Motorcycle Accidents—An Epidemic

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•APPROXIMATELY 1580 drivers and passengers of motorcycles and motor scooters were killed during 1965 in traffic accidents in the United States. Although this toll was but 3 percent of the 49,000 killed in all motor vehicle accidents, it was more than the military fatalities in Viet Nam in 1965, and it is growing at a very alarming rate.

Motorcycle[1] fatalities have been increasing at a much faster rate than total motor vehicle deaths, although the latter have risen from an annual toll of 38,000 in 1961 to 49,000 in 1965 (Fig. 1). Even more striking is the comparison of motorcycle occupant deaths to those of the occupants of all motor vehicles (Table 1 and Fig. 2). Motorcycle deaths rose 41 percent in 1965 from 1118 in 1964.

The situation is epidemic for the nation as a whole as Dr. James C. Drye determined it to be for Louisville and Jefferson County, Kentucky, and as did Drs. Dillihunt, Maltby and Drake for Portland, Maine (2, 7). There were 23 deaths in Iowa and 276

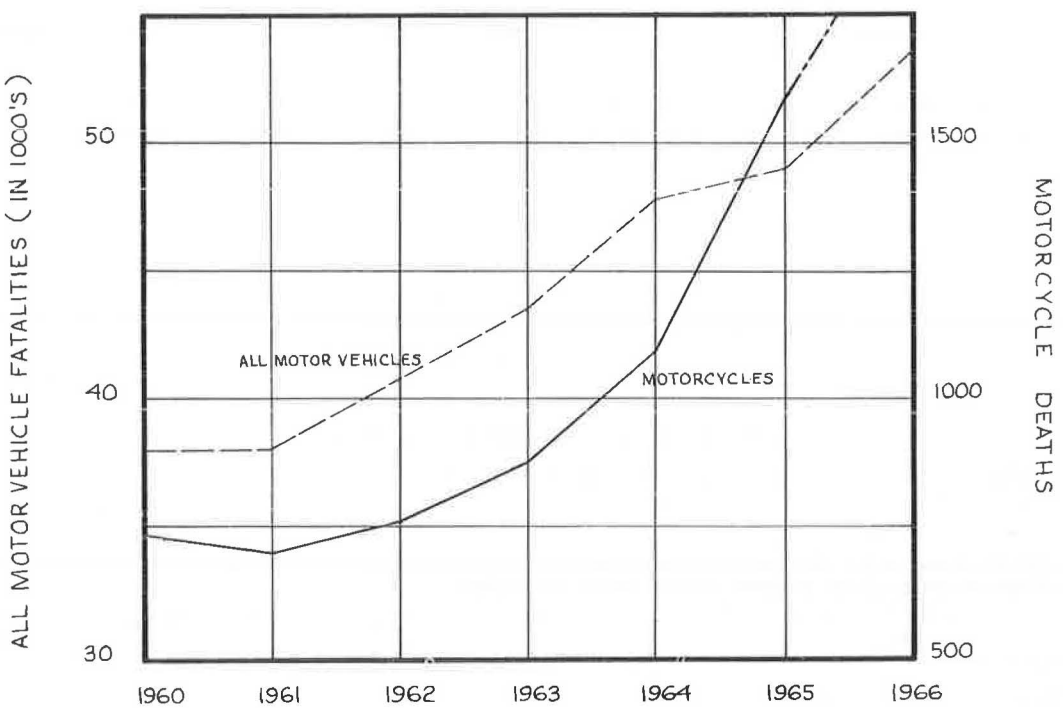

Figure 1. All motor vehicle fatalities vs motorcycle deaths.

[1]In this paper the term motorcycle is used to include the motorcycle proper, the motor scooter, the moped, and the mini-bike.

Paper sponsored by Committee on Highway Safety and presented at the 46th Annual Meeting.

TABLE 1

MOTORCYCLE AND TOTAL MOTOR VEHICLE DATA[a]
(1960-1965)

Year	Vehicles				Deaths			
	Motorcycles		Total Mot. Veh.		Motorcycle Riders		All Mot. Veh. Occupants	
	No.	Yearly Change (%)	No.	Yearly Change (%)	No.	Yearly Change (%)	No.	Yearly Change (%)
1965[b]	1,380,726	+30.8	91,300,000	+4.6	1,580	+41.3	39,400	+4.0
1964	984,763	+25.2	87,300,000	+4.6	1,118	+26.8	37,885	+9.2
1963	786,318	+19.1	83,500,000	+4.8	882	+16.2	34,694	+7.4
1962	660,400	+10.9	79,700,000	+4.3	759	+ 8.9	32,311	+8.2
1961	595,669	+ 3.5	76,400,000	+2.6	697	- 4.7	29,886	+0.4
1960	574,080		74,500,000		730		29,742	

[a]Source: Vehicles—U. S. Bureau of Public Roads; motorcycle riders—National Center for Health Statistics; motor vehicle occupants—National Safety Council. "Motorcycles" includes motor scooter, motorized bicycle, and motorized tricycle.
[b]Estimated.

fatal accidents in California (9). There are brief periods of remission during extremely cold weather followed by onsets of greater intensity.

The growth in motorcycle accidents is a direct result of growth in numbers and in use of these vehicles. The number of vehicles and the number of deaths have doubled in three years (Fig. 3). There is undoubtedly a correlative increase in vehicle-miles, but no records are kept of these data in the United States. (Even casualties often are not tabulated separately but recorded simply as motor vehicle deaths and injuries.)

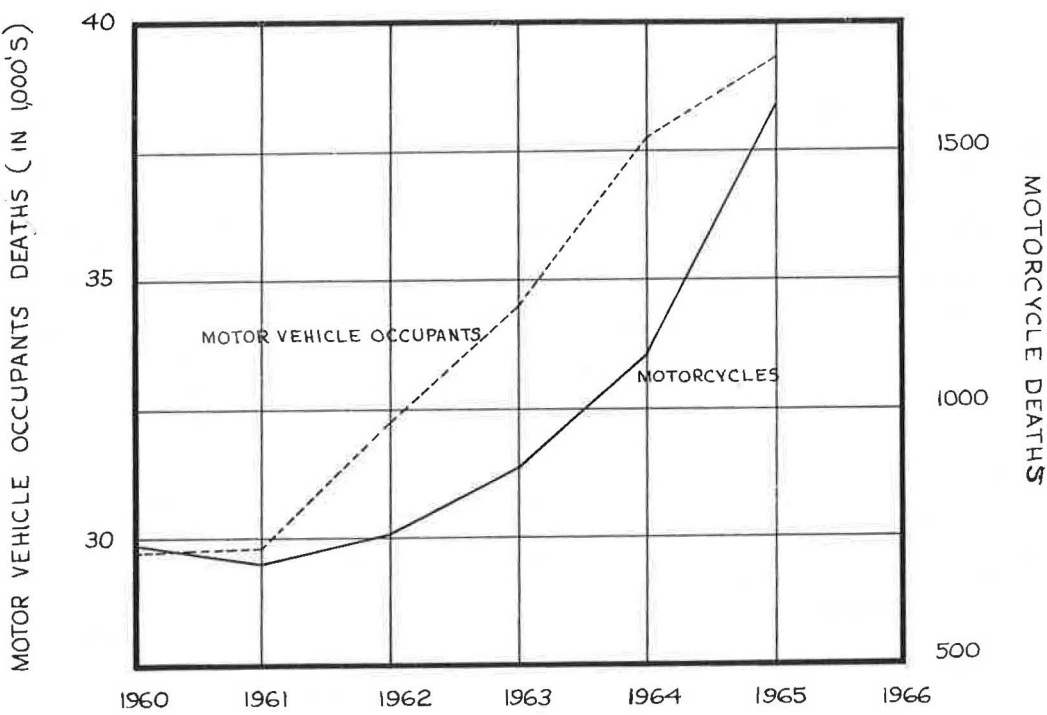

Figure 2. Motor vehicle occupant deaths vs motorcycle deaths.

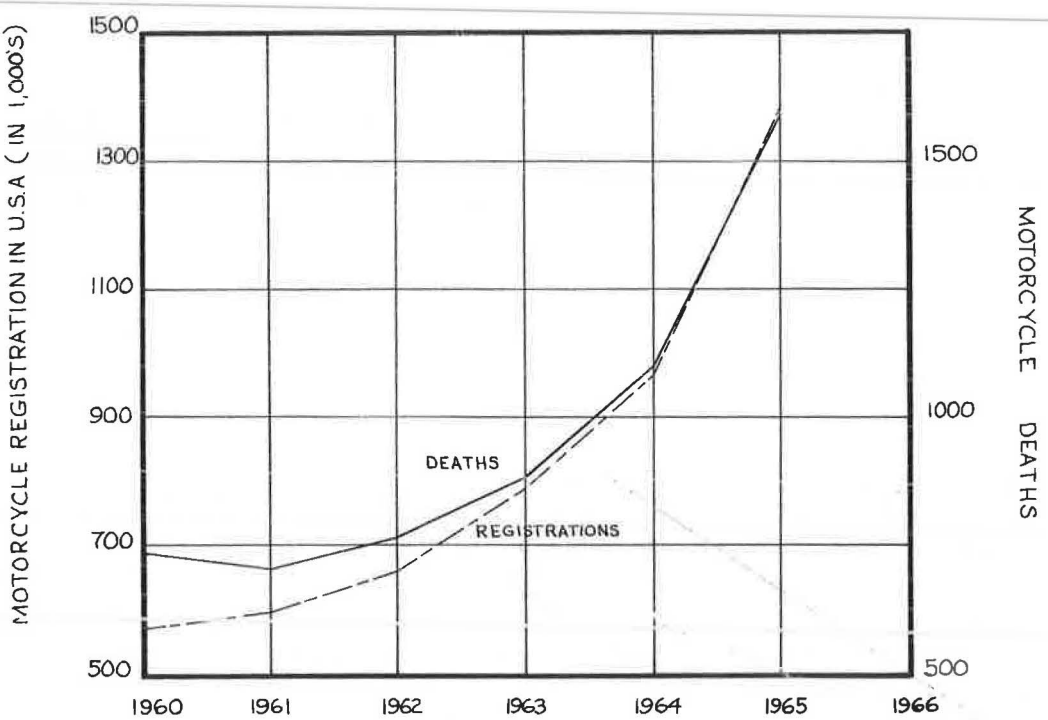

Figure 3. Motorcycle registration in USA vs motorcycle deaths.

INCREASED AVAILABILITY

Other developments compound the danger of the increased number of motorcycles. Until recent years, the machine used in the United States was the American-made motorcycle—a large heavy machine with a big frame and wide wheels. These were relatively expensive, some models as costly as small cars, and available only by outright purchase. The situation began to change several years ago with the importation of the glamorous motor scooter of postwar Europe. This started an increase in the number of vehicles and a concomitant deterioration of quality, first characterized by the importation of the lighter European motorcycle, and then by the swamping of the American market with the very light, fragile, and cheap Japanese machines. Now, American and European manufacturers are producing similar machines and all are coming to resemble the "moped" (motor-assisted pedal bicycle), but with a much greater power plant. A recent import vehicle weighs 180 lb and can achieve a velocity of 65 mph carrying a 200-lb passenger (3).

The corresponding reductions in cost have brought the motorcycle within the reach of millions of Americans who previously could not afford much more than a simple bicycle, to say nothing of the more expensive American motorcycles. Some contemporary imports are priced under $300, and American chain stores are selling models for less than $200. Furthermore, cycles can now be purchased or rented on terms that are very tempting. Rental machines are available at $1.00 an hour, and purchasing can be arranged for as low as $5.00 down and $10.00 a month. The rental business has boomed during the past few years, catering almost exclusively to teenagers seeking thrills. The low-cost purchase terms seem to induce many young adults to buy cycles for both recreation and daily commuting. Thus, recent years have seen not only an increase in the number of motorcycles, but also an equally large increase in the

number of inexperienced drivers, and a great decrease in the quality of the vehicle, especially in its capacity to absorb some of the forces of collision.

The growth in the popularity and use of the motorcycle in recent years has been engendered, in part, by its establishment as a glamorous social symbol (12). This was further fostered and compounded by the consequent adoption of the motorcycle as an advertising symbol to induce buying interest in a variety of merchandise from soft drinks to women's clothes. Even one insurance company used the motorcycle symbol in advertisments for life insurance.

OTHER FACTORS

The driver, the vehicle, and the distance driven are the primary factors affecting the number and severity of cycle accidents. Road conditions and weather have about the same relationship to these accidents as they do to all motor vehicle accidents. The majority of traffic accidents occur on straight, level sections of highway, in daylight, clear weather, and on dry pavement. In these respects, motorcycle accidents seem to be no exception in general, although cycle operation is more affected by adverse weather and roadway conditions.

There may be a disproportionate number of cycle accidents in urban areas. In 1962, motorcycle accidents in New York City alone accounted for nearly 41 percent of all cycle accidents in the state, despite the fact that the city accounted for only 25 percent of all motorcycles registered in New York (Table 2).

The most meaningful index or rate of accident experience available is that which measures the accidents or their severity against the distance traveled—the latter usually expressed in units of million vehicle-miles, 100 million vehicle-miles, or simply miles driven. There is little motorcycle information of this sort available in the United States. Great Britian, however, devotes much attention to motorcycle statistics, because nearly one-fifth of those killed on British roads and streets are motorcyclists and their passengers. The British Road Research Laboratory made an exhaustive study of all vehicle accidents in Great Britain for the years 1954 to 1959. The study included accidents involving more than 300,000 deaths or serious injuries to motorcyclists, comparable numbers of accidents involving other motor vehicles, and billions of miles traveled by motorcycles and other vehicles (4, 5).

The British study revealed the following about motorcycle accidents:

1. The chance of a motorcyclist being killed per mile ridden is about 20 times the chance of a car driver being killed.
2. The risk of death or injury to a (pillion) passenger is about 5 percent higher than the risk to the driver.
3. The personal-injury accident rate of solo motorcycles is about four times and that of motorcycles with sidecars about twice as great as that of cars.
4. Ninety-seven percent of the total casualties in collisions between motorcycles and cars or trucks are motorcyclists.
5. Most of the motorcyclists who are killed and many of those who are injured receive head injuries.
6. Motorcyclists with less than 6 months' experience have about twice as many accidents per head and per mile ridden as those with more experience.

TABLE 2

MOTORCYCLE ACCIDENTS, NEW YORK STATE, 1962

Type	Registrations	Deaths	Death Rate[a]	Injuries	Injury Rate[a]
All vehicles	5,583,656	2,407	4.3	287,048	514
Motorcycles	16,839	32	19.0	1,226	728

[a]per 10,000 registrations.

Note: New York City had 515 motorcycles involved in accidents out of a statewide total of 1,265, or 41 percent of the total, although having only 4,430 registered motorcycles, or 26 percent of the state total.

Source: New York State Department of Motor Vehicles.

THE VICTIMS

As frightening as the last conclusion is, it hardly touches the typical inexperienced driver situation in the United States. In Iowa, as in many states, the only legal control on the operator is that he is required to have a driver's license (for driving a passenger auto). William F. Sueppel, former State Safety Commissioner of Iowa, said, "In too many cases, youngsters 16 or 17 years old are renting motorbikes or motorcycles without any knowledge of the difference in their operation and the operation of cars which they learned to drive (previously). The problem is further compounded when passengers are put on these vehicles."

Dr. Drye says, "The individuals who are being injured are largely high school and college people. They are not 'leather jacket boys'." Drs. Dillihunt, Maltby and Drake, of the Maine Medical Center, say, "A most distressing fact is that the group involved are young, otherwise healthy persons. This is not an epidemic involving the aged or the infirm—rather it involves a group of young, healthy people who must be regarded as a most important group in our society."

MOTIVATION

The victims are primarily the users, and, as was noted earlier, much use of the motorcycle in America is for recreation, some use even being in the category of seeking thrills from the danger involved in driving and riding these vehicles. There is a small amount of productive usage through commuting and work trips.

However, most use is casual, well intentioned and not vicious in any sense. "They are mostly children whose parents are able to buy them cycles and, unsuspecting of the danger, think it would be nice for them to have cycles during the summer to ride to tennis courts, swimming pools and other recreational areas. These bikes are inexpensive and fun to drive" (2).

Parental approval often comes only after initial strong objection. Drs. Dillihunt et al say, "In many of our cases, parents were opposed to their offspring having such vehicles. After considerable pressure, the parents reluctantly agreed. When an accident occurred following such a situation, the psychological problems were tremendous."

THE SEVERITY OF INJURIES

The motorcycle accident victim (4) is more likely to be killed or severely injured than any other vehicle user (Table 3). Every reported motorcycle accident in Iowa City in the first 11 months of 1966 involved personal injury. Dr. Drye says, "I have treated a number of these injuries; they are bad. The only ones comparable to them are the battlefield injuries due to artillery fire that I saw in the infantry and the field hospitals of World War II."

TABLE 3

SEVERITY OF INJURY TO DIFFERENT CLASSES OF ROAD USER CASUALTIES

Class	Severity of Injury	
	$\frac{100 \times \text{Fatal Casualties}}{\text{Total Casualties}}$	$\frac{100 \times \text{Fatal and Serious Casualties}}{\text{Total Casualties}}$
Pedestrians	3.7	30
Pedal cyclists	1.3	21
Moped riders	1.5	27
Motorcyclists	2.1	31
Motorcycle passengers	1.6	24
Drivers	1.6	22
Passengers	1.2	20
All road users	2.0	25

Source: Research on Road Safety, British Road Research Laboratory.

TABLE 4

MECHANISM OF INJURY

Type	No. of Patients
Lost control of vehicle and overturned	14
Hit another vehicle (automobile)	16
Hit or swerved to miss a dog	2
Fell off vehicle (passenger)	3
Pedestrian struck by vehicle	1
Miscellaneous	2

TABLE 5

AGE GROUPS

Age	No. of Patients
15 to 20 years	23
21 to 25 years	11
26 to 30 years	2
Over 30 years	2

TABLE 6

TYPE OF INJURY

Type	No. of Patients
Major head and neck injury	9
Extremity fractures	13
Upper extremity (2 simple, 1 compound)	3
Lower extremity (4 simple, 6 compound)	10
Spine fractures	2
Pelvic fractures	2
Intra-abdominal injury, severe	2
Miscellaneous soft-tissue injuries without other injury	19

The experience at the Maine Medical Center in Portland, with motorcycle accident victims during the four months, May through August 1965 inclusively, reveals a total of 38 such victims. Of this total, there were 27 drivers, 10 passengers, and a single pedestrian. The mechanism of injury is given in Table 4, the age groups in Table 5 and the type of injury in Table 6. There were three deaths in this group; they are briefly described next. Also presented is a nonfatal case with a particularly serious outcome.

REPORT OF CASES

Case 1

This 23-year-old woman was driving a small-type motorcycle which was hit from behind by an automobile on May 23, 1965. The patient was brought to the emergency room unconscious. She died a few hours later despite vigorous emergency therapy. Postmortem examination revealed cerebral contusion, massive subarachnoid hemorrhage, and retroperitoneal hematoma (severe concussion, hemorrhage into the brain and internal bleeding).

Case 2

This 24-year-old man was a passenger on the vehicle driven by the woman described in Case 1. He was thrown from the vehicle and killed almost instantly. Postmortem examination disclosed transection of the abdominal aorta, fractures of the spine, fractures of the right tibia and fibula, separation of the symphysis, and subarachnoid hemorrhage (ruptured aorta, multiple broken bones, hemorrhage into the brain).

Case 3

This 19-year-old girl was riding a motorcycle on July 22, 1965, and struck a dog. She lost control of the vehicle and was thrown to the road. Shortly thereafter she was seen by a physician who noted a dilated, fixed right pupil and hemiparesis on the left. The patient was transferred to the Maine Medical Center where immediate exploration revealed an acute subdural hematoma accompanied by severe cortical contusion and laceration. She died of these injuries shortly thereafter (brain lacerations and hemorrhage beneath the lining of the brain).

Case 4

This 17-year-old girl was given a small motorcycle as a present on her 17th birthday. One day later, on July 30, 1965, she was involved in an accident which resulted in almost three months' hospitalization. When discharged, she was blind, disfigured and paraparetic (partially paralyzed).

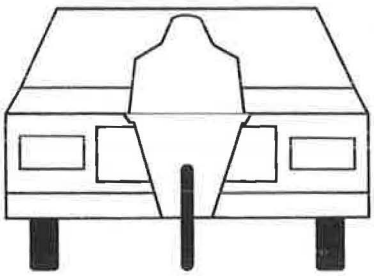

Figure 4. Silhouette comparison, motorcycle and passenger car, end view.

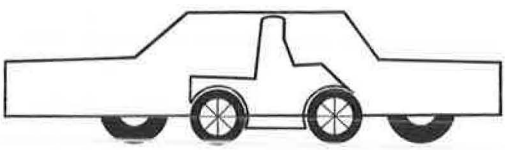

Figure 5. Silhouette comparison, motorcycle and passenger car, side view.

THE MACHINE

The motorcycle in general use in the United States today is a small vehicle with a wheelbase of about 4 to 5 ft. It varies in weight from less than 100 lb to approximately 600 lb, has engines which develop from 2 to more than 60 hp, and is capable of speeds from 35 to well over 100 mph. (A small number of vehicles, mostly those in professional use, are of the older type and may weigh more than 1000 lb.) Generally, the weight-to-horsepower ratio and the weight per occupant ratio are very unfavorable for safety. In front, side or rear elevation it presents a very small, narrow silhouette even with driver and passenger (Figs. 4 and 5).

The vehicle fatality rate, 11.5 per 10,000 vehicles, is approximately 2.7 times as great as the corresponding rate, 4.3, for all motor vehicle occupants. On a vehicle-mile basis the motorcycle is 20 times as deadly.

Although it develops some inertial stability when in motion, it is unstable to a high degree. It cannot stand alone on its own two wheels—the driver has to hold it up. It skids easily, often "walks" on its rear wheel alone, and frequently goes out of control. The vehicle is not heavy enough or strong enough to absorb in a collision even a fraction of the energy created by itself and its motor.

The lateral balance of the vehicle is very precarious. A very small lateral force is enough to destroy equilibrium either by an overturning moment or by exceeding the friction between the tires and the pavement. The tire print is very small. The overturning moment or sidewise skid often is produced by the moment or horizontal component of the weight when the vehicle is slightly inclined from the equilibrium position.

The driver and passenger are completely exposed with neither envelope nor effective shield for protection. The only security afforded the driver is his grip on the handlebars, with the consequence that he is often thrown violently into or over the colliding vehicle. The passenger, of course, has practically no security at all—only a fragile hold on the driver.

THE ENVIRONMENT

There is little doubt that the environment is hostile to this machine. In the planning, design, construction and operation of roads and streets in the United States no attention whatsoever is given to this vehicle. It is an incongruity in our traffic streams. The smallest design vehicle considered in AASHO policy is the "P Vehicle" (passenger car), 19.0 ft long and 6.5 ft wide (Figs. 4 and 5).

There are a number of elements of roadway design and traffic control which are affected by this vehicle. All aspects of sight distance would be modified if the difficulty of seeing, and seeing from, this vehicle (the height of the driver's eye and the lighting of the vehicle both front and rear) were considered. Design policy governing safe passing maneuvers and passing sight distances is based on a car driver seeing an object 4.5 ft high at varying distances up to approximately 2000 ft. If the vehicle sighted is a motorcycle, only a small portion of the driver's head, at most, would be visible over the crest of a vertical curve, virtually impossible to detect at such distances. Its lack of stability would have an important bearing on such policies as safe following distance—this

vehicle can and often does stop almost instantaneously when its tires slip sidewise and the vehicle and occupants fall to the pavement. Similarly, highway capacities, superelevation of curves, design of longitudinal profiles and many other factors would be affected.

If other motor vehicles and their drivers are included in the environment, it becomes more hostile. In a large number of collisions between cycles and other vehicles the driver of the car or truck is charged with a traffic violation. There are various aspects of this situation, but one is that the ordinary driver's vision and mind are not trained or disciplined to watch for and recognize a cycle, its speed or distance. The colliding car or truck, being several times heavier and stronger than the cycle, imposes most of the damage on the cycle and its occupants. A very common comment of the motor vehicle driver is, "I didn't even see it."

OUTLOOK FOR THE FUTURE

The number of motorcycles on United States roads doubled in three years to a total of 1,380, 726 in 1965 and the deaths of motorcycle riders also doubled in the same three years (Table 1). Sales of vehicles continue to soar, and it is likely that the total population will be approximately 2,000,000 vehicles at the end of 1966. The corresponding fatality toll may be 2000 or more.

The motorcycle population is nearing 2 percent of the total vehicle population, and the cycle death toll is approaching 4 percent of the total. However, the outlook is even more disturbing. Annual sales of cycles and scooters may soon exceed 1,000,000. Two foreign producers, to say nothing of all the others, expect to export a million vehicles a year to the United States within a short time. One exporter predicts United States motorcycles will total 5,000,000 by 1970, a conservative estimate (13).

Sales of 1,000,000 cycles per year would approximate 10 percent of all vehicle sales in the United States, and this would raise the motorcycle population toward 10 percent of the total population, or approximately 10,000,000 cycles, in a few years. The prospect of the corresponding increase in deaths and serious injuries is very frightening. Motorcycle fatalities probably would rise to more than 10,000 per year if the present rate of 11.5 deaths per 10,000 vehicles is not materially reduced.

REMEDIAL MEASURES

Epidemiology applied to accidents considers three principal parts to the problem: man, machine and environment. Using this approach to the motorcycle accident problem reveals the outstanding causal factor to be the machine, or, to put it properly as Dr. Drye does, the etiological agent is the motorcycle itself.

The motorcycle is the most deadly vehicle on the highway today, and this ghastly characteristic is inherent in the machine. The most logical remedial measures, then, would be those directed at modifications of the machine to make it safe, or the elimination of it from the public highway, or narrowly restricting its public use to specific functions such as police work, and then only with some safety modifications.

There is some small measure of relief possible through driver training and increased experience and through the use of protective equipment, particularly proper helmets. However, the resulting improvements will fall short of objectives, because British and European experience indicates that although such measures have a benefical effect, motorcycle accidents continue to be a very serious problem and a very sizable part of the traffic accident situation. In Europe and elsewhere economic necessity often forces a man to accept the risk of riding a motorcycle in order to go out and make a living, but few Americans can justify the gamble.

A fundamental approach to the problem can be made through engineering and through recently opened avenues of action. There are agencies of the government now charged with assessing the safety characteristics of motor vehicles and establishing safety requirements for all vehicles sold. These agencies could contribute materially to highway safety if they would establish standards and criteria for the vehicle as a whole as well as for some of its parts. These should include, certainly, the number of wheels and their arrangement, which would be required of all vehicles for stability. They

should specify the general nature of a body or envelope to protect the occupants of the machine. Along with a protective envelope they should require restraining devices for the drivers and passengers of all vehicles including cycles and scooters. Provisions now specified to preclude occupants being thrown to the pavement during an accident should be extended to all vehicles. A minimum silhouette area must be specified because vehicle operation depends on visual images.

A small measure of temporary relief might be achieved in a shorter time through enforcement measures. A motorcycle driver should be required to have a license specifically for driving a motorcycle. In order to secure this license he should be required to demonstrate his proficiency by virtue of a driving test using a motorcycle. He should be required to have completed a driver education course, accredited by the proper public agency, in motorcycle driving. Laws and ordinances could prohibit the carrying of passengers—this would have a direct effect and probably an indirect effect in reducing usage. An insurance requirement for the passenger would have the same effect, for such insurance is virtually unattainable because of the high risk. Protective gear should be required including helmets, goggles and shielding for the legs. In sum, any measures which would reduce usage and increase responsibility would probably produce some temporary relief.

The absolute danger remains, however, and actually is illustrated by these attempts to make an accommodation with these deadly devices. The danger is so great that no safety authority is willing to propose that a driver-examining patrolman ride the vehicle which the driver is using in his test, as is done in auto driver licensing.

The rental of motorcycles and motor scooters serves no useful purpose and should simply be eliminated. The business not only does nothing useful, but it presents a danger to the health and welfare of the public, especially to the youngsters who are more susceptible to the temptation of a cheap ride with plenty of thrills. Specific legislation would help eliminate these sources, but communities in most states probably could close them down under existing ordinances as public nuisances, or as hazards to the health of the community. Communities could accomplish the same end by licensing the dealer and requiring him to be responsible for injuries and to carry injury insurance on the drivers and passengers.

SUMMARY AND CONCLUSIONS

The motorcycle accident situation is serious, growing and epidemic in the United States. The etiological agent, or causal factor, is the machine itself.

The motorcycle is the most deadly vehicle operating on the public highway. It is unstable and completely exposes driver and passenger to the injurious forces of collisions. The fatality rate is 11.5 fatalities per 10,000 vehicles, which is 2.7 times as great as the rate for all motor vehicle occupants. Extensive research in Great Britain has shown that, per mile driven:

1. The chance of a cyclist being killed is 20 times that of a car driver.
2. A passenger on a motorcycle has an even greater chance of being killed than the cyclist.
3. The personal injury rate is about four times that of cars.
4. Cyclists with less than six months' experience have an accident rate double that of the more experienced.

The growth in casualties in recent years is directly attributable and proportional to the growth in numbers of motorcycles. The fatality toll and the vehicle population each doubled in the three years 1962 to 1965 and the growth rates continue to accelerate. The fatality total for 1965 is estimated at 1580, having increased 41 percent in one year.

There is no end in sight. The number of registered motorcycles in the United States grew to 1,380,726 in 1965, and sales of new vehicles are soaring. Sales probably exceeded 500,000 units in 1966 and soon may reach 1,000,000 units per year. These trends indicate that the cycle population may become something of the order of 10 percent of the total vehicle population. The resulting toll of deaths and injuries would constitute a calamity. Deaths alone might exceed 10,000 per year.

A small measure of temporary relief could come through strong enforcement actions such as driver licensing specifically for motorcycle driving, elimination of passengers, strong insurance requirements, and other measures to reduce usage and increase responsibility. A general program of informing the public of the extreme danger involved in driving or riding a cycle or scooter could be beneficial. Rental availability serves no useful purpose, constitutes a serious health hazard, and should simply be eliminated.

Permanent relief will come only through recognition of the absolute danger inherent in the present machines. A fundamental approach to a solution is possible through engineering and through control now available through governmental agencies charged with establishing policies and standards for the safeness of vehicles. These agencies should specify requirements for the motor vehicle as a whole as well as for some of its parts. They should determine the number of wheels necessary to insure stability and the arrangement and configuration of the wheels. A protective envelope or body should be required and the progressive collapse of its outer portion during an accident should protect the occupants from dangerous decelerations. Restraining devices and anti-ejection devices should be provided.

Such a policy to establish the safeness of the vehicle as a whole would culminate in the modification of the motorcycle to make it safe, or it would eliminate the motorcycle from the traffic stream. Either alternative would reduce the intolerable suffering and death now imposed, primarily on young men and young women.

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