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FATAL MOTORCYCLE AND CAR CRASHES ON CURVES IN SOUTH AUSTRALIA

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ABSTRACT:
A sample of 232 fatal motorcycle crashes and 811 car occupant fatal crashes from South Australia between 1985 and 1991 were examined on a number of demographic and crash variables to determine if there were any differences in the rate of these crashes on curves.

It was found that while a slightly higher proportion of motorcyclist fatalities than car occupant fatalities were on curves (39.5% vs 36.1%) the difference was not statistically significant. There were some subgroups of crashes where a difference in curve crash rates between motorcyclists and drivers were apparent. In particular these were region, time of day and number of vehicles involved in the crash. The magnitude of the overall difference in curve crash rates was increased somewhat (39.0% vs 31.8%) by controlling for these other differences between crashes involving motorcycles and cars.

KEY WORDS: motorcycle, curves, car occupant, risk, crash, fatality

CONTENTS

1. INTRODUCTION

Although motorcycles only represent a small proportion of registered motor vehicles in Australia, motorcyclists are over represented in the number of annual fatal road crashes. The Federal Office of Road Safety (1995) reported that motorcyclists represented 11.7% of national road crash fatalities in 1991, while according to the Australian Bureau of Statistics 1991 Motor Vehicle Census (Castles, 1991), motorcycles only represented 2.7% of registered vehicles in Australia.

The large number of motorcyclist fatalities and serious injuries creates a considerable financial burden on the community with recent reports estimating the cost in 1991 of a fatality at $962,115 and the cost of a serious injury, that is an injury requiring hospitalisation, at $67,874 (Torpey et al., 1991).

Due to the high rate of motorcyclist fatalities and the high cost which is associated with road crash fatalities, several studies have been conducted into the cause and possible prevention of motorcycle crashes. Apart from factors associated with differences in vehicle and crash dynamics between motorcycles and cars (reviewed by Lake (1992)), such as: the lack of crash protection a motorcyclist has compared with a car occupant; the motorcycle's lack of stability on two wheels compared with that of a car on four wheels; while braking a car usually remains stable whereas a motorcycle can become unstable if the front and rear brakes are not appropriately applied. These studies (Lake, 1992; Rogers and White, 1995; Carr et al., 1995) have identified several high crash risk groups of motorcyclists. These groups were motorcyclists on curves, motorcyclists travelling at excessive speed, inexperienced motorcyclists, and motorcyclists with a high blood alcohol concentration (BAC).

A report by Rogers and White (1995) on factors contributing to motorcycle accidents in South Australia, found that the majority of fatal motorcycle crashes occurred in low density traffic, in good weather conditions and on roads in good condition. This suggests that motorcycle rider behavioural factors are a greater cause than environmental factors in fatal motorcycle crashes. The rider behavioural factors identified in this report were excessive speed, high BAC, and the motorcyclist's inability in handling road curves, or a combination of the three. The most common fatal motorcycle crash type identified by Rogers and White (1995) involved a motorcyclist out of control on a curve. It was found that in the 1985 to 1991 period 39% of fatal motorcycle crashes in South Australia occurred on road curves. This suggests that road curves, or the motorcyclist's inability to negotiate road curves, is a major factor in the over representation of motorcyclists in fatal crashes.

The primary aim of the present study is to compare and contrast a set of fatal motorcycle and fatal car crashes in South Australia between 1985 and 1991 with particular reference to road

curves to determine whether there are inherent characteristics about curves which make them more dangerous for motorcyclists than for car occupants.

2. METHOD

2.1 Fatal Motorcycle Crash Data

In the Rogers and White (1995) study, the Coroner's files for the 239 fatal motorcycle crashes in South Australia from 1985 to 1991 were examined and 232 cases were considered relevant to the study.

A fatal motorcycle crash was included in the data set of the present study if the rider and/or pillion was killed on a South Australian public road where the posted speed limit was 60 km/h or greater. Crashes which occurred on recreational dirt tracks were not included. Crashes in which only a person other than the rider and/or pillion died were also not considered as part of this data set.

Of the 232 fatal motorcycle crashes documented by Rogers and White (1995) 228 were selected for the present study. Four cases were excluded because two files were missing (cases 40 and 50), and two cases occurred in areas where the posted speed limit was less than 60km/h (cases 153 and 227). Data pertaining to road curves and the general demographic and location information of the crashes was then extracted from these files for analysis.

2.2 Fatal Car Crash Data

The Coroner's files for the fatal car crashes in South Australia between 1985 to 1991 were copied at the South Australian Coroner's Office. A fatal car crash was defined as a fatal motor vehicle crash in which a driver or passenger of a car, or car derivative, was killed on a South Australian public road where the posted speed limit was 60 km/h or greater. Fatal crashes which only involved natural death were not included. In total 811 crashes were included in this data set. As with the fatal motorcycle crash data, information relevant to road curves and general demographic and location of the fatal car crashes was extracted from these files for analysis.

2.3 Data Analysis

The information extracted from the Coroner's files was coded and entered into a database and analysed using the SPSS statistical software package. The main categories which were compared between fatal motorcycle and car occupant crashes were:

- chronological features which included the time of day, the day of the week, the month, and the year in which the crash occurred.
- geographical features which included the region, the posted speed limit, the road

surface, the road type, the level of the road, and whether the road was wet or dry in the area in which the crash occurred.

- demographical features which included the age, sex, and BAC level of the rider or driver of the vehicle in which the fatality occurred.
- crash features which included a coding of vehicle movements prior to the crash, the number of vehicles involved in the crash, and whether the crash was considered by the South Australian Police to have been the fault of the rider or driver of the vehicle in which the fatality occurred. If the crash occurred on a curve an assessment was made of whether it was primarily due to the rider or driver's inability to handle the curve.

This data was then presented as frequencies and percentages in table form. The data was then compared and grouped so that it could be refined in order to match the two data sets. The statistical significance between the grouped variables was determined using the Chi square test and p values were reported.

2.4 Definitions

Road Type

The type of road on which the crash occurred was classified as either a straight road or a curve/bend. If a crash occurred on a straight stretch of road but resulted from a vehicle either approaching or leaving a curve it was classified as having occurred on a bend. If the crash did occur on a curve it was noted whether the curve was on a T-junction, as T-junction curves have been anecdotally reported as being hazardous to motorcycle users at night, possibly due to deceptive road markings. T-junction curves have a characteristic break in the road markings in the middle of the road at the intersection of the two roads. At night this may give the appearance that the road is straight. Crashes which occurred on curves were also classified into whether the curve was a left or right hand curve.

Region

The region in which the crash occurred was divided into three categories: Adelaide Plains, Adelaide Hills, and rural. The Adelaide Plains area contains the central city and most of the surrounding suburbs. The Adelaide Hills was defined as the semi rural area immediately surrounding Adelaide which is favoured by recreational riders and drivers. The rural region was defined as any area which is not in the other two regions.

Crash Type

The crash types were defined by the movements of the vehicles involved immediately prior to the crash using a coding method developed by Andreassen (1991). In many fatal crashes there may be more than one event which leads to the fatality. There is the event which initiates the crash or the loss of control, and subsequent events which are a consequence of the initial

event. For the purpose of this report, even if the fatality resulted from a subsequent event, the crash was coded by the initial event.

3. RESULTS

The results are presented in two sections: firstly, all drivers and riders are compared, then only male drivers and riders are compared since there were only 5 female riders in the sample.

Finally, an attempt was made to weight the data relating to car crashes on curves to allow for differences in factors other than road type between these car and motorcycle crashes. This was done to facilitate the identification of any fundamental difference in curve crash rates between motorcycle and car crashes.

3.1 All Drivers and Riders

Table 1 shows the incidence of crashes on a curve for all motorcyclist and car occupant fatalities. While the motorcyclist fatalities did have a slightly higher rate of crashes on curves than the car occupant fatalities (39.5% vs 36.1%), the difference was not statistically significant.

Table 1
Type of Road on Which Fatal Crash Occurred

Road Type	Motorcyclist		Car Occupant	
	n	%	n	%
Straight Road	138	60.5	518	63.9
Curve/Bend	90	39.5	293	36.1
Total	228	100.0	811	100.0

$\chi^2 = 0.86$, df=1, p=0.355

Table 2 shows the incidence of selected demographic and crash factors relating to motorcyclist and car occupant fatalities. Half of the variables showed statistically significant differences between the two groups of road user. The motorcycle riders in these fatal crashes were found to be more likely to be male and younger than the drivers in fatal car crashes. The motorcycle crashes were also more likely to be in the Adelaide Plains and the Adelaide Hills. The corresponding greater proportion of car crashes in rural areas probably also explains the higher incidence of car occupant fatalities in speed limit areas of 100km/hr or greater. The motorcyclist fatalities were also more likely to have occurred in multiple vehicle crashes and in crashes in which fault was attributed to the rider, by the South Australian Police, less often than to the driver in crashes resulting in a car occupant being fatally injured.

Table 3 shows the percentage of crashes that occurred on a curve broken down by motorcyclist/car occupant and the same set of variables used before regarding the crash. The in-column p values show the statistical significance level of differences within the driver/rider groups and the row p values in the right column of the table show differences between the

drivers and riders for the given variable subgroups.

The keys differences apparent in Table 3 are:

- drivers had a lower proportion of crashes on curves during the day while riders had the same proportion of crashes on curves by day as at night.
- while both drivers and riders had a higher proportion of crashes on curves in the Adelaide Hills, the proportion was significantly greater for riders.
- riders had a much lower proportion of crashes on curves on unsealed roads than drivers, but there were very few motorcycle crashes on unsealed roads.
- riders had a much lower proportion of crashes on curves on wet road surfaces than drivers, but there were very few motorcycle crashes on wet roads.
- riders were more likely to have been on a curve when they were judged to be at fault by the South Australian Police; and less likely when they were judged not to be at fault both by themselves and when compared to car drivers.

Table 2
Demographic and Crash Characteristics in Motorcyclist and Car Occupant Fatalities

Variable	Motorcyclist		Car Occupant		Stat Sig (χ^2 test)
	n	%	n	%	
Sex of Driver/Rider					p<0.001
Male	223	97.8	635	78.3	
Female	5	2.2	176	21.7	
Age of Driver/Rider					p<0.001
< 30 Years	171	75.0	414	51.2	
30+ Years	57	25.0	395	48.8	
BAC Level of Driver/Rider					p=0.873
<0.080	135	62.2	480	61.6	
0.080 +	82	37.8	299	38.4	
Time					p=0.264
Day (7am - 6pm)	106	46.5	345	42.5	
Night (6pm - 7am)	121	53.1	466	57.5	
Day of Week					p=0.762
Weekday	140	61.4	489	60.3	
Weekend	88	38.6	322	39.7	
Season					p=0.179
Warm	139	61.0	454	56.0	
Cold	89	39.0	357	44.0	
Region					p<0.001
Adelaide Plains	115	50.4	213	26.3	
Adelaide Hills	29	12.7	50	6.2	
Rural	84	36.8	548	67.6	
Speed Limit					p<0.001
<100 km/hour	144	63.2	293	36.1	
100+ km/hour	84	36.8	518	63.9	
Road Surface					p=0.072
Sealed	212	93.0	721	88.9	
Unsealed	16	7.0	90	11.1	
Road Surface					p=0.085
Wet	17	7.5	93	11.5	
Dry	210	92.1	718	88.5	
No. of Vehicles					p=0.005
Single	95	41.7	424	52.3	
Multiple	133	58.3	387	47.7	
Driver/Rider's Fault (Police)					p<0.001
Yes	167	70.6	693	85.5	
No	67	29.4	118	14.5	

Table 3
Difference Between Curve Crash Rates for Motorcyclist and Car Occupant Fatalities Broken Down by Demographic and Crash Characteristics

Variable	Motorcyclist		Car Occupant		Stat Sig
	n	% on Curve	n	% on Curve	(χ^2 test)
Sex of Driver/Rider		p=0.342		p=0.060	
Male	223	39.0	635	37.8	p=0.064
Female	5	60.0	176	30.1	p=0.154
Age of Driver/Rider		p=0.273		p<0.001	
< 30 years	171	41.5	414	42.3	p=0.867
30+ Years	57	33.3	395	29.6	p=0.568
BAC Level of Driver/Rider		p=0.005		p<0.001	
<0.080	135	31.9	480	27.9	p=0.372
0.080 +	82	51.2	299	51.2	p=0.994
Time		p=0.695		p<0.001	
Day (7am - 6pm)	106	40.6	345	27.8	p=0.013
Night (6pm - 7am)	121	38.0	466	42.3	p=0.397
Day of Week		p=0.081		p=0.019	
Weekday	140	35.0	489	32.9	p=0.646
Weekend	88	46.6	322	41.0	p=0.346
Season		p=0.09		p=0.766	
Warm	139	42.4	454	35.7	p=0.149
Cold	89	34.8	357	36.7	p=0.744
Region		p<0.001		p<0.001	
Adelaide Plains	115	31.3	213	24.4	p=0.179
Adelaide Hills	29	86.2	50	58.0	p=0.009
Rural	84	34.5	548	38.7	p=0.465
Speed Limit		p=0.028		p<0.001	
<100 km/hour	144	34.0	293	25.9	p=0.079
100+ km/hour	84	48.8	518	41.9	p=0.235
Road Surface		p=0.079		p=0.015	
Sealed	212	41.0	721	34.7	p=0.090
Unsealed	16	18.8	90	47.8	p=0.031
Road Surface		p=0.003		p=0.215	
Wet	17	5.9	93	41.9	p=0.005
Dry	210	41.9	718	35.4	p=0.085
No. of Vehicles		p<0.001		p<0.001	
Single	95	64.2	424	47.4	p=0.003
Multiple	133	21.8	387	23.8	p=0.643
Driver/Rider's Fault		p<0.001		p=0.002	
Yes	167	51.6	693	38.2	p=0.007
No	67	10.4	118	23.7	p=0.027

Table 4 examines only those crashes that occurred on curves and looks at a number of variables to contrast the motorcycle and car occupant fatalities. No significant differences are apparent.

Table 4
Differences Between Curve Variables
in Motorcyclist and Car Occupant Fatalities

Variable	Motorcyclist		Car Occupant		Stat Sig (χ^2 test)
	n	%	n	%	
Right/Left Hand Curve					p=0.551
Right Hand Curve	45	50.0	157	53.6	
Left Hand Curve	45	50.0	136	46.4	
Curve Caused Accident					p=0.364
Yes	77	85.6	261	89.1	
No	13	14.4	32	10.9	
Driver/Rider Couldn't Take Curve					p=0.995
Yes	74	82.2	241	82.3	
No	16	17.8	52	17.7	
T-Junction Curve					p=0.442
Yes	12	13.3	49	16.7	
No	78	86.7	244	83.3	
Rum Code if Curve a Factor in the Crash					
107 Turned Left in Front at Intersection	0	0.0	1	0.4	
201 Head on With Another Vehicle	20	26.0	61	23.4	
202 Turned Right in Front at Intersection	0	0.0	1	0.4	
501 Head on While Overtaking	1	1.3	0	0.0	
502 Out of Control While Overtaking	0	0.0	1	0.4	
801 Off Carriageway on Right Curve	2	2.6	13	5.0	
802 Off Carriageway on Left Curve	3	3.9	12	4.6	
803 Off Right Curve into Object	31	39.0	94	36.0	
804 Off Left Curve into Object	13	16.9	72	27.6	
805 Out of Control on Curve	5	6.5	6	2.3	
808 Mounts Traffic Island on Curve	2	2.6	0	0.0	

3.2 Male Riders and Drivers

The previous section showed that many factors involved in the motorcycle and car crashes are quite different (see Table 2). The largest difference between the two groups was in the sex of the driver/rider with 21.7% of car drivers being female and only 2.2% of motorcycle riders being female. By excluding the 5 female riders and 176 female drivers, more direct comparisons can be made between the two groups by eliminating any sex biases due to the very different sex makeup of the two groups.

Table 5 compares the incidence of crashes on a curve for all male motorcyclist and male car occupant fatalities. The small difference between the two groups for all driver/riders (Table 1) has been reduced even further here when considering only male driver/riders.

Table 5
Type of Road on Which Fatal Crash Involving a Male Rider/Driver Occurred

Road Type	Motorcyclist		Car Occupant	
	n	%	n	%
Straight Road	136	61.0	395	62.2
Curve/Bend	87	39.0	240	37.8
Total	223	100.0	635	100.0

$\chi^2 = 0.10$, df=1, p=0.747

Table 6 is the male only version of Table 2. Most of the results remain the same with the exception of BAC and time of day. When considering only males, drivers had a greater proportion of cases with BACs over 0.08 compared to riders. This effect was masked in Table 2 by the lower BAC levels of females in general. Time of day has also become significant with a greater proportion of car occupant fatalities occurring during the day compared to motorcyclist fatalities.

Table 6
Demographic and Crash Characteristics in Motorcyclist and Car Occupant Fatalities Involving a Male Rider/Driver

Variable	Motorcyclist		Car Occupant		Stat Sig (χ^2 test)
	n	%	n	%	
Age of Driver/Rider					p<0.001
< 30 Years	169	75.4	331	52.1	
30+ Years	54	24.2	303	47.7	
BAC Level of Driver/Rider					p<0.001
<0.080	133	59.6	345	54.3	
0.080 +	79	35.4	265	41.7	
Time					p=0.043
Day (7am - 6pm)	105	47.1	251	34.5	
Night (6pm - 7am)	117	52.5	384	60.5	
Day of Week					p=0.621
Weekday	138	61.9	381	60.0	
Weekend	85	38.1	254	40.0	
Season					p=0.214
Warm	135	60.5	354	55.7	
Cold	88	39.5	281	44.3	
Region					p<0.001
Adelaide Plains	115	51.6	165	26.0	
Adelaide Hills	28	12.6	45	7.1	
Rural	80	35.9	425	66.9	
Speed Limit					p<0.001
<100 km/hour	142	63.7	225	35.4	
100+ km/hour	81	37.7	410	64.6	
Road Surface					p=0.074
Sealed	208	93.3	566	89.1	
Unsealed	15	6.7	69	10.9	
Road Surface					p=0.137
Wet	17	7.6	71	11.2	
Dry	205	91.9	564	88.8	
No. of Vehicles					p=0.002
Single	92	41.3	339	53.4	
Multiple	131	58.7	296	46.6	
Driver/Rider's Fault					p<0.001
Yes	158	70.9	553	87.1	
No	65	29.1	82	12.9	

Table 7 is the male only version of Table 3. With some minor variations it presents a similar picture of crashes on curves to that shown in Table 3. Some of the more obvious differences between the motorcycle and car crashes are illustrated in the following figures.

Table 7
Difference Between Curve Crash Rates for Motorcyclist and Car Occupant Fatalities Involving a Male Rider/Driver Broken Down by Demographic and Crash Characteristics

Variable	Motorcyclist		Car Occupant		Stat Sig (χ^2 test)
	n	% on Curve	n	% on Curve	
Age of Driver/Rider		p=0.192		p=0.001	
< 30 years	169	41.4	331	44.1	p=0.566
30+ Years	54	31.5	303	31.0	p=0.947
BAC Level of Driver/Rider		p=0.006		p<0.001	
<0.080	133	31.6	345	27.8	p=0.417
0.080 +	79	50.6	265	52.8	p=0.732
Time		p=0.521		p<0.001	
Day (7am - 6pm)	105	41.0	251	26.7	p=0.008
Night (6pm - 7am)	117	36.8	384	45.1	p=0.113
Day of Week		p=0.171		p=0.008	
Weekday	138	35.5	381	33.6	p=0.685
Weekend	85	44.7	254	44.1	p=0.922
Season		p=0.349		p=0.340	
Warm	135	41.5	354	36.2	p=0.277
Cold	88	35.2	281	39.9	p=0.437
Region		p<0.001		p<0.001	
Adelaide Plains	115	31.3	165	26.7	p=0.398
Adelaide Hills	28	85.7	45	57.8	p=0.012
Rural	80	33.8	425	40.0	p=0.293
Speed Limit		p=0.035		p=0.001	
<100 km/hour	142	33.8	225	29.3	p=0.367
100+ km/hour	81	48.1	410	42.4	p=0.343
Road Surface		p=0.035		p=0.004	
Sealed	208	40.9	566	35.9	p=0.202
Unsealed	15	13.3	69	53.6	p=0.005
Road Surface		p=0.004		p=0.279	
Wet	17	5.9	71	43.7	p=0.004
Dry	205	41.5	564	37.1	p=0.266
No. of Vehicles		p<0.001		p<0.001	
Single	92	63.0	339	49.3	p=0.019
Multiple	131	22.1	296	24.7	p=0.573
Driver/Rider's Fault		p<0.001		p=0.007	
Yes	158	70.9	553	39.8	p<0.001
No	65	29.1	82	24.4	p=0.509

Figures 1 and 2 illustrate the number of fatal motorcycle and car crashes and the number of crashes which occurred on road curves which involved a male rider/driver in the different regions of South Australia between 1985 to 1991.While **Figure 3** directly compares the percentage of fatal motorcycle and car crashes which occurred on road curves which involved a male rider/driver in the different regions of South Australia between 1985 to 1991.

Motorcyclists have the greatest proportion of fatal crashes occurring on curves in the Adelaide Hills Region, while car occupant fatalities, which also have a high proportion occurring on curves in the Adelaide Hills, have a high proportion of fatal crashes on curves in the rural region.

Figure 1
Frequency of Fatal Motorcycle Crashes Involving a Male Rider in the Different Regions of South Australia from 1985 to 1991

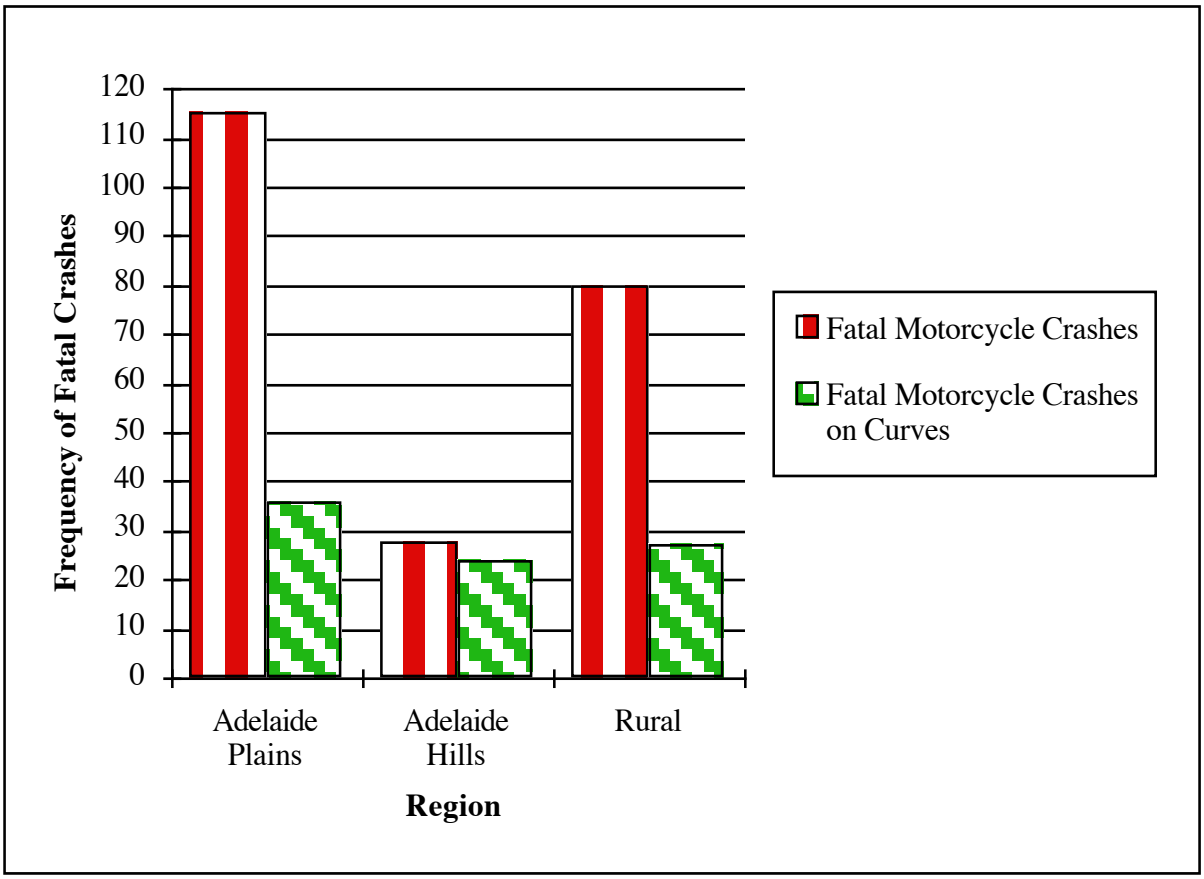


Figure 2

Frequency of Fatal Car Crashes Involving a Male Driver in the Different Regions of South Australia from 1985 to 1991

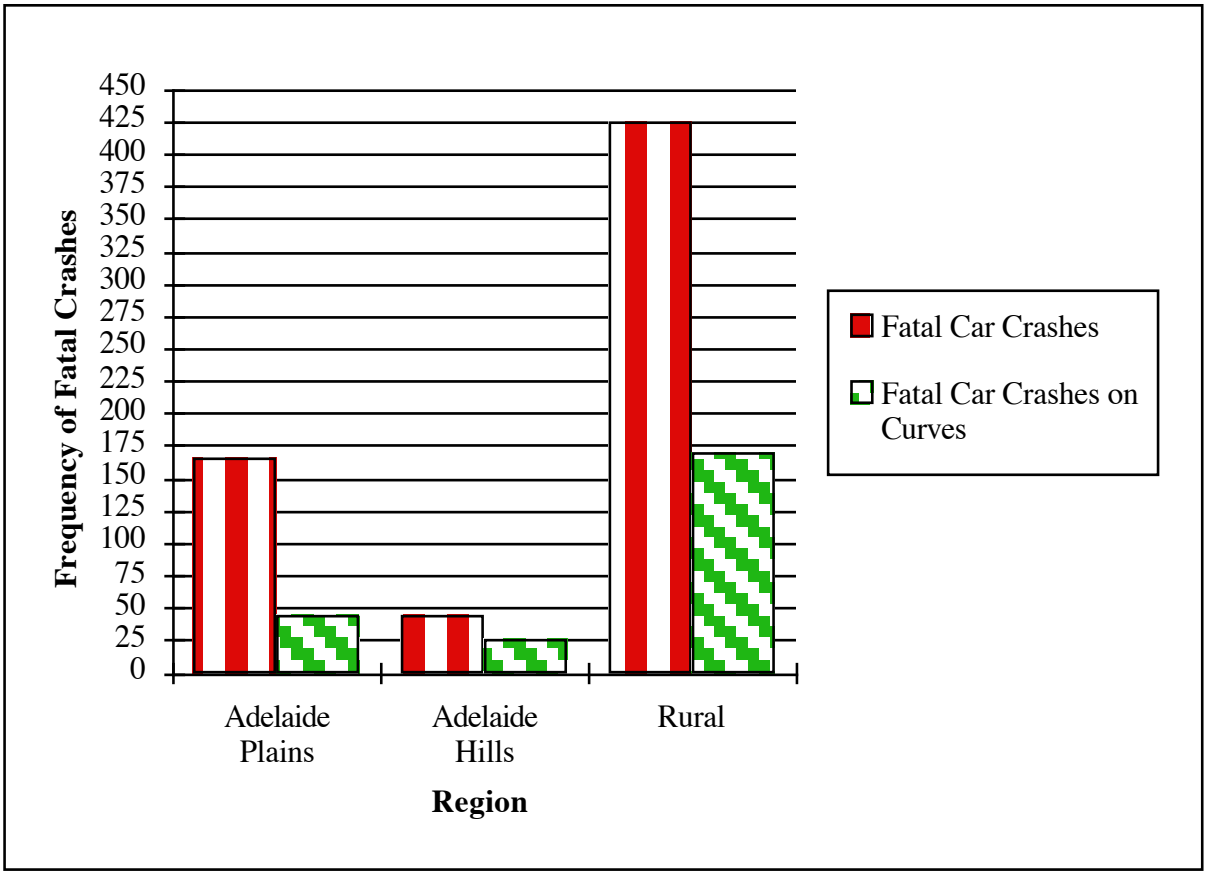
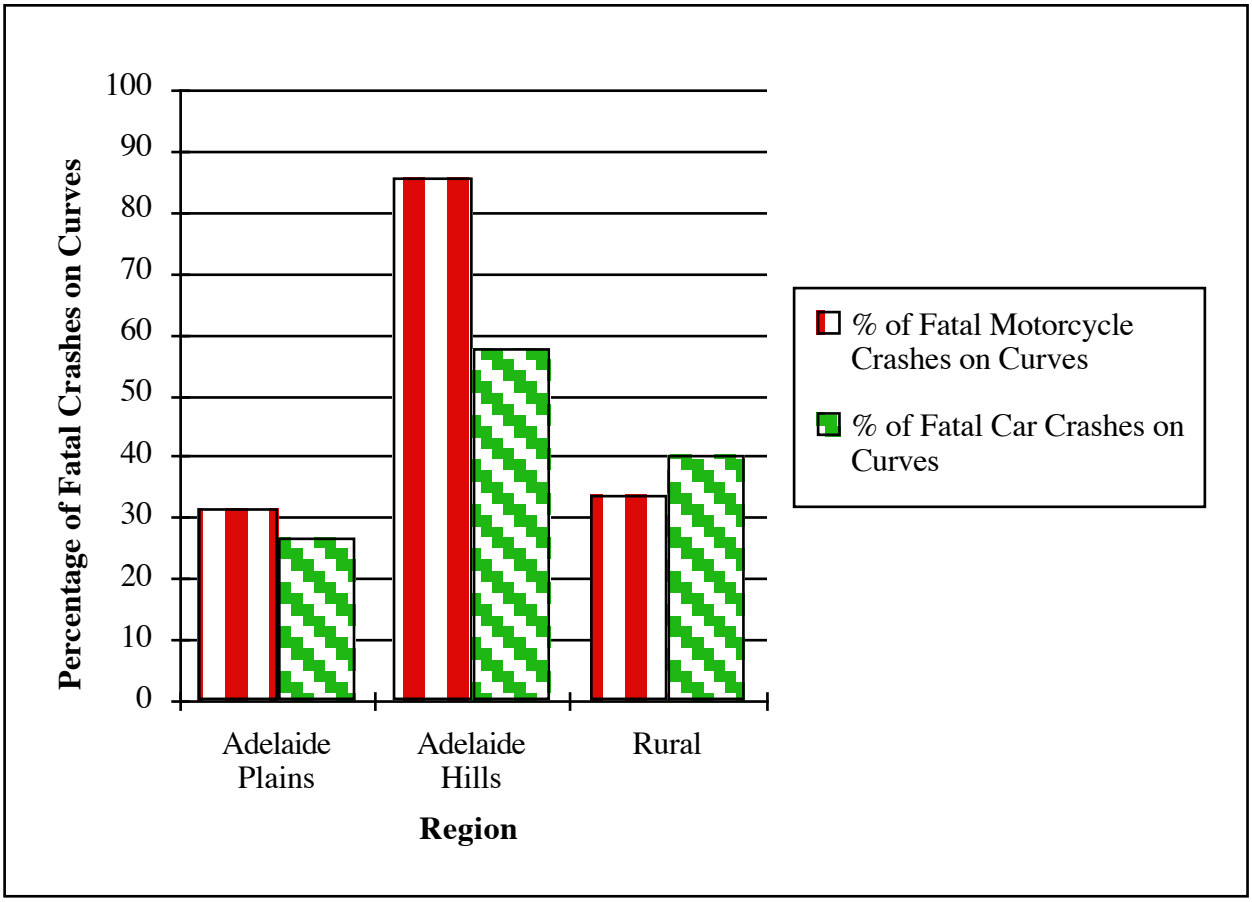


Figure 3
Comparison of the Percentage of Fatal Motorcycle and Car Crashes Which Occurred on Road Curves Involving a Male Rider/Driver in the Different Regions of South Australia from 1985 to 1991



Figures 4 and 5 show the number of single vehicle and multiple vehicle fatal motorcycle and car crashes and the number of crashes which occurred on road curves which involved a male rider/driver. While **Figure 6** illustrates a direct comparison of the percentage of single vehicle and multiple vehicle fatal motorcycle and car crashes which occurred on road curves which involved a male rider/driver between 1985-1991. It can be seen that the motorcycle crashes have a greater proportion of single vehicle crashes occurring on curves.

Figure 4
Frequency of Single and Multiple Vehicle Fatal Motorcycle Crashes Involving a Male Rider from 1985 to 1991

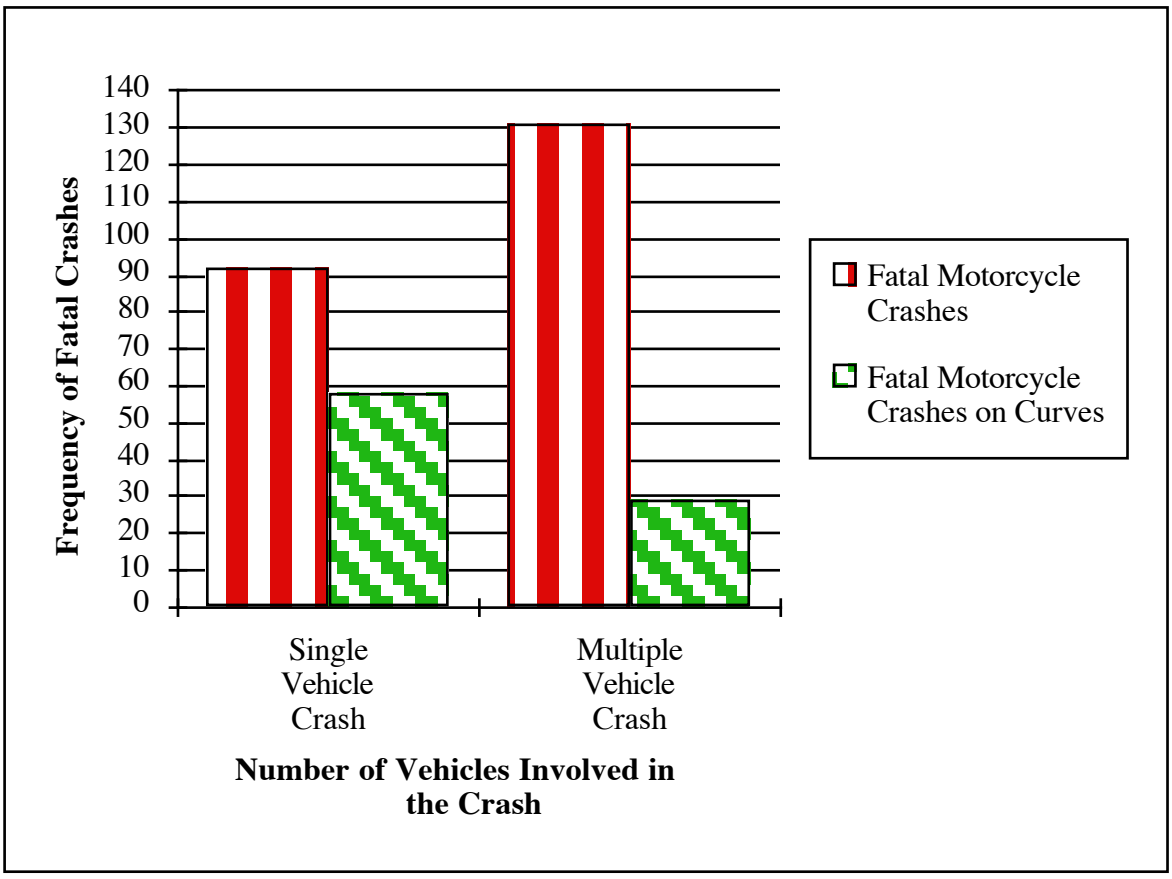


Figure 5

Frequency of Single and Multiple Vehicle Car Crashes Involving a Male Driver from 1985 to 1991

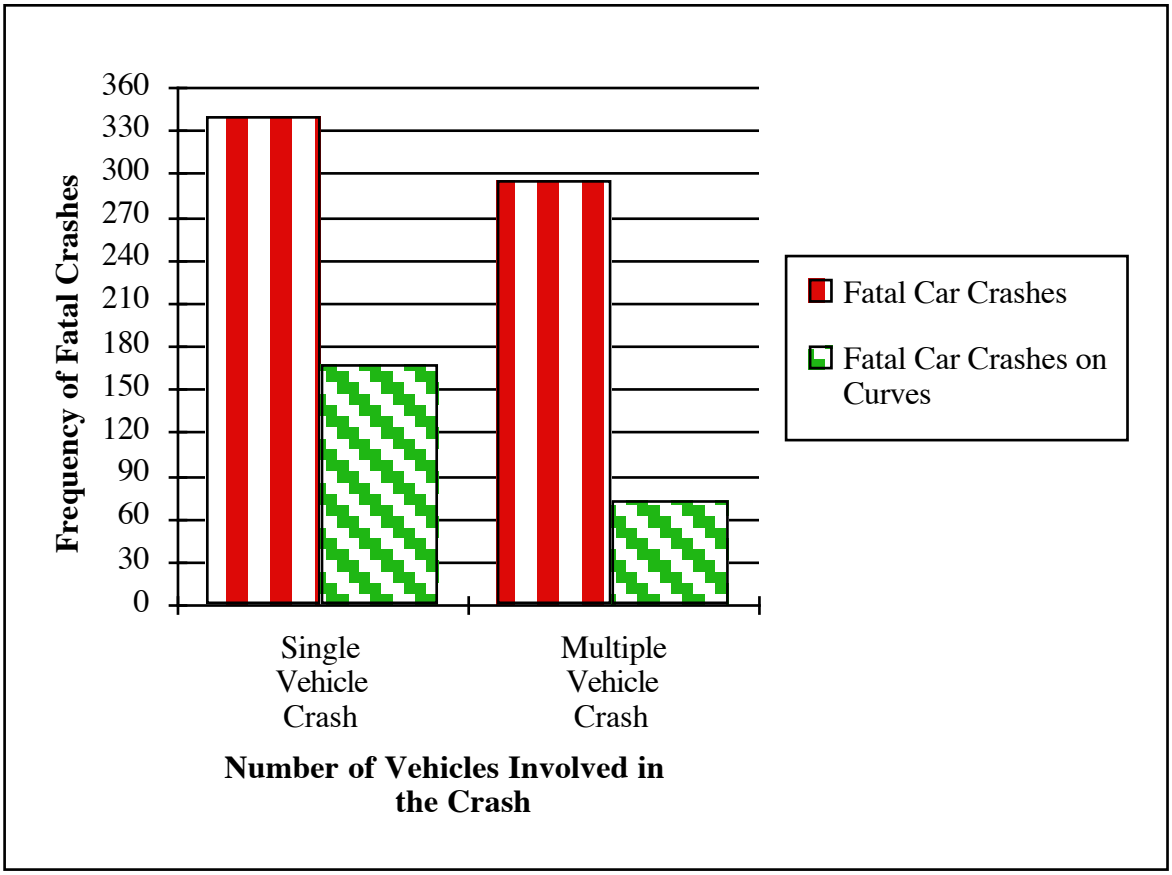
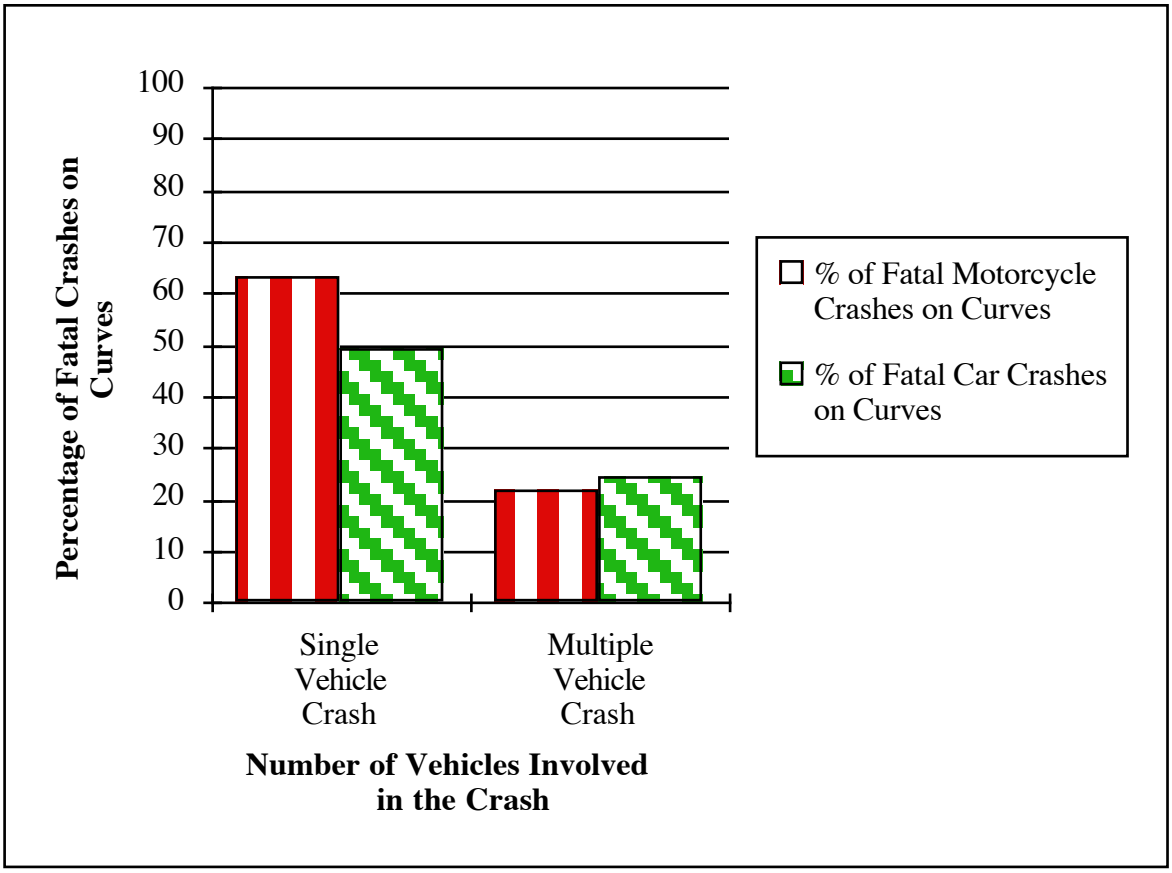


Figure 6
Comparison of the Percentage of Single Vehicle and Multiple Vehicle Fatal Motorcycle and Car Crashes Which Occurred on Road Curves Involving a Male Rider/Driver from 1985 to 1991



Figures 7 and 8 show the number of fatal motorcycle and car crashes and the number of fatal crashes occurring on a curve by the time of day at which the crash occurred. **Figure 9** is a comparison of the percentage of fatal motorcycle and car crashes which occurred on road curves during the different times of the day. As with the previous figures, these three are based only on those crashes which involved a male rider or driver from 1985-1991. Motorcycle riders have a slightly higher proportion of these crashes on curves during the day while car occupants have a higher proportion of their fatal crashes on curves at night.

Figure 7
Frequency of Fatal Motorcycle Crashes Occurring During the Different Times of the Day Involving a Male Rider from 1985 to 1991

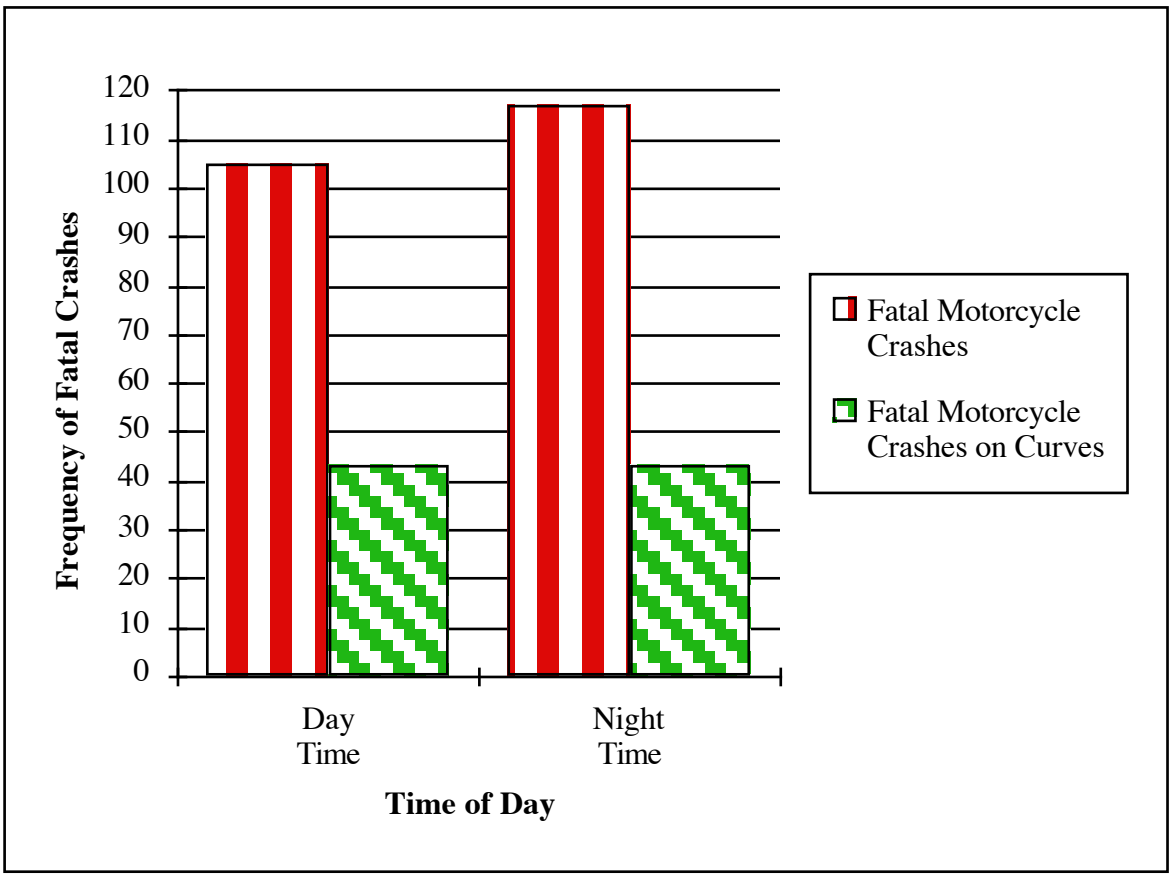


Figure 8

Frequency of Fatal Car Crashes Occurring During the Different Times of the Day Involving a Male Driver from 1985 to 1991

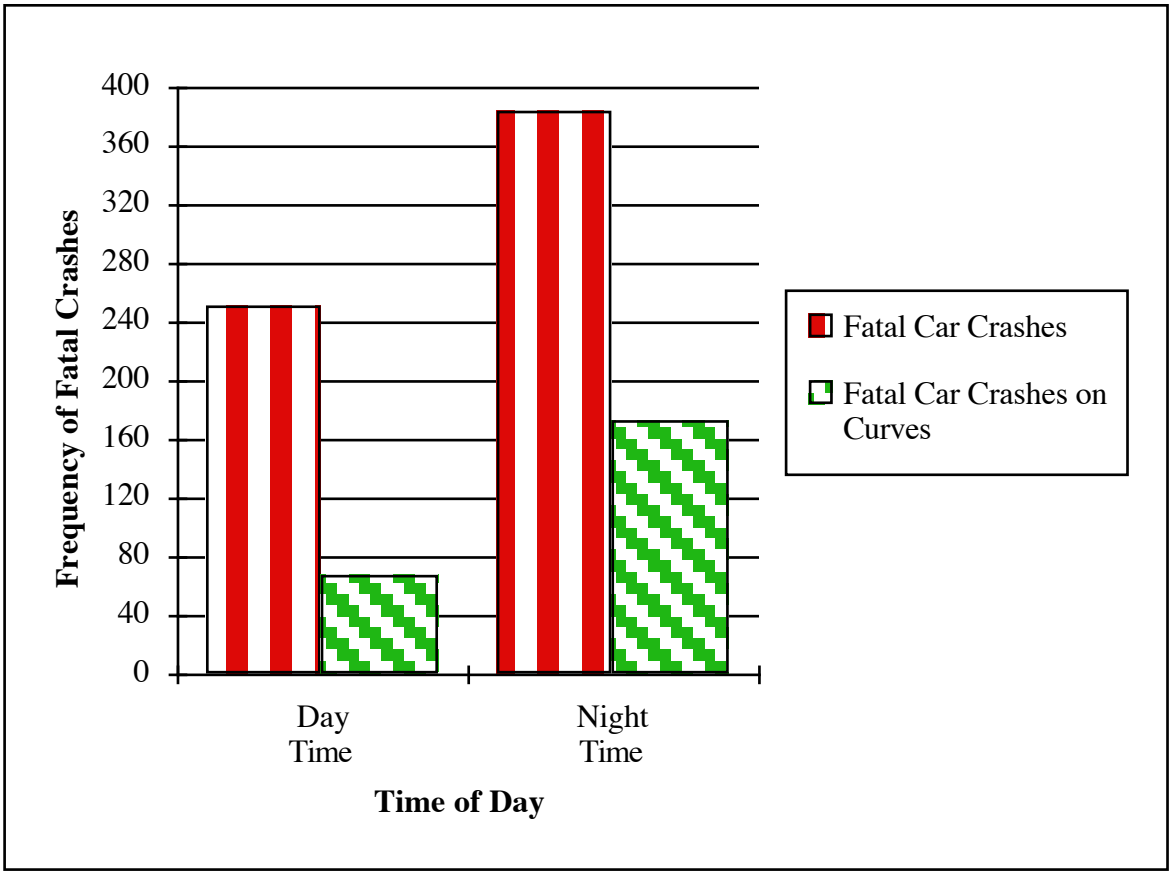


Figure 9
Comparison of the Percentage of Fatal Motorcycle and Car Crashes Which Occurred on Road Curves During the Different Times of the Day Involving a Male Rider/Driver from 1985 to 1991

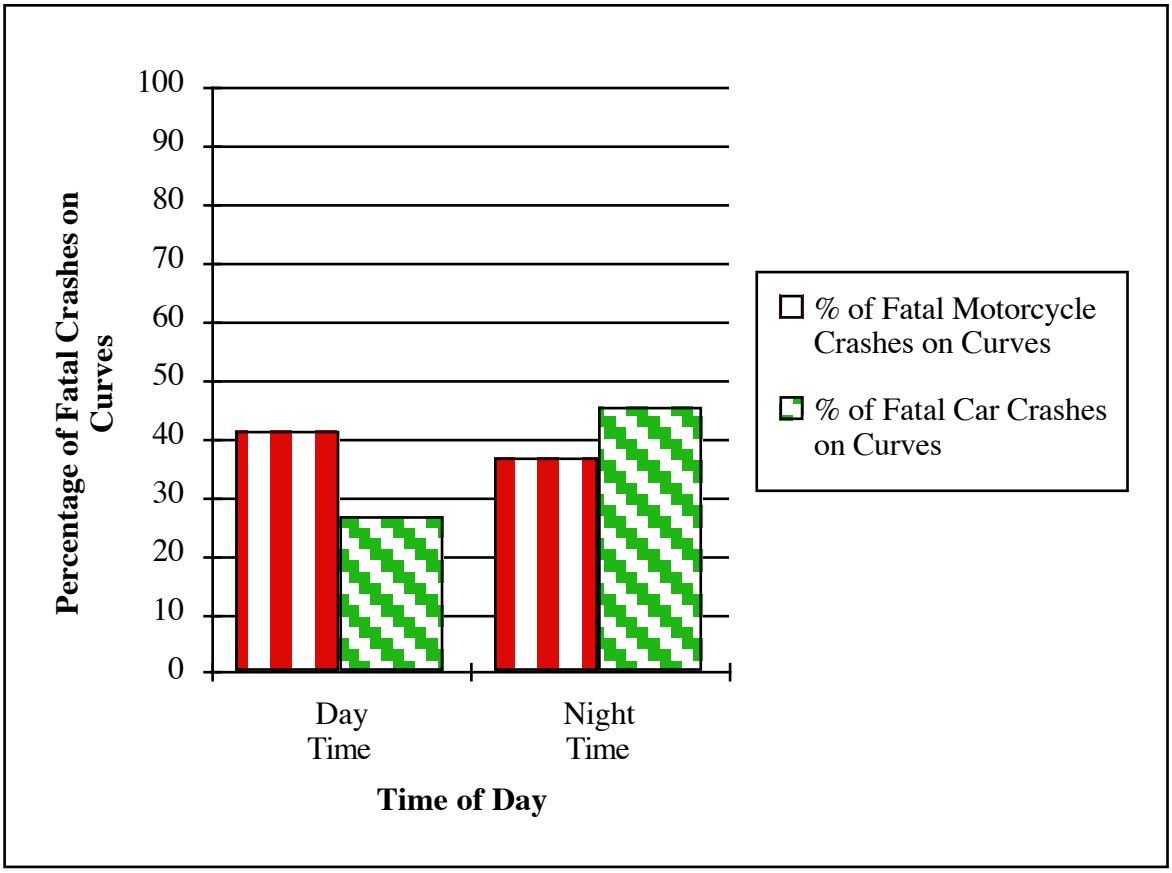


Table 8 is the male only version of Table 4 where curve variables are shown for only those cases that happened on curves. The essential comparisons are basically unchanged except for a now statistically significant difference whereby male drivers were more likely to have been judged unable to take the curve compared to male motorcycle riders. As the motorcyclist data is almost unchanged from Table 4, this means that male car drivers were less able to negotiate the curve than were female drivers.

Table 8
Differences Between Curve Variables in Motorcyclist and Car Occupant Fatalities Involving a Male Rider/Driver

Variable	Motorcyclist		Car Occupant		Stat Sig (χ^2 test)
	n	%	n	%	
Right/Left Hand Curve					p=0.635
Right Hand Curve	42	48.3	123	51.2	
Left Hand Curve	45	51.7	117	48.8	
Curve Caused Accident					p=0.171
Yes	74	85.1	217	90.4	
No	13	14.9	23	9.6	
Driver/Rider Couldn't Take Curve					p=0.010
Yes	71	81.6	220	91.7	
No	16	18.4	20	8.3	
T-Junction Curve					p=0.292
Yes	11	12.6	42	17.5	
No	76	82.4	198	82.5	
Rum Code if Curve a Factor in the Crash					
107 Turned Left in Front at Intersection	0	0.0	1	0.5	
201 Head on With Another Vehicle	20	26.7	51	23.5	
202 Turned Right in Front at Intersection	0	0.0	1	0.5	
501 Head on While Overtaking	1	1.3	0	0.0	
502 Out of Control While Overtaking	0	0.0	1	0.5	
801 Off Carriageway on Right Curve	2	2.7	12	5.5	
802 Off Carriageway on Left Curve	3	4.0	12	5.5	
803 Off Right Curve into Object	28	37.3	75	34.6	
804 Off Left Curve into Object	13	17.3	58	26.7	
805 Out of Control on Curve	5	6.7	6	2.8	
808 Mounts Traffic Island on Curve	2	2.7	0	0.0	

The variables which differed the most between motorcyclist and car occupant fatalities involving a male rider/driver were region, the number of vehicles involved in the crash, and the time of day at which the crash occurred. Tables 9-14 illustrate the differences in the frequencies of these variables on straight and curved roads between motorcycles and cars.

Tables 9 and 10 show the difference in the distribution of the frequency of fatal motorcycle and car crashes in the different regions of South Australia on straight and curved roads. It can be seen from these tables that a high proportion of motorcyclist fatalities which occur in the Adelaide Plains and Adelaide Hills occur on curves compared to car occupant fatalities. While car occupant fatalities which occur in rural areas are more likely to have occurred on curves compared to motorcyclist fatalities.

Table 9
Frequency of Motorcyclist Fatalities in the Different Regions of South Australia on Straight and Curved Roads Involving a Male Rider

Region	Road Type		Total
	Straight Road	Curve/Bend	
Adelaide Plains	79	36	115
Adelaide Hills	4	24	28
Rural	53	27	80
Total	136	87	223

Table 10
Frequency of Car Occupant Fatalities in the Different Regions of South Australia on Straight and Curved Roads Involving a Male Driver

Region	Road Type		Total
	Straight Road	Curve/Bend	
Adelaide Plains	121	44	165
Adelaide Hills	19	26	45
Rural	255	170	425
Total	395	240	635

Tables 11 and 12 illustrate the difference in the distribution of single and multiple vehicle crashes on straight and curved roads between motorcyclist and car occupant fatalities. These tables demonstrate that motorcycle crashes which occur on curves are more likely to be single vehicle crashes. While car crashes which occur on curves are much more likely to involve multiple vehicles.

Table 11
Frequency of Single and Multiple Vehicle Motorcyclist Fatalities on Straight and Curved Roads Involving a Male Rider

Number of Vehicles	Road Type		Total
	Straight Road	Curve/Bend	
Single Vehicle	34	58	92
Multiple Vehicle	102	29	131
Total	136	87	223

Table 12
Frequency of Single and Multiple Vehicle Car Occupant Fatalities on Straight and Curved Roads Involving a Male Driver

Number of Vehicles	Road Type		Total
	Straight Road	Curve/Bend	
Single Vehicle	167	172	339
Multiple Vehicle	73	223	296
Total	240	395	635

Tables 13 and 14 show the difference in the distribution of the frequency of fatal motorcycle

and car crashes at different times of the day on straight and curved roads. It can be seen that a higher proportion of motorcycle crashes occur on curves during the day while a higher proportion of car crashes occur on curves at night.

Table 13
Frequency of Motorcyclist Fatalities at Different Times of the Day on Straight and Curved Roads Involving a Male Rider

Time of Day	Road Type		Total
	Straight Road	Curve/Bend	
Day Time	62	43	105
Night Time	74	43	117
Total	136	86	222

Table 14
Frequency of Car Occupant Fatalities at Different Times of the Day on Straight and Curved Roads Involving a Male Driver

Time of Day	Road Type		Total
	Straight Road	Curve/Bend	
Day Time	184	67	251
Night Time	211	173	384
Total	395	240	635

3.3 Weighted Data Analysis

Table 15 represents an attempt to do an overall correction for the differences in the types of driver and rider crashes that occur in order to distil any fundamental difference in curve crash rates. The variables that seemed to differ the most and that had apparent differences in curve crash risk were found to be sex, region, number of vehicles and time of day (Figures 1-9). Sex was controlled by using only males in the samples. The other three variables where then stratified out as seen in Table 15. The number of motorcyclist cases was then used to weight the percentage of the car occupant cases that occurred on curves. This was done by dividing the number of motorcyclist cases for a particular set of conditions by the total number of motorcyclist cases, and this resulting percentage was then multiplied by the percentage of car occupant cases on curves for the same set of conditions. This gave the weighted percentage of car occupant cases on curves for that particular set of conditions. These weighted percentages were then totalled to give a best estimate of the percentage of car crashes on curves if the car crashes had been distributed on these variables in the same proportion as the motorcycle crashes.

The resulting weighted percentage of fatal car occupant crashes on curves for male drivers is lower than the unweighted percentage (31.8% compared with 37.8%). This implies that curves may be a factor more often in fatal crashes involving motorcyclists than for those

involving car occupants, but the difference is still not great.

Table 15
Stratification and Weighting of the Fatal Crash Data
Involving a Male Driver/Rider

Region	Number of Vehicles	Time of day	Motorcyclist		Car Occupant	
			n	% on Curve	% on Curve	Weighted % on Curve
Adelaide Plains	Single	Day	13	61.5	23.1	1.35
Adelaide Plains	Single	Night	37	59.5	46.7	7.78
Adelaide Plains	Multiple	Day	30	10.0	16.3	2.20
Adelaide Plains	Multiple	Night	35	8.6	12.2	1.92
Adelaide Hills	Single	Day	6	83.3	55.6	1.50
Adelaide Hills	Single	Night	4	100.0	61.9	0.84
Adelaide Hills	Multiple	Day	17	82.4	40.0	3.06
Adelaide Hills	Multiple	Night	2	100.0	60.0	0.54
Rural	Single	Day	17	58.8	35.2	2.70
Rural	Single	Night	15	60.0	56.4	3.81
Rural	Multiple	Day	22	13.6	22.7	2.25
Rural	Multiple	Night	25	16.0	34.2	3.85
Total			**222**	**39.0**		**31.8**

4. DISCUSSION

Crashes on curves account for between 30 and 40 percent of fatalities to motorcyclists and car occupants. While, overall, the difference in the percentage of crashes on curves is small, when particular subgroups are considered some differences related to curves are apparent.

The motorcyclists in this study had a very high rate of crashes on curves in the Adelaide Hills. While this is to some extent due to the large number of curves in the hills (as seen in the high rates also for car occupants), it was considerably higher than that for car occupants. It is well known local conjecture that some motorcyclists choose to travel at excessive speeds in the hills to beat time goals between towns. These results are consistent with such a belief.

Conversely, motorcyclists seem to handle curves better than car drivers in obviously dangerous conditions. The motorcyclists had very low curve crash rates on unsealed roads and on wet roads both compared to car drivers and to motorcyclists on sealed and dry roads. This suggests that motorcyclists maybe aware of these obvious dangers and to some extent over compensate for curves under these conditions. Alternatively, however, the finding could be partly due to the fact that the number of fatal motorcycle crashes in these conditions is very small. Therefore, the proportion of fatal motorcycle crashes on curves in these conditions is not an accurate representation of the motorcyclist's ability to handle curves under hazardous environmental conditions. The fact that there is only a small number of fatal motorcycle crashes in these conditions does not necessarily mean that motorcyclists are any more cautious than car drivers under hazardous conditions. A more likely explanation is that motorcyclists are less likely to travel in the rain or on unsealed roads.

In relation to T-junction curves it does not seem that they present a significantly greater hazard than other curves to either motorcycle riders or car drivers. One eighth of the fatal motorcycle crashes involving a male rider which happened on a curve were at a T-junction curve, while 17.5% of fatal car crashes involving a male driver which occurred on a curve were at a T-junction curve. The proportion of fatal crashes on T-junction curves is actually higher for car crashes than for motorcycle crashes, and so the hypothesis that T-junction curves, and in particular their often ambiguous road markings, present a significant problem for motorcycle riders is not supported by these cases.

While motorcyclists seem to have a slightly greater risk of having a fatal crash on a curve than car drivers, with 39.0% of fatal motorcycle crashes occurring on curves compared with 31.8% of fatal car crashes occurring on curves, this difference is still not great..

There are underlying differences in the patterns of the fatal crashes on curves in which the two groups are significantly different such as the time of day, the number of vehicles involved

in the crash, and the region in which the crash occurred. For instance motorcyclist fatalities which occur on curves, when compared to car occupant fatalities which occur on curves , are more likely to take place in the Adelaide Plains and Adelaide Hills areas, during the day, and only involve a single vehicle. While car occupant fatalities which occur on curves, when compared to motorcyclist fatalities which occur on curves, are more likely to take place in rural areas, at night, and involve multiple vehicles. Hence, even though overall both groups have relatively the same high proportion of fatal crashes on curves, the types of problems they have with road curves which cause the crash are significantly different. Therefore, if countermeasures are to be developed to try and reduce the proportion of fatal crashes on curves, different strategies may have to be developed for cars and motorcycles.

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