# UTILIZATION OF A MOTORCYCLE ACCIDENT TYPOLOGY

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This paper describes the creation of a motorcycle accident data base during the performance of a study for the Motorcycle Safety Foundation. The objective of the study was to determine the status of motorcycle accident data, to determine causal factors of accidents, to identify voids in the information, and to suggest a basis for future improved educational and public information programs. A motorcycle accident typology was devised to identify accident categories for which specific countermeasures could be designed. On the basis of the distribution of 1,191 motorcycle accidents in Maryland in 1973, 600 police accident reports were sampled in order to represent the six most prevalent accident types. Using this typology permitted the identification of accident culpability (who or what was at fault) and of primary and secondary causation factors for each of the accident types. A primary product of the study, which is described in detail in this paper, was the identification of statistically significant differences between accident types on each of the 54 accident variables coded.

•MOTORCYCLING is both a means of transportation and recreation. It is probably the form of powered transport that is the most exhilarating, economical, and, unfortunately, dangerous.

In 1945, there were 31 million registered motor vehicles in the United States. Of these, 198,000 were motorcycles. By 1973 there were 128 million registered motor vehicles, and slightly more than 4 million of these were motorcycles. Motorcycles used solely for off-road activities such as competition and trail riding and minibikes are not reflected in these statistics. Hare and Springer estimate that there were 5 million motorcycles in use nationwide at the end of 1972. This estimate includes the trail and competition cycles but excludes minibikes and motorized bicycles (2).

## MOTORCYCLE ACCIDENT RESEARCH

Studies of motorcycle accidents in a number of states in the mid-1960s indicated that the growth of the motorcycle population was accompanied by a directly proportional growth in the number of motorcycle accidents. Researchers indicated that there is a high probability that a serious injury or fatality will result from a motorcycle accident (3-8).

A national study found that the fatality rate based on vehicle mileage (exposure) was five times greater for motorcycles than for passenger cars. The study indicated that the motorcycle rider has a greater probability of being killed than the user of any other conventional means of transportation (9).

In 1973, for the first time since 1970, there was a reduction in the number of highway accident fatalities. Only the motorcycle, perhaps as a result of increased use in response to the gasoline shortage, experienced a 20 percent annual rise in fatalities (Table 1).

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## Scope

The challenge facing those responsible for motorcycle safety is one of devising programs to reduce the frequency and disproportionate severity of motorcycle accidents.

This paper summarizes some of the findings of a recent motorcycle accident study performed for the Motorcycle Safety Foundation. It describes the methodology used in developing a motorcycle accident data base and the findings obtained from a statistical comparison of accident types. The information presented can be used as a guide for the development of safety countermeasure approaches and local countermeasure programs.

## Methodology and Rationale

The analysis of motorcycle accident data began with an examination of some 50,000 motorcycle accidents listed in the 1971 National Accident Summary File (NASF) of the National Highway Traffic Safety Administration. The NASF limitation of restricting the data gathered to 11 variables did not permit determinations of culpability or accident causation factors. To satisfactorily determine these factors, we needed access to a large number of police reports containing both narrative descriptions and accident diagrams. Analysis of the hard copies of police accident reports would serve the desired purpose.

A motorcycle accident typology was devised that partitioned the motorcycle accident data into eight exclusive accident types. The typology was based on three classification variables: single- versus multiple-vehicle, rural versus urban, and intersection versus nonintersection accidents. The typology permitted identification of causal factors for each specific accident type rather than for all accidents.

Design of accident remediation techniques requires identification of the makeup of each of the major accident types that compose the total motorcycle accident spectrum. Examination of the accident variables for each of the six major types is more important than identifying these variables for all motorcycle accidents. In this case, the parts are greater than the sum. This is because the use of the accident typology permits education and training material to be developed for each identified accident type. Comparison of variables for the multiple-vehicle, urban intersection accident (type 1) to the single-vehicle, rural nonintersection accident (type 6) will permit identification of differences and, therefore, unique remediation for each. Heretofore these differences could not be identified, and countermeasures were aimed at motorcycle accidents in general, primarily with the objective of ameliorating injuries through use of protective equipment.

In December 1973, the state of Maryland provided a breakdown of 1,191 statewide 1973 motorcycle accidents. Ninety-six percent of these accidents fell into six of the eight categories. Since it would be necessary to go back over 8 years to obtain 100 usable accidents in the latter category and 3 to 4 years in the former, these two categories were dropped.

Figure 1 shows the motorcycle accident typology used. One hundred accident reports per accident type were coded from the original police hard copy. Fifty-four variables were coded for each accident. The coders were trained. A number of accidents were coded, a reliability check was made, a revised definition of the variables was provided, a larger number of accidents were coded, and more than 90 percent intercoder agreement was obtained. All 600 accidents were screened before they were keypunched and input to the computer. The computer was given acceptable limits for each of the variables to screen out errors in keypunching. These were recoded, and 600 accurately coded motorcycle accidents were combined to form the motorcycle accident data base. The variables used, especially in the areas of culpability and primary and secondary causal factors, are definitions specified by BioTechnology and represent the evaluation of the trained coders, not that of the Maryland investigating officer. These factors represent motorcycle accident descriptors heretofore not available.

The typology used permitted a comparison of all the variables among each of the six accident types. It was thus possible to differentiate between statistical significance

Table 1. Highway fatalities.

| Transportation Mode | 1972 | 1973 | Percentage Change |
|---|---|---|---|
| Pedestrian | 10,700 | 10,600 | -1 |
| Pedalcycle | 1,100 | 1,100 | – |
| Motorcycle | 2,700 | 3,300 | +22 |
| Total highway | 56,600 | 55,600[a] | -2 |

[a]Includes 1,215 grade-crossing fatalities.

**Figure 1. Motorcycle accident data base.**

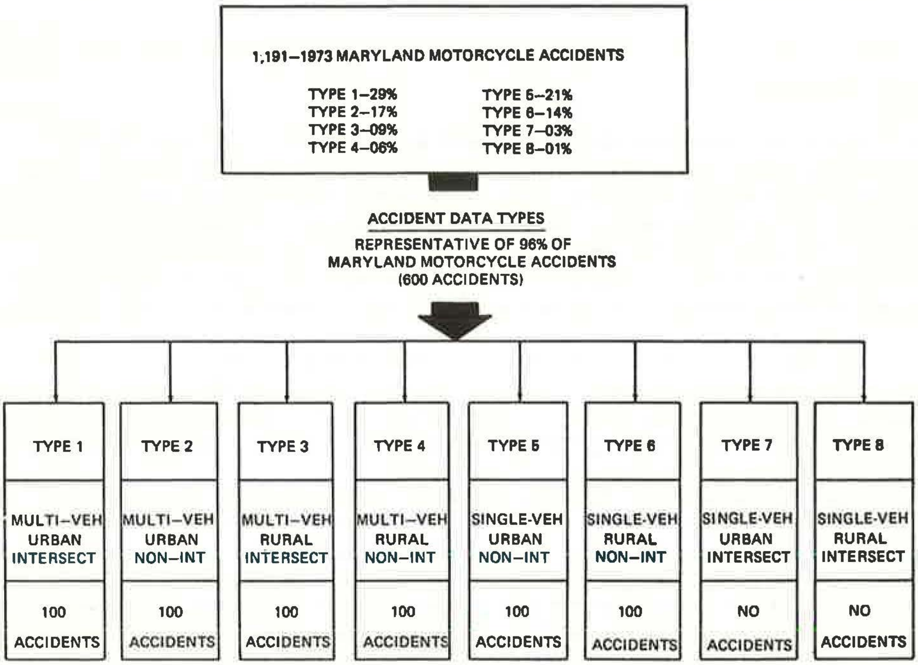
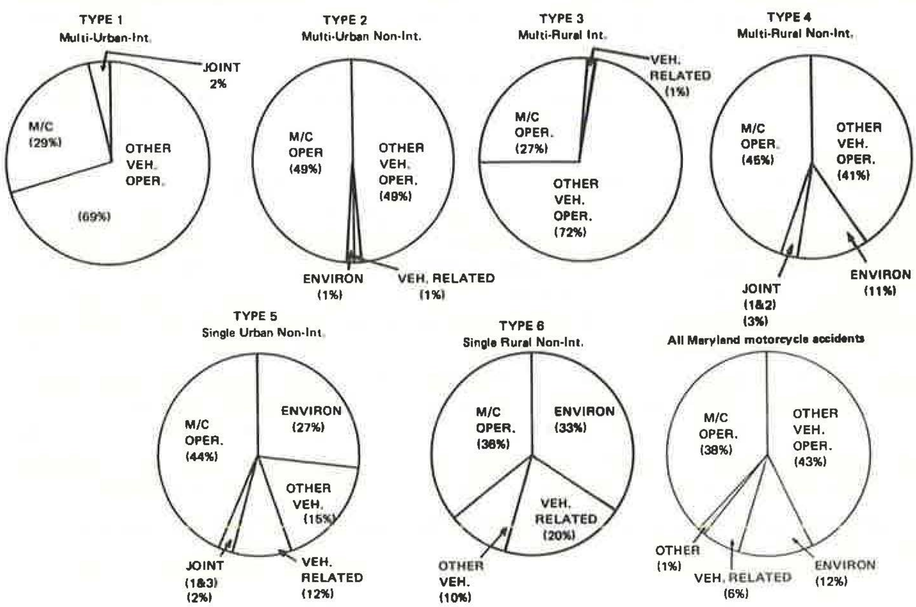



**Figure 2. Accident culpability.**



and random occurrence for each of the variables (motorcycle size, time of day, culpability, curvature of the road, etc.) by accident type. For example, a particular variable may be more prevalent in one type of accident (single-vehicle, rural nonintersection versus multiple-vehicle, urban nonintersection). This information can be used to determine data voids as well as to provide an input in the design of programs to reduce the number of accidents in each accident type.

Figure 2 shows the comparison of each accident type and all accident types for the variable culpability. The culpability for all accidents was obtained by

$$\text{Culp}_{(\text{all})} = \Sigma \ \text{culp}_{(\text{accident types 1-6})}\text{weighting factor}_{(\text{frequency of accident types 1-6})}$$

## SIGNIFICANT DIFFERENCES AMONG ACCIDENT TYPES

Fifteen paired comparisons could be made of the six accident types [n(n - 1)/2]. We restricted the present analysis to the seven most meaningful comparisons. The intent of the comparisons was to isolate those accident characteristics that distinguished one accident type from another. [In most cases a Z-test of uncorrelated proportions was used to test differences. All differences reported here were significant beyond the 0.05 level (2 tail).] In particular, we were concerned with the characteristics that differentiated

1. Multiple- from single-vehicle accidents,
2. Urban from rural accidents, and
3. Intersection from nonintersection accidents.

The construction of the Maryland data base made it possible to determine the differences and to control for potential confounding factors. We were, for example, able to compare the characteristics of multiple- and single-vehicle accidents when both types of accidents occurred at urban nonintersections. Thus, we were able to control the situational context when exploring the differences between various accident types. Table 2 gives the comparisons used to identify the differences among the three classification variables listed above.

The results of the accident comparisons are discussed below. Tables are used to show the characteristics of each accident type; the characteristics were placed under the accident type that was found to have a higher proportion of that characteristic.

### Multiple- Versus Single-Vehicle Accidents

The difference between multiple- and single-vehicle accidents was determined for both rural nonintersection and urban nonintersection contexts. Table 3 gives these comparisons.

Multiple-vehicle accidents were more frequently found to result in incapacitating injuries, and safety equipment was less often used. The riders were younger and drove smaller and newer motorcycles. The multiple-vehicle accidents were generally characterized by the failure of the motorcycle rider to obey traffic signals, yield right-of-way, and notice the other vehicle. Single-vehicle accidents, on the other hand, were more often associated with excessive speed, road and equipment defects, and avoiding another vehicle.

In the urban nonintersection context, the multiple-vehicle accident more often resulted in no injuires. The causal factors more frequently were the motorcyclist's failure to reduce speed and following too closely, and these accidents more often occur in clear weather. Single-vehicle accidents were more often caused by foreign objects on the roadway and negligent motorcycle riders.

Looking at both of the situations in which we have tested the multiple- and single-vehicle accidents, we find that, in addition to the previously discussed items, a series

**Table 2. Structure for comparing the characteristics associated with the three classification variables.**

| Variable | Accident Types Compared | Situational Context |
|---|---|---|
| Multiple- versus single-vehicle | 2 and 5 | Urban nonintersection |
| | 4 and 6 | Rural nonintersection |
| Urban versus rural | 1 and 3 | Multiple-vehicle, intersection |
| | 2 and 4 | Multiple-vehicle, nonintersection |
| | 5 and 6 | Single-vehicle, nonintersection |
| Intersection versus nonintersection | 1 and 2 | Multiple-vehicle, urban |
| | 3 and 4 | Multiple-vehicle, rural |

**Table 3. Significant ($p \leq 0.05$) characteristics of multiple- and single-vehicle accidents.**

| Accident Type | Multiple-Vehicle | Single-Vehicle |
|---|---|---|
| Rural, nonintersection | 1. Incapacitating injuries to motorcycle rider | 1. Older rider |
| | 2. No safety equipment worn | 2. Nonincapacitating injuries to rider |
| | 3. Motorcycle rider under 19; bike registered in parent's name | 3. Larger engine size |
| | 4. Newer motorcycle | 4. Defective brakes |
| | 5. Motorcycle failing to obey traffic signal | 5. Punctures |
| | 6. Motorcycle failing to yield right-of-way | 6. Darkness; no lights |
| | 7. Motorcycle failing to keep right of center | 7. Speed too great for conditions |
| | 8. Motorcycle failing to notice other vehicle | 8. Blowouts |
| | 9. Daylight | 9. Road defects |
| | 10. Other vehicle culpable | 10. Domestic animals in roadway |
| | | 11. Motorcycle avoiding other vehicles |
| | | 12. Environmental factors culpable |
| | | 13. Vehicle defects culpable |
| | | 14. 10 p.m. to 1 a.m. |
| Urban, nonintersection | 1. 1 to 4 p.m. | 1. Nonincapacitating and incapacitating injuries to rider |
| | 2. Motorcycle stopped in traffic | 2. Unspecified roadway surfaces |
| | 3. No injury to motorcycle rider | 3. Negligent driving |
| | 4. Motorcycle rider is owner | 4. Domestic animals in roadway |
| | 5. Unspecified motorcycle defects | 5. Foreign objects in roadway |
| | 6. Clear weather | 6. Environmental factors culpable |
| | 7. Three-lane roads | 7. Vehicle defects culpable |
| | 8. Motorcycle failing to reduce speed | 8. 10 p.m. to 1 a.m. |
| | 9. Motorcycle following too closely | |
| | 10. Daylight | |
| | 11. Motorcycle failing to keep right of center | |
| | 12. Other vehicle culpable | |
| | 13. Surface streets | |

**Table 4. Significant ($p \leq 0.05$) characteristics of urban and rural motorcycle accidents.**

| Accident Type | Urban | Rural |
|---|---|---|
| Multiple-vehicle, intersection | 1. Monday | 1. Saturday |
| | 2. Sideswipes | 2. Other vehicle slowing or stopping |
| | 3. Signalization | 3. Other vehicle starting from traffic lane |
| | 4. Possible injuries to motorcycle rider | 4. Stop sign |
| | 5. Other vehicle failing to obey traffic signal | 5. Divided roadway |
| | 6. Other vehicle failing to notice motorcycle | 6. Motorcycle rider properly licensed |
| | 7. Safety equipment worn | 7. Safety equipment worn |
| | 8. Surface streets | 8. Other driver older |
| | | 9. Excessive wear of tires of other vehicle |
| | | 10. Darkness; street lights off |
| Multiple-vehicle, nonintersection | 1. Other vehicle turning left | 1. Other vehicle going straight ahead |
| | 2. Other vehicle starting from parked position | 2. Incapacitating injury to motorcycle rider |
| | 3. No injury to motorcycle rider | 3. Motorcycle rider under 19; bike registered in parent's name |
| | 4. Possible injury to motorcycle rider | 4. Condition of other driver apparently normal |
| | 5. Motorcycle rider is owner | 5. Darkness; no lights |
| | 6. Improper passing for motorcycle | 6. Four lanes in direction of travel of motorcycle |
| | 7. Other vehicle failing to yield right-of-way | 7. Expressways |
| | 8. Improper entrance or exit into parking area for other vehicle | 8. Motorcycle speed too great for conditions |
| | 9. Surface streets | 9. Other vehicle failing to yield right-of-way |
| | | 10. Other vehicle speed too great for conditions |
| | | 11. Foreign objects in roadway |
| | | 12. Road curvature |
| | | 13. Environmental factors involved in accident culpability |
| Single-vehicle, nonintersection | 1. Thursday | 1. Ran-off-road collision |
| | 2. Darkness; street lights on | 2. Motorcycle slowing or stopping |
| | 3. Darkness; no lights | 3. Motorcycle punctures or blowouts |
| | 4. Other than dry road surface | 4. Four lanes in direction of travel of motorcycle |
| | 5. Two-way, undivided traffic flow | 5. Two-way, divided traffic flow |
| | 6. Operator was owner | 6. Expressways |
| | 7. Surface streets | 7. Divided roadways |
| | | 8. Motorcycle speed too great for conditions |
| | | 9. Wildlife in roadway |
| | | 10. Road curvature |
| | | 11. Blowouts primary causes |

of common factors emerges across situations. In particular, multiple-vehicle accidents more often occurred in daylight, and the motorcyclist was more frequently cited as failing to keep right of center. The other vehicle was more often judged culpable in multiple-vehicle accidents. In single-vehicle accidents, the environment, vehicle defects, domestic animals, and unknown causes were more frequently cited as contributory factors. Also, more single-vehicle accidents occurred between 10 p.m. and 1 a.m.

## Urban Versus Rural Accidents

The differences between urban and rural accidents were determined in three situational contexts. Table 4 gives these comparisons.

Urban accidents in the multiple-vehicle, intersection context were more frequently found to consist of sideswipes and occurred more often at signalized intersections. The other vehicle was more often cited as failing to obey the traffic signal in the urban accidents and more frequently failed to notice the motorcycle.

Rural accidents in the multiple-vehicle, intersection context, on the other hand, were found to be involved in accidents with vehicles that were starting up, slowing down, or stopping. The intersection more often was controlled by a stop sign, and the roads were more often divided roadways. The motorcycle operator was generally older, was more often properly licensed, and used the appropriate safety equipment.

Urban accidents in the multiple-vehicle, nonintersection context more often involved a left turning vehicle. The other vehicle more frequently started from a parked position and did so improperly. The other vehicle more often failed to yield the right-of-way. On the other hand, the motorcycle operator was more often found to pass the other vehicle improperly. The urban motorcycle operator more often escaped without serious injury.

The rural multiple-vehicle, nonintersection accident is more often characterized by excessive speed on the parts of both the motorcycle and the other vehicle. Environmental factors, foreign objects on the roadway, and road curvature were more frequently cited in rural accidents. The other vehicle was more often going straight, and the motorcycle more frequently failed to yield the right-of-way.

Urban accidents in the single-vehicle, nonintersection context more often occurred on two-way, undivided roadways where the road surface was other than dry, and the operator more often owned the vehicle. Rural accidents in the same situational context more frequently involved slowing or stopping on the part of the motorcycle, blowouts, and domestic animals in the roadway. In addition, rural, single-vehicle, nonintersection accidents more often were associated with road curvature and excessive speed for conditions and occurred more frequently on divided roads or expressways.

The only factors that differentiated urban from rural accidents (for all three situations) are roadway characteristics. Urban accidents, not surprisingly, occurred more frequently on surface streets, whereas rural accidents more frequently occurred on divided and nondivided roadways.

## Intersection Versus Nonintersection Accidents

The differences between intersection and nonintersection accidents were determined in the multiple-vehicle, urban and multiple-vehicle, rural contexts. Table 5 gives these differences.

The intersection accidents in the multiple-vehicle, urban context more often were characterized by the other vehicle's failure to obey the traffic signal and failure to notice the motorcycle. The motorcycle operator was more frequently cited for failure to yield the right-of-way. These intersection accidents more often occurred on surface streets and resulted in incapacitating injuries to the cyclist.

Nonintersection accidents in the same context were more frequently associated with the other vehicle making a U-turn, starting from a parked position and doing so im-

**Table 5. Significant ($p \leqslant 0.05$) characteristics of intersection and nonintersection motorcycle accidents.**

| Accident Type | Intersection | Nonintersection |
|---|---|---|
| Multiple-vehicle, urban | 1. Incapacitating injury to motorcycle rider | 1. Other vehicle making U-turn |
| | 2. Surface streets | 2. Other vehicle starting from parked position |
| | 3. Motorcycle failing to yield right-of-way | 3. Other vehicle stopped in traffic lane |
| | 4. Other vehicle failing to obey traffic signal | 4. No injury to motorcycle rider |
| | 5. Other vehicle failing to notice motorcycle | 5. Motorcycle rider under 19; bike registered in parent's name |
| | 6. Other vehicle culpable | 6. Motorcycle rider is owner |
| | 7. Angle collision | 7. One-lane in direction of travel of motorcycle |
| | 8. Other vehicle turning both directions | 8. Undivided highway |
| | 9. Motorcycle turning left | 9. Motorcycle following too closely |
| | 10. Other vehicle failing to yield | 10. Other vehicle stopped in roadway |
| | | 11. Other vehicle entering or exiting parking position properly |
| | | 12. Motorcycle speed too great |
| | | 13. Motorcycle failing to keep right of center |
| | | 14. Unexpected rapid deceleration |
| | | 15. Motorcycle culpable |
| | | 16. Other vehicle culpable |
| | | 17. Other vehicle changing lanes |
| | | 18. Motorcycle culpable |
| | | 19. Head-on and rear collisions |
| Multiple-vehicle, rural | 1. 4 to 7 p.m. | 1. Sideswipes |
| | 2. Safety equipment worn | 2. Motorcycle slowing or stopping |
| | 3. Driver of other vehicle is female | 3. Other vehicle going straight ahead |
| | 4. Driver of other vehicle drinking | 4. Other vehicle starting from traffic lane |
| | 5. Darkness; street lights off | 5. Other vehicle also motorcycle |
| | 6. Divided roadways | 6. Defective brakes on motorcycle |
| | 7. Motorcycle passing improperly | 7. Condition of other driver apparently normal |
| | 8. Other vehicle failing to obey stop sign | 8. Darkness; no lights |
| | 9. Environmental visual obstructions | 9. Four lanes in direction of travel of motorcycle |
| | 10. Motorcycle and environment culpable | 10. Expressways |
| | 11. Angle collision | 11. Motorcycle speed too great for conditions |
| | 12. Other vehicle turning both directions | 12. Other vehicle speed too great for conditions |
| | 13. Motorcycle turning left | 13. Other vehicle failing to keep right of center |
| | 14. Other vehicle failing to yield | 14. Foreign objects in roadway |
| | | 15. Motorcycle failing to notice other vehicle |
| | | 16. Environmental factors culpable |
| | | 17. Other vehicle culpable |
| | | 18. Head-on and rear-end collisions |
| | | 19. Other vehicle changing lanes |
| | | 20. Other vehicle decelerating rapidly |
| | | 21. Motorcycle culpable |

properly, or stopped in traffic or on the roadway. The motorcycle operator was more often the owner of the motorcycle and was more often following too closely.

In intersection accidents in the rural, multiple-vehicle context, the other driver's use of alcohol and his failure to obey stop signs were more often cited. A higher percentage of motorcyclists were found to be passing improperly. The cyclist did more often wear safety equipment. We also found that visual obstructions were more frequent in the intersection accidents.

The nonintersection accidents in the same context had a greater proportion of sideswipes. The motorcycle was more often slowing or stopping and was cited more frequently as having defective brakes. The motorcyclist more often did not notice the other vehicle in the nonintersection accidents. The other vehicle in the nonintersection accident was more often going straight ahead or starting from a traffic lane. The other vehicle was also more frequently cited for failure to keep right of center. Both vehicles were more often cited for excessive speed in these nonintersection accidents. Causal factors involving the environment were more often noted, including foreign objects on the roadway.

Analysis of both of the situations in which we tested intersection and nonintersection accidents revealed some common factors across situations. In particular, intersection accidents were more often angle collisions and involved another vehicle that was turning right or left and a motorcycle that was turning left. Failure of the other vehicle to yield the right-of-way was more frequently cited as a causal factor. On the other hand, nonintersection accidents were more often head-on and rear-end. The other vehicle was more often found to be slowing or stopping, changing lanes, or decelerating unexpectedly. The other vehicle was more often guilty of crowding the motorcycle. The motorcyclist more often was found to fail to reduce speed and keep right of center. The cyclist was also more frequently cited as culpable in nonintersection accidents.

## CONCLUSIONS

We have seen that an accident typology can be created to define culpability information and causal factors for a series of accident types. It is suggested that this information be used in the design of future motorcycle education and training programs as well as in the development of accident research programs designed to reduce the frequency of these accidents.

It is further suggested that a representative sample of additional states be used to replicate the Maryland data base and serve as the basis for a national data base.

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