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ВСЕМИРНАЯ ОРГАНИЗАЦИЯ ЗДРАВООХРАНЕНИЯ
ЕВРОПЕЙСКОЕ РЕГИОНАЛЬНОЕ БЮРО

Technical Group on Protective Devices and Restraint Systems in Road Traffic Accident Prevention

Meknès, Morocco, 26-28 June 1979

ICP/ADR 010/6
30 April 1979

ORIGINAL: ENGLISH

PROTECTION FOR TWO-WHEELED VEHICLE USERS

by

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Introduction

Two-wheeled vehicles provide a cheap means of transport and their use can be an attractive form of sport and recreation. These are probably some of the reasons why their numbers have been increasing in many countries over the last ten or twenty years. The present energy situation makes it reasonable to believe that this trend will continue over the next decades. Compared with cars, two-wheelers are inherently unstable and provide little protection for their riders in case of an accident. This calls for special attention to this group of road users from the point of view of injury prevention. Accident statistics support this view.

In recent years an increase in two-wheeler accidents has been reported from several parts of the world. At present in some countries more than one-third of all traffic deaths are found among users of two-wheeled vehicles, with a large proportion of bicycle and moped deaths.

Among bicycle fatalities 30-50 per cent are below the age of 20 and 20-30 per cent are between 10 and 14 years of age. Older cyclists are also heavily represented among bicycle deaths. A similar pattern is seen in moped riders. For motorcycle drivers and passengers fatalities are highly concentrated in the younger age groups, with 50-70 per cent between 15 and 25 years of age.

Legal aspects

Legislation concerning two-wheelers varies considerably from one country to another. In general no licence is required for cyclists although some countries have prescribed a minimum age for cycling on public roads. In some countries the carrying of passengers is dependent on the age of the rider but most countries permit child passengers to be carried although some require suitable equipment to be fitted for this.

For driving motorcycles most countries require a licence. Wearing of crash helmets is compulsory for both drivers and passengers in many countries. Apart from a passenger seat and foot rests there seem to be few restrictions regarding the carrying of passengers. Motorcycles are usually subject to the same speed limits and priority rules as motorcars.

Mopeds in many respects form a group between bicycles and motorcycles and the definition of a moped varies considerably from country to country. It is usually a two-wheeled vehicle fitted with a motor whose construction is such that it cannot exceed a given speed. This speed, however, varies a great deal. Some countries require mopeds to be fitted with pedals for propulsion. A driving licence is required in a few countries but is then valid for mopeds only. The minimum authorized age for moped users varies from 14 to 16 years. A passenger may generally be carried provided the moped is fitted with a passenger seat and foot rests. Some countries require both driver and passenger to wear a crash helmet.

Each type of two-wheeler covers a wide range of vehicles with regard to wheel size, frame design, engine capacity for motorcycles and number of speeds for bicycles, etc. In addition there are some categories of motorized vehicles which do not fit into this general pattern.

Trends in two-wheeler accidents

The problem of two-wheeler accident and casualty risk is difficult to describe in a global perspective mainly because exposure data are often lacking and urgently needed. However, there are indications that the risk of accidents with casualties is considerably higher for mopeds and motorcycles than it is for cars. The bicycle risk is possibly somewhat lower but still higher than that for cars.

The characteristics of accidents with two-wheelers have been described in a number of studies devoted to a detailed analysis of two-wheeler accident statistics. In-depth studies have also been performed in some places. It is difficult to compare the results from different countries because the traffic mix and travelling patterns are different. Some useful information can, however, be extracted concerning the most common vehicle movements in the most frequent accident types for two-wheelers in the countries of study:

- the two-wheeler and the other vehicle carry straight on, but intersect each other's paths;
- one vehicle turns left, while the other comes from the opposite direction;
- one vehicle turns left, while the other comes from the left;
- on the right-hand side of a straight road a two-wheeler has a single-vehicle accident.

The greatest number of two-wheeler accidents seem to occur in urban areas where the traffic density is far higher than in rural areas, the speed of traffic is much lower than in rural areas, and the traffic picture is more complex. The intersection accidents are more serious compared to accidents occurring on street sections. Heavy traffic volumes and lack of space for evasive manoeuvres are some characteristics which may influence these accidents.

Two-wheeled vehicles are believed to be very sensitive to bad road conditions such as loose materials, holes, studs, horizontal markings and drain covers. However, the vast majority of accidents seem to occur when the two-wheeler has been in a stable condition in the pre-crash phase. In rural areas the number of accidents are relatively lower, usually involving a car or a lorry, and the severity of these accidents is relatively higher compared to accidents occurring in urban areas.

Injury patterns

To a great extent the injury patterns are similar for all three main types of two-wheelers. The explanation for this is probably that the majority of accidents occur at relatively low speed and often involve a collision with another vehicle. In general this implies that the most frequently injured segments of the body are the extremities and the head. The riders of the slower bicycles and mopeds tend to have a slightly higher frequency of injuries to the upper extremity than the riders of motorcycles. But the lower extremity is more frequently injured in both groups. The explanation for the high frequency of lower limb injury probably is that the leg is often squeezed between the rider's own vehicle and the striking vehicle or the ground.

These injuries can be quite severe but are not often life threatening. The leading causes of death in two-wheeler accidents are: among pedal cyclists injuries to the head, and among motorcyclists injuries to the head and chest. Serious abdominal injuries are sometimes seen in children after bicycle accidents. These injuries occur when the child falls against the free end of the handlebar. Other soft-tissue injuries seen in riders of two-wheeled vehicles are caused by protruding objects on the motorcycle, on the other vehicle or on the ground.

The most serious injuries are usually seen in accidents which involve the highest rate of change in the velocity of the rider. Most accidents in rural areas fall within this category. In urban areas the most serious accidents are those where there is a significant change in the trajectory of the rider. This happens when the two-wheeler collides with another vehicle or a stationary object large enough to change the path of travel of the rider. If on the other hand the object is low enough for the rider to pass over it the trajectory will not change significantly, but the rider will usually continue in his original direction until he hits the ground, or some other object, at some distance from the site of the collision. This distance is determined mainly by his original speed and is longer for motorcycle riders than it is for moped riders and cyclists. While airborne the rider may tumble and therefore it is not possible to predict his attitude at impact with the ground.

Injury protection

Compared with occupants of other vehicles riders of two-wheeled vehicles are virtually unprotected in the event of an accident. In trying to reduce casualties for this group of road users the pedal cycle remains a particular problem, since changes in vehicle design to provide protection would tend to increase the weight to an unacceptable level. For mopeds and motorcycles this restriction is not so evident and some studies have been performed on the possibility of reducing the risk of injury to their riders by changes in vehicle design. The elimination of protruding details which can cause injury and the development of efficient roll bars are the most significant attempts in this direction. For all three classes of riders improvements in acceptable protective clothing would also help reduce the number and severity of injuries.

Crash helmets

The most important item of equipment for reducing the severity of two-wheeler accidents is, without doubt, the crash helmet. To date the use of helmets has only been seriously considered for motorcycle and moped riders. However, some work has been done on the development of a cyclist helmet. The main factor here is that the cyclist requires very nearly the same protection as the motorcyclist because the head impact situations are quite similar.

Several studies have been performed about the effectiveness of crash helmets. These are difficult to compare not only because of the differences in exposure data but also because the design of the helmets has been changed over the years. In early helmets only the top of the head was covered by a rigid shell. Later the shell was extended over the sides of the head and a shock-absorbing liner was introduced. Recently the full face integral helmet has become very popular. This development represents an extension of the protection to cover more and more of the head and face of the wearer and also in improvement of the shock-absorbing capacity of the helmet.

From the literature one can conclude that when using a helmet the risk of sustaining a head injury is reduced on average by 30 per cent and the risk of being killed is often reduced by 40 per cent. The type of severe head injury seen in two-wheeler accidents has changed character by the introduction of the crash helmet. Earlier one could often see an open linear or depressed fracture of the forehead under a severely lacerated scalp, often smeared with dirt from the road and with rather localized brain damage. The fractures are nowadays more often localized at the base of the skull, the brain damage more diffuse and lacerations less frequently seen in the scalp.

It seems reasonable to believe that crash helmets prevent laceration of the scalp to a great extent. They can also prevent skull fractures and brain damage in a number of impact situations. In the more severe accident situations the helmets are probably less effective, and special attention should be given to the lateral impacts common in intersection collisions. Data from

some studies indicate that while injuries of all severities are more frequent in frontal impacts, injuries of higher severities dominate in the lateral impact situation. Impacts to the rear and to the top of the helmet seem to be quite rare.

Another aspect which has not been discussed very much until recently is what actually happens at head impact. For a long time it has been taken for granted that the head usually impacts perpendicularly into the other vehicle or to the ground and is consequently subjected to linear acceleration. Standard test methods used in approval tests simulate this situation and the requirements also apply to this kind of impact. The high frequency of intersection collisions and the fact that the rider is often thrown some distance before his impact with the ground indicate that many head impacts may well be oblique rather than perpendicular and may therefore induce angular as well as linear accelerations to the rider's head. Research in this direction is in progress in some countries. As a result of angular head accelerations one would expect tearing of the bridging veins and more diffuse brain lesions.

The extension of the protection offered by the helmet to the sides of the head as in the so-called jet type helmets seems to be a desirable development, as is also the further development seen in the full face helmets. There are, however, side effects from this which have to be taken into consideration, such as the increased weight, the hearing loss which occurs when the ears are covered and the possible build-up of carbon dioxide inside a full face helmet. However, compared to the benefits in the reduction of injury severity which follow from the use of crash helmets the possible side effects are small, and a number of studies are in progress to solve these problems and to improve the effectiveness of crash helmets.

Wearing of leather clothing can obviously reduce the risk of superficial soft-tissue injury which can otherwise be extensive. Leather clothes also seem to reduce the tendency of the body to tumble and give it a smoother motion when it slides over the road surface during an accident. The wearing of leather boots can to some extent protect the lower legs and feet and should therefore be encouraged.

Concluding remarks

Exposure and accident data on two-wheelers are largely missing and urgently needed. Hospital data on injury patterns and injury severity together with accident data on vehicle and rider trajectories are needed for a better understanding of the biomechanics of these accidents.

For the prevention of accidents improvements are needed in driver behaviour and conspicuity.

Changes on the exterior of motor vehicles will eventually lead to a reduction of injury severity especially on the lower extremity of riders of two-wheeled vehicles.

The most important item of equipment for injury prevention is without doubt the crash helmet. Wearing of leather clothing and sturdy boots will also help to reduce the overall injury severity.