"CRASH VIOLENCE" WITHIN THE TRAFFIC SYSTEM - FATAL INJURY RISKS AND THEIR REDUCTION IN ROAD TRAFFIC ON TWO-LANE MAIN ROADS

Seppo Olkkonen Marko Kelkka*, Esa Räty*, Marja-Terttu Juurinen*, Timo Kari*, Kari Laakso and Timo Ernvall***

Finnish Institute of Occupational Health and Helsinki University of Technology***

ABSTRACT

The aim of the study was to explore the severity of injuries sustained by the driver and passengers of a vehicle involved in a fatal crash, based on the risks posed by the traffic system, and to evaluate the scope for preventing road traffic casualties. The study was based on detailed data of multidisciplinary accident investigations of 422 fatal motor vehicle accidents where 524 victims died on two-lane main roads during the years 1996–2003 in Finland. Accidents due to alcohol, failure to wear seatbelts and speeding were filtered out, as were those due to sickness or categorized as suicidal. Of all victims 58% died as a result of head-on collisions. The probability of dying in a head-on collision began to grow when the speed change (Δv) in the accident exceeded 40 km/h. The study also revealed high death rates (>50%) when the Δv reached 80 km/h. The results support either the installation of median barriers on two-lane main roads with a speed limit of 80 km/h or higher, or switching to a 70 km/h speed limit.

Key words: traffic safety, traffic accidents, fatality, public roads.

THE AIM OF THE STUDY WAS TO EXPLORE THE SEVERITY OF INJURIES sustained by the driver and passengers of a vehicle involved in a crash, based on the risks posed by the traffic system, and to evaluate the scope for preventing road traffic casualties.

The study concentrated on examining the events in the final phases of accidents investigated by road accident investigation teams; it considered the immediate cause of death and possible ways to alleviate fatal consequences. Accidents that were not considered interpretable as human error, but instead were perceived as including definite risk-taking or actions contrary to the intended use of the traffic system, were not included.

The material of the study is comprised of fatal multiple and single vehicle accidents on ordinary two-lane main roads (not on motorways or divided highways) in rural areas (on roads not marked by built-up area signs) in 1996–2003. The accidents in the data were investigated by multidisciplinary road accident investigation teams in Finland. At least one person was killed in each of the studied accidents.

The study was based on detailed data of 422 fatal motor vehicle accidents where 524 victims died. The study sample includes all of the occupants of all of the vehicles involved. The following cases were *excluded* from the study: 1) driving while intoxicated, insufficient use of seatbelts, and excessive speeding, 2) accidents involving pedestrians, bicycles, mopeds and motorcycles, 3) accidents involving animals, 4) accidents in which death resulted from a sudden fit of illness or an assumed suicide, 5) under-aged drivers.

RESULTS

The research material included 422 accidents involving altogether 1,417 persons. Of them, 524 were killed, 545 injured, and 348 uninjured. Most of the accidents occurred with passenger cars (68.6%), while 22% involved trucks, 7% vans, and 1.8% others. Of the persons killed, 92% were drivers or passengers in passenger cars, 5.7% in vans, 1.5% in trucks, and 0.8% in other vehicles.

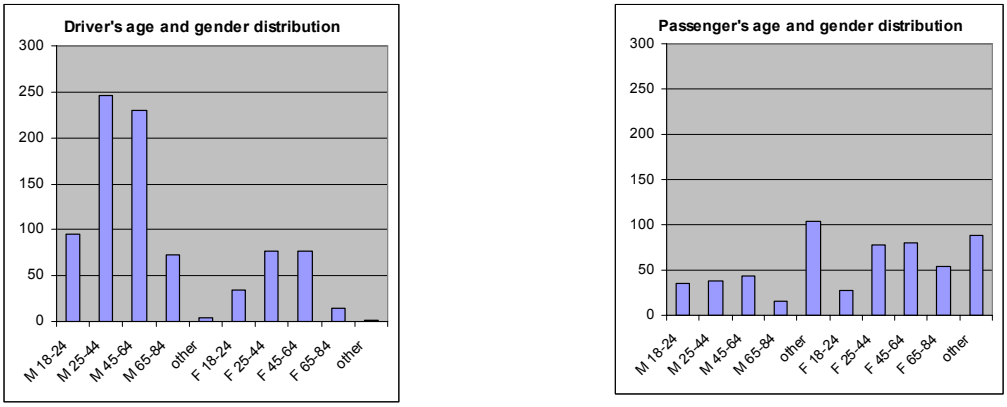

Figure 1. Involved drivers and passengers by age and gender (M=male, F=female).

Of all the drivers involved in the accidents, more than three in four were male and the majority were 25 to 64 years old (Figure 1). The age and gender distribution of the passengers was more even. The accidents had serious consequences (Figure 2). More than 75% of the persons killed died instantly, and over 80% died before receiving care.

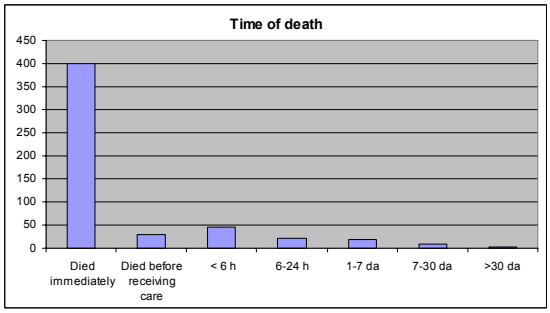

Figure 2. Time of death of the victims.

The most serious injuries of the persons who were killed were in the head or chest area (Table 1). The number of head injuries increased as the mass of the other vehicle increased.

Table.1. Number of persons killed (n=428) and injured in passenger cars examined according to the other vehicle involved. Killed and injured persons' body area with the most serious injury (ICD-10 code) (heavy vehicle=bus, truck).

Body area	*Passenger cars*				*Vans*				*Heavy vehicles*			
	Killed		*Injured*		*Killed*		*Injured*		*Killed*		*Injured*	
	n	%	n	%	n	%	n	%	n	%	n	%
Head	61	30.5	13	15.5	17	41.5	1	12.5	88	47.1	5	27.8
Back	32	16.0	9	10.7	2	4.9	4	50.0	16	8.6	1	5.6
Chest	57	28.5	3	3.6	17	41.5		0.0	49	26.2	1	5.6
Abdomen and hips	15	7.5	12	14.3	1	2.4	2	25.0	4	2.1	3	16.7
Limbs	2	1.0	18	21.4	1	2.4	1	12.5	1	0.5	3	16.7
Multi	9	4.5	14	16.7	1	2.4		0.0	19	10.2	2	11.1
Other	24	12.0	15	17.9	2	4.9		0.0	10	5.3	3	16.7
Total	*200*	*100.0*	*84*	*100.0*	*41*	*100.0*	*8*	*100.0*	*187*	*100.0*	*18*	*100.0*
Uncategorised			217				22				38	

The seriousness of the accidents is illustrated by the fact that half of the persons killed died as a result of crashing into the structures of the vehicle or because the structures of the passenger space penetrated them; nearly one in five died because the vehicle was crushed (Table 2).

Table 2. Body area with the most serious injury among the persons killed in accidents (n=523) according to the injury mechanism. Impact and penetration means a situation where an obstacle from outside penetrate the structure of a car during a collision. Such obstacles may include, for instance, a bumper of opposite vehicle or a fence. In case of "crush", the structure of the passenger compartment has collapsed over the passengers. Passengers are typically killed by squeezing.

	Impact		*Impact and penetration*		*Crushed vehicle*		*Other mechanism*		*Not specified*
Body area	n	%	n	%	n	%	n	%	n
Head	27	31.8	73	27.8	35	35.7	23	30.3	1
Back	13	15.3	30	11.4	5	5.1	5	6.6	
Chest	17	20.0	66	25.1	10	10.2	11	14.5	
Abdomen and hips	1	1.2	10	3.8	1	1.0	4	5.3	
Limbs	1	1.2	3	1.1	3	3.1	1	1.3	
Multi	1	1.2	7	2.7	15	15.3	2	2.6	
Other	25	29.4	74	28.1	29	29.6	30	39.5	1
Total	*85*	*100*	*263*	*100*	*98*	*100*	*76*	*100*	*1*

By far the most fatalities (302 deaths) resulted from meeting accidents between vehicles coming from the opposite directions on a main road: 56% were killed in meeting accidents between passenger cars, and 38% were killed in meeting accidents between a passenger car and a heavy vehicle. After meeting accidents, the second most common cause of fatalities were crossing accidents* (66 deaths) and the third were overtaking accidents (59 deaths). Most of the single vehicle accidents (N=37) happened on a dry or wet road. Most of the overtaking accidents (N=59) occurred on a snowy or icy road. Meeting accidents happened equally on dry or wet and snowy or icy roads.

The probability of death in a head-on collision began to grow when the speed change (Δv) in the accident exceeded 40 km/h (Figure 3). The study also revealed high death rates (>50%) when delta v exceeds 70 km/h. The probability of death was also influenced by collision angle, mass difference, and the age of the car and of the victim. The road accident investigation teams estimated that airbags decreased the death risk of drivers and front seat passengers by 25%. Electronic stability control systems (e.g. ESP) and driver alertness detectors could each decrease the number of fatal accidents by 15%. Due to the high average age (about 10 yr.) of cars in the accidents, the number of new cars ($\geq$1998) was too small (N=44) to yield statistically significant results when comparing the safety of new vs. old cars.

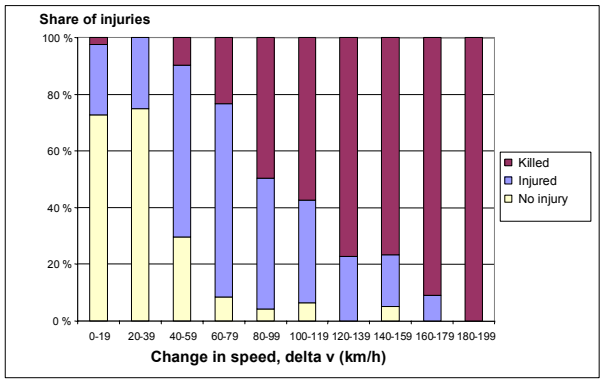

Figure 3. Share of persons killed versus persons who survived in relation to the change in speed.

* In a crossing accident one vehicle drives along the main road and the other comes from a secondary road. The vehicles may drive straight through the crossing or turn.

AGE AND GENDER PATTERNS IN MOTOR VEHICLE CRASH MORTALITY. The sample contained 886 male (62.5%) and 531 female subjects (37.5%). Of the 524 fatally injured, 308 were males (58.8%) and 216 females (41.2%). The mortality of females (victims per all occupants) was

higher (40.7%) than that of males (34.8%) (p< 0,03). The relation of share of fatal injury to age had a J-shaped curve (Figure 4).

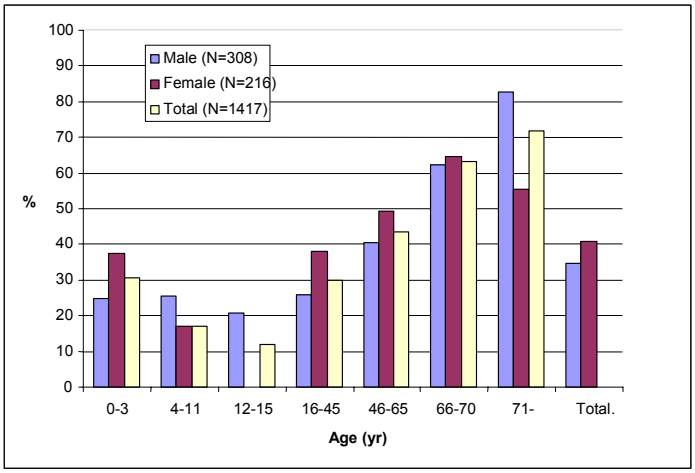

Figure 4. Share of fatal injury in relation to age.

DISCUSSION

The relation of sex and age to the risk of fatality from physical trauma has been examined by other researchers, including Evans (1988), who found that males in their twenties had the lowest death rates. In our results, the lowest death rate was in the age group of 4 to 15 years. This might be due to the small number of cases.

A heavy vehicle as a participant in a collision is a very dangerous risk factor in the main road network. Even at lower speeds, a collision with a heavy vehicle can be fatal (Evans 1994). Since it is impossible to design a passenger car which is safe in all crashes, the focus should be on the prevention of accidents. Occurrences of loss of control on a slippery road could be reduced by ensuring the appropriate condition of tires and by use of modern stability control systems. Still further improvement of the level of winter road maintenance should be considered, and winter traffic management should be enhanced. Warning about poor driving conditions in advance and in real time and even closing the roads considered the most exposed to risk for the duration of winter maintenance procedures might serve to reduce the number of accidents on slippery roads.

As our estimate of the benefits of the Electronic Stability Control is in line with the statements of other authors, we strongly recommend that all new cars be required to have ESC as standard equipment (Lie et al 2005). Airbags must be developed further, for example to enhance their functionality in multiple impact collisions. More use of side impact airbags is justifiable. Moreover, seatbelts should be developed, for example to improve protection in cases of side impact (Morris et al. 1995).

In conclusion, the limitations of human tolerance for crash violence must be taken into consideration in the traffic system. The current 80 km/h speed limit advocates a speed where the steepest increase in fatalities has already been bypassed. The possibilities of staying alive are significantly smaller at a collision speed of 80 km/h than at 60 km/h. Serious injury in the traffic system should be made impossible or improbable. The results speak for the installation of a median barrier on two-lane roads (Donnell and Mason 2006) especially when driving speeds exceed 80 km/h. An alternative solution could be an increase in the use of 70 km/h speed limits.

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