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Road Traffic Casualties and Risky Driving Behavior in Hualien County, 2001–2005

*Yin-Ming Li**

Department of Family Medicine, Buddhist Tzu Chi General Hospital and Tzu Chi University, Hualien, Taiwan

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Abstract

Objectives: The highest number of road traffic fatalities has consistently occurred in eastern Taiwan, with an average of 150 lives lost in 1 year. In this study, the risk of fatal crashes caused by drivers' error was assessed, including controlling environmental factors or types of crash.
Materials and Methods: Police records of motor vehicle crashes occurring in Hualien county, from January 2001 to December 2005, were used. The analyses were based on 9611 crashes caused by drivers' error.
Results: On average, the fatality rate was 5.2%. Half of the deaths were caused by drivers' driving under the influence of alcohol (DUI) and speeding. Risky driving behavior was more common in rural areas. Multivariate analysis showed that DUI and speeding were significant factors associated with fatality in rural areas.
Conclusion: Risky driving behavior is common in rural areas in eastern Taiwan. The characteristics of road users and the efficiency of trauma rescue systems should be further assessed. Road safety campaigns and public transport education should be discussed. (*Tzu Chi Med J* 2007;19(3): 152–158)

*Corresponding author. Department of Family Medicine, Buddhist Tzu Chi General Hospital, 707, Section 3, Chung Yang Road, Hualien, Taiwan.
E-mail address: yinming@mail.tcu.edu.tw

1. Introduction

Fatal road traffic accidents have decreased in the last decade in Taiwan (1). However, they are still a major concern, killing 5000 people a year. Compared with other Asia Pacific countries, the standardized vehicle mortality of Taiwan is the highest (1). Although fatal road traffic accidents account for only a small minority of deaths, they constitute the leading cause of death in those aged below 40 years in developed countries (2). Over 50% of such deaths were in young adults aged 15–44 years. Among children (aged 5–14 years) and young people (aged 15–29 years), road traffic injuries are the second leading cause of death worldwide (2). In Taiwan, during 2001 to 2005, there was an average of 4735 road crash deaths per year and 38.9% of the victims were aged 15–29 years (1). Road traffic accident mortalities are highest in eastern Taiwan, a county with a population of 320,000 in 2006 (1). On average, in the last 5 years, more than 150 lives per year have been lost due to road traffic accidents (3).

Driving is a complex task, conducted in a constantly changing environment and, consequently, there are many factors that contribute to a collision. Aside from engineering factors such as the construction

and maintenance of vehicles and roads, a large percentage of road traffic accidents are attributed to human error, such as speeding, driving under the influence of alcohol (DUI) or other violations (4). Our previous studies revealed that risky driving behavior is common in this district (5–8). Is this risky driving behavior the major cause of the casualties? In this study, we assessed risk factors associated with fatal road traffic accidents and analyzed the significance of risky driving behavior, including controlling environmental factors or types of crashes. We aimed to raise awareness of this issue and highlight its preventability.

2. Materials and methods

The data examined in this study were from an electronic database operated in cooperation by the Taiwan transportation department. Our analyses were based on a total of 10,053 crashes that occurred in Hualien county, from January 2001 to December 2005. During the study period, the number of registered vehicles increased by 11.2% (from 295,624 in 2001 to 328,743 in 2005). Further, the number of residents decreased by 1.6% or 5841 persons. Information on all road traffic accidents is collected by road police. Detailed information is collected on the crash, vehicles, drivers and persons involved. Data on the crash also include the time of day, location, number of fatalities and injuries, type of road, posted speed limit, weather, crash type and causes. Severity of injury was divided into two categories: death and injured. Road traffic accident deaths were limited to those fatalities occurring within 24 hours after the time of the accident reported in police records. This differs from the system used in determining vital statistics, which includes fatalities within 30 days after the accident.

According to police judgment, the cause of road traffic accidents was mainly drivers' error (86.8%). No cause was found for 64 crashes, 33 were due to engineering factors, and 261 crashes were caused by a pedestrian. Sixty-seven crashes occurred in very bad weather, on roads under repair/construction or in other unpredictable conditions. In this study, only 9611 crashes whose primary cause was drivers' error were included in the analysis: 5.2% of them or 495 crashes included fatalities. Risky driving behavior was divided into four categories: speeding, DUI, other violations and other unsafe driving behavior. Other driving violations included overtaking, inappropriate path following and not obeying traffic signals. Other unsafe driving behavior included not keeping a safe distance, inattention, fatigue, driving under the influence of drugs, talking on a cell phone or inappropriate parking.

Severity was defined as someone being killed due to the crash. Fatality rate was defined as the percentage of fatal crashes per 100 crashes. Districts with a density of population of 3500/m^2 or above were defined as urban areas and those with a lower density population were defined as rural areas. Frequency, percentage and χ^2 tests were used to analyze the epidemiological characteristics of the vehicle crashes. Multivariate analyses of significant factors associated with fatality were evaluated by odds ratio (OR) with 95% confidence interval (CI).

3. Results

3.1. *Epidemiological characteristics of vehicle crashes*

Of the 9611 vehicle crashes, 495 were classified as severe. Speeding (6.6%) and DUI (11.7%) accounted for one-fifth of the primary causes of the crashes. In total, the crashes killed 541 people and injured more than 12,000. DUI accounted for 38.2% and speeding accounted for 17.7% of the fatal crashes. On average, about 100 people died and 2500 people were injured in road traffic accidents per year. The average overall fatality rate was 5.2%; it was highest in winter (5.5%) and lowest in autumn (4.7%). The highest average fatality rate was in December (6.0%), followed by January (5.1%), while the lowest fatality rate was in February (4.5%). Fatality rates were highest on Thursdays (5.6%) and Sundays (5.4%), and lowest on Wednesdays (4.7%). No significant difference was found between fatal and non-fatal crashes by season (p=0.65) or month (p=0.93).

The epidemiological characteristics of the crashes are shown in Table 1. Two-thirds of the crashes occurred in fine weather, 20.7% on cloudy days and 13.0% on rainy days. About 10% of crashes that happened at night where there was no street lighting or on a single track road were fatal. A quarter of the severe crashes occurred between midnight and 7 a.m. (26.3%). Crashes occurred on pedestrian roads with the highest fatality rate (18.2%). The fatality rate of vehicle crashes was much lower in urban districts (1.3%) compared to rural districts (7.7%). Fatal crashes were three times more likely to occur in aboriginal districts than in non-aboriginal districts (14.6% *vs.* 4.6%). More than 80% of the crashes involved two or more vehicles, and 3.5% of them were classified as severe crashes. About 4% of the collisions involved vehicles and pedestrians, and 15.1% of them included fatalities. The fatality rate was highest among crashes due to DUI (15.2%), followed by speeding (12.4%). Environmental factors, such as time of day, street lighting, weather, location, crash

Table 1 — Factors associated with fatality of vehicle crashes in Hualien county, 2001–2005

Risk factor	Total *n*	Injured (*N*=9116) *n* (%)	Severe (*N*=495) *n* (%)	*p**
Weather				<0.05
Sunny	6371	6108 (95.9)	263 (4.1)	
Cloudy	1991	1860 (93.4)	131 (6.6)	
Rainy	1249	1148 (91.9)	101 (8.1)	
Time of day				<0.05
23:00–2:59	635	570 (89.8)	65 (10.2)	
3:00–6:59	481	416 (86.5)	65 (13.5)	
7:00–10:59	2146	2071 (96.5)	75 (3.5)	
11:00–14:59	2204	2113 (96.0)	91 (4.1)	
15:00–18:59	2439	2343 (96.1)	96 (3.9)	
19:00–22:59	1706	1603 (93.4)	103 (6.0)	
Light conditions				<0.05
Natural light	6087	5844 (96.0)	243 (4.0)	
Dim early morning	432	401 (92.8)	31 (7.2)	
Night with light	2541	2381 (93.7)	160 (6.3)	
Night and no light	551	490 (88.9)	61 (11.1)	
Road surface condition				<0.05
Dry and fine	7835	7475 (95.4)	360 (4.6)	
Wet/with deficit	1776	1641 (92.4)	135 (7.6)	
Road alignment				<0.05
Curved road	5608	5442 (97.0)	166 (3.0)	
Straight road	4003	3674 (91.8)	329 (8.2)	
Roadway configuration				<0.05
Intersection	5501	5346 (97.2)	155 (2.8)	
High way	3687	3424 (92.9)	263 (7.1)	
Pedestrians use road	423	346 (81.8)	77 (18.2)	
Aboriginal district				<0.05
No	9112	8690 (95.4)	422 (4.6)	
Yes	499	426 (85.4)	73 (14.6)	
Urbanization				<0.05
Urban area	3863	3812 (98.7)	51 (1.3)	
Rural area	5748	5304 (92.3)	444 (7.7)	
Crash type				<0.05
Vehicle-to-people	350	297 (84.9)	53 (15.1)	
Vehicle-to-vehicle	7935	7658 (96.5)	277 (3.5)	
Single vehicle	1326	1161 (87.6)	165 (12.4)	
Primary cause of crash				<0.05
Speed driving	639	560 (87.6)	79 (12.4)	
DUI	1120	950 (84.8)	170 (15.2)	
Other violations	4926	4808 (97.6)	118 (2.4)	
Other unsafe driving behavior	2926	2798 (95.6)	128 (4.3)	

*χ^2 test. DUI = driving under the influence of alcohol.

type and cause, were significantly different between non-fatal and fatal crashes.

3.2. Fatal crashes in rural districts

In rural districts, of the 5748 road traffic accidents, the primary causes were DUI (15.3% or 880 events) and speeding (9.0% or 517 events). The average fatality rate was 7.7%. Of the 444 fatal crashes, speeding (14.7%) and DUI (35.1%) contributed to nearly half of them. The characteristics of fatal crashes in rural districts were studied further (Table 2). One-third of these fatal crashes happened after midnight and half occurred on cloudy or rainy days, or on highways. Crashes occurring in aboriginal districts were twice as likely to be fatal. The weather, time of day, location, conditions, types of crashes and causes were significantly different between non-fatal and fatal crashes.

Of 3863 crashes that occurred in urban districts, the average fatality rate was 1.3%. Speeding (3.3%)

Table 2 — Factors associated with fatality of vehicle crashes in rural districts

Risk factor	Total (N=5748) n	Injured (N=5304) n (%)	Severe (N=444) n (%)	p^*
Weather				<0.05
Sunny	3526	3298 (93.5)	228 (6.5)	
Cloudy	1396	1275 (91.3)	121 (8.7)	
Rainy	826	731 (88.5)	95 (11.5)	
Time of day				<0.05
23:00–2:59	381	324 (85.0)	57 (15.0)	
3:00–6:59	298	244 (81.9)	54 (18.1)	
7:00–10:59	1242	1178 (94.9)	64 (5.2)	
11:00–14:59	1331	1248 (93.8)	83 (6.2)	
15:00–18:59	1493	1402 (94.0)	90 (6.0)	
19:00–22:59	1004	908 (90.4)	96 (9.6)	
Light conditions				<0.05
Natural light	3637	3421 (94.1)	216 (5.9)	
Dim early morning	256	227 (4.3)	29 (11.3)	
Night with light	1481	1338 (90.3)	143 (9.7)	
Night and no light	374	318 (85.0)	56 (15.0)	
Road surface condition				<0.05
Dry and fine	4577	4258 (93.0)	319 (7.0)	
Wet/with deficit	1171	1046 (89.3)	125 (10.7)	
Road alignment				<0.05
Curved road	3028	2886 (95.1)	142 (4.7)	
Straight road	2728	2418 (88.9)	302 (11.1)	
Roadway configuration				<0.05
Intersection	2994	2861 (95.6)	133 (4.4)	
High way	1514	1273 (90.0)	241 (10.0)	
Pedestrians use road	340	270 (79.4)	70 (20.6)	
Aboriginal district				<0.05
No	5279	4878 (92.9)	371 (7.1)	
Yes	499	426 (85.4)	73 (14.6)	
Crash type				<0.05
Vehicle-to-pedestrian	213	165 (77.5)	48 (22.5)	
Vehicle-to-vehicle	4396	4149 (94.4)	247 (5.6)	
Single vehicle	1139	990 (86.9)	149 (13.1)	
Primary cause of crash				<0.05
Speed driving	517	441 (85.3)	76 (14.7)	
DUI	880	724 (82.3)	156 (17.7)	
Other violations	2545	2443 (95.9)	102 (4.0)	
Other unsafe driving behavior	1806	1696 (93.9)	110 (6.1)	

*χ^2 test. DUI = driving under the influence of alcohol.

and DUI (6.2%) accounted for about 10% of the primary causes of the crashes. Of these crashes, the average fatality rate was around 3% to 6%. More than half of the crashes were vehicle to vehicle and one-third were single vehicle collisions. The primary cause and severity of crashes in rural and urban districts were significantly different (data not shown).

3.3. Multivariate analyses of risk factors associated with fatal vehicle crashes

Environmental factors, such as weather, time of day, street lighting, road condition and types of crashes were controlled by logistic regression analysis. The analysis of 9611 crashes showed that the three most significant factors associated with fatality were occurrence in a rural district (OR, 4.4; 95% CI, 3.2, 6.0), collision involving a vehicle and pedestrian (OR, 3.3; 95% CI, 2.3, 4.6), and DUI (OR, 3.0; 95% CI, 2.3, 3.8) (Table 3). Since fatality was significantly higher in rural districts, independent analysis was repeated on collisions in rural and urban districts. Among the 5748 vehicle crashes in rural districts, 7.7% of them or 444 were fatal: multivariate analysis showed that collisions involving a vehicle and pedestrian (OR, 3.3; 95% CI, 2.3, 4.7), DUI (OR, 3.0; 95% CI, 2.3, 3.9) and speeding (OR, 2.7; 95% CI, 2.0, 3.6) were

Table 3 — Multivariate analysis of risk factors associated with fatality of vehicle crashes in Hualien county

	Reference	Total*		Rural district†		Urban district‡	
		OR	95% CI	OR	95% CI	OR	95% CI
Environmental factors							
Cloudy/rainy	Sunny	0.85	0.68, 1.07	0.85	0.67, 1.08	0.80	0.39, 1.65
23:00–6:59	7:00–18:59	**2.43**	**1.76, 3.35**	**2.29**	**1.62, 3.23**	**3.13**	**1.23, 7.98**
19:00–22:59	7:00–18:59	1.23	0.90, 1.80	1.26	0.87, 1.82	1.22	0.40, 3.76
Night with light	Day light	0.88	0.65, 1.12	0.94	0.66, 1.30	0.59	0.25, 1.41
Not fine road	Fine road	1.25	0.97, 1.60	1.27	0.98, 1.64	0.81	0.35, 1.90
High way	Intersection	1.57	1.27, 1.95	1.60	1.27, 2.01	1.43	0.78, 2.61
Rural area	Urban area	**4.39**	**3.23, 5.95**				
Aboriginal district	Not aboriginal district	1.54	1.16, 2.05	1.56	1.17, 2.08		
Risky driving behavior							
Speeding		**2.57**	**1.91, 3.44**	**2.68**	**1.97, 3.63**	1.53	0.43, 5.43
DUI	Other unsafe driving	**2.98**	**2.34, 3.80**	**3.00**	**2.32, 3.87**	2.22	0.97, 5.09
Other violations		1.27	0.90, 1.79	1.30	0.89, 1.88	1.02	0.40, 2.63
Crash type							
Vehicle-to-people	Vehicle-to-vehicle	**3.26**	**2.32, 4.59**	**3.28**	**2.27, 4.73**	**3.38**	**1.25, 9.12**
Single vehicle		**1.34**	**1.06, 1.69**	1.19	0.93, 1.52	**5.53**	**2.55, 12.0**

*Based on 9611 traffic crashes of which 495 were fatal: $\chi^2 = 565.4$, $df = 12$, $p < 0.0001$; †based on 5758 rural traffic crashes of which 444 were fatal: $\chi^2 = 309.4$, $df = 12$, $p < 0.0001$; ‡based on 3863 urban traffic crashes of which 51 were fatal: $\chi^2 = 57.1$, $df = 11$, $p < 0.001$. DUI = driving under the influence of alcohol.

significant factors associated with fatality. Occurrences on a straight road, during the night or in aboriginal districts were also significant factors associated with fatality. Among the 3863 collisions occurring in urban districts, 1.3% or 51 were fatal events: a collision involving a single vehicle was the number one factor associated with injury severity (OR, 5.5; 95% CI, 2.6, 12.0), collisions involving pedestrians was the second highest factor (OR, 3.4; 95% CI, 1.3, 9.1) and occurrence at midnight (OR, 3.1; 95% CI, 1.3, 8.0) was the third.

4. Discussion

In this study, we revealed that DUI and speeding were still common in eastern Taiwan. About half of the traffic fatalities were attributed to these two types of risky driving behavior. In rural areas, DUI and speeding were even more common. After controlling other risk factors, crashes due to DUI or speeding were two to three times more likely to cause fatalities. Alcohol consumption by drivers puts themselves and other road users at risk, and the risk increased rapidly with blood alcohol concentration [9]. Speeding is also common among drunk drivers [8] and excessive speed increased the severity of the crashes. Our result is similar to other studies [10–13]. Alcohol consumption is often related to road traffic deaths [4,14,15]. A positive blood alcohol test at the time of the crash increases the risk of death [4,9]. More than 40% of drivers in motorcycle crashes in Thailand were DUI and these crashes were five times more likely to be fatal compared to those involving non-drinkers [12]. About 28% of the drivers in fatal road accidents in Oxford had alcohol levels over the legal limit of 80 mg/100 mL blood [13]. According to a previous study, 15–20% of victims who died in traffic accidents were associated with acute alcohol drinking [15]. Furthermore, a collision involving a vehicle and pedestrian was the most significant factor associated with fatality. This might imply that pedestrians are the group of road users most frequently killed [4]. Drivers should keep in mind their own safety, as well as the safety of other road users and avoid DUI.

The vehicle crash fatality rate was more than twice as high on rural roads compared to urban roads. This finding was consistent with other studies [16–19]. Yang et al also found that rural areas exhibited higher mortality rates in motor vehicle crashes between 1981 and 1990 in Taiwan [19]. Studies from Western countries revealed that the distance from medical care directly increases mortality in time-limited situations of acute injury [20]. The increased fatality rate could be attributed in part to such delays. However, it might also be partly attributed to pre-crash factors such as higher speeds, drunken driving, failure to drive safely, unsafe vehicles or roads, and trauma system deficiencies [17–20]. Drivers' characteristics may also contribute to increased injury severity [4,21]. Rural drivers are less likely to wear seat belts [16], more likely to drive at higher speeds and more likely to drive after drinking alcohol. Another possible explanation would be an increased proportion of older road users in rural areas, who have increased

fragility and are more likely to die in a crash [21,22]. The age of drivers [21], use of safety equipment, injury severity, crash severity, license type, vehicle types and type of road users should be further assessed. Also, the efficiency of trauma rescue systems should be evaluated.

In urban areas, single vehicle, and vehicle and pedestrian collisions that happened after midnight were significant factors associated with fatality. Speeding and DUI were higher risk factors of fatality but were not statistically significant. This result may be due to the few deaths in urban areas. Also, urban traffic is normally constrained to travel slower and speed limits are on average lower [13], so the impact is not as severe.

Our result is concrete proof of the dangers of drinking and driving. The toll on lives is partly avoidable. Law enforcement against drunken driving has been in force since 1999 in Taiwan. Police have carried out countless traffic crackdowns but they do not seem adequate [23]. Drivers in rural areas are still not aware of the risk of DUI, nor do they worry about encounters with the police. Police might find it difficult to step up traffic law enforcement in rural areas due to limited manpower. Vigorous enforcement of the laws might be effective but it is time to promote traffic education. In many developed countries, traffic education is an integral and important part of public education. Clearly, public information and education programs are crucially needed to prevent risky driving in rural areas in eastern Taiwan.

Several limitations have to be mentioned. First, the crashes were restricted to crashes with injuries and therefore overestimate fatality rates. However, deaths were limited to those fatalities occurring within 24 hours after the time of the accident reported in police records. This data source is, therefore, also likely to underestimate the true magnitude of road traffic fatalities. Second, injury classifications in databases are based on police officers' judgment at the crash scene and are not revised in light of professional medical evaluation. However, police officers usually correctly identify drivers as either dead or uninjured. Third, the demographic characteristics of drivers and trauma rescue systems have not been studied. Since data from police reports are useful for evaluating time trends in overall crash rates, the results of this study highlight the strategy of road safety in eastern Taiwan.

In conclusion, road traffic fatality was high in rural districts. Speeding and DUI were leading causes associated with road traffic casualties. Strategies to prevent DUI and speeding are crucially needed to promote road safety. Further research on the characteristics of road users and the efficiency of emergency medical services is needed.

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