

# Helmet Use for the Prevention of Brain Injuries in Motorcycle Accidents

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## 1. Introduction

The results of numerous studies show the effectiveness of helmets in avoiding or reducing the severity of injuries in a motorcycle accident (Hundley et al., 2004; Keng, 2005; La Torre, 2003; León & Hernández, 2004; Liu et al., 2004). Despite the proven effectiveness of helmets in avoiding or reducing the severity of brain injuries and legislation requiring their use by both motorcycles drivers and passengers in Spain since 1992, research has found that 29% of those killed in motorcycle accidents in 2007 were not wearing a helmet at the time of the accident (Spanish Interior Ministry, 2008). Similar legislation exists in most European countries.

One model that can be used to predict risk and prevention behaviour among drivers is Bandura and Walters (1963) socio-behavioural approach. According to this model, a large proportion of social learning takes place through observing the real actions of others and the consequences these have (Bandura, 1986) Social approval for a specific conduct may change a risk behaviour, principally among young people and adolescents. According to the socio-behavioural model, adolescents' use of a helmet when riding a motorbike is related to their beliefs regarding friends and relatives' use of the same protective headgear.

Other theoretical approaches, such as Bayés (1992) illness prevention model, postulate that the immediate consequences of past conducts are the most relevant variables in predicting future behaviour. Adolescents will therefore tend to produce behaviours which have immediate positive consequences or avoid immediate negative consequences.

Various different studies have identified a number of variables related to adopting preventive behaviours when driving, including: social influence (Bianco et al., 2005, State of Hawaii Department of Transportation, 2004; Canada Safety Council, 2006; Fuentes, 2007; Fuentes et al., 2010), belief in the effectiveness of the behaviour (Gras et al., 2007; Fuentes, 2007; Fuentes et al., 2010) and the immediate consequences of its use (Block, 2001; Chiliaoutakis et al., 2000; Cunill et al., 2004; Cunill et al., 2005).

If we focus on gender, according to a recent study (Fuentes et al., 2010) young men ride motorcycles more frequently than young women (23.4% vs. 6.9%) ( $p < 0.05$ ) and eight out of every ten male and female adolescents say they always wear a helmet when riding a motorbike, with no differences by gender.

The main reason adolescents who ride motorbikes wear a helmet is the safety it provides (87.2%), whereas there are three reasons for not wearing one: the characteristics of the

journey (it being short, for example) (34.8%), not having one (30.5%) and its use bothering drivers (21.7%) (Fuentes et al. , 2009).

## 2. Consequences of motorcycle accidents

The most common injuries caused by motorcycle accidents are lower limb contusions, abrasions and fractures due to direct impact with another vehicle or a secondary fall and sliding on the floor or flying through the air. In the case of frontal collision with a fixed obstacle, diaphyseal fractures of both femurs can be caused by the driver being projected over the handlebars. Also frequent are fractures of vertebral bodies, whether affecting the medulla or not, from falling in front of the motorbike and colliding with an obstacle (Figure 1), and skin abrasions and injuries due to severe friction and tearing of the skin with deep wounds from impact with fixed barriers on the road (Hernando, 2001). The poorly named “protective barriers” are the cause of 50% of serious injuries suffered by motorists and 20% of deaths in motorcycle accidents. This is why motorists are demanding a double safety barrier on roads to prevent these acting as knife blades.

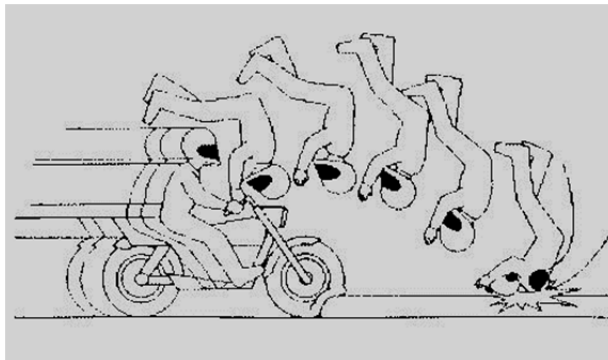


Fig. 1. Mechanism producing fractures in motorcycle accidents.

Other types of injury are traumatic brain injuries (TBI) and traumatic facial injuries (Figure 2). The term TBI includes all cases in which, following a traumatism, victims present one or some of the following symptoms: loss of consciousness, post-traumatic amnesia, convulsive seizure, laceration of the frontal scalp, brain injury or cranial and/or facial fracture (Net & Marruecos-Sant, 2001). In an epidemiological study conducted in San Diego (USA), TBI was defined as any physical injury or functional deterioration of the cranial content, secondary to a brusque interchange of mechanical energy. This definition takes into account external causes that may provoke concussion, contusion, haemorrhaging or laceration of the brain, cerebellum and encephalic trunk as far as the first cervical vertebra (Kraus et al., 1984).

The estimated incidence of TBI in Spain is 200 cases/100,000 inhabitants, of which 90% receive hospital medical attention. Incidence is higher among men than women, by a ratio of 3:1, particularly in the 15 to 25 age range. Approximately 10% of TBI is considered serious, 10% moderate and 80% mild. The most frequent causes are traffic accidents (73%), followed by falls (20%) and sports injuries (5%). Motorbike accidents are mainly found among the

under 25s and car accidents in adults (Ezpeleta, 2002). Differences are observed according to gender, with drivers who crash or lose control of the vehicle predominantly being men, and women predominant among injured companions (Muñoz & Murillo, 1993). According to other data, 6% of TBI are suffered by motorcyclists (Gennarelli et al., 1994). TBI are the primary cause of death and disability in people aged under 45 (Goikoetxea & Aretxe, 1997).

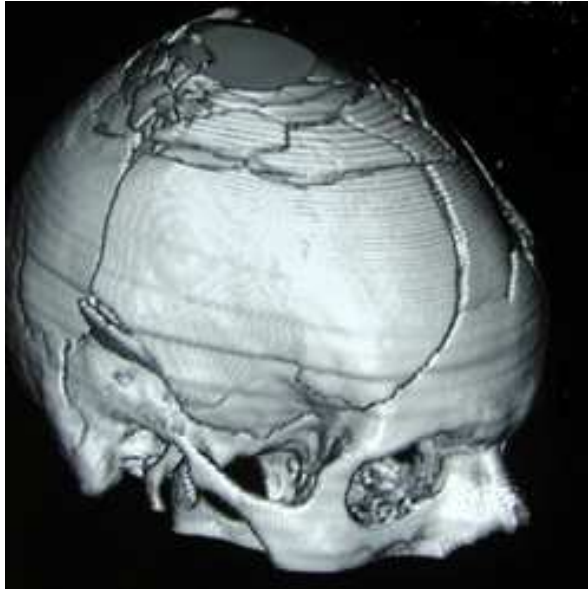


Fig. 2. Cranial fractures due to a frontal fall from a motorcycle without a helmet

The severity of TBI is measured neurologically using the Glasgow Coma Scale (ECG) (Moore et al., 2003). Another scale for measuring trauma severity is the Injury Severity Score (ISS) (Jaramillo et al., 2001). This instrument considers injuries in different regions of the body and the result is obtained by applying the Abbreviated Injury Scale (AIS).

We must not forget possible sequelae caused by injuries resulting from traffic accidents. In a study conducted by the Legal Medicine Institute in Castelló (Spain) for the period 1995 to 2000 evaluating bodily damage caused by traffic accidents, for all types of accidents (work-related and non work-related) an average of one sequela per accident was observed. Over 50% of car and motorbike accidents did not have sequelae. However, the type of accident with most sequelae, 21 to be precise, was caused by the motorcycle accident (De Luís, 2003).

The approximate distribution of results and sequelae in patients with severe TBI is: death, 30-36%; persistent vegetative state, 5%; severe disability, 15%; moderate disability, 15-20% and satisfactory recovery, 25%. In patients with moderate TBI, the distribution of results and sequelae is as follows: death or persistent vegetative state, 7%; severe disability, 7%; moderate disability, 25%, and satisfactory recovery, 60% (Moore et al., 2004).

Other types of sequelae to take into account in TBI are psychological and behavioural disorders persisting over time (Brooks et al., 1996).

Another aspect that has been studied in victims with injuries and sequelae due to traffic accidents is what is known as “social pain”, which includes hospitalisation, sick leave, professional incapacity and the need for third party involvement and adapted housing and vehicles. In a study conducted in Spain, 2,180 accident victims were monitored over 4 years, 500 with severe sequelae. Of the overall sample, 15% required hospitalisation, this figure rising to 37% among the 500 most severe cases. The type of vehicle or means of transport in which most social pain was observed was motorcycle accidents or walking. The study differentiates between injuries and sequelae. It is observed that injuries provoking extreme social pain among accident victims are located in the central nervous system (SNC)/spinal medulla, peripheral nervous system (SNP) and ocular system. On the other hand, the sequelae that provoke extreme social pain are related to the SNC/spinal medulla, visual apparatus, significant aesthetic damage and head /cranium /face (Consultrans & UVAME, 2005, as cited in Rodríguez, 2005).

All of the above costs money, not only in health expenditure but also due to social and work-related consequences. In the aforementioned Consultrans and UVAME study (2005, as cited in Rodríguez, 2005), a cost of over 100,000 euros per accident was estimated. Other authors, as well as demonstrating that victims of motorcycle accidents not wearing a helmet suffer more severe injuries than those who are wearing one, regardless of alcohol or drug consumption, also observe that the cost to society of motorcycle drivers having accidents without a helmet represents 70 million dollars annually (some 53 million euros) and, of this amount, some 30 million (over 22 and a half million euros) was not covered by private insurance. This represents a small burden for society, 25 cents (19 euro cents) annually per citizen, which is why the authors state that whether to wear a helmet or not can be seen as an issue for individuals, with few social connotations (Heller & Jacoby, 2005; Hundley et al., 2004).

### **3. Active and passive safety measures in motorcycle riding**

Two concepts exist in traffic road safety: active and passive safety.

Active safety is the set of design elements, systems or concepts incorporated into the vehicle which ensure its correct functioning when in use (European Automobile Commissariat [CEA], 2005). These include the brakes, tyres, lights and mirrors, which help the driver to avoid accidents when the motorcycle is in use. Motorcycles are manufactured in accordance with safety regulations and contain a whole series of elements which, if subject to any type of modification or adaptation, lose their effectiveness and endanger the life of the driver and any other public highway users. These elements are: size and weight, number of seats, engine capacity, maximum speed and level of environmental pollution. It should be observed that the motorcycle must also pass periodical checks and maintenance in order for the safety elements to work properly. Those elements that require periodical checks are basically the mirrors, lights, brakes, suspension, tyres, engine and bodywork.

Passive safety elements are those which are designed to protect the integrity of the user in the event of an accident. In the case of motorcycle drivers, the main passive safety element is without doubt the helmet. Results from numerous studies demonstrate the effectiveness of helmets in avoiding or reducing the severity of injuries in the event of traffic accidents for two-wheeled vehicles (Hundley, et al. 2004; Keng, 2005; La Torre, 2003; León & Hernández, 2004; Liu et al., 2004; Nakahara et al., 2005; Norvell & Cummings, 2002; Peek-Asa et al., 1999; WHO, 2003).

#### 4. Bandura and Walters' socio-behavioural model

Bandura and Walters (1974) base their work on the operant learning model, and award significant importance to social variables in acquiring new behaviours.

Bandura (1987) proposes that behaviours are learnt by observing others (modelling).

Operant conditioning models behaviour in the same way a sculptor models a mass of clay (Skinner, 1953, as cited in Bandura, 1974). A powerful modelled influence can simultaneously modify the observer's behaviour, thought patterns, emotional responses and judgements (Rosenthal & Bandura, 1978, as cited in Bandura, 1987). Much of social learning takes place on the basis of observing the real behaviours of others and the consequences they lead to.

Many theorists have considered modelling to be imitation, and that this plays a very important role in acquiring deviant and adapted behaviour (McBrearty et al., 1961, as cited in Bandura, 1974). When we refer to learning by imitation, the cultural importance of learning by observation is most clearly demonstrated in anthropological explanations of the socialisation process in other societies. For example, in many languages the word "teach" is the same word for "show", and in many cultures children do not do what adults tell them to do, but rather what they see them do (Reichar, 1938, as cited in Bandura, 1974). Bandura insists that in acquiring a skill, more than a response to imitation, modelling constitutes a rule of learning (Bandura, 1987). With advances in technology, more trust is increasingly being placed in the use of symbolic models, such as plastic models (audiovisual media). Motivating factors and anticipation of positive or negative reinforcement increase or reduce the likelihood of responses to observation, which are the essential aspect of learning by imitation.

Three effects derive from observing models of learning behaviour:

1. The observer acquires new responses that did not previously exist in their repertoire, giving rise to the modelling effect, where the model has to exhibit very new responses and the observer reproduce them identically.
2. Observing models may strengthen or weaken inhibitory responses; here the provoked responses already existed in the subject's repertoire and do not have to be identical to those of the model.
3. Observing a model may at times provoke previously learned imitation responses in the observer because the perception of certain behaviours acts as a trigger for responses of the same kind.

The characteristics of the observer influence modelling. These are the result of their reinforcement histories and will determine to what extent they will have a tendency to imitate.

According to Bandura and Walters' model, the best way to promote helmet use among adolescents and young motorcycle drivers is to provide them with models of this type of behaviour.

#### 5. Bayés' illness prevention model

The Illness Prevention Model (Bayés, 1992; 1995) is structured into three time phases: past, present and future (Figure 3).

According to Bayés (1992), the past includes all prior knowledge and specific baggage (information, emotional reactivity, interactive style, functional skills) subjects have in their personal history.

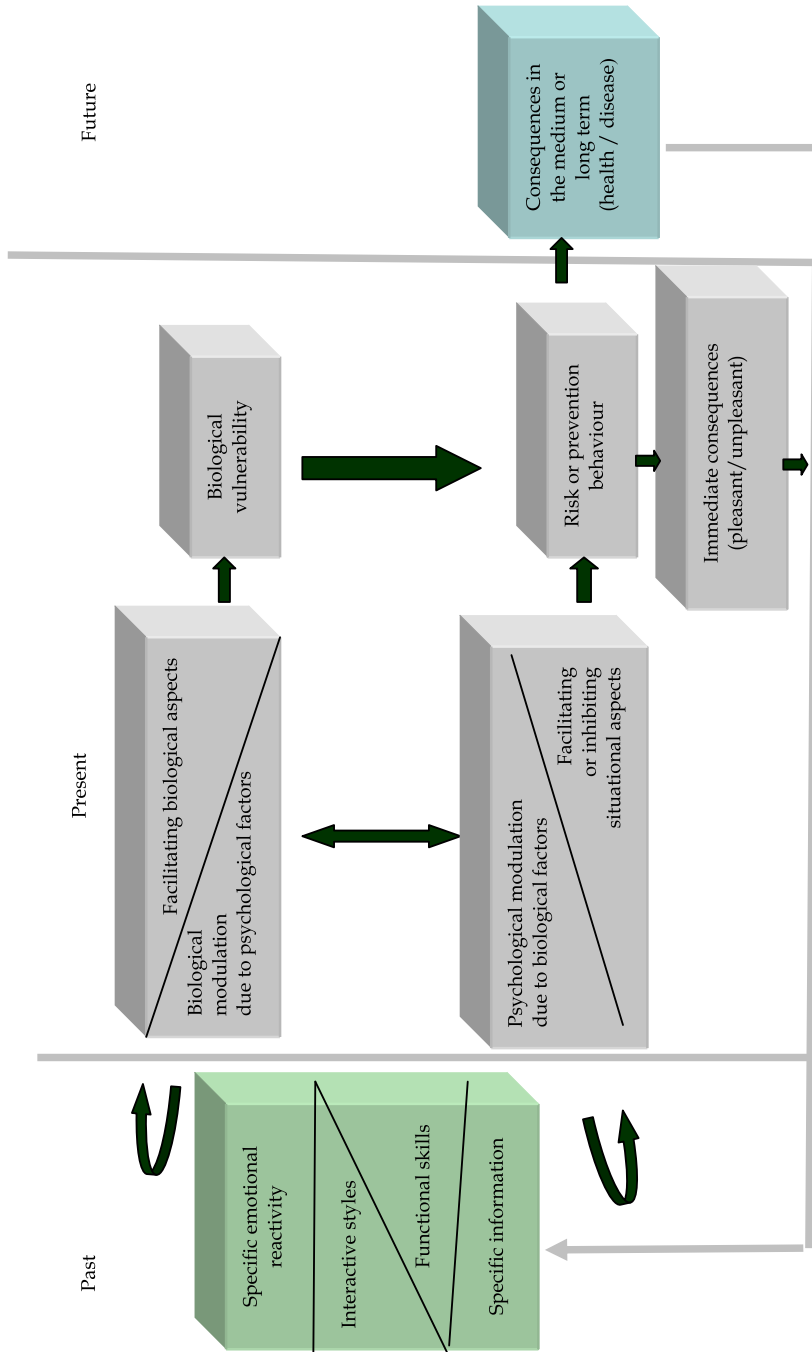


Fig. 3. Illness Prevention Model (Bayés, 1992 cited as Rodríguez Marín, 1994)

Information refers to questions such as to the extent to which the subject knows what effective preventive behaviours are and how to effect them, what signs indicate the existence of risk, or the immediate and delayed consequences of the behaviour.

For example, with regard to helmet use, young people must know that wearing one is an effective behaviour in absorbing the effect of blows in the event of an accident or avoiding being fined by the police. They must also know how to detect when the risk of an accident or fine is greater (for example, when riding at faster or slower speeds, in urban or rural areas, etc.) and the short and long-term consequences of using a helmet (annoyance, more severe injury in the event of an accident, etc.). According to Bayés (1992), information is a necessary but not sufficient condition for predicting preventive behaviour: it is a reality that practically all adolescents “know” that the helmet is an effective preventive measure in reducing injuries in the event of a motorcycle accident and what consequences not wearing one may have in this case; but having this information does not guarantee its use.

### 6. Helmet use among adolescents

A study conducted on a sample of 874 students (46.8% male; average age 15.08; SD = 0.82) in public secondary schools in the city of Girona (Spain) (Fuentes, 2007; Fuentes et al., 2010) evaluated such variables as frequency of motorcycle use (every day, more than once a week, once a week, less than once a week, or never), wearing a helmet when riding a motorcycle or as a passenger (always, sometimes or never), belief in the effectiveness of helmet use (0 = not effective at all / 10 = extremely effective) and belief in its use among friends and family members (always, sometimes or never).

The results indicate that young men use motorcycles more often than young women (23.4% vs. 6.9%) ( $p < 0.05$ ) and 8 out of every 10 adolescents say they always wear a helmet when riding a motorcycle, with no differences by gender. Self-informed helmet use increases with age, rising from 66.6% at 14 to 85.7% at 16 or over ( $p < 0.05$  (Table 1). Adolescents who always wear a helmet consider it to be more effective than those who use it only sometimes or never (Table 2).

	Age	Drivers	Passengers
<b>Motorcycle use</b>	14	29.2% (n=63)	58.4% (n=128)
	15	37.8% (n=152)	66.7% (n= 268)
	16 or over	44.6% (n=112)	71.8% (n=181)
	Total	37.4% (n=327)	66.0% (n=577)
<b>Helmet use</b>	14	66.6% (n=44)	72.6% (n=93)
	15	76.3% (n=116)	79.8% (n=214)
	16 or over	85.7% (n=96)	86.7% (n=157)
	Total	78.28% (n=256)	80.4% (n=464)

Table 1. Motorcycle and helmet use, by age (Fuentes et al., 2010).

Additionally, social influence is the variable that best predicts helmet use on all occasions: 56.5% of adolescents who always wear one believe that their friends do too, whilst this is true for only 13.5% of those who do not always wear one ( $p < 0.05$ ); for family members, the percentages are 94.8% and 69.8%, respectively ( $p < 0.05$ ) (Figure 4).

In this study, 66% of the participants reported riding a motorcycle as passengers quite frequently, with no gender differences. These findings are remarkably similar to a study of

Italian adolescents, which found that 66% of their participants reported using motorcycles as drivers or passengers (Bianco et al., 2005). However, the present findings are considerably higher than those found in a study of the general public conducted by the Directorate General of Traffic (2003), where the percentage was less than 20%. This leads us to conclude that adolescents travel by motorcycle far more often than older people, who may have access to other types of vehicles. Thus, prevention campaigns aimed specifically at this sector of the population would be an appropriate way to improve motorcycle safety overall. Among the adolescents in this sample, motorcycle use increased with age, both as drivers and passengers. Furthermore, helmet use, particularly among passengers, also increased with age. These results differ from those found by Plieggi et al. (2006), but are in agreement with those found by other researchers. For example, in a study carried out in India, the prevalence of various health-risk behaviours among the adolescent student population (such as not using a helmet) was found to be significantly associated with lower ages and the male gender (Sharma et al., 2007). In addition, a recent Taiwanese study of accidents involving motorcyclists has also found that young male drivers were more likely to disobey traffic regulations (Hsin-Li & Tsu-Hung, 2007).

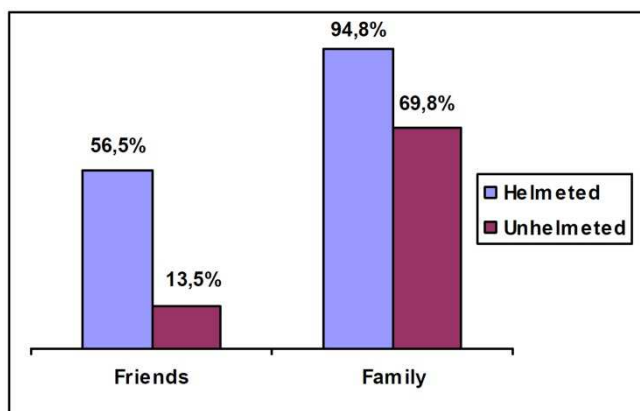


Fig. 4. Belief in the use of a helmet by friends and family members according to helmet use by adolescents (Fuentes et al., 2010).

The safety of the helmet is the main reason why adolescent motorcycle drivers use this preventive measure (87.2%). Other reasons are shown in Table 3, classifying users according to whether they are drivers or passengers. By contrast, three reasons are given for not wearing one: the characteristics of the journey (for example, short) (34.8%), not having one (30.5%) and the fact that it is annoying to use (21.7%) (Fuentes et al., 2009). Table 4 shows the distribution of motorcycle users (drivers and passengers, according to helmet use) (Fuentes et al; 2009).

These results agree with those obtained in previous studies. According to research conducted by the Directorate General of Traffic (2003), journeys undertaken by adolescents using a helmet correctly are longer on average (16.5 km) than those undertaken by adolescents who do not wear one or do so incorrectly (8.4 km). Paradoxically, according to reports from the Catalan Traffic Service (Larriba et al., 2006), in Catalonia 93.3% of motorcycle accidents take place in urban areas.



GENDER	HELMET USE	DRIVERS		PASSENGERS	
		Mean (SD)	N	Mean (SD)	N
Male	ALWAYS	8.7 (1.3)	164	8.6 (1.3)	212
	OMETIMES OR NEVER	7.7 (2.7)	41	7.9 (2.4)	54
	<i>Total</i>	8.5 (1.7)	205	8.5 (1.6)	266
Female	ALWAYS	8.5 (1.9)	84	8.5 (1.5)	244
	SOMETIMES OR NEVER	7.7 (2.2)	19	7.3 (2.3)	47
	<i>Total</i>	8.3 (1.9)	103	8.3 (1.7)	291
TOTAL	ALWAYS	8.7 (1.5)	248	8.5 (1.4)	456
	SOMETIMES OR NEVER	7.7 (2.5)	60	7.6 (2.4)	101
	<i>Total</i>	8.5 (1.8)	308	8.4 (1.7)	557

Table 2. Means and standard deviations for beliefs about the helmet’s effectiveness, by helmet use and gender, for motorcycle drivers and passengers (Fuentes et al., 2010).

Adolescents generally reported that helmets are effective in preventing serious injuries or even death in the case of an accident, and both drivers and passengers who report using them tend to give helmets higher effectiveness scores than those who do not use a helmet regularly. In the case of passengers, males believed more strongly in the effectiveness of helmet-use, although this difference did not result in greater use of these safety devices by males. Previous research on other safety devices, such as car seat belts, has also found that belief in the effectiveness of the device is a significant predictor of its use among car drivers (Gras et al., 2007).

The results of research by Fuentes et al. (2010) support Bandura’s social cognitive theory (1990), as belief in the effectiveness of a helmet was strongly related to engaging in the preventive behaviour of wearing a helmet. Consequently, disseminating information that highlights and proves the effectiveness of helmet-use can strongly encourage greater use of this device by adolescents.

Adolescents believe their relatives use helmets more frequently than their friends do. The perception that relatives, who are generally adults, take more precautions than young people has been confirmed by other researchers (Bianco et al., 2005; Canada Safety Council, 2006; State of Hawaii Department of Transportation, 2004; Lajunen & Räsänen, 2001) and accident data. This again highlights the excessive risks taken by young people, especially males (Goldenbeld et al., 2008; Hsin-Li & Tsu-Hurng, 2007; Sharma et al., 2007).

Adolescent motorcycle drivers who reported that most of their friends use helmets when riding motorcycles adopt this safety measure more frequently than those who do not believe

their friends use them. In fact, belief in helmet use by friends was the best predictor of helmet use by adolescents on all occasions. This relationship was also found between adolescents' self-reported helmet use and whether or not they believe their relatives use a helmet. This variable also predicted helmet use among adolescent motorcycle drivers. In accordance with Bandura and Walters (1979) and Bayés (1995) these results back the hypothesis of social influence as a relevant variable for predicting preventative behaviour, and are in agreement with the findings of other researchers in relation to: helmet use (e.g. Bianco, 2005; Canada Safety Council, 2006; State of Hawaii Department of Transportation, 2004; Plieggi, et al. 2006); seat belt use (Chliaoutakis et al., 2000; Cunill et al., 2004; Gras et al., 2007; Harrison et al., 2000); and in relation to driving style and how this effects the number of motoring offences committed by children and their parents (Beck et al., 2001a,b; Bianchi & Summala, 2004; Shopeet al., 2001).

REASONS FOR WEARING A HELMET	DRIVERS	PASSENGERS
Safety reasons	217 [87.2%]	360 [84.7%]
Legal reasons, fines or obligation	23 [9.2%]	42 [9.9%]
The death of a friend in an accident	3[1.2%]	6[1.4%]
Driver-related	-	4[0.9%]
Other reasons	6[2.4%]	13[3.1%]
<i>Total</i>	249[100%]	425[100%]

Table 3. Distribution of motorcycle users according to reasons for wearing a helmet

REASONS FOR NOT WEARING A HELMET	DRIVERS	PASSENGERS
Characteristics of the journey (short or rural)	16 [34.8%]	13 [18.8%]
Not having one	14 [30.5%]	45[65.2%]
Annoying	10 [21.7%]	4 [5.8%]
Other reasons	6 [13%]	7 [10%]
<i>Total</i>	46 [100%]	69 [100%]

Table 4. Distribution of motorcycle users according to reasons for not wearing a helmet

Another study on 500 adolescents attending secondary schools in the county district of La Selva (Girona, Spain) (49.5% male, average age = 14.19; SD = 0.76) analysed variables such as: helmet use the last time they rode a motorcycle, intention to use one next time they travel with

this vehicle, expectations regarding the results of using this safety measure, expectations regarding self-efficacy in using one, some immediate negative consequences (annoying, messes up your hair) and the belief that friends and family also use one (Cunill, 2009).

Eight of every ten adolescents say they used a helmet the last time they rode a motorcycle. These data are similar to those found in the study conducted by Fuentes, et al. (2010), where this variable was recorded using a scale with three values: always, sometimes and never, considering only those participants who say they "always" use a helmet.

Those adolescents who used a helmet on their last journey by motorcycle believed more in its effectiveness for avoiding serious injuries or death in the event of an accident and perceive themselves as having more self-efficacy in using one in the future compared to those who did not use one.

In addition, adolescents who did not use a helmet on their last journey consider that using them is more annoying, unnecessary if riding in the city and that wearing one unbuckled is effective in avoiding injuries in the event of an accident, more than those who did use one.

## 7. Conclusions

Programmes and campaigns promoting helmet use should take into account the modelling effect peer role models and other models have on adolescent helmet use. In addition, faced with the problem that motorcycle accidents among adolescents represents, it is advisable to remind parents, legal guardians and other relatives of the strong influence they have on adolescents' driving behaviour, and to start educational programmes before adolescents begin driving vehicles.

Results of different studies into helmet use suggest the following different preventive actions for increasing use and avoiding possible brain injury in the event of an accident:

- Improve helmet design to make them more comfortable.
- Use positive social influence to increase helmet use, employing models who are important points of reference for young people's behaviour (singers, sportsmen and women, etc.).
- Remind parents of adolescents that in their vehicle driving behaviour they are also modelling behaviour for their children.
- Continue to create programmes aimed at health professionals that enable them to act as agents involved in educating young people with regard to risk prevention behaviour when riding a motorbike. Said educational intervention should take place in primary, secondary and tertiary healthcare.
- Promote further research into potentially avoidable injury and mortality from traffic accidents in order to design new prevention strategies.

These actions may help to prevent important sequelae of brain injury and reduce mortality among adolescents on the roads.

It is therefore essential to ensure the involvement in this endeavour of teaching professionals, educators, health professionals and associations and bodies involved in the prevention of risk behaviour in adolescents and vehicle use.

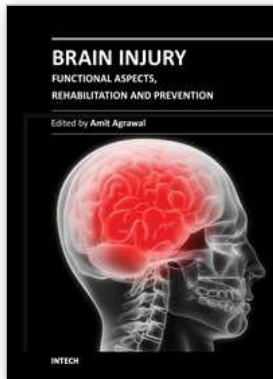
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