

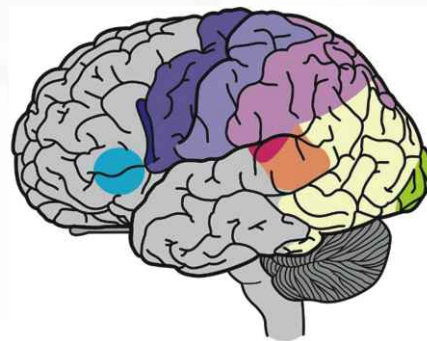
# Head Injuries and Helmets:

## Helmet Legislation and Enforcement in Karnataka and India

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# Director's Message



Road traffic deaths and injuries are continuously increasing in all states and union territories of India. More than 100,000 persons are killed and around 500,000 are injured every year in India. An estimated 7000 persons died and 51,000 persons sustained serious injuries during 2004 in Karnataka. Bangalore city witnessed about 900 deaths and injuries among 10,000 persons during the year 2004. Among those killed and injured, nearly 40% occurred among motorcycle riders and pillions, with more than a third due to traumatic brain injuries. For the affected families, it is a time of intense agony and suffering along with huge socio-economic burden.

Human brain is the single most important organ in our body responsible for all our activities. Injury to this part can lead to instantaneous death or various types of damage and disabilities. The quality of life among injured is often poor and affects them for the rest of their lives.

Prevention of brain injuries should be of great importance in the Indian region. Several proven and cost-effective strategies are available today based on years of scientific research. Helmet legislation is one such strategy, which has demonstrated its effectiveness over a period of time from all around the world including India. There is an unambiguous and direct relationship between presence of a universal helmet law, helmet usage and decline in brain injury deaths and injuries. Undoubtedly, implementation of this intervention can lead to reduction of deaths, injuries and disabilities. The present decision of the State Government is timely, appropriate and a step in the right direction. Citizens need to take note of enormous benefits likely for themselves and their families with this strategy.

A handwritten signature in black ink, appearing to be 'D. Nagaraja'.

Dr. D. Nagaraja  
Director/Vice-Chancellor  
NIMHANS, Bangalore.

**K**arnataka is experiencing motorization at a rapid pace. Every day, nearly 500 motor-vehicles ( including 375 motorcycles, scooters and mopeds) are added on to the existing roads. Data from both police and hospital sources indicate that nearly 40% of those killed and injured are motorcyclists. Nearly 60% of traumatic brain injuries (TBIs) are due to road traffic injuries (RTIs). Those injured and killed are predominantly men and in the age group of 15-44 years (75%). The number of women drivers is fast increasing in Karnataka and Bangalore city. Consequently deaths and injuries will increase among women in the coming years.

Evidence available till date indicates that helmets decrease the likelihood of death, the severity brain of injury, number of skull fractures, neurological disabilities, and overall cost of medical care and social hardships. The risk of death is nearly 2.5 times more among unhelmeted riders compared with those wearing helmets.

Without helmet laws, only less than 5% of riders and pillions wear helmets in Bangalore and might be < 1% in other parts of Karnataka state. Helmet use can reach nearly 80-90% when law requiring motorcyclists to wear helmets is notified and enforced. This single strategy brings enormous benefits to the society.

Baseless arguments float in the society discouraging helmet law and often leading to withdrawl of notification. Research from all over the world indicates that there is no evidence for these arguments that exists among the public. While educational programmes will be of help to clear these misconceptions, strict-uniform and people-friendly implementation will undoubtedly reduce deaths and injuries. Needless to say political leadership will be the driving force. This initiative of Karnataka should be welcomed by every citizen of the state.



# 1. Introduction

The recent decision of the Government of Karnataka with regard to reintroduction of Helmet legislation should be welcomed by all citizens of the State. The decision was pending for a long time despite recommendations by technical, academic, statutory and administrative bodies. These include NIMHANS and other academic institutions, professional bodies, health task force of Government of Karnataka, the Hon'ble High Court of the Government of Karnataka, the Department of Transport and Police, and several concerned citizens road safety groups. Even the media has strongly supported reintroduction of the legislation for a long period of time by taking scientific information to the public arena and stimulating a healthy discussion around the issue. The citizens of Bangalore had publicly acknowledged the importance of helmets in media. In the last 3 years, several campaigns on helmet usage (Friends for Life Campaigns - 2003, Safe Chalao Citi Bajao - 2004, Road Safety Week Celebrations - 2005) have been conducted and newspaper articles have been in the city of Bangalore. Despite these recommendations and suggestions, few had opposed the law for simple and trivial reasons.

*The time is appropriate at this juncture to clearly examine the scientific issues and societal benefits of helmet legislation and identify mechanisms for smooth and people-friendly implementation of the law during the coming years. The present report has attempted to bring in available scientific evidence on helmet legislation from all over the world and its efficacy to reduce brain injuries. The report examines the current motorization pattern; increasing road traffic injuries and deaths in Karnataka and Bangalore, specially among motorcyclists; nature and pattern of brain injuries among two wheeler rider and pillion along with impact of road traffic injuries on individual, family and society. Secondly, the mechanism of brain injury and role of protective nature of helmets are discussed in brief. Thirdly, the existing Indian Motor*

*Vehicle Act (1988) and its implication are highlighted along with what works to promote helmet usage in Indian Society. The efficacy and effectiveness of helmet laws are reviewed in Section 11 along with existing myths and facts of helmet usage (section 12) as the fourth important issue. Lastly the report sets in place series of guidelines for proper implementation and enforcement of helmet laws in Karnataka.*

Road Traffic Injuries (RTIs) are one of the leading causes of deaths, hospitalizations, disabilities and socio-economic losses in India, Karnataka and Bangalore. The number of people killed, hospitalized or disabled exceeds the problems of many other emerging health problems like Cancer, HIV/AIDS, Diabetes, Cardiovascular diseases and others (WHO, 2002). With liberalized economic reforms, industrialization, migration and changing values of the large middle class - young and middle age sections of the society, the motorization phenomena in Karnataka has been rapid and marked. Aggressive marketing by vehicle manufacturers, easy availability of loans, the glamour of free and speedy mobility and the bear necessity to travel have resulted in increasing motorization. As transportation and mobility becomes an essential component of our life, motor vehicles have become a necessity. As there has been no significant increase in mass public transportation systems, two-wheeled motorcycles have become the major choice of people. Considering the constraints of time and the need for travel, individual-personal modes of transport are becoming the law of the land. Large number of poor and middle-income families are compelled to use two wheelers, as they are not highly expensive. Even though motorcycles are economical for the individual, this motorization has placed considerable problems in the society. An accompanying future of this change has been a consequent increase in RTIs and deaths. Apart from injuries-deaths, other accompanying problems like traffic congestion, air and noise pollution and other psychosocial problems are also placing a huge burden.



## 2. Motorization Patterns

India is witnessing rapid motorization over a period of time with nearly 70% of total vehicles being two-wheelers alone, as shown in Figure 1 and 2 (www.morth.nic.in).

Figure 1: Motorization pattern in India, 1991-2002 ('000s)

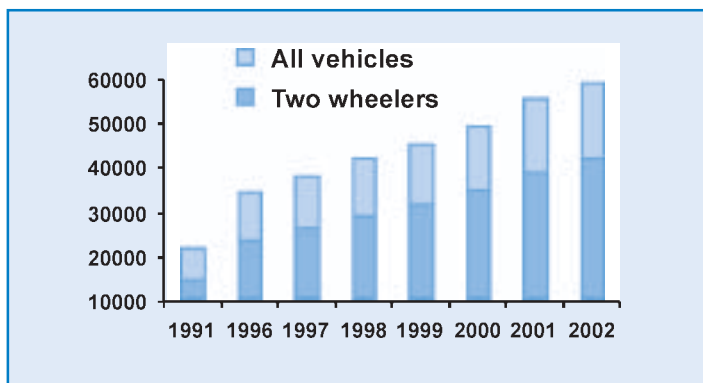
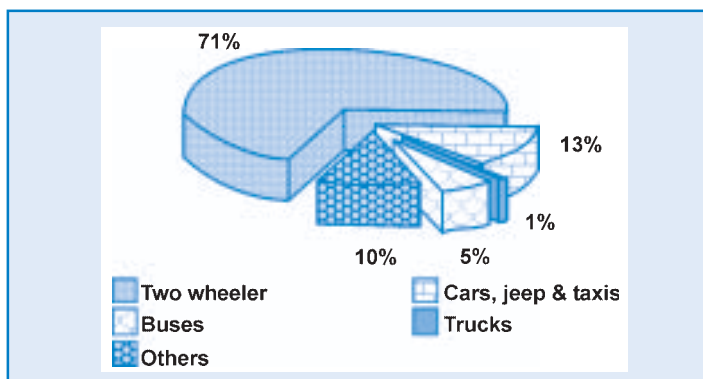


Figure 2: Distribution of vehicles in India (%), 2002



Karnataka is one of the states witnessing rapid motorization. This has been more marked across cities, districts and taluk headquarters, while rural parts have not lagged behind. The total number of vehicles in the state has increased from nearly 2,000,000 to 5,000,000 during the period 1995-2004 as shown in Figure 3 and 4 (Ministry of Road Transport and Highways, 2002). Among the total vehicles, motorized two wheelers (refers to motorcycles, scooters and mopeds) constitute nearly 70% of total registered vehicles. Among the various districts, all district and taluk headquarters have registered more number of motorized two wheelers apart from major cities.

Figure 3: Total registered motor vehicles in Karnataka, 1995-2002 ('000s)

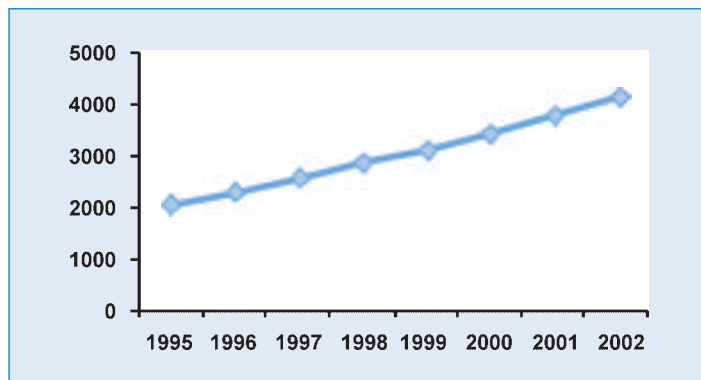
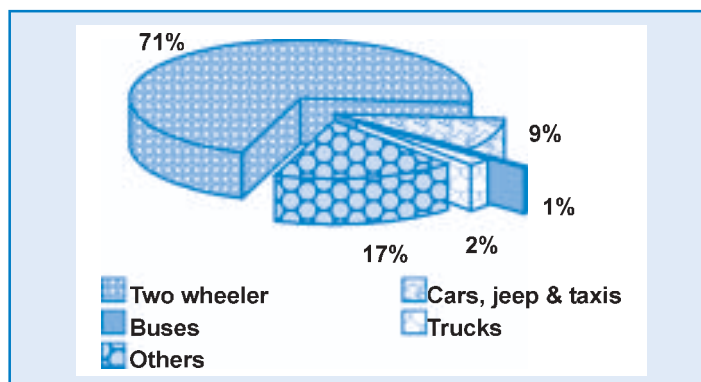


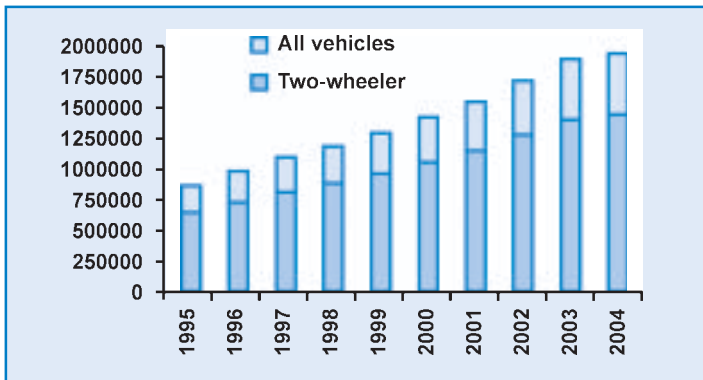
Figure 4: Distribution of vehicles in Karnataka (%), 2002



The city of Bangalore, one of the "High-tech cities in the world" and "an emerging IT hub in South-East Asia", has witnessed rapid motorization in the last decade. From 7,73,904 vehicles in 1994, the city has a total number of 19,58,590 vehicles as on 31.12.2004. Once again, two wheelers constitute 75% of the total vehicles (n=14,59,122) as shown in Figure 4 & 5. During the same period the public transport vehicles like buses increased from 25,494 to 61,034 (increase by nearly two times) and cars have multiplied twice from 103,872 to 277,609. An increase in two wheelers in the city has been marked and phenomenal (Personal Communication: Bangalore City Police) from 8,00,000 in 1995 to 15,00,000 by 2004.



Figure 5: Total registered motor vehicles in Bangalore, 1995, 2004 ('000s)



It needs to be acknowledged that the city adds a minimum of 500 vehicles every day on to its existing roads. The road infrastructure development, acceleration of traffic managing police force and other safety issues on roads have lagged behind due to absence of comprehensive road safety policies or programmes in the state or the city. In addition, majority of people entering as qualified (!) drivers every year are predominantly young people in the age group of 20-30 years.

### 3. Road traffic deaths and injuries

During 2002, nearly 85,000 persons died and more than 400,000 were injured as per official reports (NCRB, 2001; Ministry of Road Transport and Highways, 2002) as depicted in Figure 6 & 7. The recent "First India Injury Report" has estimated that nearly 1,20,000 persons were killed and 18,00,000 persons seriously injured in India during the year 2004.

Figure 6: Distribution of vehicles in Bangalore, 1995- 2004 ('000s)

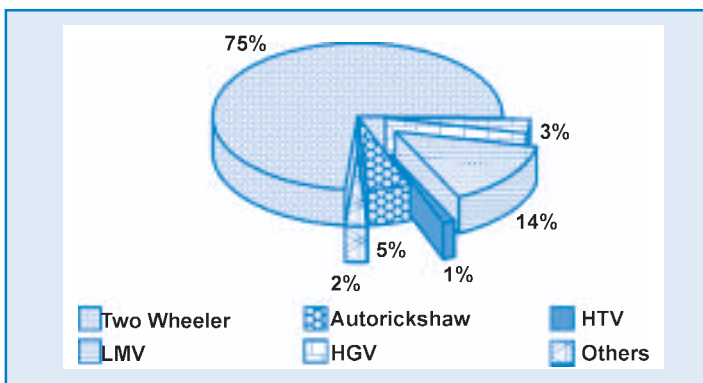
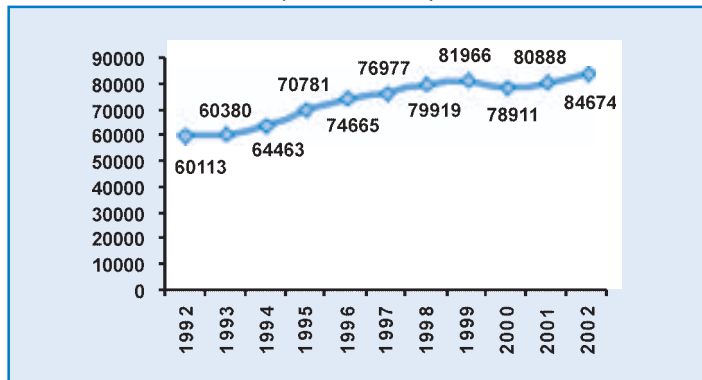
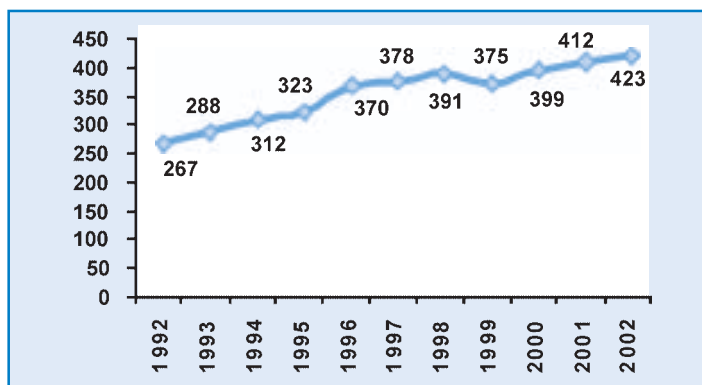


Figure 7: Road traffic injuries and deaths in India (1980 – 2002)



Deaths in India

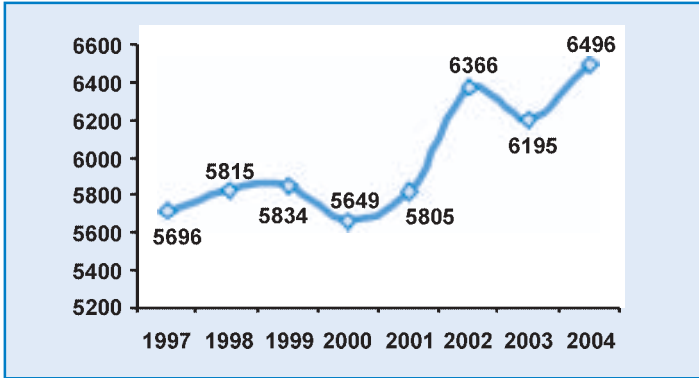


Injuries in India ('000s)

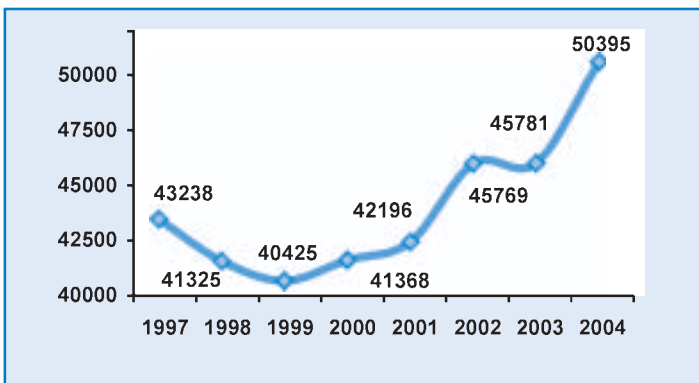
In Karnataka during the year 2004, 5,786 and 33,083 fatal and nonfatal accidents were reported by official agencies resulting in deaths and injuries of 6,496 and 50,395 persons, respectively (Figure 7). There has been an increase from nearly 4,000 deaths in 1994 to 6,496 with similar increases in injured persons from nearly 35,295 to 50,395. Considering various aspects of underreporting, it can be estimated that more than 7,000 persons are killed every year with serious injuries among nearly 1,00,000 persons in the state. Amongst the various districts, Bangalore (713 deaths and 3,289 injured persons), Belgaum (445 deaths and 3,524 injuries) and Chitradurga (226 deaths and 2,653 injuries) occupy the top three places. Other districts with high number of deaths and injuries were Tumkur, Gulbarga, Bellary, Bagalkot, Bijapur, Mandya and Kolar (Personal Communication – Office of the Commissioner for Traffic and Road Safety, Bangalore, 2005).



Figure 8: Road traffic injuries and deaths in Karnataka (1997-2004)

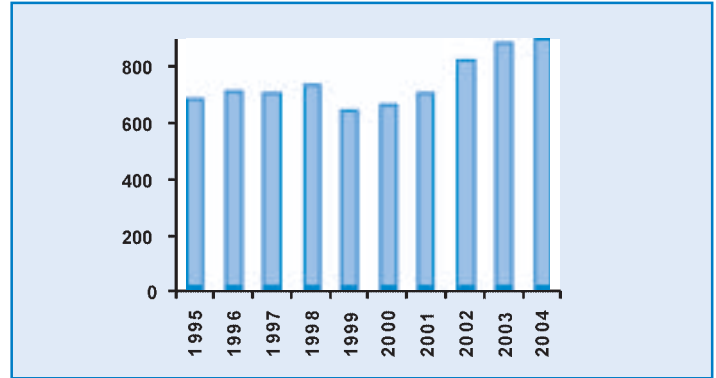


RTI Deaths

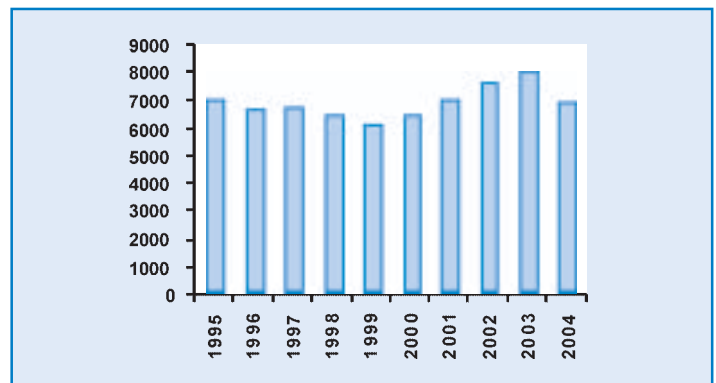


Road Traffic Injuries

Figure 9: Road Traffic Injuries and deaths in Bangalore (1995 - 2004)



RTI Deaths



Road Traffic Injuries

In the city of Bangalore, nearly 903 people were killed and 7000 persons were injured due to RTI with a ratio of 1:8 during 2004 (Figure 9 & 10). This has been an increase from nearly 500 deaths in 1994 to the present level of 900 deaths with similar figures of 4,000 to 7,000 for injured persons (Personal Communication, Bangalore City Police, 2005). Studies undertaken by NIMHANS have demonstrated that the official reported figures are an underestimation of the real problem as all deaths and injuries (from various hospitals) are not reported to official agencies (Gururaj G et al, 2000). The study concluded that deaths are underreported by 10% and injuries by nearly 50%. Based on this, it is estimated that the city of Bangalore would experience nearly 1000 deaths and serious injuries among 15,000 persons, every year.

A consistent and uniform finding across the entire Indian region including Karnataka has been that individuals in the age group of 15-44 years (approximately 75%) and predominantly men are killed and injured to a higher extent.

#### 4. RTIs: a public health problem

Most significantly RTIs in India are still considered as Police, Transport, Legal and individual issues and not as a public health problem. In most of the high-income countries of the world, RTIs are considered as a public health problem and comprehensive efforts are made to understand the problem and to identify and implement remedial measures. In India and its states and cities, RTIs are a health problem only after an injured or killed person reaches a hospital.



The effect of RTIs can be both direct and indirect, and impact individual, families, employers and society at large (Gururaj G, 2004). It is undoubtedly true that even when only one person is involved in a road crash, the entire family is affected: financially, socially and emotionally. In a recent hospital based study of traumatic brain injuries, it was observed that nearly 30% of patients were leading poor quality of life (Gururaj G et al, 2005). Several health problems depending on age, sex, severity and nature of injuries, availability and accessibility to care influence recovery from injuries and resultant disabilities. Nearly 1/3rds of the surviving injury members were suffering from posttraumatic problems of depression, anxiety, fear, suicidal tendencies, alcohol problems (Channabasavanna SM and Gururaj G, 1994). Within the study population, nearly 5% of the children had become orphans or had lost one of their parents, depriving themselves of psychosocial stability and socioeconomic support.

The major direct economic costs incurred by family are for medical expenses. Legal expenses along with cost of repair of damaged vehicles and subsequent repairs can be huge and phenomenal. Medical costs include prehospital, hospital and post hospital expenditure for survivors. In a situation where health care is subsidized, these are difficult to measure due to methodological problems. The costs vary and depend on nature of injury, methods of intervention and length of stay. The 'out of pocket expenses' vary over a period of time and are determined by extent and nature of injuries along with availability and accessibility to care. The resulting effect of crash not only includes direct out of pocket expenses but also indirect cost of loss of work time, household response to the sudden emergency, damage to goods and property and long term rehabilitation costs.

In a recent study, it was observed that medical costs varied from Rs 17,000 to 35,000 for hospitalized people (Aeron Thomas et al, 2004; Gururaj G, 2004). The total recovery time from injuries was substantially higher in urban poor families (87 days) compared with rural families

(58 days). The number of children who missed due to school was again comparatively higher in rural and slum populations compared with the urban families. On an average, nearly 90 days of work were missed for a serious RTI across all categories.

The social burden and impact of RTIs is huge and phenomenal; more so in developing countries due to absence of social support systems and low levels of income. The sudden death of an economically productive person often places major and long-term responsibilities on other family members. This often forces others to seek jobs, get employed in low paying jobs (resulting in poor self esteem) and loss of confidence. Children often miss education or will be forced to take up employment to lead the family. The dissatisfaction resulting from long term and lengthy criminal / legal proceedings is often frustrating. To meet economic hardships, families have to make loans (at exorbitant rates with private money lenders at high rates of interest) and sell even the meager family assets (anything that is with them). In the recent survey (Gururaj G and Suryanarayana SP, 2004), at one year following an injury only 70% of urban, and 54% of rural people were able to return to their jobs and had noticed a 20% decline in income levels compared to pre injury status. Majority of households (nearly 80%) reported decrease in their total income. In rural areas, the food production and availability had decreased in 21% of households. 52% of the households had to borrow money from external sources and 11% had to sell their family assets to meet the emerging demands. In 14% of households, a non-earning member or an earning member had to take an additional job to meet the increasing demands. In order to take care of the injured person, 20% of earning members had to stay away from their jobs or discontinue the job on a long-term basis. Only less than 5% of the bereaved households had received compensation from government or from their employers or from insurance companies. Social engagements like weddings, religious trips, naming ceremonies in the family or any other planned activities had to be postponed due to an injury resulting in additional economic burden.



## 5. Deaths and injuries among motorcyclists

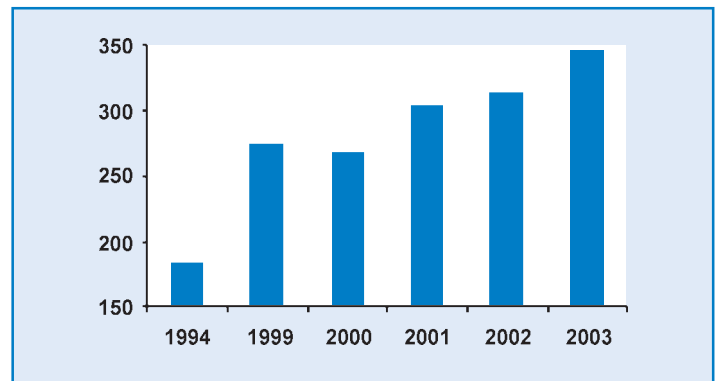
RTIs are non-random events and can occur at any place - anytime - and to anyone. However, several research studies in India have conclusively demonstrated that two wheeler riders and pillions account for nearly 40% of deaths and injuries, followed by pedestrians (Gururaj G, 2005; Mohan D and Bawa PS, 1985; Sathyasekaran BWC, 1991; Jha N, 2003). The official figures of Karnataka and Bangalore also indicate similar patterns with nearly 75% of deaths and injuries among two wheeler occupants, with a male to female ratio of 3:1.

The total number of killed and injured motorcyclists in Karnataka is not available in the public domain. The precise number of injured is difficult to establish as all hospitals (in various cities and districts) do not report to any single agency. However, it can be estimated that every year, more than 2,000 are killed and 30,000 sustain serious injuries (seriously or moderately and receive care in different hospitals) in Karnataka.

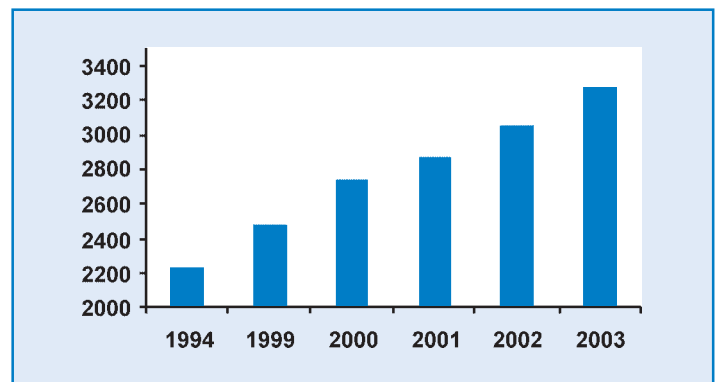
Data for the period 2001-2003, for Bangalore reveals that two-wheeler deaths and injuries have increased from 330 in 2002 to nearly 400 deaths in 2004 with corresponding increase in number of injured persons from 2,000 to 3,551 (Figure 10). Deaths and injuries of two wheeler occupants was the number one category of road users killed and injured in the city of Bangalore (Personal Communication; Bangalore City Police, 2005).

- ❑ A study undertaken by NIMHANS during 1994 revealed that riders and pillions of motorcycles constituted 31% and 8% of total deaths, respectively. Similarly, 22% and 12% of those injured were occupants of motorcycles (Gururaj G et al, 1993).
- ❑ In a collaborative study with 23 hospitals of Bangalore city, it was observed that motorcyclists were the leading categories of road users killed and injured to the extent of 42% (Gururaj G et al, 2000).

Figure 10: Two-wheeler occupants injured and killed in Bangalore (1999-2004)



Deaths in Bangalore



Injuries in Bangalore

- ❑ In a recent large-scale study of Traumatic Brain Injuries (TBIs) by NIMHANS on a series of 4,190 RTI subjects, 42% of deaths and 43% of injured persons were motorcyclists (including drivers and pillions). Pedestrians were the next largest group to the extent of 26% in the series (Gururaj G et al, 2005).
- ❑ In a recent large-scale population based survey, covering 96,959 individuals from urban, rural and slum populations of Bangalore, it was observed that the incidence and mortality of RTIs were 164 and 217/100,000 for poor and non-poor in urban areas and 270 and 328/100,000 in rural areas, respectively. Motorcyclists were the major category of road users killed and injured in all areas. The burden of RTIs was found to be substantially higher in rural, slum and middle class segments of the study population, specially among the poor communities (the usage of two-wheeler is also higher in this population). Among



the various road user categories, two-wheeler occupants constituted 39% of total subjects.

Sathyasekaran BWC, 1993; Jha N, 2003) have revealed that two wheelers riders and pillions are killed and injured in disproportionately large numbers compared to other categories of road users.

Several studies from different centers in the country (Sidhu et al 1993; Mohan D and Bawa PS, 1985;

**Table 1: Distribution of vulnerable road users in different studies**

	1993 <sup>+</sup>		1999 <sup>+</sup>	2004 <sup>+</sup>		2004 <sup>*</sup>	2003 <sup>**</sup>	
	Inj	Death		Inj	Death		Inj	Death
Pedestrian	30	37	26	26	33	26	32	39
Two-wheeler rider	21	31	44	31	30	39	45	41
Two-wheeler pillion	13	8	~	12	7	~	~	~
Bicyclist	10	6	6	8	5	3	4	6
Others	26	18	24	23	25	32	19	14

\* *population based survey*

\*\* Police data

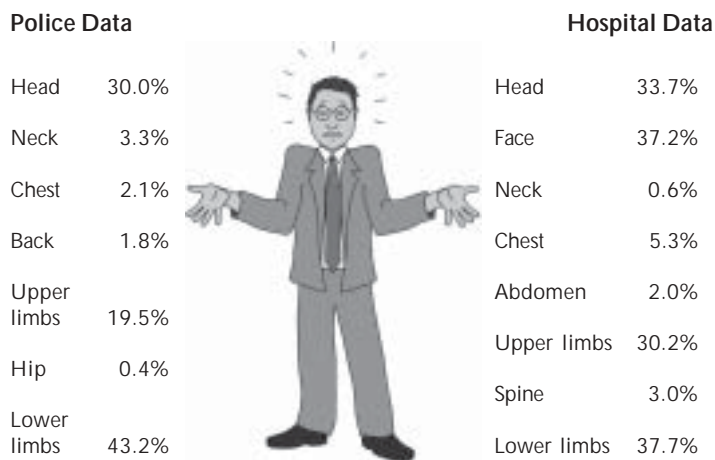
+ *Hospital based studies*

~ Pillions included with riders

## 6. Injury patterns among two wheeler occupants

Large-scale databases nor injury surveillance systems as existing in high income countries have not been established in Karnataka and efforts are in progress in this direction. Limited studies reveal that TBIs constitute nearly 40-50% of total injuries (Gururaj G et al, 1993; 2005b). RTIs account for 60% of TBIs and nearly half of these are among motorcycle (including scooters and mopeds) riders and pillions. Studies of RTIs reveal that head is the most commonly injured organ of the body among two wheeler occupants (Gururaj G, 2000; Mohan D, 1983; Jha N, 2003). These studies indicate that approximately 40-50% of injured motorcyclists and 1/3<sup>rd</sup> of killed motorcyclists had sustained an injury to the brain. Analysis of both police and hospital data indicate that nearly 1/3<sup>rd</sup> of injured motorcyclists have a brain injury (Figure 11). The various types of brain injuries commonly seen among motorcyclists are concussion (60-70%), contusion (15-30%), hemorrhage (10-15%) and skull fracture (5-10%). Along with this, injury to the facial organs are also noticed among 50% of subjects. Injury to the neck was seen in only 2% of individuals.

**Figure 11: INJURED AREAS**



Studies from the Centre of Biomedical Engineering, IIT, New Delhi have also shown that brain injuries are noticed among 50-80% of motorcyclists. Unhelmeted riders were found to be at higher risk of sustaining brain injuries compared to helmeted riders (Mohan D, 1983; 1992). Only 24% of helmeted riders sustained head injuries (AIS > 5) compared with 55% of unhelmeted riders. NIMHANS studies have shown that mortality among unhelmeted riders and pillions was 2.2 times higher compared with helmeted riders. The incidence of



skull fractures, contusions and haemorrhages was more among those without helmets. Concussive head injuries were more among those wearing helmets, thus indicating that in the event of a crash, injuries are of a less severe nature in the presence of helmets (Channabasavanna SM and Gururaj G, 1994; Gururaj G et al, 1993). The studies have shown that -

- ❑ About 60% of total head injuries and deaths were due to road traffic accidents.
- ❑ On an average about 100-120 two wheeler riders and pillioners sustain head injuries every month out of which 10-12 succumb to death.
- ❑ Two wheeler riders and pillioners constituted 30-40% of total head injuries.
- ❑ Among those not wearing helmets deaths were 2 times more compared to those with helmets.
- ❑ The severity of head injuries was higher among those without helmets (based on Glasgow Coma Scale).
- ❑ The incidence of skull fracture was 1.2 times more among those riders without helmets as compared to those with helmets.
- ❑ The duration of hospitalization was comparatively more among those without helmets.

## 7. Mechanisms of brain injury

The bio-mechanics and human tolerance to brain injury have been examined by number of approaches like real life studies, artificial dummies, use of human volunteers, studies in human cadavers, animal experiments and computer simulation exercises. Each of these methods have added immensely to our understanding of the mechanics of brain injury in the event of a crash along with possible methods of reducing the severity and impact (Mohan D, 1993).

In a crash, the interaction of agent with host results in release of energy and is absorbed by the human body.

In the case of two wheeler occupants, the rider or the pillion can hit the colliding object, (which can be an incoming vehicle, a roadside stationary object or the ground) (at different speeds and velocities). The resulting energy release and its impact on the brain is determined by the amount of energy generated, presence or absence of protective equipment, viz., helmet, physiological characteristics of the injured person and energy threshold levels. Skull and brain injuries are produced by either static or dynamic forces. Holburn as early as 1943, in his classical experiments observed that in the event of an injury, the shear strains were different in different parts of the brain and could result in "tearing of blood vessels, axons, cell bodies, synopsis and nerves" (Holburn, 1943; quoted in Mohan D, 1993). It was concluded that brain injury is caused by deformation of the skull and/or sudden rotational movements. It is now clear that head impacts produce both linear and rotational accelerations for varying period of time. Two major mechanisms by which injury to the brain occurs are by deformation of the skull with or without skull fractures and, sudden rotation of the head resulting in contracoup injuries leading to hemorrhages, contusions and probably concussion. Work in the last 5 decades has opened new understanding in biomechanics and has clearly provided an impetus for prevention of brain injuries.

Among the various types of head injuries, skeletal injuries and soft tissue injuries are extremely common. Skull fractures with or without brain damage is possible. Skull fractures can be linear, depressed or compound depressed fractures. When pieces of skull bone penetrate or impact the brain, structural and neurological damage is commonly seen. Soft tissue injuries to the brain can be generalized or focal in nature. Focal injuries can be contusions and hemorrhages (epidural, subdural or intracerebral). Diffuse injuries can be very wide spread and are referred to as concussion and diffuse axonal injury. The structural damages to the brain can be severe even in the event of diffuse and generalized injuries. Both these type of injuries can occur in isolation or in togetherness (Zwienberg-Lee M and Muizelaar JP, 2004).

As per Goldsmith, there are 3 physical processes causing brain injury - (i) collision of the head with a solid



object at an appreciable velocity, (ii) an impulsive load producing sudden motion without significant physical contact and (iii) a static or quasi-static load compressing the head with gradual force. The extent and type of brain injury resulting from head injury depend on nature of force (contact or inertial loading), the type of injury (rotational, translational or angular), magnitude and duration of impact. Contact force to the head occurs when head is prevented from moving after impact. An inertial force occurs upon acceleration or deceleration of head from a differential motion of brain relative to skull. Contact forces result in focal injuries, either locally or away from the impact. Translational acceleration results in focal injuries such as contusions and haematomas. Rotational acceleration result in concussions and diffuse axonal injury, which are generalized in nature. Sometimes injuries due to rotational acceleration can result in damages of deeper structure of brain. Angular forces can result in moderate to severe injuries (Zwienberg-Lee M and Muizelaar JP, 2004).

The human injury tolerance limits determined by time, onset and severity of injury are crucial in designing protective mechanisms for brain injury. Several types of studies in laboratories and populations have shown that severity of impact, magnitude of acceleration, duration of impact and type of movement of the head determine the extent, nature and severity of brain injuries. The recognition of the fact that falls on hard surfaces from increasing heights result in severe injuries and, blunt impact to the head can cause brain damage resulted in development of safety mechanisms for road users across the world. This resulted in the development, design and application of helmets for making two-wheeler riders and pillions safer in the event of a crash. Biomechanical studies of head injuries have been undertaken in the Indian region by the Centre for Bio-mechanical Engineering at IIT, New Delhi ([www.iitd.ac.in/tripp](http://www.iitd.ac.in/tripp)).

## 8. Two-wheeler vehicles: Common but unsafe

Riders and pillions of motorcycles, scooters and mopeds face increased risk of brain injury or death in the

event of a crash due to brain injuries (Mohan D and Patel R, 1992; [www.highwaysafety.org/safety\\_facts](http://www.highwaysafety.org/safety_facts)). The specific reasons for this increased risk are that -

- ❑ two-wheeler vehicles rest and move on two points and are thus relatively unstable on the road.
- ❑ constant and continuous manoeuvring and balancing is required on the part of the rider while driving.
- ❑ two-wheelers being small size vehicles are not highly visible on the roads and are at a greater risk of sustaining crashes.
- ❑ two-wheeler vehicles are totally unprotected unlike cars, auto rickshaws and buses leaving the rider directly exposed to environment and objects.
- ❑ in the event of a crash, the head of the rider or the pillion directly hits a mobile or immobile object directly causing injury.

Many other unsafe behaviors like usage of cell phones, talking with pillion, squeezing through the traffic are noticed, thus adding to the already existing risk (sometimes vehicles are driven with only one hand).

## 9. How does a helmet work?

Due to anatomical positioning of the body and considering the importance of brain for survival and functioning of an individual, special importance is given for protecting brain in the event of a crash. In an impact, the head after hitting an object is brought to a stop within a few seconds after transverse and/or rotational movements. These impacts are noticed at all levels of speed. When an unprotected head hits a rigid surface at even 15-20 kms per hour, the contact forces can be as high as 50,000 newtons with peak decelerations in the range of 600-700 gms. This transfer of energy results in different types of injuries to the brain varying from concussions, contusions, haemorrhages, skull fractures to axonal injuries (Mohan D, 1993). Extensive research in the last 5 decades has confirmed beyond doubt that a helmet reduces the impact of energy in number of ways.



Hence, helmets have been recommended all over the world as one of the important mechanisms to prevent brain injuries. Based on similar mechanism and risk, helmet usage is even strongly recommended even for bicycle riders in recent years.

The presence of a helmet reduces the impact forces on the head by cushioning the impact and absorbing the energy along with bringing the head to a stop in a more gradual manner. If the forces on the skull are decreased, the subsequent brain damage will also decrease due to limitation of transverse and rotational movements (Mohan D, 1993). Thus, helmets act by:

- ❑ absorbing the energy and reducing the impact of the forces on the head by.
- ❑ cushioning the impact through the polystyrene or thermocol lining.
- ❑ acting as a mechanical barrier between the head and energy producing objects.
- ❑ bringing the head to a stop more slowly because of which the brain will not hit the skull with a greater force.

For the helmets to be really effective, it should satisfy 4 performance tests (Mohan D, 1991). These are;

- ❑ Shock absorption test for examining cushioning capabilities of the padding inside helmets.
- ❑ Resistance to penetration to make sure that the outer shell of the helmet is strong enough to avoid penetration by outside objects.
- ❑ The retention system test which tests the stretching of the skin strap, and
- ❑ The rigidity test, which underlines the structural properties and safety performance.

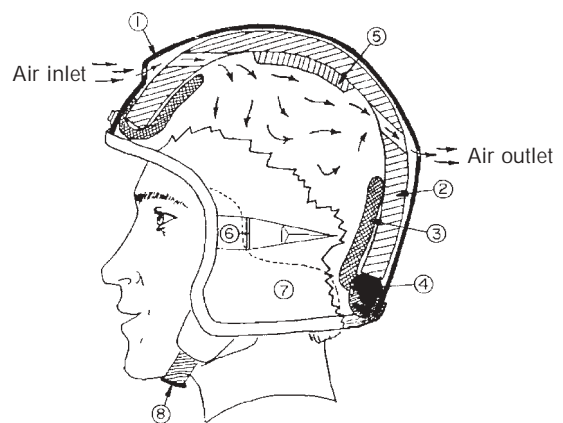
Based on these properties and strengths of tests, helmets have been conclusively proven to reduce the

impact of forces, thereby brain damage and consequent neurological disabilities. Further improvements are being recommended to improve safety aspects within the existing helmets.

TRIPP, New Delhi, undertook a study of helmets collected from the injured admitted to hospitals (Mohan D et al, 1985). It was observed that the damage to the brain was more on the sides compared to the crown. It was observed that the helmets had met all safety criteria and were capable of preventing impacts.

There is need to improve the quality of helmets in tropical countries to reduce minor discomfort for riders and pillions. This minor discomfort present for limited period of journey time should not be a deterrent for legislation. The quality can always be improved with research and technological developments. New helmets coming in the market have perforators allowing more air into the scalp region. The Centre for Bio-Medical Engineering, IIT, New Delhi has developed a new type of helmet with better air flow, additional protection along with a locking device as shown in Figure 12 (Patel R and Mohan D, 1993).

**Figure 12: Improved Helmet Design**



Technical features of the new design. Key: 1 - Fibre Reinforced Plastico shell; 2 - Expanded Polystyrene cap; 3 - inner lining; 4 - neck padding; 5 - clearance padding; 6 - locking slot; 7 - side padding; 8 - chin cushion (Source: Patel R and Mohan D, 1993)



## 10. Promoting helmet usage

With the recognition that helmets are lifesavers, all high income countries have considered this as a major road safety strategy. In India, the Indian Motor Vehicles Act (1998) stipulates compulsory wearing of helmets by riders and pillions (www.morth.nic.in).

### **Chapter 7, Section 129 of Indian Motor Vehicle Act (1988) stipulates that**

Every person driving or riding (otherwise than in a on a motor cycle of any class or description) shall, while in a public place, wear protective headgear conforming to the standards of Bureau of Indian Standards.

Provided that the provisions of this section shall not apply to a person who is a Sikh, if he is, while driving or riding on the motor cycle, in a public, wearing a turban:

Provided further that the Government may, by such rules, provide for such exceptions as it may think fit.

Explanation - "Protective Headgear" means a helmet which -

- a) by virtue of its shape, material and construction, could reasonably be to afford to the person driving or riding on a motor cycle of protection from injury in the event of an accident; and
- b) is secured to the wearer by means of or other fastening provided on the headgear.

**Section 212 as per Karnataka Gazette notification** says that "Every rule made by any state government shall be laid as soon as may be after is made before the state legislature".

Efforts to promote helmet usage have been done through educational or legislative/enforcement strategies. Despite the presence of a central law, the notification has been left with individual states in India. Except the states of Delhi and the union territory of Chandigarh, and recently Maharashtra and Gujarat, all other states including Karnataka do not have a notified law.

Considerable efforts have been made by government agencies and professionals to inform the society of using helmets in the last few years. In the last several years, information to public has been provided by campaigns, competitions, posters, slogans, road safety awareness programmes and several other strategies. Even the public strongly acknowledge that helmet is a life saving strategy for two wheelers riders and pillions. In a recent study by NIMHANS entitled, "public perceptions on road safety", among the 4,522 two wheeler riders, 85% of riders acknowledged that helmets are vital, but would not go to the extent of using it in the absence of a law (Gururaj G, 2005c). This isolated education approach (undertaken sporadically in an untargeted manner) has not resulted in decline of deaths and injuries among motorcyclists. On the contrary, deaths and injuries among motorcyclists have been increasing in Karnataka and its cities over the past few years. The recent world report on road traffic injury prevention after reviewing the available evidence on educational approaches for road safety (including helmets) highlights that "when used in isolation, education, information and publicity do not generally deliver tangible and sustained reductions in deaths and serious injuries ..... Although such efforts can be effective in changing behaviour, there is no evidence that they have been effective in reducing rates of road traffic crashes" (WHO, 2004). Educational programmes can be effective in developing social norms for safety and to build consensus on issues. Such programmes provide knowledge to road users which may or may not lead to changes in practice. Educational programmes will be of benefit when combined with other approaches to inform public for better acceptance of laws and products (Robertson LS, 1993).

Notification of helmet laws and subsequent enforcement by police agencies is another population based strategy to reduce injuries and deaths. Road safety legislative practices are likely to be effective as people still respect the law, the penalties are likely to affect them, interactions with police can be avoided, enforcement is easy and does require any additional resources and has demonstrated decline in deaths and injuries (Robertson LS, 1993). An examination of the effect of helmet laws in Karnataka indicates that deaths and injuries increase, every



time the law is repealed. In addition, it sends confusing signals to public reduces the commitment of police to enforce law and makes an individual to ignore the law. Few observational studies by NIMHANS indicate that the rate of helmet usage in the absence of legislation is less than 5% (Gururaj G, 1996; 2005b). The decision of the government to implement the law has increased the usage rates to 15-20% (as observed during the period 20th April to 1st May, 2005). Notification will upscale this to 30%, general implementation to about 50% and visible uniform implementation in a strict manner to about 70%. The continuous, sustained and targeted implementation can increase helmet usage rates to about 80%. In Karnataka, this type of implementation combined with increasing awareness at all levels of society (among different sectors) combined with targeted education programmes among two-wheeler riders can result in increasing helmet usage and a consequent decline of brain injuries.

Safety on Roads is a complex and integrated activity. For people to be safe on roads, they need to perform a large number of simultaneous activities 'voluntarily', (wear helmet, not to drink and drive, travel in lesser speeds, wear seat belts, follow road safety rules, avoid danger on roads, cross in specified places, not to use cell phone while driving, etc) every time they are on roads. It is common to see even the most knowledgeable people undertaking risk behaviours on roads. Given the limitations of human behaviour, the type of vehicles people use and the responsibility of governments for safety, it is observed that establishing systems to make people safer on roads is possible; cost effective, sustainable and yields better results. Safety rules and regulations covering people, vehicles and roads should be an integral part of the systems in the society. Helmet law and enforcement is one such strategy for saving lives of people by preventing brain injuries and deaths.

## 11. Efficacy and effectiveness of helmet laws

Many high-income countries of the world have enacted and implemented helmet legislation over a period

of time. With the proven fact that helmets offer protection and reduce severities, fatalities and disabilities along with realizing the limitations of human behavior, legislation and enforcement of helmet laws are often found to be the best strategy. In many countries helmet laws have been systematically evaluated over a period of time to document changes before and after the law. No such systematic studies have been undertaken in India. Some examples of efficacy and effectiveness of helmet laws are provided below:

- ❖ "On January 1, 1961, legislation became effective in Victoria (unique in Australia and perhaps in the world) making the wearing of protective helmets compulsory for motorcyclists and pillion-riders.
  - ❑ The legislation for the compulsory wearing of helmets by motor-cyclists in Victoria has been highly successful,
  - ❑ The law is largely self-enforcing and the rate of wearing has been close to 100%,
  - ❑ The motor-cyclist fatalities for the years 1961 and 1962 have been reduced by half, and this; reduction appears to be directly attributable to the; compulsory use of helmets,
  - ❑ The risk of fatality to a motor-cyclist in an accident is reduced by wearing a helmet to about one-third of the risk without a helmet.
  - ❑ These results have been achieved at a modest total cost and an extremely low cost per life saved.
  - ❑ Had the law been applied throughout Australia in 1961 and 1962 an estimated 87 additional lives would have been saved.
  - ❑ Because of its ready enforceability, high effectiveness, moderate total cost and very low cost per life saved, this countermeasure-compulsory helmets for motor-cyclists-should commend itself to all Australian state and territorial governments"

*(Foldvary LA and Lane JC, 1964).*



- ❖ "A review of studies in USA has demonstrated that:
  - ❑ Motorcyclists who do not use safety helmets have twice as many total head injuries and three to nine times as many fatal head injuries as helmet wearers.
  - ❑ In States with mandatory usage laws helmet wearing is high (90-100%) but the usage rate falls rapidly to less than 60 percent following repeal of such laws.
  - ❑ As a result of the reduction in helmet usage the post-repeal total head injury rate per crash-involved rider rises and the fatal head injury rate doubles.
  - ❑ A detailed study of 899 crashes in Southern California indicated that: a) hearing was not very important to crash avoidance and, in any case, there was no evidence that the helmet interfered with hearing; and b) that the slight reduction of 3 percent in the field of vision produced by the safety helmet is not important, because most highway threats are more or less directly in front of the motorcyclist rather than to one side.
  - ❑ The same study in Southern California of over 980 head injuries found only four cases of minor injury attributed to the helmet out of 173 head and neck injuries to 355 helmeted riders. In each of these cases a much more serious injury would have resulted had the helmet not been worn  
*(US Department of Transportation, National Highway Traffic Safety Administration, 1979)*
- ❖ "It is concluded that helmet laws are effective in encouraging helmet use among motorcyclists and will prevent unnecessary medical expenditures as well as unnecessary pain and suffering among injured motorcyclists" *(Muller A, 1980)*.
- ❖ "Thirty-five states repealed or altered mandatory motorcycle helmet legislation since May 1976. In-depth evaluation of the impact of the change has been reported from four states, The results reveal significant decreases in helmet usage and significant increases in the sad injury and deaths. In one state (Kansas) there was also an increase in the accident rate. Evaluation of the financial impact reveals up to 200% increase in medical costs and a significant increase in days of disability. Repeal of mandatory helmet legislation is extremely costly in any parameter measured" *(McSwain NE and Petrucelli E, 1990)*.
- ❖ "Only 24% of those who claimed helmet use sustained head injuries with severity of AIS (Abbreviated injury score) < 5 whereas the figure for unhelmeted riders was 55% and the figures for neurological deficit were 14% and 33% respectively" *(Mohan D and Bawa PS, 1985)*.
- ❖ "Examination of the data on the law regarding compulsory usage of helmets before and after the introduction shows an absolute and percent reduction in the number of head injuries." *(Nurchi GC, 1987)*.
- ❖ "Helmets also protect the face as facial fractures are twice as common in the non helmeted riders" *(Bachulls BL et al, 1988)*.
- ❖ "It was found that helmets are 28 (±) 8% effective in preventing deaths being similar for males and females and drivers and passengers. An additional result that was found was that the risk of death in the driver's seat increased by 26 (±) 2% as compared to passenger's seat" *(Evans L and Frick MC, 1988)*.
- ❖ "Laws requiring motor cyclists to use helmets reduce motor cyclist deaths by about 24 to 30%. The presence of law would result in a cost reduction of \$393 Million in human capital terms or \$1.5 Billion by other estimates" *(Rice DP et al, 1989)*.
- ❖ "Population based rates adjusted for age, sex and race in states with partial or no motor cycle helmet use laws were almost twice those in states with comprehensive helmet use laws. Two states that weakened their helmet use laws from comprehensive through partial during the study period had increases in motor cycle related head injury death rates (18.4%



and 73%), and one state that strengthened its law from partial to comprehensive had a decline in its death rate by 44%" (*Sosin DM et al, 1990*).

- ❖ "Average hospital stay in days for helmeted riders is 5.8, non-helmeted 11.8. Fatality rate per thousand motorcycle registration is 6.2 for non-helmeted and 1.6 for helmeted. The medical costs decrease by 48.8% and average disability reduced by 26.7% The medical costs for non-helmeted was 30.6% greater than helmeted. Based on 1989 figures, about \$120.8 million of additional medical care and rehabilitation expenses per year were due directly to non usage of helmets" (McSwain NE and Belles A, 1990).
- ❖ "The non-helmeted patients had higher injury severity scores (11.9% Vs 7.02%), sustained head/neck injuries more frequently (41.7% Vs 24.1%) and had lower Glasgow Coma Scores (13.7% Vs 14.5%). A 23% increase in health care cost was demonstrated for non-helmeted patients" (*Kelly P et al, 1991*).
- ❖ "The helmet use law was temporarily associated with a 26% decrease in the reported rate of motorcycle crashes in Nebraska (USA) compared with five other states" (*Muelleman RL et al, 1992*).
- ❖ "Helmet use decreased the need for and duration of mechanical ventilation, the length of ICU stay, the need for rehabilitation, and prevented head injury. Costs of acute care were significantly less in helmeted patients. Regression analysis, controlling for age, gender, and blood alcohol level (as well as non-head injury severity), confirmed that acute costs were 40% less with helmet use" (*Offner PJ et al, 1992*).
- ❖ "In California, after implementation of the helmet use law, statewide motorcycle crash fatalities decreased by 37.5%, from 523 fatalities in 1991 to 327 in 1992, more than 37%, and an estimated 92 to 122 fatalities were prevented. Motorcycle fatality rates were reduced by 26.5%, from 70.1 per 100000 registered motorcycles in 1991 to 51.5 per 100000 in 1992. Head injuries decreased significantly among both fatally and non-fatally injured motorcyclists. Enactment of an unrestricted helmet law significantly reduces the incidence of motorcycle crash fatalities and the number and severity of head injuries" (*Kraus JF et al, 1994*).
- ❖ "Motorcycle fatalities decreased 14% after the introduction of the helmet law in Taiwan. Head injury fatalities fell 22% while fatalities from injuries to other bodily areas rose 20%. Non-fatal motorcycle injuries fell 31%. This study indicates that large, immediate public health benefits resulted from the mandatory motorcycle helmet law in Taiwan" (*Tsai MC and Hemenway D, 1999*).
- ❖ "This study offers the first evaluation of a helmet law using combined -forensic and police data in a large south European urban area where there is widespread use of motorcycles. Our results confirm the effectiveness of the helmet law, as measured by the reduction in the number of deaths and mortality ratios after the law implementation. The findings reinforce the public health benefits of mandatory non-restricted" (*Ferrando J et al, 2000*).
- ❖ "The repeal of a motorcycle helmet law significantly increased the number and severity of brain injuries admitted to our trauma center" (*Hotz GA et al, 2002*). "An evaluation of the helmet law in Italy demonstrated a 66% decrease for TBIs among motorcycle - moped crashes. The rate of TBI admission to neurosurgery decreased by greater than 31% and epidural haematomas almost completely disappeared in crash injured moped drivers" (*Servadei F et al, 2003*).
- ❖ "In an analysis of injury patterns among 5,790 motorcycle riders drawn from emergency rooms, presence of facial injury increased the odds of TBI by 3.5 times and facial fracture by 6.5 times. Helmet use and presence of skull fracture were found to be significant effect modifiers" (*Kraus JF et al, 2003*).
- ❖ "A total of 9,769 patients were identified by the National Trauma Data Bank of which 6756 (69.2%)



were helmeted and 3013 (30.8%) were non-helmeted. Helmet use was associated with lower injury severity, mortality, and resource utilization. Non-helmeted motorcyclists accrued greater hospital charges and were significantly less likely to have health insurance. When controlling for alcohol or drug use, mortality continued to be significantly associated with non-helmet use. Non-helmeted motorcyclists have worse outcomes than their helmeted counterparts independent of the use of alcohol or drugs. Furthermore, they monopolize more hospital resources, incur higher hospital charges, and as non-helmeted motorcyclists frequently do not have insurance, reimbursement in this group of patients is poor. Thus, the burden of caring for these patients is transmitted to society as a whole" (*Hundley JC et al, 2004*).

- ❖ "The study by Nakahara et al (2005) investigated the temporal distribution of risky behaviors among injured motorcyclists, that is, riding unhelmeted or while intoxicated, and showed how they are associated with risk of fatal injuries. Unhelmeted riding peaked late in the evening and riding while intoxicated peaked around midnight. Both were associated with increased fatality risk after stratification by time of day; the odds ratios were 3.49 (95% confidence interval (CI) = 1.48-9.36) and 3.01 (CI = 1.71-5.19), respectively. Unhelmeted driving was prevalent and associated with higher fatality risk among younger drivers, whereas intoxicated driving was less prevalent among teens but associated with increased risk among those aged 20-39 years. This study shows that riding unhelmeted or while intoxicated can explain the increased fatality risk at night, suggesting that safety education or enforcements should be targeted at specific age groups and appropriate times" (*Nakahara S et al, 2005*).
- ❖ "In a recent Cochrane review on the role of helmets for preventing injury in motorcycle riders based on 53 studies from around the world it was observed that "motorcycle helmets were found to reduce the risk of head injury; from five well conducted studies

the risk reduction is estimated to be 72% (OR 0.28, 95% CI 0.23-0.35)". The study also confirmed that helmets have no effect on the risk of neck injuries and are protective for facial injury" (*Lui et al, 2004*).

- ❖ "Based on such observations from independent studies, the World Health Organization in its 2004 World Report on Road Traffic Injury Prevention recommends the mandatory use of helmets for motorcycle riders and pillions (including scooters and mopeds) in all countries. As early as 1984 WHO observed that "For two wheeler vehicle users, an obvious measure for protection against injury is the wearing of helmets, which on an average reduces the risk of sustaining a head injury by 30% and of being killed by up to 40%" (*WHO, 1984; 2004*).
- ❖ "The well-known Indian textbook of Preventive and Social Medicine highlights that "Safety helmets reduce the risk of head injury by 30% on average and that of fatalities by 40%" (*Park JE and Park K, 2002*).
- ❖ Based on series of studies undertaken by NIMHANS (Gururaj G et al, 1994; Channabasavanna SM and Gururaj G, 1994), Bangalore, it was observed that with mandatory helmet laws -
  - ❑ death rate among the two wheeler riders due to head injuries are decreased by 30 to 40%.
  - ❑ head injuries are reduced by 20 to 30%.
  - ❑ severity of the head injury is reduced by 40%.
  - ❑ consequent neurological disability reduced by 40%.
  - ❑ duration of hospitalization is reduced by 20 to 40%.
  - ❑ medical costs towards the treatment of head injuries reduced by 25 to 30%.

Since India and several of its states are passing through a major motorization and consequent increase in deaths and disabilities, the strategy of notification and enforcement will be a cost effective and sustainable measure for safety of two wheeler riders and pillions.

Based on these experiences, introduction of helmet legislation and uniform - strict enforcement is likely to reduce approximately 1000-2000 deaths in Karnataka and



150-200 deaths in Bangalore city. A corresponding decline in severity and disability will also be possible over a period of time.

## 12. Myths and Facts

Despite the enormous evidence of advantages of helmet laws, there are number of misconceptions among public leading to several questions. Several arguments are put forth by selected few in the society opposing helmet laws. In a recent study entitled "Public Perception on Road Safety" (Gururaj G et al, 2004) in Bangalore, 10,194 individuals in the age group of 16-49 years have been contacted to understand public understanding - perception and initiatives on road safety. In the group 4,522 persons were riders of two-wheelers. The study focused on large number of issues on road safety and opinion and self reported practices on helmet usage was one of the issues. The opinions on helmets were classified as positive and negative. The positive response mentioned were: life saving device, avoids head injury, prevents facial injury, prevents entry of dust-sand-smoke and insects, lessens noise pollution, protects from cold-rain and sun burns, one feels secure - confident, and is able to concentrate better. Some opined that it is highly essential for whole family travel. Only 1/5 reported any negative opinion which included - hair loss, hearing problem, headache, expensive, visor affects vision during rainy drives, hot in summer, difficult to carry, neck pain, cannot talk, etc. The final opinion of people could be summed up as "while everyone appreciated the benefits of helmets, few were actually wearing them and very few had negative opinion about helmets".

The following myths expressed in the society are based on an analysis of media reports undertaken by NIMHANS during 1996 and also the above mentioned study. Based on available research, it can be concluded that there is no evidence for any of these arguments.

- ❑ Helmets do not prevent accidents

Commonly people believe that helmets are for preventing accidents. It needs to be understood that helmets prevent the occurrence of brain injury, reduce

severity and deaths resulting from brain injuries. In a larger perspective, this would lead to reduction of overall brain injuries, deaths, and disabilities over a period of time.

- ❑ If two wheeler driver is wearing helmets, he/she tends to be more careless

People wearing helmets generally tend to be more safety conscious. Every time it is used, the helmets remind the person of the risks involved in riding an unstable two wheeler. This safety behaviour extends to other practices as well.

- ❑ Helmets are not necessary at low speeds

This is not true. Studies have shown that even serious brain injuries can result at low speeds of 10-15 kmph. Helmets are more effective in crashes that occur at low speeds (Mohan D, 1993). Since the impact of the crash depends on what hits the person or where your head hits? all two wheelers riders and pillions irrespective of the size and speed of the vehicle need to wear helmets for protection.

- ❑ Helmets cause neck injury

Research till date does not indicate that the risk of neck injury increases when helmets are worn. Recent report suggests a higher incidence of severe neck injuries in riders without helmets. Orsay and Sarkar S in the state of Illinois, USA, demonstrated that helmets actually decrease the number of significant spinal injuries (Sarkar S et al, 1995; Orsay et al, 1995).

- ❑ Helmet straps cause strangulation

Based on investigation of crashes there is no scientific proof for this around the world (<http://www.highwaysafety.org>). A properly placed helmet does not cause strangulation in any way. Many times, the type of helmets worn by the rider is unsuited for his head and people need to wear comfortable helmets.



- ❑ Helmets decrease hearing abilities

This is also not true. Helmets may reduce the loudness of sounds marginally, but do not prevent the rider from hearing the horn of vehicles coming from behind (Mohan D, 1993). It is observed that as long as the rider can hear the sounds of his motorcycle, he can also hear sounds from all directions.

- ❑ Helmets reduce vision

Research has shown that helmets limit peripheral vision by less than 5% (Mohan D, 1993). Most of the crashes have been known to occur within 45 degrees on either side of the head. McKnight JA observed that wearing of helmets neither restricts the ability to hear horn signals nor the likelihood of visually detecting a vehicle in an adjacent lane, prior to a lane change ([www.highwaysafety.org](http://www.highwaysafety.org)).

- ❑ Children need not wear helmets

In fact, children are at a much higher risk of sustaining injury due to several factors. Due to smaller size, elasticity and softness of the skull, they can have more serious injuries, which can be prevented by helmets. As India still does not have child helmets, this will be difficult to implement at present. In addition, parents are generally more safety conscious, while carrying children.

- ❑ Helmets are of poor quality and there is no use wearing them

All helmets are capable of absorbing energy of the impact by the presence of the shell and the internal padding. Helmets with ISI mark specially) are made of fiberglass outer shell with thermocol polystyrene lining and are designed to withstand the impacts. Helmets with ISI mark undergoes all the tests mentioned in the earlier part of the report and are certified subsequently. Studies at IIT, Delhi has shown that all helmets are protective in nature (Mohan D and Patel R, 1993).

- ❑ Helmets are difficult to wear in summer conditions

The belief that helmets increase sweating is a myth. Generally there is increased sweating during summer irrespective of wearing helmet. Secondly sweating is related to individual body constitution and personal hygiene and this cannot be linked to helmets.

- ❑ Helmets are not required for short travel

Once again not true. Crashes and fall from vehicles can occur at any street or in any corner due to so many factors. People tend to think that they would go and come back fast. But this fast and short trip can be disastrous. It is good to wear helmets irrespective of time or distance of travel.

- ❑ Helmets need to be carried when you walk

Being predominant vehicle for middle and lower sections of the society and also for the young yuppie crowd, this is often cited as a major problem. Most of the recent vehicles manufactured today have facilities for storing, locking and for leaving them with the vehicle when parked. Several of the new motorbikes have locking systems and the riders can safely leave the helmets with their bikes. An occasional theft of helmet should not be used as a reason for dismissing the law.

- ❑ Helmets are expensive

In majority of the Indian metros and states, the cost of a good quality helmet varies from Rs.500-750 during normal time. If people spend approximately Rs. 50,000/- for purchasing a motorbike or a scooter, spending 1% of that amount, towards helmets is not expensive. The governments could ensure that prices are fixed, helmets are easily available in regulated outlets and also sold compulsorily at the time of vehicle purchase.

- ❑ With helmets my hairstyle is gone

A broken head is more dangerous than a spoilt



hairstyle. People are required to wear helmets only for journey time and not for all 24 hours. Hence, hairstyle is never affected by wearing a helmet.

- When roads are in bad shape, why should one wear helmets?

The other set of arguments mentioned are that - there is poor road maintenance, faulty traffic systems, negligent drivers, lack of speed limits, inadequate lighting, stray animals on the road and others, and hence why should one wear a helmet.

The presence of these risk situations and conditions rather reflect the need and importance of saving people's lives and limiting injuries and disabilities. Road safety is an integrated activity and there is need and scope for improvement in all areas. As roads improve, speeds definitely increase and more accidents are likely to occur. Hence, there is a greater need for protection of two-wheeler riders and pillions.

- It is my choice and why should it be enforced?

In recent years, promoting health of people has become a major responsibility of governments (e.g., anti-tobacco laws). The question of individual's freedom of choice is often being quoted by opponents of helmet laws. However, it is not merely an individual's choice and many other people like family members, employers and the government are involved in safety issues in every society. Several laws in road safety are enacted to reduce risk behaviour of people and to make them safer. With this perspective, there are several laws with regard to speed, drunken driving, traffic rules, etc. Further, much of the expenses with regard to treatment and rehabilitation, compensation and loss of productivity is met by the governments. The presence of helmet laws has been proven to reduce the economic burden on the society over a period of time by reducing severity, deaths and consequent medical expenditure and social hardships.

In the study on 'public perception on road safety' two-wheeler users reported that helmets are

important, useful and lifesaving measure. They also reported that 'once the law becomes mandatory, they will use them.

- Why should Karnataka enforce a law, when it is not in practice across other countries or states?

Helmet laws are in effect in almost every country of the world. The State of Victoria in Australia, introduced the first motorcycle helmet use law on January 1, 1961.

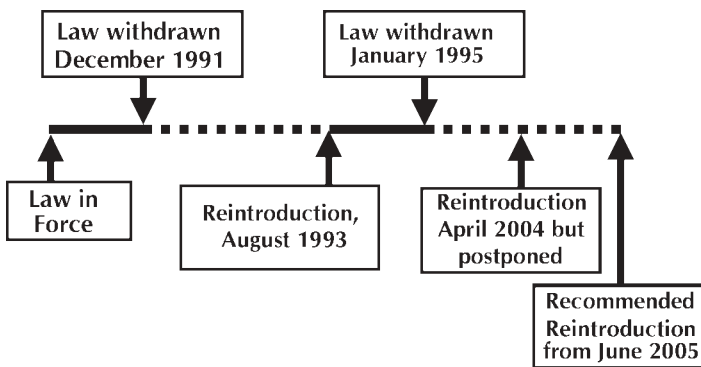
As mentioned in the earlier sections of this report helmet laws are specified in the Indian Motor Vehicles Act, but notification of the same has been left to individual States. In New Delhi and Chandigarh, helmet enforcement has been in practice for long period of time. Recently, Maharashtra, Andhra Pradesh and Gujarat have implemented helmet laws in a stepwise manner. The Hon'ble High Court of the Government of Kerala has also supported the law in the past. Activists of road safety in Chennai, Tamilnadu have urged the state Government to make it mandatory for two wheeler riders to wear helmets. A petition has been filed in Tamilnadu seeking the direction of High Court to implement the provisions of the Motor Vehicles act. (The Hindu, May 21, 2005) In view of the increasing number of deaths and injuries due to brain damage across several states, many states are recognizing the importance of helmet law as a safety mechanism in the society. In several Indian States, notification and withdrawal have been common practices leading to confusion and unnecessary debates.

The Government of Karnataka introduced helmet legislation in 1993 but subsequently withdrew it in 1995 (Figure 13). In recent period there has been a steady increase in two wheeler deaths and injuries and the Hon'ble High Court had informed the Government to reintroduce the legislation. Subsequently, there has been support expressed by several citizens groups, members of the public and professionals for reintroduction of legislation. The recent government decision comes in the backdrop



of these developments and should be supported by every one.

Figure 13: Policy and People



- Helmet legislation alone will not reduce deaths and injuries

Very true. Helmet legislation and enforcement is an important component of overall strategy to reduce deaths and injuries among two-wheeler occupants. This group forms the single largest group (40%) of deaths and injuries.

- Helmets are required only for cities like Bangalore and not important in other parts of the state

This is not true. As per available statistics, only about 890 deaths and ~ 8,000 injuries occur in Bangalore in the total of 6,496 deaths and 50,395 injuries. As mentioned in earlier sections of report, nearly 40% of injuries and deaths occur among two-wheeler riders and pillions. Thus, large number of people are injured and killed outside Bangalore city and hence helmet laws are required all over the state. In addition as traffic is in chaos, trauma care is poor and road infrastructure unlikely to improve significantly in the immediate future, prevention is a better strategy in road safety.

- Helmets are not required for highway riders and pillions

Nearly 30-40% of deaths and serious injuries occur on highways. A total of 2,494 (38%) deaths and 15,392 (30%) injuries were reported from crashes and

the rest in different places on highways within Karnataka. The severity of injuries is high due to collision of heavy vehicles (in high speed) with small sized two-wheelers. Also, due to poor visibility on highways, greater number of two-wheeler riders and pillions are injured. In addition, large number of people enter cities from highways. Such people cannot be asked to follow 2 sets of laws (wear helmet inside city and do not wear outside city). This implies that uniform laws are required throughout the state.

- Nothing happens with mild injuries to brain

For a long time, it was believed that mild brain injuries are not important and are not associated with brain damage. However, in recent years, scientific observations from all over the world has shown that even mild brain injuries (mainly concussive head injuries with Glasgow Coma scores of 12 and above) can have serious impact on posttraumatic complications and affect quality of life (WHO, 1995). Studies have shown that these people can have posttraumatic syndrome features with headache, vague aches and pains, information processing deficits, memory problems, behavioral problems and others. These type of injuries can be effectively reduced with the presence of a helmet in the event of a crash.

Such unscientific personal beliefs among people (disseminated by the media also) has given rise to anguish and anxiety. The one and only way of addressing these issues is by having a uniform law throughout the state.

## 13. Choosing the right helmet

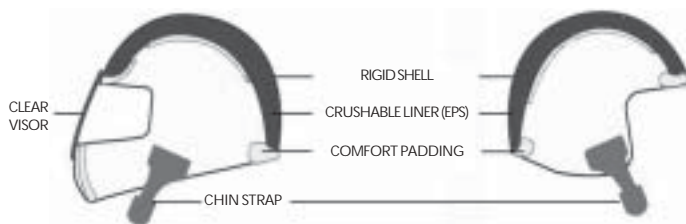
At present, 3 types of helmets are currently available. These are full face helmets, partial open face helmets and half helmets. The half helmets are commonly worn by military and police personnel and are not recommended. Full face helmets are found to be better as they provide protection for both head and face. The full face helmet also protects the lower jaw in the event of a crash. These helmets have thicker



polystyrene padding than half face helmets.

A helmet should fit the head of the person comfortably and cover maximum area of the head and face. It should not be too tight or too loose and should have adequate minimum space to avoid any discomfort.

**Figure 14: Cross-sectional view of a good helmet**



A visor can provide additional benefits by protecting the face and preventing entry of dust and mud during travel and in the event of a fall. It is important to ensure that the visor is rigidly attached to the helmet and should not fall off suddenly.

Choosing a helmet in colours of white or orange or any other light colours (preferably with reflective strip or material) will improve visibility of the rider and pillion during night times. A recent study (Wells S et al, 2004) has showed that compared with wearing a black helmet, use of a white helmet was associated with a 24% lower risk. Self reported light coloured helmet versus dark coloured helmet was associated with a 19% lower risk.

A proper buckle is important to ensure that the helmet stays on the head during times of travel. This should not be too tight or too loose. Many times, patients have reported that the strap was too loose and helmets had fallen off frequently. The strap should be tied properly and should be easy to open by others.

It should be ensured that there are no cracks, holes or any sharp pointed objects protruding inside the helmet. These damaged helmets which people commonly believe to be safe are highly unsafe.

## 14. Behaviors among helmet users

It is important that helmets are properly worn during the entire time of travel to obtain maximum benefits. Even in the absence of legislation, it is common to see many riders wearing helmets on their own. However, many a time it is also common to see many hazardous practices among wearers of helmets.

In a study of 7464 two wheelers in Delhi, it was observed that 10% of the drivers had not strapped their helmets often resulting in helmets falling out of a persons head during a crash (Mohan D, 1983; Mohan and Patel R1992). The study revealed that less than half the total riders had properly strapped their helmets. The study concluded that only 19% of these riders would have proper helmet protection.

Observational studies by NIMHANS has shown that many times helmets are locked to the motor bikes even when the person is riding; riders carry helmet on their hands instead of on their heads; and pillion carry the helmet instead of wearing them. When crashes occur in such situations, people believe that helmets have not offered protection by seeing a helmet lying on the road. These behaviors are detrimental and do not offer any protection.

## 15. Safety of two wheeler riders and pillions

There is need to develop a comprehensive and integrated approach to make two wheeler occupants more safer. Helmet legislation is one of the important strategies to reduce brain and facial injuries and deaths within this group. Apart from helmets, major interventions are required in the areas of reducing drinking and driving, avoiding hazardous practices like usage of cell phones and, reducing speeds. Speed reduction can effectively be achieved by several road and vehicle engineering methods (scientifically designed speed breakers, traffic separation, use of red light cameras, traffic claming methods, greater use ofabouts round, enforcement of speeds on different types of roads and several other techniques). Traffic safety



needs to focus on minimizing unsafe behaviors (overtaking another vehicle, overtaking in speed, riding on footpaths, jumping lights, etc.) by a combination of road engineering, enforcement and awareness programmes. All vehicles and helmets manufacturers can manufacture their products in more bright and reflectorizing color to increase visibility. The braking and lighting systems of vehicles should be improved along with better stability of two wheelers. Prehospital and emergency care and management in hospital settings require strengthening in several ways. Broader population based interventions like improving public public transportation facility (will decrease the use of two wheelers and consequent risk exposure in the long run), improving conditions of roads, traffic calming measures, improving visibility on roads and others are urgently required for making two wheelr occupants safer. Undoubtedly, road safety is an integrated - coordinated - intersectoral activity. Two wheeler safety should be integrated with safety of other vulnerable road users like pedestrians and bicyclists in the broader Road Safety Strategies in Karnataka.

- ❑ Overall safety of two-wheeler rider and pillion population in view of the ever increasing motorization (75% of vehicles are two-wheelers alone).
- ❑ Total benefits from the law for large number of two-wheeler rider - pillions, their families and society at large.
- ❑ All-inclusive social and economic benefits to the society.
- ❑ Recommendations of many institutions, task force on health and honourable high court of Government of Karnataka.
- ❑ Experience of many countries in the world with regard to helmet laws and changes observed over a period of time as available through scientific literature.
- ❑ Recommendations of various scientific bodies from all over the world including World Health Organization.
- ❑ Voices of the suffering, those dead and their families.

## 16. Guidelines for enforcement of helmet legislation

The notification of the law would alert all citizens about the need to compulsorily wear helmets. The Karnataka government has proposed legislation in phases beginning from June 1, 2005, in all major cities with gradual expansion to other towns and rural areas. The rule is applicable within the limits of Bangalore Metropolitan Region Development Authority and City Corporation limits of Mangalore, Mysore, Belgaum, Hubli-Dharwad and Gulbarga. Hopefully, it will be extended to the entire state in the next phase.

After receiving comments from public, the Government has to take a conscious decision by considering merits and demerits of helmet law. To arrive at this decision it is important to consider the -

- ❑ Safety of millions of people which in turn should be the guiding principle.

Helmet laws are easily enforceable

To facilitate easy and smooth implementation, the following guidelines have been recommended for the consideration of policy makers and enforcement agencies.

- ❑ Continuous dialogue with provision of scientific information through multimedia channels should be undertaken over a period of time. Several sections of the society like students union, two wheelers associations, citizen's forums should be involved to clear misconceptions and to communicate the scientific advantages of helmet laws. Needless to say political leadership should pave the way as safety of people is of importance.
- ❑ Education of the public for compliance with the law by understanding individual benefits of helmet wearing is crucial. These programmes should be continuous, specific and targeted to specific



population in 20-40 years age group with use of both print and visual media.

- ❑ Political support is crucial for implementation of law. Helmet legislation and enforcement is a broader societal safety mechanism for reducing injuries and deaths among motorcycle riders and pillions. This single strategy has far reaching health, social and economic benefits to society.
- ❑ Educational activities with involvement of professionals specially in district and peripheral areas of the State to increase awareness among public and to improve compliance with the law should be promoted.
- ❑ The first one or two months of implementation should also be a period of intense information dissemination (should continue later also) with people friendly - non harassing enforcement activities.
- ❑ Governments should also take serious note of the fact that once law is notified, it should not be repealed for any reason. Public should be given adequate information with regard to the advantages of laws.
- ❑ Sufficient quantities of quality helmets should be easily available in the market and unnecessary exploitation by private dealers should be discouraged. Government and private outlets should be identified for selling rather than roadside helmets. Sale of helmets through regulated and notified outlets should be encouraged.
- ❑ All agencies selling two wheelers throughout Karnataka should be informed to make helmets available at the time of vehicle purchase in all cities and districts.
- ❑ Helmet manufacturers need to be informed to manufacture all helmets in brighter and reflective colors (preferably white or orange) as this would increase the visibility of two wheelers and pillions in darkness. Reflective tapes on helmets should be encouraged.
- ❑ Prior to implementation of law, senior and middle level officials from police and transport departments needs to be sensitized- oriented and made aware of benefits of helmet law to the society. This is important as they have to inform riders and pillions on the road in the event of unpleasant situations. This has to be carried out by a one-day workshop at state level and also at district (regional) levels.
- ❑ The penalty for not wearing helmets should be clearly informed through all media channels prior to the beginning of enforcement.
- ❑ The enforcing agencies should be people friendly and humane in approach while implementing the law. Unnecessary harassment, exploitation and corruption should not be permitted during the course of implementation.
- ❑ The enforcement strategy has to be clearly prioritized by the police department. While the law should be universal, it should be targeted primarily for riders and pillions in the age group of 15-49 years (birth certificates should not be asked for).
- ❑ Enforcement has to be focused more towards extension -peripheral - residential and business areas (ring roads, extension areas, twilight areas) of Bangalore - Mysore and other cities. In all other district and taluk areas, it has to be uniform.
- ❑ As nearly 60 % of crashes occur between 12 noon and 12 midnight, enforcement has to be intensified during these times and should be targeted to those in the age group of 15 - 49 years.
- ❑ The revenue collected from the public should be pooled into a central road safety fund and should be utilized for augmenting resources for road safety and increasing road safety literacy across the society.
- ❑ Safety assessment and promotional activities needs to be initiated simultaneously for improving the quality of helmets.



- ❑ Health professionals need to actively get involved in health promotion and helmet usage activities specially at district levels. Interactions with local officials and public will help in clearing many doubts in the minds of public and help in better compliance with laws.
- ❑ The law needs to be monitored to identify the benefits over a period of time. Since road safety information systems are not strong and realistic enough to recognize the impact of the law, it needs to be adequately strengthened with the development of a hospital based RTI surveillance systems to track changes in the future. In addition, all police registered RTI deaths and injuries should specifically document the presence and absence of the helmet at the time of crash.

Every activity in road safety needs an integrated and coordinated approach, including helmet legislation and enforcement. The transport department needs to examine the existing act and notify the law for universal coverage and to put legislation in place. Police agencies need to enforce the law in a humane basis in a participatory manner on a uniform basis. The media (print and visual) has to disseminate the advantages of helmet law and benefits of helmet wearing to public along with clearing existing misconceptions. Health professionals ( doctors, trauma care physicians, orthopedic specialists, general surgeons, Neurosurgeons and all other medical specialists) need to actively take part by taking scientific evidence to public along with advantages of helmet laws. In addition, a good surveillance programme documenting changes in deaths and injury patterns needs to be set up to monitor the impact of law. The civil society (educational institutions, corporate companies, industrial and business houses and others) and public should realize that the law is implemented for their own safety and become compliant with the same.

Undoubtedly, a series of other measures to develop an integrated approach to road safety should be initiated

with the development of a comprehensive road safety policy in the State of Karnataka. The death of nearly 10,000 persons and injuries among more than 50,000 people are not a small number to be ignored. There is need for setting up of an independent Road Safety Board with adequate authority and resources along with help from technical experts to guide, develop, coordinate and evaluate road safety interventions in Karnataka. It is essential to have long-term policies and programmes based on a scientific approach

## Summary

Evidence from all research studies in India reveal that -- Road Traffic deaths and injuries are on the increase; among those killed and injured, two wheeler riders and pillion constitute the single largest group of road users; among them, injuries to brain is the single most important type of injury; and Brain injury lead to death and poor quality of life among those who survive. Since human brain is the most important organ in the body it is important to develop mechanisms, programs and policies to reduce deaths and injuries to this organ in every society.

There is overwhelming evidence from all over the world, including India, that helmets offer protection to two-wheeler riders and pillions. The presence of helmet law increases usage of helmets thereby resulting in decline of deaths, serious head injuries, neurological disabilities, duration of hospitalization and associated medical and social costs.

The decision of Government of Karnataka to reintroduce helmet legislation is a step in the right direction. The enforcement should be visible, uniform, strict, people friendly and humane in approach. All other states and UTs of India should consider implementing helmet laws and needs to be integrated with other safety measures.



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## HISTORY SPEAKS .....

### Motorcycles .....

Automobiles have been the reply to the 19th Century dream of self-propelling the horse drawn carriage (<http://auto.indiamart.com>). Similarly, motorcycles are an improvised version of the self-propelled bicycles. Many bicycles/pedal cycles were improved with the addition of small, centrally mounted spark ignition engines during 1900's. 'Two wheelers' owe their descent to the safety bicycle; i.e., bicycles with front and rear wheels of same size with a pedal crank mechanism to drive the rear wheel. Bicycles of 1800s (called bone-crushers) were improvised to high wheel bicycles and then to engine driven two wheeler motorbikes. The World's first motorbike was built by Gottlieb Daimler (who later formed the Daimler-Benz Corporation and known as "father of the motorcycle"), with a wheel in front and back in 1885. It was constructed mainly of wood with wheels being iron-banded wooden-spoked Wagon type (was a definite bone crusher those days). The first motorcycles were later designed by many other countries.

With improvements and modifications, the vehicle population increased during I World War period (1914-18), mainly used for dispatching. This interest continued during 2nd World War period with minor changes. The moped (55 cc machine with simple control and low cost) was developed by adding engines to bicycles initially started in Europe and parts of USA during 1950's. A 125 CC model was later developed in Italy after World War II. Capacities varied from 50-225 cc and four speed gearing was added to existing vehicles.

The first real successful two-wheeler was made in 1894 by Hilde brand and Wolf Mueller in Munich. By 1895, the French company Dedion-Buton built an engine that made mass production and common use of motorcycles really possible. The notable Harley-Davidson later started producing the early version of present day motorbikes by 1902. Since this time, the vehicles has

undergone several design and performance changes with improvements in safety. Today India has several industrial houses manufacturing the Indian Version of motorcycles, scooters and mopeds.

### People .....

Speed and how to move faster? Was always on the minds of makers and movers of motorbikes. Motorcycles have come a long way from when they were first created by doing nothing more than adding an engine to a bicycle ([www.motorhelmets.com](http://www.motorhelmets.com)). The need to travel, being economical and affordable, ready acceptance by youth, sexiness of vehicles, capability to move faster even in traffic congested areas made motorcycles as cheap transportation vehicles ([www.guggenheim.org](http://www.guggenheim.org)). With increasing sales and usage, the dark side of this began to emerge with increasing deaths and injuries. This propelled people and researchers to identify safety mechanisms for two wheeler riders and pillions. Helmets began to appear this way.....

### Head Protection Technology .....

Modern head protection technology began in 1950's at the University of Southern California with excellent work by Charles F. Lombard and Smith W. Ames who were developing helmets for US Air Force. The unique energy absorbing helmet property was later applied to motorcyclists, sporting activities, aviation workers and others. This work later resulted in establishment of Head Protection Research Laboratory in California (<http://www.hpri.org/history.htm>). Over the last 5 decades, advances in head protection have been understood by biomechanical research conducted on real life studies, human dummies, human volunteers, human cadavers, animal experiments, computer modelling and hospital based and population based studies. The pioneering work of Denny-Brown and Russel in 1941, Holburn in 1943, DeHaven in 1945, Slapp in 1957 and several other paved the way for understanding biomechanics and subsequently



for development of head protection by helmets. This knowledge started getting applied to people and were encouraged to use helmets everytime they are on road. By understanding limitations of human behaviour and the need to protect large number of riders and pillions, stringent laws by helmet legislation came up and are in place in many parts of the world.

### **Helmets .....**

When Colonel T.E. Lawrence ("Lawrence of Arabia") was fatally injured in a motorcycle accident in 1932, Huge Cairns, was a neurosurgeon attending to him. He was moved immensely by this tragic death. He later went to demonstrate the unnecessary loss of lives of army dispatch riders due to head injuries during the Second World War period. His 1946 article on crash helmets documented the monthly totals of motorcycle fatalities in United Kingdom from 1939-1945. In 1941, when helmets become compulsory, a decline in number of fatalities was evident. His research revealed that use of crash helmets

by motorcyclists would save significant number of lives. Later, this knowledge was translated to compulsory helmet laws in UK. As a consequence of treating T.E. Lawrence and through research at Oxford, Sir Huge Cairns work pioneered legislation for helmets for motorcyclists on roads and subsequently at work places and in sporting activities. This knowledge expanded to other countries of the world leading to the fact that helmets saves lives. This single measure over a period of time, has saved countless lives (Maartens NF et al 2002).

### **Helmet Law .....**

The World's first motorcycle helmet law was introduced in state of Victoria Australia on Jan 1, 1961. ([www.highwaysafety.org/safety-facts](http://www.highwaysafety.org/safety-facts)) Later it was expanded to other parts of Australia. Before 1967, only 3 States of USA had motorcycle helmet use laws. 30 years later, it is observed that every country of the world has mandatory motorcycle helmet laws, including some states (Delhi, UT of Chandigarh, Maharashtra) in India.



