

**The Reinstated Comprehensive
Motorcycle Helmet Law in Texas**

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ABSTRACT

On September 1, 1989, Texas reinstituted mandatory helmet use for motorcyclists of all ages. Time series analyses of police-reported crashes in the state indicate an 11 percent reduction in serious injury crashes per registered motorcycle as a result of the law change, which corresponds to about 500 fewer serious injury crashes during 1990. A comparison of hospital injury information during the first nine months of the law with information from a study of the same hospitals three years earlier confirmed that injured cyclists not wearing helmets were twice as likely to have suffered a head injury and four times as likely to have suffered a serious one (AIS 3-6) as injured cyclists who were wearing helmets. Compared with cyclists injured before the law, those injured after the law suffered less serious injuries (as measured by Injury Severity Scores). Motorcyclists reporting to the hospitals with injuries after the law change were less likely to have head, face, or external (superficial cuts and bruises) injuries.

INTRODUCTION

Before 1968, protective helmets for motorcyclists was not required by law in Texas. The first legislation requiring helmet use by motorcyclists of all ages was implemented on January 1, 1968 and remained in place until August 29, 1977. The Texas law was modified in 1977 to require protective helmets only for individuals 18 years of age and younger. This weaker law was in effect until September 1, 1989, when a new comprehensive helmet law was put into place. As before, the comprehensive law requires helmet use by both operators and passengers of motorcycles, mopeds, and motorscooters, regardless of the age of the rider.

Observational surveys revealed helmet use by Texas motorcycle operators increased from 44 percent just before implementation of the comprehensive helmet law to 98 percent 10 months after the law took effect (Womack, 1990; Lund, Williams, and Womack, 1991). Similarly, the proportion of helmeted passengers increased from 32 percent to more than 90 percent over the same period. These survey results are consistent with data collected in other states where laws requiring helmet use by riders of all ages were implemented (McSwain and Willey, 1985).

The effect of helmet laws on motorcycle deaths and injuries has been studied extensively, particularly in states where comprehensive helmet laws were subsequently repealed or weakened to apply only to certain age groups. Between 1975 and 1984, the number of states with helmet laws for riders of all ages decreased from 47 to 19. Nationally, the repeals were found to be associated with an estimated 21 percent increase in the motorcycle fatality rate calculated on a per crash basis (deWolf, 1986). Four years later, an updated analysis again estimated about a 20 percent increase in motorcycle fatalities nationwide resulting from the repeal of comprehensive helmet laws (Hertz, 1989).

These increases have been reversed in other states, like Texas, that have reinstated legislation requiring helmet use for all riders. The reenactment of Louisiana's motorcycle helmet law was assessed in terms of observed helmet use, the incidence and severity of head injuries in relation to other body injuries, and the financial costs associated with helmeted versus unhelmeted crash-involved motorcyclists (McSwain & Willey, 1984). Similarly, Muelleman examined the effect of Nebraska's comprehensive helmet law on statewide motorcycle crash rates and fatalities, as well as the incidence of severe head injuries and acute medical costs for injured motorcyclists in two counties (Muelleman, Mlinek, and Collicott, 1992). Both studies reported significant reductions in the incidence of severe head injuries with increased helmet use

among crash-involved motorcyclists. Furthermore, these decreases were accompanied by reductions in associated medical charges following the implementation of comprehensive helmet legislation.

The present study examines the effect of the reinstated comprehensive helmet legislation in Texas. Time series analyses were conducted of statewide crash data to assess changes in motorcycle operator injuries and fatalities that may have occurred coincident with the law's implementation. Trauma data were compared for a pre-law and post-law sample of motorcyclists who were transported from the scene of a crash to assess changes in the incidence and severity of head injuries.

METHOD

Time Series Analysis of Motorcycle Crash Data

Statewide crash data and motorcycle registration files maintained by the Texas Department of Public Safety were analyzed to determine if a reduction in motorcycle operator injury crash rates (calculated per 100,000 motorcycle registrations) occurred following the reinstatement of the comprehensive helmet law.

The injury classification scheme used on Texas traffic accident reports reflects the following police-reported injury codes: K (fatal), A (incapacitating), B (non-incapacitating), and C (possible). Beginning with January 1985, and continuing through December 1990, monthly counts of crashes in which a motorcycle operator received injuries that were either fatal (K), severe (K+A), or serious (K+A+B) were accumulated. Counts for all crashes resulting in reportable injuries to the motorcycle operator (K+A+B+C) were analyzed, as well. For simplicity, these will be referred to in all subsequent discussions as fatal, severe, serious, and total injury crashes, respectively. Although police-reported injury codes are subjective and have limited accuracy with respect to the actual severity of non-fatal injuries, these codes were expected to have sufficient accuracy to assess changes in injury crashes over time. The principal threat to the validity of the intended analysis would be any variation in police reporting policies or procedures during the designated period of study. No such changes could be identified.

Crash rates were calculated for each of the injury severity levels by dividing the monthly injury counts by monthly counts of registered motorcycles. As shown in Table 1, motorcycle registrations in Texas were declining during the period of the study. Only annual registration figures (calculated as of December 31) were available; monthly counts were interpolated assuming the observed decrease in motorcycle registrations each year to be linear.

Table 1
Annual Motorcycle Registration In Texas
(1885-1990)

Year	Registrations as of December 31
1985	277,551
1986	248,715
1987	226,038
1988	207,976
1989	187,687
1990	170,642

Separate time series models were built for each injury rate series, using procedures developed by Box and Jenkins (1976) and incorporated in SAS computer procedures (SAS Institute, 1984). The change in each injury crash rate series associated with the introduction of the comprehensive helmet law in September 1989 was tested using a technique known as intervention analysis (Box and Tiao, 1975). In general, intervention analysis allows for a sudden change in the time series at a specified time (in this case, the implementation date of the reinstated helmet law).

A marked seasonal pattern was observed in each monthly injury crash rate series necessitating a seasonal adjustment to the data. Each series was differenced with respect to years (i.e., differences taken 12 months apart) and a multiplicative moving average model with two parameters, corresponding to lags of 1 and 12 months, was fit to each differenced series (see example 1, Box and Tiao, 1975). A sudden change in the series at the time of the intervention was modelled, as well.

The residuals were examined for patterns that would indicate lack-of-fit of the model, and their autocorrelations were tested for randomness. The residuals from all models showed no indication of nonrandomness by the chi-square test. For completeness, models containing first differences, in addition to the clearly needed seasonality adjustment, were examined. No improvement was seen in the precision of the residuals or in their correlation structure as a result of this addition to the models. In the interest of parsimony and increased statistical power for testing the intervention, the models without first differences were preferred.

A further adjustment was made to the models based on examination of the original series and the residuals from the models described above. A marked, but unexplained, decrease in motorcycle injuries and fatalities was observed near the end of 1986 in Texas and elsewhere across the nation (FARS, 1989). When a second intervention term was added to the models to coincide with this unexplained change (September 1986), the decreases in severe, serious, and total injury crash rates corresponding to this intervention were found to be statistically significant ($p < 0.025$). Therefore, this intervention term was retained in the final model. No patterns were observed in the residuals from the final model that would indicate lack of fit, and tests for white noise yielded no evidence of deviations from that hypothesis.

Trauma Data Analysis

Data on injury severity for crash-involved motorcyclists were obtained from 14 hospitals that participated in a previous study conducted by the Department of Public Safety in cooperation with the Texas Department of Health (Goodnow, 1989). The pre-law sample included injured motorcyclists who crashed over a 16-month period, but to enhance the comparability of the two samples, only those crashes that occurred during equivalent nine-month periods (September 1986 through May 1987 and September 1989 through May 1990, respectively) were included in the analyses.

A computerized list was prepared by the Department of Public Safety of all motorcycle crashes that met the following criteria: (1) the crash occurred in one of the five counties in which the designated hospitals were located (Randall, Potter, Travis, Nueces, and Bexar); (2) the crash date fell between September 1, 1989 and May 31, 1990; and (3) a motorcyclist was transported from the scene of the crash to a medical facility.

Traffic accident reports were obtained of the 283 crashes that satisfied the criteria described above. These crashes represented 40 percent of the 710 total motorcycle crashes that occurred in the respective five counties during the specified time period. From these crashes, a total of 271 surviving motorcyclists were identified as being transported to one of the specific hospitals included in the study sample.

With the cooperation of the Texas Department of Health, information on the nature of the injuries sustained by each motorcyclist in the sample was abstracted from the respective medical records. The abstracts were then sent to the Johns Hopkins University's Injury Prevention Center for assignment of Abbreviated Injury Scale (AIS) scores (Association for the Advancement of Automotive Medicine, 1985) and Injury Severity Scores (ISSs) (Baker, O'Neill, Haddon, and Long, 1974).

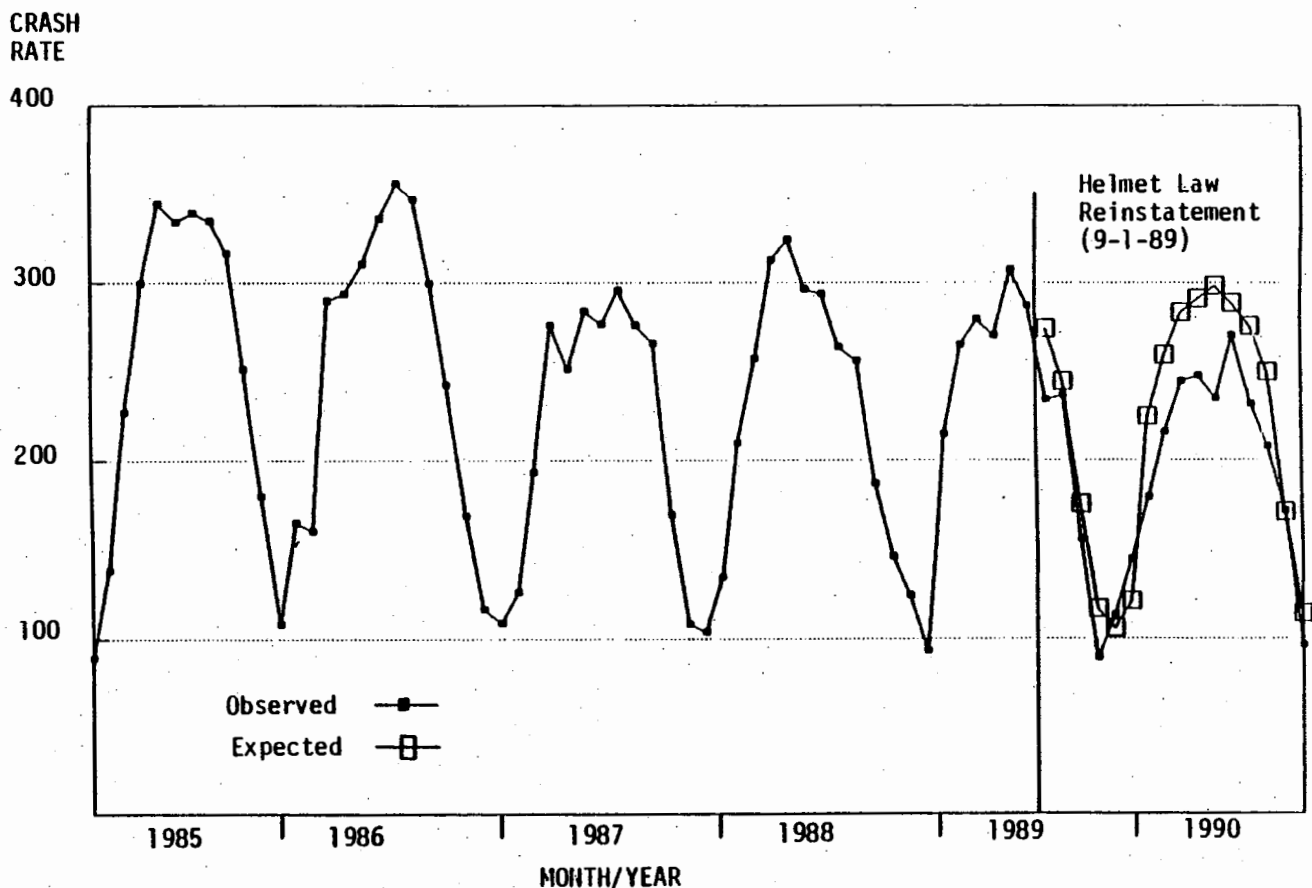
Since the designated hospitals in the study sample participated in a pre-law study of injury severity, the proportion of helmeted versus unhelmeted motorcyclists admitted to the respective hospitals before and after helmet legislation could be compared, as could the injury severity assessments for the two groups of motorcyclists. Helmet use in both the pre-law and post-law samples of crash-involved motorcyclists was determined by the information recorded on police crash reports. All test results reported as statistically significant met or exceeded the five percent probability level for one-tailed tests.

RESULTS

Time Series Analysis of Motorcycle Crash Data

Statistically significant decreases ($p < 0.025$) were noted in the rates of severe, serious, and total injury crashes following the rein-statement of the comprehensive helmet law. Of the three series, the one for serious injuries had the highest t-value ($t = 2.98$). Observed values for the serious injury crash rate series are compared with the estimated values that would be expected had the helmet law not been enacted in Figure 1.

Figure 1
Serious Motorcycle Operator Injury Crash Rates



The parameters of the final model correspond to an estimated 11 percent reduction in both the severe and serious motorcycle operator injury crash rates following the reinstated law, while a 9 percent reduction occurred in the crash rate comprised of all reported injuries. To translate these percentage reductions into rough estimates of prevented injuries, an average of the observed values for each series was calculated for the 12-month period preceding the law's implementation (see Table 2). The 11 percent reduction in the rate of severely injured motorcyclists translates to approximately 10 individuals per month. For the rate of seriously injured motorcyclists, the 11 percent reduction corresponds to approximately 25 individuals per month. The 9 percent reduction in the total injury rate translates to approximately 24 individuals per month. Coupled with motorcycle registrations of 170,642 as of December 31, 1990, the results suggest that because of the helmet law, about 500 fewer motorcyclists were seriously injured (injury codes K, A, or B) during that year ($25 \times 1.7 \times 12$ months). Given the declining trend in motorcycle registrations, the use of the year-end figure in the previous calculation provides a conservative estimate of the reduction in serious injuries.

The percent decrease in the fatal injury crash rate at the time of the law's implementation was not statistically significant. However, the relatively small number of motorcycle operator fatalities increased the variability of the fatal injury crash series which, in turn, reduced the statistical power of the model to detect an intervention effect.

Table 2
Estimated Changes In Motorcycle Injury Crash Rates,
In Texas After Comprehensive Helmet Legislation

Injury Level	Average Numbers of Injuries Per Month*	Percent Reduction After Law
Any injury	263	9**
Serious injury	225	11**
Severe injury	90	11**
Fatal	9	10

* Per 100,000 Registrations.

** Significant at $p < 0.05$

Analysis of Trauma Data

In the pre-law period, police reported that 32 percent of the injured motorcyclists in the hospital sample were helmeted, while in the post-law period, 84 percent were helmeted. Police-reported helmet use was unknown for approximately 8 percent of the combined sample (9 percent in the pre-law period and 8 percent in the post-law period).

Head injuries for helmeted and unhelmeted motorcyclists were compared with data from the pre-law and post-law periods combined. As shown in Table 3, the difference in the proportion of head injured among helmeted and unhelmeted motorcyclists was highly significant. Compared to the helmeted motorcyclists in the sample, the unhelmeted motorcyclists were twice as likely to suffer any (AIS > 0) head injuries ($Z = 4.012$, $p < 0.0001$), and four times as likely to suffer serious (AIS ≥ 3) head injuries ($Z = 4.278$, $p < 0.0001$).

The protective effect of helmets resulted in a reduction in injury severity for motorcyclists after the new law. The average injury severity score (ISS) for motorcyclists in the pre-law period was significantly higher than the average ISS for motorcyclists in the post-law period (6.51 vs. 6.07, respectively) ($Z = 2.342$, $p = 0.02$). Moreover, a highly significant decrease in the total number of injuries sustained by motorcyclists in the post-law period was revealed ($Z = 8.143$, $p < 0.0001$). Motorcyclists injured in the pre-law period suffered an average of 3.5 injuries, compared to an average of 2.8 injuries suffered by riders in the post-law period.

Table 3
Head Injury for Helmeted and Unhelmeted Motorcyclists

	Most Severe Head Injury					
	AIS = 0		AIS > 0		AIS ≥ 3	
	No.	(%)	No.	(%)	No.	(%)
Helmeted (n = 279)	249	(89)	30	(11)	7	(3)
Unhelmeted (n = 241)	183	(76)	58	(24)*	30	(12)*

* $p < 0.05$

The distribution of total (AIS > 0) and serious (AIS $\geq$ 3) injuries by AIS region revealed decreases in the proportion of head and neck, face, and external injuries in the post-law period (Table 4). Ten percent of the pre-law sample sustained a serious injury to the head and neck region (which includes injuries to the head, neck, or cervical spine), compared to only six percent of the post-law sample ($Z = 1.73$, $p = 0.05$). A slightly smaller difference was found in terms of serious injuries to the head alone (9 percent vs. 6 percent, respectively) ($Z = 1.51$, $p = 0.07$). A decrease in the number and proportion of motorcyclists with any head injury was not statistically significant.

Motorcyclists with facial injuries represented a significantly smaller proportion of the total sample in the post-law period (5 percent vs. 9 percent in the pre-law period) ($Z = 1.74$, $p = 0.05$), but these injuries were rarely serious during either period.

Table 4
Distribution of Injured Motorcyclists Before and
After Comprehensive Helmet Legislation in Texas

	Before (N=381)		After (N=227)	
	AIS ¹ > 0 No. (%)	AIS $\geq$ 3 No. (%)	AIS > 0 No. (%)	AIS $\geq$ 3 No. (%)
Body Region				
Head and Neck	84 (22)	37 (10)	44 (19)	13 (6) ²
Head	74 (19)	34 (9)	34 (15)	13 (6)
Neck	1 (0)	1 (0)	0	0
Cervical Spine	13 (3)	2 (1)	13 (6)	0
Face	35 (9)	1 (0)	12 (5) ²	1 (0)
Chest	31 (8)	13 (3)	19 (8)	11 (5)
Abdomen and Pelvic Contents	24 (6)	3 (1)	18 (8)	3 (1)
Extremities	197 (52)	74 (19)	122 (54)	42 (19)
Upper	103 (27)	12 (3)	63 (28)	4 (2)
Lower	128 (34)	66 (17)	80 (35)	39 (17)
External	303 (80)	3 (1)	164 (72) ²	0

¹ AIS of most severe injury to indicated body region.

² $p < 0.05$ compared to rate of similar injuries in "before" period.

The reduction in the proportion of injured motorcyclist with external injuries ($Z = 2.06$, $p < 0.05$) was not expected, given that these injuries are typically minor and are not limited to body regions protected by helmet use. However, of all external injuries, those occurring to the head and face are thought to be the ones most likely to result in transportation to a hospital. That is, uncertainty at the scene of a crash regarding the seriousness of head or facial contusions, lacerations, or abrasions may increase the likelihood that a motorcyclist will be sent to a medical facility for examination and treatment. External injuries to other body regions, unless accompanied by more serious injuries, would be less likely to require transport from the scene. It follows that an increase in helmet use would result in fewer external head and facial injuries which, in turn, would conceivably reduce the number and proportion of motorcyclists with external injuries in the post-law hospital sample.

SUMMARY AND IMPLICATIONS

The initial objective of mandatory helmet legislation is to increase the use of protective helmets among motorcycle operators and passengers. Available evidence clearly documents the legislation's effectiveness in this regard. In Texas, as in other states covered by helmet laws, compliance rates approaching 100 percent have been consistently reported.

Previous studies have found helmets to be extremely effective at reducing head injuries, the leading cause of morbidity and mortality for motorcyclists of all ages (U.S. DOT, 1988; McSwain and Willey, 1984; Oklahoma State Department of Health, 1990; Shankar, Dischinger, Ramzy, and Clark, 1990). Thus, the underlying expectation when helmet laws are passed is that increased helmet use will be accompanied by reductions in the severity of injuries sustained by crash-involved motorcyclists.

Motorcycle injury and fatality rates in Texas have, in general, been declining in recent years. However, the reinstatement of the comprehensive helmet law further reduced motorcycle operator injury crash rates by about 10 percent. Comparisons of injuries sustained by helmeted versus unhelmeted motorcyclists revealed highly significant differences in the proportion of head-injured riders in general, as well as the proportion who sustained a serious head injury.

In general, motorcyclists in the pre-law period suffered a significantly higher average number of injuries than did their post-law counterparts. Furthermore, the average injury severity score for motorcyclists in the pre-law period was significantly higher than the average injury severity score for motorcyclists in the post-law period.

A significant reduction was found in the proportion of motorcyclists who sustained serious head, neck, or cervical spine injuries in the post-law period. The reduction in serious head injuries,

while not statistically significant, was only slightly smaller in magnitude. Furthermore, the proportion of motorcyclists who sustained facial injuries was significantly smaller following the reinstatement of the helmet law. There was no evidence that helmet use increased neck injuries, contradicting claims by some that the added mass of the helmet could increase the likelihood of such injuries in high speed crashes (see, e.g., Goldstein, 1986). Together, these findings support the results of previous research that credit comprehensive helmet legislation with reducing both the number and severity of injuries sustained by crash-involved motorcyclists.

It has been noted elsewhere that the institution of a motorcycle helmet law may reduce the number of unlicensed motorcycle operators on the road and, consequently, the number of crashes (see, e.g., Muelleman et al., 1992). Within the present post-law study sample, 34 percent of the crash-involved motorcycle operators were not licensed to operate a motorcycle at the time of the crash. While comparable pre-law figures and exposure data are not available, it appears that a large number of motorcycle operators still are not complying with licensure requirements in Texas.

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