TRENDS IN THE MOTORCYCLE CRASH PROBLEM

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INTRODUCTION

Motorcycle safety was a prominent public and political issue during the 1980s largely because of the dramatic increase in the number of deaths and injuries occurring at that time, commensurate with the growth in the number of vehicles and licensed riders (Simpson and Mayhew 1991). Since then, deaths and injuries have declined steadily and, as a consequence, motorcycle safety has become a relatively low priority in Canada and the United States.

Although the reductions in the number of deaths and injuries suggest there have been major safety improvements over the past decade, other explanations are possible. For example, the declines might be attributable solely to changes in exposure - fewer riders who are driving less or under less risky circumstances.

It is, therefore, important to understand the extent and nature of the positive changes in the problem that have occurred over the past decade. Moreover, despite the declines in mortality and morbidity, a significant number of motorcyclists are still killed and injured annually in Canada and the United States. In 1998 in Canada, 165 motorcyclists were killed and over 5,000 motorcyclists were injured in road crashes; in the same year in the United States, 2,284 motorcyclists were killed and over 49,000 were injured in road crashes. Further safety efforts are needed. A better understanding of recent trends in motorcycle crashes as well as the characteristics and causes of the problem will provide guidance for such efforts.

Accordingly, this paper examines contemporary trends in the magnitude and characteristics of the motorcycle crash problem in Canada and the United States. It also considers the implications of the findings for countermeasure development, especially for rider licensing and rider education and training programs.

The study used data from two principal sources: The U.S. Fatality Analysis Reporting System (FARS) and the TIRF Fatality Database[1]. FARS contains annual data on all fatal traffic crashes in the United States, including data on fatal motorcycle crashes. The TIRF

[1] The TIRF Fatality Database project is co-sponsored by the Canadian Council of Motor Transport Administrators (CCMTA) and Transport Canada.

Fatality Database contains annual data on all fatal motor vehicle crashes in Canada, including data on fatal motorcycle crashes. This study also used data from other sources, including published reports from National Highway Traffic Safety Administration (NHTSA) and Transport Canada (e.g., for registration and exposure data) and from other motorcycle crash studies. These sources are cited in the text and described in the reference section.

TRENDS IN ROAD DEATHS AND INJURIES

Table 1 presents information on the number of deaths and injuries to motorcyclists (riders and passengers) in Canada and the United States from 1987 to 1998. In 1998 in Canada, 165 motorcyclists were killed and over 5,000 motorcyclists were injured in road crashes. By comparison, a decade earlier in 1987, 372 motorcyclists were killed and 13,919 were injured. Thus, in Canada, the number of motorcyclists killed and injured has decreased by 56% and 62%, respectively, over this 11-year period.

Table 1

Number of Motorcyclists Killed and Injured
in Canada and the United States: 1997-1998

	CANADA		UNITED STATES	
	Killed	Injured	Killed	Injured
1987	372	13,919	4,036	N/A
1988	265	11,068	3,662	105,000
1989	258	10,048	3,141	83,000
1990	258	9,227	3,244	84,000
1991	231	8,529	2,806	80,000
1992	187	7,519	2,395	65,000
1993	212	7,038	2,449	59,000
1994	158	6,237	2,320	57,000
1995	165	6,129	2,227	57,000
1996	128	5,202	2,161	55,000
1997	123	5,062	2,116	53,000
1998	165	5,364	2,284	49,000

Similar declines have occurred in the United States. The number of motorcyclists killed declined steadily, from 4,036 deaths in 1987 to only 2,284 in 1998 - a decrease of 43%. The number of motorcyclists injured also decreased, from 105,000 in 1987 to 49,000 in 1998 - a decrease of 53%.

These data show that the motorcycle crash problem, defined in terms of deaths and injuries, has improved dramatically in both Canada and the United States over the past decade. These significant reductions in deaths and injuries among motorcyclists in both countries suggest that there have been major safety improvements over this study period. Other explanations are, however, possible and they are examined in the next section.

TRENDS IN DEATH AND INJURY RATES

One of the most common explanations for changes in the number of deaths and injuries is exposure - i.e., the number of riders/vehicles and the amount they travel. To control for these variables, the number of persons killed or injured is expressed as a rate (e.g., number of motorcyclists killed per registered vehicle). Table 2 presents death and injury rates among motorcyclists in Canada and the United States from 1987 to 1998. As can be seen, in both Canada and the United States, the number of registered motorcycles has declined - in Canada by 26% and in the United States by 22% (NHTSA 1999; Transport Canada 1999).

Table 2

Number of Registered Motorcycles and Death and Injury Rates*
in Canada and the United States: 1997-1998

	CANADA			UNITED STATES		
	Registered Motorcycles	Death Rate	Injury Rate	Registered Motorcycles	Death Rate	Injury Rate
1987	448,000	83.04	3107	4,885,772	82.61	N/A
1988	400,000	66.25	2767	4,584,284	79.88	2294
1989	378,000	68.25	2658	4,420,420	71.06	1887
1990	359,000	71.87	2570	4,259,462	76.16	1979
1991	350,000	66.00	2437	4,177,365	67.17	1925
1992	339,000	55.16	2218	4,065,116	58.92	1601
1993	333,000	63.66	2114	3,977,856	61.57	1494
1994	328,000	48.17	1902	3,756,555	61.76	1528
1995	320,000	51.56	1915	3,897,191	57.14	1475
1996	311,000	41.16	1673	3,871,599	55.82	1428
1997	319,000	38.56	1587	3,826,373	55.30	1374
1998	333,000	49.55	1611	N/A	N/A	N/A

* per 100,000 registered motorcycles

Although the number of registered motorcycles and, presumably the amount of riding, has declined in both countries, the decreases in registrations have not been as dramatic as the corresponding decline in motorcyclist deaths and injuries. As a consequence, the per-vehicle death and injury rates decreased from 1987 to 1998. For example, in Canada, the death rate decreased by 40%, from 83.04 motorcyclist deaths per 100,000 motorcycles in 1987, compared to a death rate of only 49.55 in 1998. And, the injury rate decreased by 48%, from 3,107 injured motorcyclists per 100,000 motorcycles in 1987 to only 1,611 in 1998.

In the United States, the death and injury rates also declined by 33% and 40%, respectively - death rate of 82.61 in 1987 compared to a death rate of 55.30 in 1998; an injury rate of 2,294 in 1989 compared to an injury rate of 1,374 in 1997.

The changes in death and injury rates suggest that the decrease in the absolute number of motorcyclists killed and injured cannot be accounted for simply by changes in the number of registered vehicles. Although there were nearly 25% fewer registered vehicles, there were nearly 50% fewer deaths and injuries. However, the number of registered motorcycles provides only a very indirect measure of exposure. Annual distance traveled by motorcycles provides a more direct measure; such information is available for the United States but not Canada. Table 3 shows the number of vehicle miles of travel and the per-mile death and injury rates in the United States over the study period. Estimated annual miles of travel by motorcycles has remained largely unchanged over the study period, fluctuating between 9 billion and 10 billion miles. Despite little change in travel exposure, death and injury rates, based on distanced traveled, have still declined. The per-mile death rate for motorcyclists decreased by 51% -- from 42.5 motorcyclist deaths per 100 million miles in 1987 compared to only 21 in 1997. The per-mile injury rate for motorcyclists also decreased by 50% -- from 1,049 motorcyclists injured per 100 million miles in 1988 compared to only 522 in 1997.

These results suggest that changes in riding, as defined by registrations and vehicle miles of travel, accounted for some, but not all, of the decreases in road deaths and injuries among motorcyclists. The fact that the per-vehicle death and injury rates in both Canada and the United States and the per-mile death and injury rates in the United States continued to decline suggests that there have been significant safety gains.

Table 3

Vehicle Miles of Travel and
Death and Injury Rates* in the United States

	Vehicle Miles Travelled (millions)	Death Rate	Injury Rate
1987	9,506	42.5	N/A
1988	10,024	36.5	1049
1989	10,371	30.3	805
1990	9,557	33.9	882
1991	9,178	30.6	876
1992	9,557	25.1	681
1993	9,906	24.7	600
1994	10,240	22.7	561
1995	9,797	22.7	587
1996	9,920	21.8	557
1997	10,076	21.0	522
1998	N/A	N/A	N/A

* per 100 million vehicle miles of travel

CHANGES IN CRASH PATTERNS

To gain some insights into where these gains have occurred, changes in motorcycle crash patterns were examined. Table 4 shows the percentage of fatally injured motorcycle drivers accounted for by specific driver-related and crash-related factors in 1987 and 1998 in both Canada and the United States.

Driver-related factors or characteristics examined include: age; gender; license status (e.g., valid license, suspended, revoked); alcohol involvement, helmet use; previous crashes; previous suspensions; and previous convictions for driving while impaired, speeding and other types. Clearly, in both Canada and the United States, the greatest changes have been in driver age and alcohol involvement. For example, in 1987, drivers aged 16-19 accounted for 20.5% and 14.7% of motorcycle driver deaths in Canada and the United States, respectively. By 1998, young drivers accounted for only 11% and 6.3% of motorcycle driver deaths in Canada and the United States. Given that young drivers are a very high risk group (Mayhew and Simpson 1990a, 1995, 1999; Simpson 1996; Williams 1996), the decline in their representation among motorcyclists, at least among those involved in collisions, may partially account for the decreased numbers who have been killed and injured.

The percentage of fatally injured motorcycle drivers positive for alcohol has also declined dramatically over this study period. In 1987 in Canada, 56.8% of fatally injured motorcycle drivers had been drinking compared to only 32.3% in 1998 - a decline of 43%. In 1987 in the United States, 55.7% of fatally injured motorcycle drivers had been drinking compared to 48.2% in 1998 - a decline of 14%. Given that alcohol increases the risk of collision for all drivers but more so for motorcyclists (Mayhew and Simpson 1990b), the lower incidence of alcohol has likely contributed to the lower death and injury rates.

Table 4 also shows that motorcycle helmet use increased in the United States, from 37.1% of fatally injured motorcyclists wearing helmets in 1987 to 52.8% in 1998.

And, there was a decrease in the percentage of fatally injured motorcycle drivers with an invalid license (21.7% versus 17.4%), with previous DWI convictions (8.7% versus 5.6%), with previous speeding convictions (37.7% versus 29.8%) and with previous other convictions (31.7% compared to 25.6%). All these factors suggest that the characteristics of the motorcycling population have changed - today riders are more likely to comply with the rules of the road.

Crash-related factors or characteristics examined were: type of crash (single versus multiple vehicle); time of day (day versus night); day of week (weekday versus weekend); season; weather conditions; rural versus urban location; posted speed limit; and manner of collision - i.e., angle, head-on, rear end.

Table 4

Trends in Crash Patterns Among Fatally Injured Motorcycle Drivers
in Canada and the United States: 1987 compared to 1998

	Canada		United States	
	1987	1998	1987	1998
DRIVER-RELATED FACTORS				
Age 16-19	20.5	11.0	14.7	6.3
Age 25-34	27.9	33.7	35.3	30.7
Male	97.3	97.5	97.7	97.7
Invalid Licence	N/A	N/A	21.7	17.4
Positive BAC	56.8	32.3	55.7	48.2
Helmet Used	N/A	92.5	37.1	52.8
Previous Crashes	N/A	N/A	22.3	18.5
Previous Suspension/Revocation	N/A	N/A	21.1	21.1
Previous DWI Conviction	N/A	N/A	8.7	5.6
Previous Speeding Conviction	N/A	N/A	37.7	29.8
Previous Other Conviction	N/A	N/A	31.7	25.6
CRASH-RELATED FACTORS				
Single Vehicle	41.0	43.5	43.2	46.0
Night	55.2	49.7	60.6	51.0
Weekend	48.1	49.7	49.2	51.5
Summer	51.9	54.0	39.9	40.4
Adverse Conditions	N/A	N/A	3.8	3.3
Rural	N/A	N/A	43.2	49.8
Posted Speed Limit 55 +	N/A	N/A	33.6	37.0
Angle (% Multiple Vehicle Crashes)	N/A	N/A	57.9	57.6

The analyses revealed mostly minor changes in crash-related factors from 1987 to 1998. The percentage of crashes that were at night decreased in both Canada and the United States. The percentage of crashes that were single vehicle, on weekends, in the summer, in rural locations and on roads with a posted speed limit of 55 and over increased in the United States over the study period.

The data suggest that although driver- and crash-related factors have changed somewhat from 1987 to 1998, certain factors remain significant - i.e., alcohol, poor driving record, single vehicle, at night, on weekends.

CAUSES OF THE PROBLEM

Programs should be established in response to the causes of the problem. In this regard, the findings above suggest there is a continued need to address the high-risk rider. Alcohol remains a factor in almost one half of the fatal motorcycle crashes in the United States and one-third of those in Canada. More importantly, in 1998 among fatally injured motorcycle drivers who have been drinking, 59% in Canada and 55% in the United States had excessively high blood alcohol concentrations (BACs) over .15. Many fatally injured motorcyclists in the United States did not have a valid license (17%), were not wearing a helmet (47%), had previous suspensions/revocations (21%) as well as previous convictions for speeding (30%) and previous collisions (19%). These findings as well as the finding that almost half of the motorcycle driver deaths occurred in single vehicle collisions (44% in Canada and 46% in the United States) suggest that high-risk riders are often at fault.

This possibility is supported by a recent study of 2,074 crashes that resulted in a fatality to a motorcycle driver. Preusser et al. (1995) found that the following five crash types accounted for 86% of all motorcycle fatal crashes: ran-off the road (41.3%); ran traffic light (18.1%); head on (10.8%); left turn oncoming (8.5%); and motorcyclist down (7.3%). Run-off the road, the largest crash type accounting for almost half of the crash events, often involve late-night weekend crashes, occurring on rural roads, on higher speed roadways and at curves, and motorcyclists with high BACs. These crashes are typically the fault of the motorcyclist as were the head-on crashes - i.e., leaves the appropriate travel lane and collides with a vehicle coming from the opposite direction. Taken together, these two crash types accounted for 52% of the crash events. By contrast, "ran traffic control" and "left-turn oncoming" typically involved the other vehicle failing to grant the right of way to the motorcyclist. These two crash types, in which the other driver was at fault, accounted for only 27% of the crash events.

COUNTERMEASURE IMPLICATIONS

Historically, and even today, efforts to improve motorcycle safety have included measures related to the roadway environment, to the vehicle as well as the packaging of the rider, and to rider/driver behavior (see Mayhew and Simpson 1989; Simpson and Mayhew 1990; Haworth and Schulze 1996). Further safety gains may result from efforts to improve road and vehicle design - e.g., reduce the hostility of roadside furniture; improve the braking performance of motorcycles. Improving the conspicuity of motorcycles and riders will also have safety benefits as will improving the effectiveness of protective equipment and gear. And, there is still a need to encourage and pursue efforts to improve sharing the road by other motorists.

However, influencing rider attitudes and behavior is likely the most promising means for achieving long-term cost-effective crash reductions. Certainly, the findings show there is a pressing need to address the high-risk rider, who in the majority of the cases is at fault. Increased enforcement of alcohol, speed and other serious traffic violations may have a

positive influence on these illegal and unsafe riding behaviors. These enforcement efforts, however, have to be combined with more effective sanctioning, considering that many fatally injured motorcyclists did not have a valid license and had previous license suspension/revocations and previous convictions for speeding and other violations. Recent strategies for dealing with hard core drinking drivers undoubtedly have relevance here given that motorcycle drivers who have been drinking, especially those with high blood alcohol levels, comprise a considerable proportion of those involved in fatal crashes (see Simpson et al. 1996).

Even greater long-term safety inroads may be achieved by targeting novice riders before they have bought into a lifestyle of risky riding behaviors. Although the contribution of young riders aged 16-19 to the fatal-crash problem has declined over the past decade, this situation may change in the future because the teen population will increase dramatically over the next ten years (NHTSA 1998).

Improved rider licensing and rider education/training programs hold the most promise for influencing novice riders, and eventually, all motorcyclists in the future. In particular, graduated driver licensing, integrated with multi-stage driver education/training that focuses on rider skills as well as rider motivations and attitudes, appear warranted. Graduated licensing systems impose a set of restrictions on the beginner - e.g., night curfew, zero BAC, limits on the age of passengers - which are gradually and systematically lifted, so the novice enters driving in a step-by-step progressive manner. Upon graduation from the system, the driver is granted unrestricted driving privileges.

NHTSA and the American Association of Motor Vehicle Administrators (AAMVA) have published guidelines on an improved graduated driver licensing system to assist states in licensing novice drivers as well as motorcycle operators (NHTSA 1996). In addition, NHTSA, AAMVA and the Motorcycle Safety Foundation have developed a model system for motor vehicle administrators who wish to improve the effectiveness of their state's motorcycle operator licensing program (AAMVA 1997).

A few Canadian jurisdictions that have implemented graduated driver licensing for operators of passenger vehicles also apply this approach to novice motorcyclist. Although many states have adopted graduated driver licensing programs, they typically do not extend this licensing practice to motorcyclists. This is unfortunate given that recent evaluations have shown that graduated driver licensing programs have been very effective in reducing passenger vehicle crashes (Mayhew et al. in press).

Integrating improved driver education and training could also enhance the effectiveness of graduated driver licensing. In this regard, NHTSA, in a 1994 report to Congress recommended the development of a cost-effective two-stage driver education program that is an integral part of a graduated licensing system. Such an approach could also be applied to novice motorcyclists. However, efforts should be made to improve the form and content of existing training programs for novice motorcyclists because the safety benefits of the programs that have been evaluated to date have remained unproven (see Mayhew and Simpson 1998).

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