law or under a limited law [requiring only some riders to wear helmets], helmet use generally ranged from 42 to 59 percent. These data also indicated low helmet use among young riders in states with limited helmet laws” (GAO, 1991, p. 4).



GAO found 20 studies that compared motorcycle rider fatality rates under universal helmet laws with rates during periods before enactment or after repeal of these laws.

“These studies consistently showed that fatality rates were lower when universal helmet laws were in effect; most rates ranged from 20 to 40 percent lower. Several of these studies compared periods before a helmet law was enacted, while it was in effect, and after it was repealed.

They showed that the decreases in fatality rates when laws were enacted were matched by comparable increases when the laws were repealed” (GAO, 1991, p. 4).

GAO found 13 studies with data on some aspect of the societal costs of motorcycle crashes.

“These studies indicated that nonhelmeted riders were more likely to (1) need ambulance service, (2) be admitted to a hospital as an inpatient, (3) have higher hospital charges, (4) need neurosurgery and intensive care, (5) need rehabilitation, and (6) be permanently impaired and need long-term care” (GAO, 1991, p. 4).

More Recent Studies of Helmet Use

Since the 1991 GAO report a number of studies have been conducted that examine helmet use rates before and after helmet law changes. Kraus et al., (1995) observed helmet use at 60 locations in seven California counties, twice before and four times after California’s 1992 adoption of an all-rider law. They concluded that helmet use increased from about 50 percent in 1991 to more than 99 percent in 1992. Preusser et al., (2000) found that following Arkansas’ all-rider law repeal in 1997, helmet use declined from 97 percent to 52 percent. Texas enacted an all-rider helmet use law in 1968, repealed it in 1977 and required helmet use only for riders under 18, then re-enacted an all-rider law in 1989. Lund et al., (1991) present data showing that helmet use increased from less than 50 percent just before the 1989 universal law to 90 percent immediately after the law became effective and to 95 percent two months later. Texas again repealed its all-rider law in 1997. Preusser et al., (2000) report that this repeal was accompanied by a decline in helmet use -- from about 97 percent use before the repeal to about 66 percent after repeal. Similar findings are reported for the all-rider law repeals in Kentucky and Louisiana (Ulmer and Preusser, 2003).

More Recent Studies of Fatalities

A number of studies relating fatalities and fatality rates to helmet use laws have also appeared since the GAO report. Kraus et al., (1994) compared California’s motorcycle crash experience in 1991, before adoption of its all-rider law, with 1992, after the law was in effect. Motorcycle fatalities statewide decreased 37 percent in 1992 compared with a year earlier. The fatality rate per registered motorcycle decreased 26 percent. Maryland’s all-rider helmet law was adopted in 1992. Mitchell et al., (2001) used autopsy records to study the effects of the law. They reported there was a 36 percent decline in the number of motorcyclist fatalities in the 33-month period immediately following the law compared to the 33 months just prior to the law. Helmeted motorcyclists were significantly less likely to have died from traumatic brain injury as compared to non-helmeted motorcyclists after Nebraska’s all-rider helmet law became effective in January 1989. Mulleman, et al., (1991) observed a 26 percent reduction in crashes per registered motorcycle in 1990, compared to the five previous years and to 5 adjoining States without all-rider helmet laws. They also studied all motorcyclists with reported crash injuries in two urban counties during 1988 and 1989 (421 in 1988 and 250 in 1989). They found that the universal law produced declines in the numbers and rates of injuries, hospital transports, hospital admissions, severe injuries to the head, and deaths. In the five full

years (1984-1988) before Washington's all-rider law was adopted, the State experienced an average of 77 motorcyclist fatalities per year. In the five full years after the law (1991-1995), the average declined to 39 fatalities per year (source: FARS).

Studies of the effects of all-rider law repeals in Arkansas, Kentucky, Louisiana, and Texas have all shown substantial increases in motorcyclist fatalities comparing the two years after the laws' repeals with the two years before repeal (Arkansas +29%; Kentucky +58%; Louisiana +109%; Texas +37%). Fatalities per registered motorcycle also increased in Kentucky, Louisiana, and Texas, but not in Arkansas (Preusser et al., 2000; Ulmer and Preusser, 2003).

More Recent Studies of Injury Patterns and Costs

- Studies of Injury Patterns

Kraus and Peek (1995) studied injured motorcyclists treated at 18 hospitals in 10 California counties between January 1, 1991 and December 31, 1993 (2,037 patients in 1991, before California adopted an all-rider law, and 2,753 in 1992 and 1993, after the law). Helmet use among these injured motorcyclists rose from 30 percent in 1991 to 86 percent in 1992 and 88 percent in 1993. Both the severity and number of head injuries per rider decreased after the law.

Mulleman et al., (1991) studied all Nebraska motorcyclists with reported crash injuries in two urban counties in the year before and the year after adoption of an all-rider law. They found that the law produced declines in the numbers and rates of injuries, hospital transports, hospital admissions, severe injuries to the head, and deaths.

Following Texas' 1989 re-enactment of an all-rider law, Mounce et al., (1992) examined hospital data from the first nine months after the law and showed that motorcyclists injured after the law suffered less serious injuries and were less likely to have head or face injuries than motorcyclists injured before the law. Fleming and Becker (1992) found a 57 percent decrease in head-related fatalities and a 55 percent reduction in severe head-related injuries among hospital-admitted motorcyclists. Following the Texas 1997 repeal of its all-rider law, Preusser et al., (2002) linked EMS and trauma registry data for motorcycle crashes and found a marked increase in traumatic brain injury cases and in the costs of treating these cases.

Washington's all-rider helmet law became effective in June 1990. Mock et al., (1995) analyzed data on motorcycle crash victims admitted to the Seattle region's only level 1 trauma center from 1986 through 1993. They report that severe head injuries decreased from 20 percent of all admitted patients before the law to 9 percent after the law.

Kelley et al., (1991) studied 398 motorcycle crash victims in eight Illinois medical centers from April through October 1988. Illinois had no helmet law at that time. They concluded that non-helmeted patients had higher overall injuries (Injury Severity Score) and more frequent head and neck injuries than helmeted motorcyclists.

Gabella et al., (1995) examined the risk of head injury in motorcycle crashes in El Paso County, Colorado in 1989-1990. Not wearing a helmet was found to increase the likelihood of a head injury by a factor of 3 relative to the risk of head injury for helmeted motorcyclists.

Kraus et al., (1995) studied 174 fatally injured and 379 non-fatally injured crash-involved motorcyclists in Los Angeles County, California, in 1988-1989, before California's all-rider helmet law. They concluded that "those not using helmets where helmet use is voluntary are a higher risk population than helmet users. They are more likely to be involved in crashes but, because they are un-helmeted, less likely to be protected against serious head injury." Sakar, Peek, and Kraus (1995) also studied fatally injured motorcyclists in Los Angeles County. They found that head and cervical spine injuries were more frequent in non-helmeted than in helmeted fatally injured motorcyclists.

Rowland et al., (1996) studied 86 fatally injured and 386 hospitalized motorcyclists in the State of Washington in 1989 (when Washington's helmet law covered only riders under age 18). They concluded that "motorcycle helmet use is strongly and independently associated with reduced likelihood and severity of head injury, reduced overall injury severity, and reduced probability of motorcycle-related hospitalization and death attributable to head injury."

- Studies of Injury Costs

As part of the 1991 ISTEA legislation, Congress required NHTSA to study the effects of safety belt and motorcycle helmet use in crashes. NHTSA conducted the analysis using its Crash Outcome Data Evaluation System (CODES) data system, in which 7 States linked data from their police crash reports, emergency medical services, hospital emergency departments, hospital discharge files, claims, and other sources. NHTSA's 1996 Report to Congress found that "motorcycle helmet effectiveness ranged from 9 percent in preventing any kind of injury to 35 percent in preventing a fatality." "The average inpatient charge for motorcycle crash victims receiving inpatient care was \$14,377 for those who used helmets, and \$15,578 for those who did not" (NHTSA, 1996). The CODES data showed that helmet use for motorcycle riders involved in crashes ranged from 80 to 98 percent in 3 CODES States with all-rider helmet laws and from 30 to 49 percent in 3 CODES States without all-rider laws. Helmets were estimated to be 67 percent effective in preventing brain injuries in a crash (NHTSA, 1998).

Bigelow (2001) examined CODES data from 18,394 motorcyclists involved in crashes in the State of Wisconsin. Helmeted riders were less likely to have sustained traumatic brain injury across a variety of crash related factors including crash type, speed limit, highway type, and alcohol involvement. The average hospital charge for the brain injury cases was almost \$28,806 and the average length of stay was 10.6 days.

Finison (2001) examined CODES data from 806 motorcyclists involved in crashes in Maine during 1995 and 1996. Riders not wearing helmets were found to be 3 times more likely to have head injuries requiring EMS transport, hospitalization, or resulting in death than motorcyclists who were helmeted. Hospital charges were higher for those with head injury than those with other injury. Also, among the head injury cases, those who were helmeted had shorter hospital stays (4.2 days versus 9.3 days for the not helmeted) and lower treatment charges (\$14,639 versus \$33,443).

Shankar et al., (1992) linked all Maryland police motorcycle crash reports, hospital emergency department data and trauma registry data for a 12-month period to examine head injury and treatment cost as related to helmet use. They found that non-helmeted motorcycle operators were twice as likely to have sustained head injury and had acute care costs 3 times that of helmeted operators injured in crashes.

Max et al., (1998) examined the effects of California's 1992 adoption of its all-rider helmet law on injury costs. They found that the rate of motorcyclist hospitalizations per registered motorcycles declined by 25 percent comparing 1993 with 1991. The rate of hospitalizations for head injuries declined by 48 percent. Total hospitalization cost for motorcycle injuries declined by 35 percent comparing 1993 with 1991. Approximately three-quarters of the decline was attributed to reduced costs for patients with head injuries.

Rutledge and Stutts (1993) used the North Carolina Trauma Registry to examine the relationship of crash injury outcomes and helmet use. They compared helmeted and unhelmeted riders who were admitted to a hospital for at least a 24-hour period and found that when overall degree of injury is equalized among cases, hospital charges; length of stay; and other measures of resource utilization did not differ, but the risk of head injury was twice as high for unhelmeted riders as it was for those who were helmeted. They note that the equal resource utilization was due to the high costs of treating very severe injuries to the extremities.

Zaloshnja et al., (2004) provide extensive data on the costs of injuries to various body parts resulting from motor vehicle crashes. Medical costs for brain/intercranial injury ranged from \$42,148 for minor (MAIS1) injuries to \$249,356 for critical (MAIS5) injuries. Adding other costs such as police and fire services, lost wages, property damage, etc., brought the total monetary costs for a minor brain/intercranial injury to \$66,790 and to \$1,431,918 for a critical injury.

The studies since the 1991 GAO report overwhelmingly confirm GAO's conclusions. All available studies indicate that universal motorcycle helmet laws raise helmet use to 90 percent or higher from pre-law levels of 50 percent or lower. Conversely, repealing all-rider laws results in substantially reduced helmet use. All-rider laws are shown to reduce motorcycle fatalities, fatality rates, and severe head injuries. The studies also confirm that helmets reduce the probability of injury, of head injury, and of fatality for crash-involved motorcyclists. States that repealed all-rider helmet laws in recent years have experienced declines in helmet use and increases in fatalities and fatality rates.