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Pattern of Fatal Motorized Two-wheeler Crash Injuries in Northern India: Is Safety Helmet Adequate Prevention

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Abstract: This retrospective study sought to collect a representative sample of motorized two-wheeler crashes having fatal outcome with reference to their age, sex, riding position, type of vehicle, nature of accident, pattern of injuries etc. among the helmeted and non-helmeted riders. We examined the pattern of fatal injuries between the helmeted and non-helmeted motorized two-wheeler crash victims in 134 cases subjected to autopsy during five years from 2000 to 2004. Young adults of the age-group 21-25 years constituted the majority of the victims, 48 (36%) and the 16-30 year age group accounted for 98 (73%) motorized two wheeler deaths. The overall male: female ratio was 1.6:1. Motorcyclists were exclusively male. The male: female ratio of scooterists was 1.7:1, however, among the moped crash victims, this ratio was 1:2.2. Scooterists accounted for the majority of crash victims, 70 (52%) and drivers in all the three categories, 88 (66%), outnumbered the pillion riders, 46 (34%). Sixty-two (46%) victims were helmeted, of which males, 49 (79%), were the majority. Of all the three categories of motorized two wheeler users, non-helmeted victims were far more than the helmeted ones in the moped users, the ratio of helmeted: non-helmeted users being 1:2.4; again in this category, the male: female ratio was 1:4.7. Motorized heavy vehicles were responsible for majority of deaths, 53(40%) while slips on roads etc. accounted for 15 (11%) deaths. All the non-helmeted victims sustained scalp injuries, with 70 (97%) of them suffering fractures to the skull, as compared to 18 (29%) of the helmeted ones. However, as regards the injuries to the thorax and abdomen, the helmeted: non-helmeted victim ratio was 4.3:1. Of the victims who died within one hour of the accidents, 36 (75%) were non-helmeted. Helmets prevent and/or reduce the deaths due to head injury, however in majority of cases, there being multiple injuries, other road safety and injury prevention measures need to be devised and implemented. However the implications for safety measures also deserve consideration.

Key words: Motorized two wheelers, motorcycle crash, head injury, chest injury, abdominal injury, helmet, mandatory helmet-use law

INTRODUCTION

Injuries to the head and neck are the leading causes of death from motorcycle crashes, with many deaths occurring despite optimal use of the available and sophisticated therapy measures. At the same time, there is substantial evidence that motorcycle safety helmets are effective in reducing the incidence and severity of head injuries due to motorcycle crashes (Sosin *et al*., 1990). According to the reports, death is the outcome for only 1% of motorcyclists injured severely enough to receive medical care (Barancik *et al*., 1986), while non-use of motorcycle helmets results in a shift in the spectrum of injuries, not only to more fatalities but also to more severe nonfatal injuries (Sosin *et al*., 1990).

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States introducing mandatory helmet use laws have been reported to experience a decrease in the number of both fatal and nonfatal motorcycle crashes, while States repealing helmet laws have experienced subsequent increases in motorcycle trauma (Chenier and Evans, 1987; Watson *et al*., 1980). According to a survey report, the statewide motorcycle crash fatalities decreased by 37.5% from 1991 to 1992, more than 37% fatalities were prevented and the incidence of head injuries decreased significantly among both fatally and non-fatally injured motorcyclists, due to the mandatory helmet use law (Kraus *et al*., 1994).

Chiu *et al.* (2000) demonstrated the effectiveness of the motorcycle helmet use law, as shown by several trends: a 33% decrease in motorcycle-related injuries; decreases in severity of injury, associated injuries, and length of hospital stay and better outcome. According to the study, data provided by the Department of Health showed that after implementation of the helmet law, the number of motorcycle-related injuries decreased by 14%, length of hospital stay decreased by 14.5% and costs of hospitalizations from motorcycle-related injuries decreased by an average of US $3.93 million per month. Furthermore, the total number of fatalities from motorcycle head injuries decreased by 561 between 1996 and 1997. Yet another study concluded that head injury is a common injury outcome among motorcyclists who crash and the motorcycle helmet has been the principal countermeasure for decreasing head injury in crashes (Krantz, 1985). Many other studies of helmet effectiveness have concluded that helmets decrease the severity of injury, the likelihood of death, and the overall cost of medical care (Fleming and Becker, 1992, McSwain and Belles, 1990).

To improve voluntary helmet use in the absence of mandatory helmet-use laws, motorcyclists need an increased awareness of their vulnerability. The ground reality, however, is just the converse: 1) Most injured motorcyclists who do not wear helmets report that they did not expect to be injured; 2) 40% of the head injury-associated deaths are ascribed to the motorcyclist's loss of control, not, apparently, to some action of the driver of another motor vehicle; 3) Changes in speed limit laws, access to alcohol, or vehicle miles traveled do not appear to explain the temporal trend. Under these circumstances, comprehensive motorcycle helmet-use legislation appears to be a viable and scientifically sound component of the efforts to prevent injury.

Several clinical studies have examined the patterns and severity of injuries in motorcyclists (Krantz, 1985; Bachulis *et al*., 1988; Sood, 1988; Sarkar *et al*., 1995; Sinha *et al*., 1995), however, few studies of autopsy findings of helmeted and non-helmeted riders have been reported (Krantz, 1985, Sarkar *et al*., 1995; Hitosugi *et al*., 1999). We performed a retrospective analysis of injury pattern among the helmeted and non-helmeted motorized two-wheeler riders with relation to the type of motorized two-wheeler and the nature of accident.

MATERIALS AND METHODS

This retrospective, autopsy based study was conducted in the Dept. of forensic medicine and toxicology, Govt. Medical College Hospital, Chandigarh, from 2000-2004. Motorized two-wheeler users (drivers and pillion riders), who died as a result of injuries sustained in road traffic accidents (death due to motor vehicle crash), were the subjects of the study. Data regarding their age, sex, whether helmeted or not, details of incident, survival period, areas of major injury sustained, etc. were recorded after a thorough perusal of the hospital and autopsy records, and where-ever possible, police records of the case.

A head-injured motorcyclist was defined as a motorcycle driver or pillion rider who, after having received direct or indirect trauma to the head, exhibited obvious brain concussion, contusion, skull fracture, or any of their clinical manifestations, such as loss of consciousness, amnesia, neurologic deficits, and seizures. Clinical evidence of skull fractures and intracranial hemorrhages was also included

to define the extent of head injury. In general, a motorcyclist with one or more of the aforementioned symptoms or diagnoses was registered as a head-injured motorcyclist.
The victims were categorized with reference to five variables:

- Riding position-a) driver; b) pillion rider.
- Type of motorized two-wheeler - a) scooter; b) motorcycle; c. moped.
- Sex of the victim-a) male; b) female.
- Nature of accident-a) major collisions with other powered or larger vehicles; b) minor collisions with stationary objects, bicycles, pedestrians, or stray animals; c) minor accidents including falls from motorized two wheeler or a slip of the vehicle without an actual collision.
- Use of helmet-a) helmeted; b) non-helmeted.

RESULTS

Out of a total number of 1714 autopsies conducted at the department during the period under study, 494 (29%) deaths were due to vehicular accidents, of which, 134 (27%) were the victims of motorized two-wheeler crashes. While the number of deaths due to vehicular accidents, in general, showed a slight decrease from 32 to 29%, the percentage of motorized two-wheeler crash victims registered a steady increase from 24 to 27%, with a peak (32%) in the year 2002 (Fig. 1).

Young adults, of the age group of 21-25 years, constituted 48 (36%) of the victims; followed by the 16-20 years group, 29 (22%) and 26-30 year group 21 (16%). Overall, the 16-30 year age group accounted for 98 (73%) of the deaths among motorized two-wheeler users. The overall male: female ratio was 1.6:1. Of the three types of motorized two wheeler crash victims, motorcyclists were exclusively male and the majority of the users belonged to the 21-25 age group, 10 (42%) cases, followed by the 16-20 age group, 07 (29%) cases. 92% (22 cases) of the motorcycle drivers belonged to the 16-30 years age group. Victims of scooter crash also had a male predominance, the male: female driver's ratio being 1.7:1. However, the number of moped crash victims was more among the females, their ratio being 2.2:1, as compared to the males. Amongst the males, the older age group i.e. >50years, also preferred mopeds, 2 of the total 3 cases of drivers in this age group (67%) being moped drivers. Scooterists, both drivers and pillion riders accounted for the maximum number of crash fatalities, 70 (52%) cases; followed by motorcyclists, 40 (30%) cases. Drivers, 88 (66%) outnumbered the pillion riders, 46 (34%) (Table 1).

A total of 62 (46%) victims were wearing helmets at the time of the accident. Of these, males, 49 (79%) outnumbered the females, 13 (21%). However, among those who had not worn helmets, females,

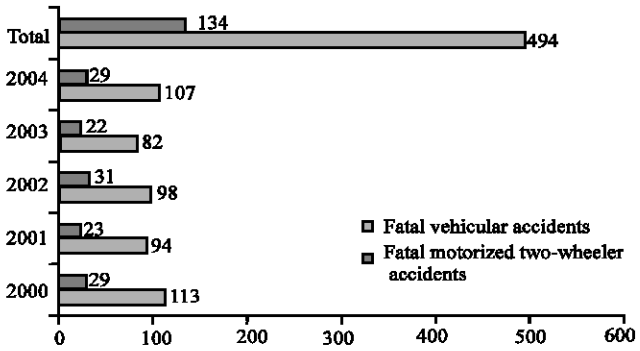

Fig. 1: Annual distribution of fatal motorized two-wheeler accidents in relation to fatal vehicularaccidents

Table 1: Relation between the type of motorized two-wheeler, riding position, age and gender

	Motor cycle (n = 40)				Scooter (n = 70)				Moped (n = 24)					
	Driver (n = 24)		Pillion rider (n = 16)		Driver (n = 45)		Pillion rider (n = 25)		Driver (n = 19)		Pillion rider (n = 05)		Total (n = 134)	
Age (Years)	M	F	M	F	M	F	M	F	M	F	M	F	M	F
0-10	00	00	00	01	00	00	01	01	01	00	00	01	02	03
11-15	00	00	01	00	01	00	02	02	01	02	01	00	06	04
16-20	07	00	02	02	04	04	02	01	01	04	00	02	16	13
21-25	10	00	03	03	11	07	04	03	01	05	00	01	29	19
26-30	05	00	02	01	06	03	01	02	00	01	00	00	14	07
31-40	02	00	00	00	03	02	02	00	00	00	00	00	07	02
41-50	00	00	01	00	02	01	01	02	00	00	00	00	04	03
51-60	00	00	00	00	01	00	01	00	01	01	00	00	03	01
>60	00	00	00	00	00	00	00	00	01	00	00	00	01	00
Total	24	00	09	07	28	17	14	11	06	13	01	04	82	52

Table 2: Relation between the type of motorized two-wheeler, Helmet usage, age and gender

	Motor cycle (n = 40)				Scooter (n = 70)				Moped (n = 24)					
	Helmeted (n = 19)		Unhelmeted (n = 21)		Helmeted (n = 36)		Unhelmeted (n = 34)		Helmeted (n = 07)		Unhelmeted (n = 17)		Total (n = 134)	
Age years	M	F	M	F	M	F	M	F	M	F	M	F	With Helmet	With Helmet
0-10	00	00	00	01	00	00	01	01	00	00	01	01	00	05
11-15	00	00	01	00	00	00	03	02	00	00	02	02	00	10
16-20	05	00	04	02	04	02	02	03	01	01	00	05	13	16
21-25	08	00	05	03	10	04	05	06	01	02	00	04	25	23
26-30	04	00	03	01	05	02	02	03	00	00	00	01	11	10
31-40	02	00	00	00	03	01	02	01	00	00	00	00	06	03
41-50	00	00	01	00	02	01	01	02	00	00	00	00	03	04
51-60	00	00	00	00	02	00	00	00	01	00	00	01	03	01
>60	00	00	00	00	00	00	00	00	01	00	00	00	01	00
Total	19	00	14	07	26	10	16	18	04	03	03	14	62	72

Table 3: Nature of collision vs victim

	Driver				Pillion rider				Total					
Nature of collision	Helmeted		Unhelmeted		Helmeted		Unhelmeted		Helmeted		Unhelmeted		Total	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
With a Moving Vehicle														
Heavy Motor Vehicles	21	53.8	18	46.2	06	42.9	08	57.1	27	50.9	26	49.1	53	39.6
Light Motor Vehicles	14	58.3	10	41.7	07	58.3	05	41.7	21	58.3	15	41.7	36	26.9
Motorized 2/3 wheeler	03	42.9	04	57.1	04	66.7	02	33.3	07	53.9	06	46.1	13	09.7
Non Motor 2/3 wheeler	00	00	03	100	00	00	02	100	00	00	05	100	05	03.7
Bullock cart, etc	00	00	02	100	02	40.0	03	60.0	02	28.6	05	71.4	07	05.2
With a stationery object														
Divider/tree/vehicle	01	25.0	03	75.0	01	100	00	00	02	40.0	03	60.0	05	03.7
Two wheeler slips/skids														
On road	02	33.3	04	66.7	01	25.0	03	75.0	03	30.0	07	70.0	10	07.5
Pothole, etc	00	00	03	100	00	00	02	100	00	00	05	100	05	03.7
Total	41	46.6	47	53.4	21	45.7	25	54.3	62	46.3	72	53.7	134	100

39 (54%) were slightly more. Considering the three motorized two-wheeler categories, helmeted victims were slightly more than the non-helmeted ones among the scooterists, their ratio being 1.1:1, while among the motorcyclists, this ratio was 1:1.1. However, among the moped users, non-helmeted victims far outnumbered the helmeted ones, the ratio being 2.4:1. In the non-helmeted moped crash victim category, the females were 4.7 times more than the males, where as in all other categories; their

Table 4: Distribution of injury sustained

Injury sustained	Cases (n = 134)		Helmeted (n = 62)		Non-Helmeted (n = 72)	
	No.	(%)	No.	(%)	No.	(%)
Head and Face						
Scalp injuries	113	84.33	41	66.13	72	100
Skull fracture	88	73.13	18	29.03	70	97.22
Extradural Hemorrhage	44	32.84	11	17.75	33	45.83
Subdural Hemorrhage	99	73.88	30	48.39	69	95.83
Subarachnoid Hemorrhage	96	71.64	30	48.39	66	91.67
Intra-cerebral Hemorrhage	28	20.90	08	12.90	20	27.78
Cerebral contusion/laceration	79	58.96	22	35.48	57	79.17
Cerebral edema	61	45.52	17	27.42	44	61.11
Assoc. Spinal injuries	11	08.21	08	12.90	03	04.17
Thorax						
Fracture ribs	54	40.30	33	53.22	21	29.17
Fracture sternum	05	03.73	04	06.45	01	01.39
Haemothorax	17	12.69	15	24.19	02	02.78
Lung contusion/laceration	13	09.70	12	19.36	01	01.39
Myocardial contusion./tear	09	06.72	09	14.52	00	00
Assoc. Spinal injuries	07	05.22	07	05.22	00	00
Abdomen						
Liver laceration	37	27.61	31	50.00	06	08.33
Splenic rupture	27	20.15	23	37.10	04	05.56
Rupture kidney	14	10.45	13	20.97	01	01.39
Intestinal perforation	06	04.48	06	09.67	00	00
Limbs						
Fracture pelvis	31	23.13	17	27.42	14	19.44
Fracture femur	24	17.91	11	17.74	13	18.06
Fracture tibia/ fibula	12	08.96	06	09.68	04	05.56
Fracture ankle joint	05	03.73	02	03.23	03	04.17
Fracture humerns	13	09.70	06	09.68	07	09.72
Fracture radius/ulna	15	11.19	09	14.52	06	08.33

number was far less or just equal to the males. Taking the age groups into consideration, all the victims of<15 years were non-helmeted at the time of accident. In the 16-20 years age group [13 (45%) cases] and the 41-50 years age group [3 (43%) cases], helmeted victims were slightly less than the non-helmeted ones, whereas in the all other age groups, it was the opposite (Table 2).

As regards the nature of accident, motorized vehicles on the whole, accounted for the maximum victims, 102 (76%), of which motorized heavy vehicles alone were responsible for 52% (53) deaths; followed by 'slips' of the victim's vehicles, 15 (11%). Deaths due to collision with non-motorized vehicles, stationery objects and slips were more in cases of non-helmeted victims, 25 (78%) cases, as compared to helmeted ones, 7 (22%) cases. This ratio was the maximum in cases of drivers, the helmeted: non-helmeted being 1:5, while in cases of pillion riders it was 1:2.5 (Table 3).

All the 72 non-helmeted victims suffered injuries to the scalp while 70 (97%) sustained skull fractures. However, only 41 (66%) of the helmeted victims suffered scalp injuries while 18 (29%) sustained skull fractures. Similarly 65% of the non-helmeted victims sustained intracranial hemorrhages as compared to 32% of the helmeted ones. Cerebral edema and injuries were observed in 70% of the non-helmeted victims as compared to 31% of the helmeted ones, while only 3 (4%) non-helmeted victims had spinal injuries in association with head injury, in comparison to 8 (13%) helmeted ones. As regards the fatal injuries to the thorax and abdomen, helmeted victims outnumbered the non-helmeted ones, the overall ratio of helmeted: non-helmeted victims being 4.3:1. However, the number of victims sustaining injuries to the pelvis and limbs among both the helmeted and the non-helmeted victims was almost equal, the ratio of helmeted: non-helmeted victims being 1.1:1 (Table 4).

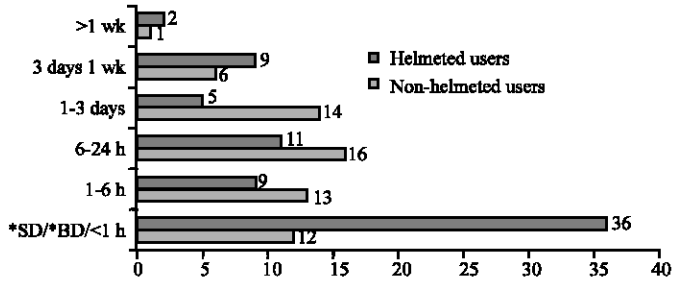

Fig. 2: Survival period of helmet isers in comparison to non-helmet users

Analyzing the time from injury to death, we observed that 48 (36%) of the victims died within one hour of the crash, either on the spot (SD) or while being shifted to the hospital (BD). Of these, 75% were non-helmeted. 28% of the victims had a survival period ranging from one day to one week, of which, 57% (21/37) were helmeted (Fig. 2).

DISCUSSION

Road traffic injuries are the ninth leading cause of burden of disease and the third leading cause of death among people between 5 and 44 years of age (Dandona 2006). Although, often considered to be a problem of countries with high income, 90% of deaths due to road traffic injury occur in countries with low or middle incomes. Moreover, rates of mortality caused by road crashes have been reported to be increasing rapidly in most low and middle income countries; during 1975-1998, mortality attributed to road traffic injuries increased by 79% in India, 237% in Colombia, 243% in China and 384% in Botswana (Mock *et al*., 2005). This increase may be attributed to peculiar road conditions in developing countries as is evident from the photograph that speaks for itself about the vehicular traffic on an Indian Road (Fig. 3).

An estimated 82,700 people died and 4,04,800 were injured in road traffic crashes in India in the year 2002, of which, 60% were pedestrians and motorized two-wheeler riders (Government of India, 2002). It has been reported that one person dies in less than every five minutes in India, due to vehicular accidents and the accident rate i.e., number of accidental deaths per 100,000 population is 24.3 (Murty, 1999). State-wise, Goa (71%) tops the list of accident rate followed by Daman and Diu (69.9%), Maharashtra (63.96%), Pondicherry and Delhi. City-wise, Mumbai records the maximum number of accidental deaths followed by Delhi (Murty, 1999). In Delhi, there were 3194 accidents and 305 deaths in 1966, 3730accidents and 587 deaths in 1976 (Chandra, 1999), 6420 accidents and 1100 deaths in 1986 and 5547 deaths in 1995 (Murty, 1999). Haryana witnessed 335 accidents and 140 deaths in 1966, 4707 accidents and 594 deaths in 1990 and 8131 accidents and 2870 deaths in 1999 (Singh, 2000a), while in Punjab, the figures were 1010 accidents and 472 deaths in 1980 and 3579 accidents and 2295 deaths in 1998 (Singh, 2000b). One hundred and twenty eight persons in 1998, 137 in 1999 (Singh, 2000c).

There are many studies which describe and compare patterns of the severity of injuries for the various types of road users; for example the patterns of physical injury associated with being a vehicle driver or passenger, motorcyclist or pedestrian and on particular issues such as the use of seat belts and helmets (Bachulis *et al*., 1988; Chiu *et al*., 2000; Lin *et al*., 2001). Clinical studies and epidemiological studies comparing helmeted with non-helmeted motorcyclists consistently found a strong protective effect of helmets against head injury (Bachulis *et al*., 1988; Chiu *et al*., 2000). However, few studies of autopsy findings of helmeted and non-helmeted motorized two-wheeler riders have been published.

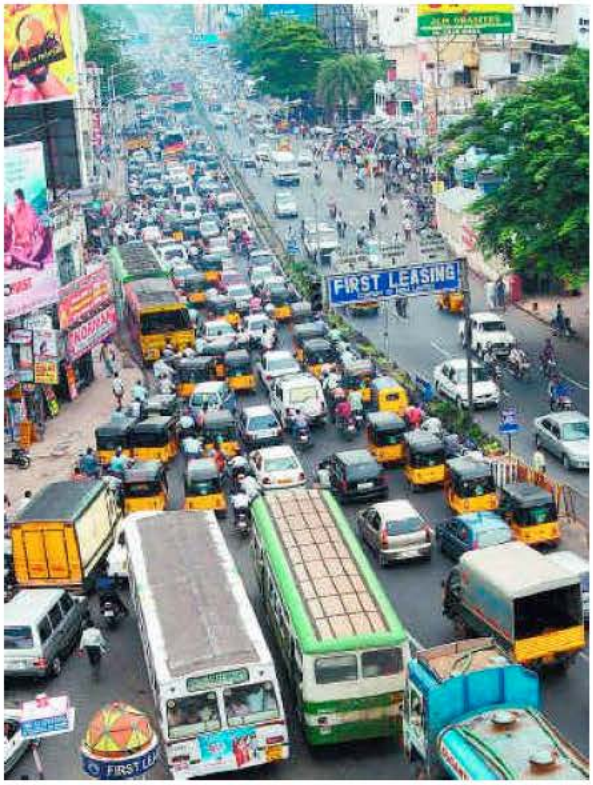

Fig. 3: Showing vehicular traffic on an Indian road

Although there have been recent advances in access to sophisticated trauma care systems and in the management of head injuries, much of the morbidity and mortality of head injuries persists despite optimal use of such therapeutic advances (LaHaye *et al*., 1991). Injury prevention efforts are, thus, vital to decrease the impact of head injuries. Helmets have been shown to reduce the probability of the occurrence of head injuries, the severity of head injuries when they occur, and the probability of death in both bicycle and motorcycle crashes (Offner *et al*., 1992; Sosin and Sacks, 1992; Thomas *et al*., 1994). We observed in the present study that 75% of the spot deaths or deaths within one hour of a road traffic accident were non-helmeted while other studies have shown an 8% decrease in Bicycles related mortality and a 21% decrease in Motorcycle related mortality (Rivara *et al*., 1994; Mock *et al*., 1995).

The high percentage (54%) of non-helmeted victims in our study despite the mandatory helmet use law, could be attributed to certain aspects of motorized two wheeler driving peculiar to the Indian conditions:

- Helmet though compulsory for the driver as well as the pillion rider at many places, is used mainly to prevent the penalty imposed (challan) by the traffic police, particularly among the youth. This fact explains a high percentage (73%) of the motorized two-wheeler crash fatalities belonging to the age group of 16 to 30 years. Our observation is in conformity with findings of other studies that have reported 66% incidence of motorcycle crash victims among young riders aged 16 to 25 years (Lin *et al*., 2001).
- Some riders wear turbans (a substitute for the helmet) whose efficacy in protecting against head injury is not known.

- Nearly all female pillion riders sit sideways with both legs to the left of the vehicle because the common mode of dress, the sari, prevents them from sitting astride and they do not wear safety helmets. Majority of the female motorcycle drivers also does not wear helmets. This factor can be attributed to a substantial percentage (38%) of female victims of motorcycle crash fatalities.
- Motorized two-wheelers are one of the most important means of transportation, unlike the developed countries where they are used for recreation and as such the number of pillion riders may be more than one.

Studies have reported a strong protective effect of helmets, however, among motorcyclists with head injury, the proportion with serious head injury has been higher (Tham *et al*., 2004). This seems to imply that there is a limit to the protection by helmets against head injury, beyond which other factors, for example crash characteristics, will affect severity of head injury even in helmeted motorcyclist. Realization of this fact and promotion of safe riding habits and behavior by the public health educationists can go a long way in preventing and/or reducing the incidence of motorcycle crashes and thereby decreasing the number of motorcycle casualties, particularly among the youth.

A two-wheeler rider is at greater risk of injury than is an automobile occupant because the rider's body is fully exposed without the protection of automobile's frame and body. Therefore motorcyclists often sustain severe injuries in multiple anatomic regions. We noted that only 66% helmeted motorcycle crash victims suffered head injury in comparison to 100% non-helmeted. This is in conformity with other studies, which conclude that helmet use decreases the severity of injury, the mortality rate, and the cost of medical care associated with motorcycle accidents (Kraus *et al*., 1994; Fleming and Becker, 1992; Mc Swain and Belles, 1990). However it was also observed that fatal thoracic and abdomiual injuries were 4 times more common among the helmeted victims of motorized two-wheeler crashes. This observation demands for other safety measures for two wheeler riders.

Where the helmet law has been successful in changing the pattern of head injury among motorcyclists, they remain vulnerable to extremity injuries. Leg injuries have been reported to account for approximately 60% of serious injuries to motorcyclists, and frequently lead to permanent disability. Leg protectors have been suggested as a way of reducing such injuries. Unfortunately, research has resulted in contradictory claims for the efficacy of leg protectors, with some studies suggesting that they would reduce leg injuries, but others suggesting that they might even increase the risk of other injuries. Further research and development is required to establish the most effective design(s) for particular types of motorcycles (www.persoualinjury.com).

The major determinants of fatality are the rider's crash speed (kinetic energy) and modern motorcycles are often very powerful machines, capable of rapid acceleration and extremely high speeds. We do not believe that there is any justification for producing such powerful vehicles, which can so easily reach speeds of more than twice the maximum speed limit. There is some evidence that more powerful motorcycles have a higher accident risk and in particular are associated with a higher proportion of accidents and casualties on non-built up roads, at night, and while going ahead on a bend or while overtaking. A Feasibility Study into the development of intelligent speed adaptation devices for motorcycles is needed (www.rospa.com).

There is a need to study and understand motorcycle crash characteristics. Braking, especially in an emergency, is one of the most difficult tasks of riding a motorcycle. Errors in applying brakes to a motorcycle may easily lead to skidding, capsizing or the vehicle becoming unstable. Incorrect use of motorcycle brakes is considered to be a factor in many two-wheeler motor vehicle accidents. There is a need for technological development in this regard (www.rospa.com). Furthermore, the road conditions and the condition of roads are of great significance, particularly in the developing countries affecting the motor vehicle accidents and hence demand attention of the concerned (Sharma *et al*., 2002).

However, there can be certain implications of safety devices as well and whether introduction of the additional safety devices alone will add to safety of the motorcyclist or not needs to be seen in the light of the Swedish experience with the change from left hand to right hand traffic in 1967 where contrary to government and safety experts' expectations, the change was followed by an immediate and major reduction in the per capita traffic deaths and injury rates, which, however, returned to original level within two years. Here the change led to a sudden surge in the level of perceived risk, which was now much higher than the level of risk accepted, and people drove more cautiously, which in turn, reduced the rate of road crashes. After some time, people discovered, through their own and others' experience and through the mass media, that the roads were less dangerous than they had thought and became less cautious in their actions thereby causing the crash rate to return to normal. A similar short-term fluctuation in the rate of road crashes was experienced when Iceland changed over to right hand traffic in 1968 (Lave and Weber, 1970).

CONCLUSION

Current laws and technologies have aimed to decrease the incidence and severity of brain injury in motorcyclists. However, despite increased helmet use, far too many motorized two-wheeler riders continue to sustain serious and fatal head injuries owing to the great risk of striking the head. Furthermore motorized two-wheeler riders still die of injuries to vital thoracic and abdominal organs. More effective helmets and devices for preventing fatal chest and abdominal injuries, on one hand and, strict implementation of protective gear use law on the other, are needed to decrease deaths from motorized two-wheeler accidents, particularly in the developing world where motorized two-wheelers are one of the most important means of transport, not recreation. Availability of high-speed motorized two-wheelers may be restricted to sporting events and not to common road conditions. Technological developments like speed adaptation devices, safe braking system, and well-maintained roads etc. can go a long way in preventing motorized two-wheeler crashes.

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