Study of Ran-Off-Roadway Fatal Accidents in Louisiana

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Thirty ran-off-roadway single-vehicle fatal accidents in an eight-parish area of Louisiana were studied by an interdisciplinary team. This team consisted of a highway engineer and the research director (authors of this paper), an automotive specialist, a psychologist, a sociologist, and two state police officers. Three-fourths of these accidents occurred on curved two-lane rural highways. More than one-half of the accident sites had roadside hazards within 20 ft of the pavement. No vehicle defects were found to cause any accident. Young, white, male drivers who have no more than a high school education and came from a working class family were particularly susceptible to an accident of this type. An epidemiological conceptual model of accidents was adopted to evaluate the interaction of the agent (vehicle), the host (driver), and the environment (physical and social). The evaluation showed that, although the vehicle and highway can contribute to the severity of an accident, the human factor is the major contributor to the accident. Countermeasures to reduce the number of ran-off-roadway accidents will require strategies for changing the behavior of susceptible drivers, primarily through law enforcement and educational programs. Reduction of the severity of these accidents will require manipulation of situational (engineering) factors related to the vehicle and physical environment.

Within the past decade the relative number of single-vehicle fatal accidents has been increasing in the nation and state. Single-vehicle accidents currently account for approximately 40 percent of highway fatalities nationwide and almost as large a percentage in Louisiana.

Ran-off-roadway fatal accidents in rural areas of Louisiana have attracted the attention of the Louisiana Highway Safety Commission because of their increase since 1973 (Figure 1). Because of the seriousness of the problem and in light of the paucity of information regarding this particular type of accident, the Louisiana Highway Safety Commission initiated a preliminary research project of an interdisciplinary nature designed to shed light on the factors related to single-vehicle ran-off-roadway fatal accidents.

STUDY OBJECTIVES

The Louisiana Highway Safety Commission research project had several specific objectives, all of which related to reducing highway accident numbers and fatalities in the state and nation.

The first objective was to develop a comprehensive interdisciplinary research approach to the investigation of accidents. This was because accidents appeared to occur because of human responses and behavior as well as because of mechanical and environmental factors. Therefore, social scientists were included on the study team to broaden the base of accident investigative procedures.

The second objective was to establish procedural guidelines to ensure the collection of as much data as possible pertinent to the study from each accident investigated. Certain data critical to the determination of the cause of accidents were not normally heretofore collected. For example, very little information on the behavior of the driver prior to an accident or on the sociocultural background of the driver was routinely obtained.

The third and final goal was the development of strategies and recommendations for accident prevention programs. Given that human behavior and physical factors combine in some way to produce an accident, it was considered reasonable to assume that educational processes could be devised to raise the consciousness of drivers to accident-causing factors. Thus, the goal was to obtain as much background information on the driver of vehicles involved in accidents as possible.

STUDY PROCEDURE AND METHODOLOGY

The study was designed as a pilot investigation. We decided that the first 30 subject cases, which occurred in rural areas of the State Police Troop A region after July 1, 1977, would satisfy the requirements for a preliminary study. (Rural was defined to include all territory outside the incorporated boundaries or limits of towns that have a population of 2500 or greater.) The methodological procedures for the study were designed accordingly.

The study area served by Louisiana State Police Troop A is shown in Figure 2. This area contains widely differing geographic features. On the west side of the Mississippi River and south of Baton Rouge, the terrain is typical of flood plains and contains extensive swampy areas. By contrast, the part of the Troop A region that falls to the north and east of Baton Rouge is characterized by rolling hills and expanses of pine and hardwood forests. Driving conditions are therefore somewhat different in the two parts of the region. Beyond geographic differences, there are also rather distinct cultural variations in the region. The inhabitants of the delta areas along the Mississippi River tend to reflect the Cajun culture. That is, they are likely to be of French or Spanish descent, Catholic, and to have distinct social patterns in such things as food habits and music. Those persons who live in the uplands are more likely to be of Anglo-Saxon or Scotch-Irish heritage and to belong to protestant denominations. They are characterized as more puritan in their life-styles.

The location of the 30 case accidents is shown in Figure 2 so that an association with geographic and cultural features can be made. A rather easily followed definition of an accident was essential since cases had to be determined to be suitable for the study:

1. The accident must have occurred within the geographical boundaries of the study area,
2. The accident must have produced a fatality,
3. Only one vehicle was involved in the accident, and
4. The final accident requirement was that the subject vehicle must leave the roadway totally (pavement or other surface) at some time during the development of the accident.

Since one of the objectives of the study was to develop an interdisciplinary approach to accident investigation, a team of specialists was recruited to investigate each accident. This team included professionally trained and experienced individuals from the disciplines of psychology, sociology, civil engineering, and automotive mechanics. The interdisciplinary group, as a team, was given the responsibility for identifying data requirements, collecting relevant data, and analyzing the data relative to each accident, both individually and collectively. A research specialist coordinated the team's work and two specially trained state police sergeants were assigned to work with the team. The latter gave special assistance in the reconstruction

of each accident and in verification of the data collected at accident sites.

Before the field part of the study was launched, a protocol was established to alert and notify the accident investigation team of the occurrence of an accident. All state police troopers were advised to notify headquarters whenever they believed a fatal accident met the study criteria. If the accident reported was determined to meet the criteria of the study, one of the two sergeants assigned to the study team was contacted by state police headquarters or by the Louisiana Highway Safety Commission and given the circumstances of the case. The project director was then contacted and he alerted other team members.

Note that several accidents (5) occurred on parish (county) roads during the study period. These cases were investigated by sheriffs' deputies rather than by state police. In such instances the team did not receive direct notification of the accident. The first information on the accident was received through news media or from the fatality accident reporting system (FARS) officer at the Louisiana Highway Safety Commission. This procedure had a drawback in that an extended period of time elapsed between team notification and the occurrence of the accident. Once it was determined that such an accident met the criteria of the study, the same follow-up procedure was initiated.

The investigative procedure on an accident may be briefly described as follows. Primary data on each case were collected at the scene of the accident. Standard vehicle accident report forms were used to obtain basic information from the driver, occupants of the vehicle, and witnesses. These forms were completed or checked by one of the state police sergeants assigned to the team. The project director and the engineer generally accompanied the troopers to the accident scene. They made first-hand observations and participated in the collection of data. In certain cases the team psychologist also visited the scene and interviewed the principals involved.

A survey crew under the direction of the project engineer was dispatched to each accident site as soon as possible to map and locate relevant features implicated in or caused by the accident. The project engineer also obtained the road construction plans and accident history records of accident sites from the Louisiana Department of Transportation and Development. Some time after the accident, the subject vehicle was inspected for mechanical defects by the automotive specialist. Usually this was done at the place where the vehicle had been towed.

Detailed information about each driver was obtained at a later date through personal interviewing. The interviews were conducted by using a questionnaire prepared by team members in consultation with representatives of the Louisiana Highway Safety Commission. In all but two cases interviews were taped. At a later date the tapes were studied

Figure 1. Proportion of highway fatalities by select accident categories, Louisiana, 1972-1978.

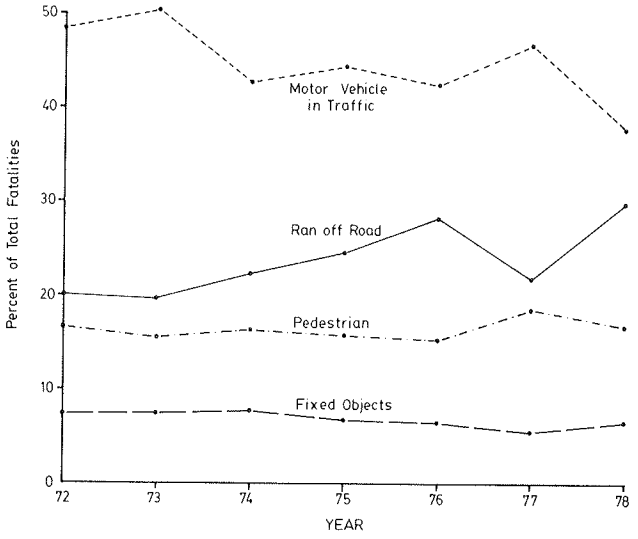
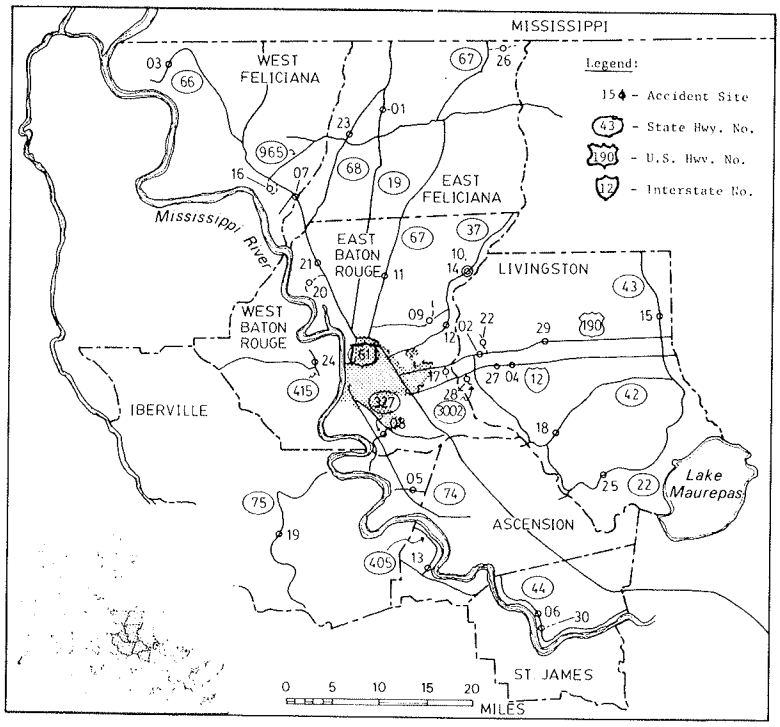


Figure 2. Study area and location of 30 case accidents.



carefully by team members. In those cases where the driver was killed in the accident, interviews were conducted with persons who knew him or her well. Usually this was next of kin, but on occasion more distant relatives, close acquaintances, or surviving occupants of the vehicle provided information on drivers.

Blood alcohol test results and driver record files for drivers were obtained through the state police, as was vehicle licensing information.

All information obtained about the accident was employed to reconstruct the sequence of events that led to each accident. A psychological and sociological profile of each driver and the mechanical condition report of each vehicle were prepared as part of the study procedure.

During the course of the study, periodic conferences were held to discuss accident findings and research problems. These conferences included all members of the research team plus representatives of the Louisiana Highway Safety Commission. The discussions that took place aided greatly in placing each accident in a truly interdisciplinary perspective.

Altogether, a total of 32 cases were studied from May 1977 to September 1978. The first two cases were worked in a pretest phase of the study. The purpose of the pretest was to verify and correct deficiencies in the methodology and protocol and to refine research procedures.

The research phase of the study began July 1977 and ended September 1978. As noted, a total of 30 cases met the accident criteria and were investigated. These cases were and are considered as a pilot research effort in use of a case-history and an event-reconstruction approach. The findings and analyses presented in the remainder of this report must be interpreted accordingly.

ACCIDENT CHARACTERISTICS

Although no 2 of the 30 accidents occurred in precisely the same way, there were similarities among a number of the accidents. These similarities provide points of departure for the understanding and study of ran-off-roadway single-vehicle fatal accidents. The number of cases is too small for statistical generalization; however, we think that the findings generated are highly enlightening.

Place and Time of Accidents

At least one accident occurred in each of the eight parishes in the study area, nine each occurred in the parishes of East Baton Rouge and Livingston (see Figure 2).

Of the 30 accidents investigated, nearly one-half (43 percent) occurred on a Saturday and approximately three-quarters (73 percent) occurred during the weekend (Friday-Sunday). The preponderance of accidents on weekend days was determined to be related to trip plans associated with leisure activities. This finding suggests an association of accidents with type of trip and helps explain the greater probability of alcohol as a contributing factor. Nearly one-half (47 percent) of the accidents covered in this study occurred after 9:00 p.m. but before 6:00 a.m. With only one exception all of the accidents during this time period (night) were on weekends. Forty percent of the case accidents occurred between 3:00 and 9:00 p.m. These accidents were nearly evenly divided between weekdays and weekend days.

Driver Characteristics

In addition to normal demographic data, the sociologist and psychologist on the study team compiled additional case history data on most of the 30 drivers involved. The median age of the drivers was 22; 40 percent were younger than 21 and only two were over 40. Only two drivers were female. Only 20 percent were black compared with 35 percent of the area population.

Well over half of the drivers had not finished high school. Fifty-four percent were classified as semi-skilled or unskilled laborers, none as professional. Thirty-five percent were single, twenty-three were married, and the rest had unstable family life.

Almost none of the drivers participated in formal organizations. Seventy-five percent belonged to a church, but only 5 were active members. Over half were engaged in outdoor recreational activity to a moderate extent. Fifty-eight percent led rather normal social lives. All drivers came from a working class background.

Among the deviant and substance-abuse behavior found, eighty-nine percent of the drivers consumed alcoholic beverages; fifty-eight percent were heavy drinkers. One-third used drugs, mostly marijuana. More than half smoked. Seventy-seven percent had one or more traffic violations. Well over half had unstable work habits; 40 percent were highly unstable.

Attitudinally, the drivers were classed as nonpathological (60 percent). These drivers are not deliberate risk takers and are not overtly hostile to the law and society. They are disinclined to drive defensively with a view to preventing accident situations from occurring; they are inclined, instead, to place undue reliance on quick reaction time to get them out of difficulty.

Quite another attitudinal pattern was evidenced by those drivers classified as macho (18 percent). These were deliberate risk-takers. Drivers classified as sociopathological (14 percent) presented personal histories wherein active hostility was directed toward social convention and authority figures (father, law enforcement officers, or teachers).

Other contributory psychological factors were inexperience (only one case), fatigue (40 percent) (established for five and surmised for seven cases), psychotic episodes (two cases), acute stress without psychotic episodes (seven cases), and depressive personalities experiencing acute stress just before accident (four cases).

Characteristics of Vehicles Involved

Vehicle characteristics were derived from information collected at the scene of the accident and from follow-up inspection conducted after the vehicle had been removed from the accident scene. Chevrolet made 57 percent of the vehicles. Sixty percent were two-door sedans. Median vehicle age was six years. The owners drove 70 percent of the vehicles. None of the accidents was attributed to vehicle defects. Two-thirds were being driven above the speed limit. The seat belts in over half the vehicles were removed or rendered unusable.

Roadway Characteristics

The general highway characteristics include roadway type, previous accident history, geometric design features, and the presence of roadside obstacles. For the 30 accident sites in this study, 83.3 percent were state maintained and all but two were two-lane, two-way highways.

Most of the highway sections (±1 mile) did not

Figure 3. Left-hand curve site of two ran-off-road fatal accidents.

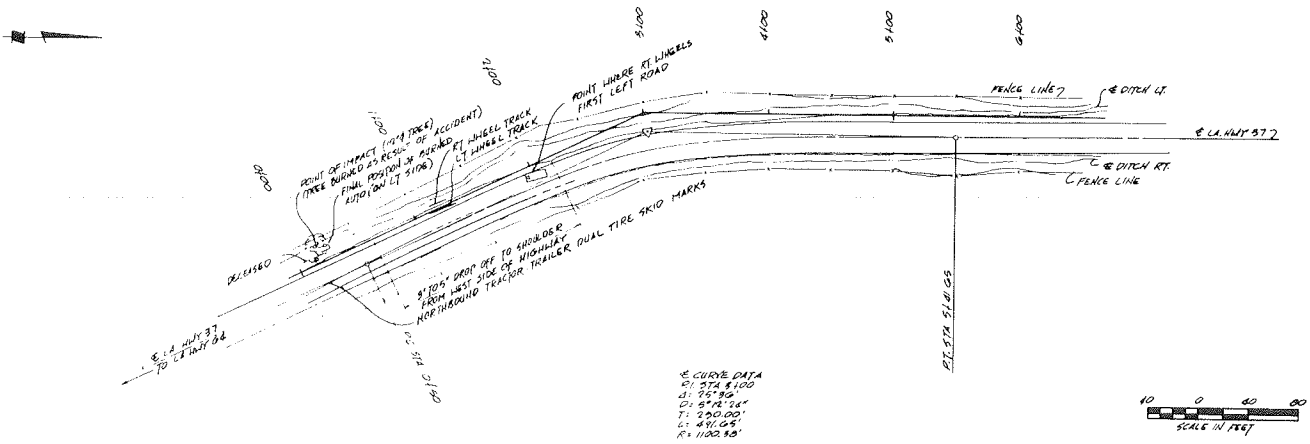
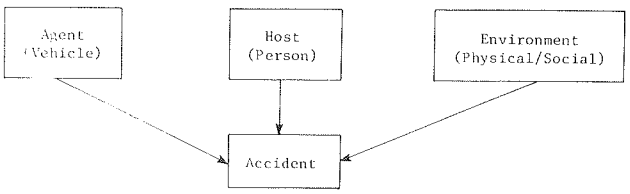


Figure 4. Epidemiological model for ran-off-road, single-vehicle fatal accidents.



have a serious accident history (3 years before study case). Twenty-eight percent had more than three accidents per year. Thirty-two percent had no previous ran-off-road accident. Only two sites had more than one ran-off-road accident.

Eighty-seven percent of the highway sections had at least one substandard design element. Sixty-three had substandard pavement width, 70 percent had substandard shoulder width, and 53 percent were deficient in both pavement and shoulder widths. Seventy-seven percent were curves (6° median curvature): 39 percent had excessive curvature and 44 percent had inadequate superelevation. Roadside hazards and obstacles (i.e., sharp ditches, trees, poles, culverts, or fences) within 20 ft of the pavement edge were found at 57 percent of the highway sections. Twenty-three percent of the accidents happened at bridges, and 71 percent of these locations had inadequate guardrails.

Of the curved roadways involved, 65 percent curved to the left. This corresponds to previous studies of this subject like that of Wright and Robertson (1). An example of such a site is illustrated in Figure 3. This location was the only section where two fatal accidents occurred during the course of this study.

ANALYSIS OF ACCIDENT CAUSAL FACTORS

Obviously many accidents represent a complicated sequential chain of events that can be related to several contributory factors or variables. These factors are exceedingly complex in that they range in degree from the physical (road or weather) to the mechanical (characteristics of the vehicle) to the human (personality traits and social and cultural background). Because of the way these variables interact, accidents appear to be capricious in and of themselves. But, accidents are a recurring phenomenon and, as such, have a relatively high degree of predictability. However, prediction addressed to accidents has usually been limited to the number and types of accidents, number of fatalities, and immediate characteristic of drivers. This study, within the limits of its pilot or case nature and localized setting, presumed to go somewhat further and to isolate, identify, and describe the predictable aspects of the precrash milieu that more or less predestine the accident. Said another way, a certain combination of physical, mechanical, and human factors is necessary for an accident to happen. The objective was not only to determine the nature and importance of these contributory factors but also to gain an understanding of the likelihood of interaction between them that would culminate in an accident-causing syndrome.

Conceptual Framework

The conceptual perspective that provided the initial orientation for the analysis of study findings is known as the epidemiological model. This model has been used successfully in many previous studies (2). Epidemiology, as an investigative and analytical technique, was developed primarily in the medical field. This conceptual approach has been modified for application to nondisease injury and fatality experience such as accidents. The rationale for the use of the model in accident investigations is that human behavior and experience follow some sort of epidemiological pattern.

The epidemiological conceptual model of accidents that was adopted focused on three basic components: (a) a host, (b) an agent, and (c) an environment (Figure 4). Within the context of the type of highway accident under consideration, the host was the person or persons involved in the given accident, the agent in the accident was the motor vehicle, and the environment was the sum of the physical and social conditions present that contributed to the accident. The physical parameters of accidents included weather conditions and the roadway conditions and design. The social parameters included the set of sociological and psychological variables that comprised the social (or human) aspects of the accident.

In a given accident all three sets of variables were investigated. The relevant information necessary to ascertain or infer causal relation was collected. The epidemiological model provided the frame of reference for the analysis that follows. This analysis was designed to answer questions related to the cause of accidents and to predict future accident occurrence.

Relative Importance of Factors that Contribute to Accidents

The first analytical procedure was to determine which of the overall components or factors appeared to be predominant in the cases under study. Thus, careful attention was given to the agent (vehicle), environment (physical and social), and host (driver). The factors discovered fall far short of telling the whole story of accident causation when considered independently. Until the factors are related in some sort of interaction matrix that provides an understanding of the relative importance of each component in the specific accidents and for accidents in general, the picture of accident causation will remain unclear. In keeping with this thought, each of these sets of components was considered in turn and evaluated.

Vehicle

The vehicle was the agent in which the host (driver and passengers) experienced an accident that resulted in a fatality. Logically, there is justification for suspicion of mechanical malfunction or failure as the major contributing cause of accidents. For none of the 30 vehicles associated with accidents was there positive and unmistakable evidence of primary responsibility for the accident. Although some of the vehicles were not in the best mechanical condition (three had more than 100 000 miles) and about half had tires that showed heavy wear, no clues were found that would suggest breakdowns or failures possible of leading to an accident. The vehicles, in and of themselves, were simply the agent for the accident and not a major contributory factor to the accident. This is not, of course, to rule out some breakdown once the sequence of the accident was under way. Obviously, worn tires and tied down seatbelts could add to the severity of the accident. All in all, in terms of the epidemiological model, there was no justification for assigning vehicles more than a minor role in accidents. This conclusion suggested that a close look be given to the environmental and host elements of the model.

Physical Environment

Two variables in the physical environment were carefully investigated, including ambient conditions and roadway conditions. In both instances, some evidence suggested association with accidents.

The most obvious clue to ambient conditions was that a large percentage of the accidents occurred at night. Night driving tends to be more hazardous than day driving. Other than this variable, no aspect of ambient conditions appeared to contribute to accidents. There were no incidents of storms, very little rain involvement, and no fog conditions were reported.

Roadway conditions at some sites were determined to be potential contributors to accidents. We found that 26 (87 percent) of the sections of roadway where accidents occurred had at least one substandard geometric element. These included any one or a combination of narrow pavement, narrow shoulders, sharp ditches close to pavement, trees and utility poles close to shoulders, excessive curves, and superelevation problems. Curves to the left were the most troublesome sites.

Roadway defects could not, except circumstantially, be given direct accountability for accidents. But there was little doubt that in some instances the unforgiving nature of the road contributed to the sequences that ended in fatalities. A tired driver, an inattentive driver, or a driver under the influence of alcohol or drugs was more likely to have an accident on a substandard roadway than on one that was in keeping with the safety standards recommended by highway engineers.

Social Environment

It was quite clear that drivers that had certain sociopersonal characteristics and certain social backgrounds were involved more frequently in accidents. The more immediate, specific sociopersonal indicators of accidents were age, sex, race, educational attainment, and working class background. Taken together these characteristics were important predictors of the drivers involved in the accident cases studied. In this regard, it appeared that a young, white, male driver who had no more than a high school education and who came from a working class family was particularly susceptible to an accident.

Psychological traits of drivers that were found to be related to accidents included substance abuse (primarily alcohol), speeding, deviant behavior (such as arrest records and unstable work habits) and certain attitudinal patterns (macho, hostility, or inattentiveness). In only one or two instances were psychopathological conditions suspected.

Beyond the sociodemographic and psychological characteristics noted above, the social environment surrounding an accident included another important social variable. This was the immediate precrash activity of the drivers. Weekend accidents related closely to precrash activity. Approximately three-quarters of the accidents were associated with leisure precrash activities, most of which involved the consumption of alcoholic beverages. The investigation turned up cases where the subject driver had left a lounge, party, outdoor recreational activity, or was simply joy riding and drinking. In only two cases were drinking drivers involved in work-related precrash activities. Both of these cases occurred after 5:00 p.m.

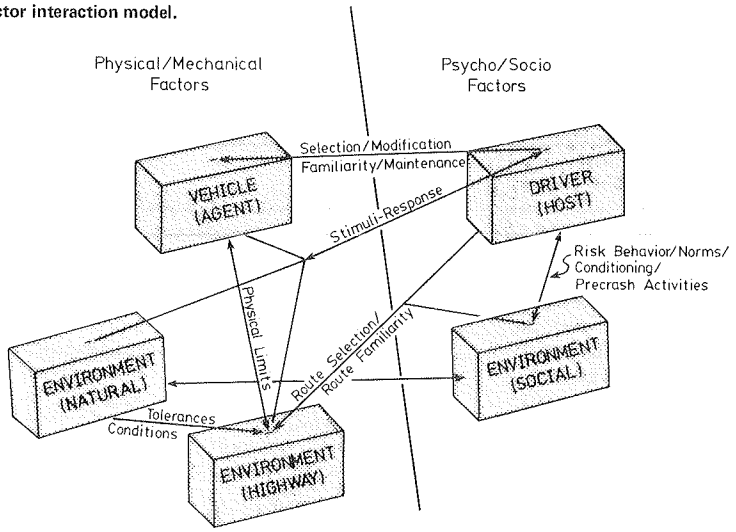
Drivers

In an overview sense, the sociodemographic and psychological characteristics of drivers, including their styles of life, tended to follow three major patterns. The first type of driver was termed the macho type. Many of the drivers had internalized acts such as drinking and speeding as an acceptable way to prove their manliness. Obviously such ideas are traceable to a socialization process (i.e., learning experiences received in the home, in work groups, or in other social groups). The young appear more susceptible to such patterns of behavior, which bring recognition and acclaim among their peers, than do older persons. At any rate, drinking and certain types of risk-taking could be seen as a part of the style of life of the macho driver.

The second type of driver clearly identifiable was classified as an inadequate performance type. This class of driver was generally described as moderate, dependable, and conservative in his or her behavior. The cause of their accidents was a breakdown in their performance as drivers that was not directly associated with drinking or speeding. Beside inexperience, fatigue and lapse of attention apparently accounted for inadequate performance, especially in more-demanding situations. The number of drivers in this class was not large, about one out of five, or 20 percent.

The third type of driver isolated was termed a physical or psychological breakdown type. Such drivers had undergone a complete physical or psycho-

Figure 5. Accident factor interaction model.



logical collapse that rendered them helpless as drivers. For example, one person apparently fell asleep while driving and a second seemed to have a mental breakdown that placed him in a trance. In the cases of three drivers, there was some suspicion of a physical breakdown.

Overall Assessment and Conclusions

We must reemphasize that broad generalizations cannot be made from the study findings because of the limited number of cases and the limited area of investigation; however, the information gathered and analyzed was of sufficient nature to warrant the design of an accident factor interaction model. This model, shown in Figure 5, is based on the theoretical (epidemiological) model presented in Figure 4. The model shows how, in an analytical sense, a given accident is the result of the interaction of factors in the epidemiological model. This interaction, when it achieves a certain state, predestines an accident. In light of study findings, the human factor in the model (social environment and psychological characteristics of the driver) is depicted as the overriding interactional or causal variable in accidents in general.

Given that the engineering and maintenance of roads and highways, weather conditions, and vehicle malfunction are situational variables that are contributory to accidents and must be addressed if accidents are to be reduced, the basic thrust of a preventive effort must still be concerned with the human factor. In this regard, we must conclude that the socialization processes that an individual undergoes and the opportunity structure that he or she experiences largely account for the behavior that leads to an accident. In more precise terms, none of the drivers was from a middle or upper class background. This pattern may be unique to the area studied, but it is one that appears to need intensive study. It strongly suggests that the human factor is mainly responsible for accidents. Thus, accidents will persist at rates that are too high to tolerate unless remedial action can be taken to change or alter the behavior of accident-prone individuals.

RECOMMENDATIONS FOR COUNTERMEASURES

Despite the small sample size of this study, we can identify countermeasures and intervention measures that might reduce accident frequency. From the theoretical standpoint taken, accident reduction is seen to entail two major countermeasure options that have both short-term and long-term implications:

1. Education or control of the driver through law enforcement and
2. Protection of the driver (and occupants) by manipulating situational factors related to the vehicle and physical environment.

The short-term human factors immediately and directly identified with accidents included the following:

1. Alcohol and drugs,
2. Speeding,
3. Inattention,
4. Fatigue,
5. Inexperience,
6. Poor judgment, and
7. Psychopathology.

Short-term physical factors are road and vehicle design condition. Long-term human factors include particular socialization experiences of individuals or, more precisely, an inadequate sociocultural background. Long-term physical factors include the redesign and improvement in the standards of vehicles and roads.

Countermeasures to reduce accidents in the relatively near future must address the immediate human factor and short-term physical factors that cause accidents. Countermeasures aimed at long-term control must look at programs of an educational nature administered over time and to safer vehicles and roads. In recommending countermeasures of both types, we are keenly aware that what is involved is the alteration of human attitudes and behavioral patterns of drivers and many others. Many of these patterns are normative within given cultures and will be difficult to change. This will make intervention extremely difficult. In this regard some of the recommendations include control measures over which there may be serious political and social-philosophical conflict:

1. Substance abuse control--Individuals who insist on driving while under the influence of alcohol or drugs have been the subject of much study (3-6). Their preponderance among accident-involved drivers suggests the need of more-effective control. Early revocation of license and other severe penal-

ties should be carefully considered.

2. Inadequate performance control--Countermeasures for this type of driver must be directed toward reducing the incidence of careless driving, of driving while fatigued, and of overreaction by inexperienced persons. The only feasible countermeasure appears to be the imposition of serious penalties for individuals detected in violation of a traffic regulation because of such failures. This may appear a harsh measure for errors that are not necessarily willful, but the frequency with which such behavior is associated with accidents necessitates some preventative measure.

3. Vehicle control--The contribution of vehicle factors to accidents was minimal among the cases investigated. Yet, there appears to be some justification for tougher legislation and controls related to the regulation of tire tread depths, use of safety restraints, and general vehicle maintenance. The recommendation is for police to make vehicle inspection a higher-level priority and enforcement of violation penalties more stringent.

4. Physical environment control--The roadway sites where accidents occurred were determined to have a considerable number of substandard features. Many of these features, such as lack of proper guardrails or of railings on bridges, can be easily and quickly remedied. We thus recommend that measures be taken to correct these deficiencies along all roads as quickly as possible. Attention should also be given to improving traffic control devices and delineation of hazardous locations. Priority should be given to those roads that have higher rates of accidents. Other needs, such as improved shoulders, curves, and grades, should be identified and made a part of longer-term planning and development.

Short-Term Countermeasures

The issue of control of the problem driver has been debated since the beginning of automobiles and continues to be a controversial subject. However, legislative requirements for the revocation of licenses and other penalties that would effectively limit the number of problem drivers would undoubtedly reduce accidents. A screening mechanism for identifying problem drivers would have to be developed in order to implement this recommendation.

Speed has also been a perennial problem related to driver control. The most effective short-term countermeasure is more-stringent enforcement of posted speeds, particularly on two-lane highways. This measure entails more police personnel, but it should go somewhat further. Multiple offenders should receive penalties sufficiently severe (including the revocation of licenses) to alter their driver practices.

Long-Term Countermeasures

Because of the obvious association of accidents with the social and cultural background of individuals, a massive socialization effort must be mounted to change driver behavior. This means that educational material must be generated for use in schools and the media and comprehensive informational programs must be planned. In this regard, emphasis should be placed on reaching youngsters from working class families. Although such a program is ambitious in character, it is not unrealistic. Many examples of programs that have changed behavioral patterns, such as practices related to health and disease control, can be cited. However, such an effort must be planned for long-term benefits and is quite costly in nature.

Observations showed that the techniques used by police in the handling of driving violation cases are not maximally effective in dealing with some types of drivers. Thus, attention should be given to the development of a simple, rapidly administered, on-site screening technique to enable the officer to determine whether he or she is dealing with a macho or sociopathic personality. (This screening is analagous to procedures used in airport security screening that entails human factors.) Further, officers should be given instruction in suitable postapprehension behavior for such violators. This countermeasure would involve the use of social scientists in the development and validation of tests and in the conduct of training courses.

The recommendation for control of the physical environment is simply that all new and reworked roadways be made to conform to standards that will minimize accidents. This would include parish (county) roads as well as state and federal-aid highways.

Long-term planning in terms of vehicle control must involve careful study of the mechanical features that tend to minimize accidents such as rollovers. This type of measure would eventually involve the establishment of design criteria for manufacturers. Again, such an accomplishment is challenging and would require the enlisting of informed advice from appropriate specialists and the support of the populace at large.

CONCLUSION

This study has highlighted that ran-off-roadway, single-vehicle fatal accidents are attributable to vehicle, human, and physical and social environmental factors. These factors interrelate in various ways to trigger a particular accident. Almost always, however, the human factor is the major contributor to the accident. For this reason, the accident rate cannot be reduced unless strategies for changing the behavior of those individuals most prone to have accidents is initiated. The planning and implementation of programs to modify human behavior plus the action that must be taken to make the physical environment of roads and mechanical characteristics of vehicles less accident prone will require a sound fund of information and data. The implication of this preliminary investigation is that more systematized research be directed toward the accident phenomenon studied.

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REFERENCES

1. P.H. Wright and L.S. Robertson. Priorities for Roadside Hazard Modification: A Study of 300 Fatal Roadside Object Crashes. Insurance Institute for Highway Safety, Washington, DC, March 1976.
2. R.A. McFarland. The Epidemiology of Motor Vehicle Accidents. In Health and the Community: Readings in the Philosophy and Sciences of Public Health (A.H. Katz and J.S. Felton, eds.), The Free Press, New York, 1965, pp. 74-93.

3. R.R. Blackburn and E.J. Woodhouse. A Comparison of Drug Use in Driver Fatalities and Similarly Exposted Drivers. National Highway Traffic Safety Administration, Washington, DC, July 1977.
4. R.G. Mortimer and S.P. Sturgis. Effects of Alcohol on Driving Skills. National Institute on Alcohol Abuse and Alcoholism, U.S. Department of Health, Education, and Welfare, Rockville, MD, Jan. 1975.
5. S. Pollack and others. Drinking Driver and Traffic Safety Project. National Highway Safety Bureau, Washington, DC, July 1970.
6. Drinking Drivers: A Bibliography with Abstracts. U.S. Department of Commerce, 1978. NTIS: PS-78/0607.

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Abridgment

Costs of Operating Aircraft for Rural Traffic Enforcement

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This paper describes the cost of operating airplanes for law enforcement, including traffic patrol, in rural areas. Included are all costs associated with ownership and operation of airplanes, cost for pilots and support personnel, and the ground-support costs associated with enforcement of traffic laws. Total costs are approximately $96/h. Of this, 54 percent represent direct operating costs for the airplane, including fuel, periodic maintenance, and depreciation. An additional 34 percent of the costs are for salaries of the pilots, and the remaining 12 percent cover the overhead costs. When used for line patrol, the airplane costs $1.33/mile. Based on productivity of the pilots in Illinois, the cost per stop initiated by aerial patrol is $35. The use of the airplane solely for enforcement of the speed limit at fixed locations costs approximately $22/stop. Line patrol of highways with aircraft can be cost effective when compared with the same type of patrol by the officer on the ground. For enforcement of the speed limit at selected locations, an aircraft is substantially more expensive than a comparable operation that uses a radar operator and chase cars. A team of officers, including a radar operator, can perform the same task at approximately one-half the costs.

Although the hourly operating costs of airplane operation are high, the speed and coverage of airplanes make them practical to use for certain types of rural law enforcement. Aircraft are particularly superior for coverage of large areas. The area viewed from an aircraft for manhunts, searches, and general surveillance far exceeds that from the ground. The equipment, however, must be operated for traffic law enforcement in order to help offset the cost of purchase and storage.

Except for a report completed for the Illinois State Police (ISP) in 1979 (1), most other studies of aircraft costs have included only the direct costs of operation. Costs for fixed-wing aircraft ranged from $7.00-$43.76/h (2,3). Hourly costs for operating helicopters ranged from $23.01-$119.64 (2-5). The higher costs of helicopters tend do limit their use to metropolitan areas where the ability to hover and land at practically any location help outweigh the higher costs. The primary defect with the study for the ISP in 1979, which included an hourly operating cost of $137.42, was that it examined such costs under a specific operating policy. The costs in this report, which were derived from the methodology of the 1979 report, are presented in a more general fashion.

OPERATING COSTS

The operating costs for the aircraft include costs for depreciation, hangars, commodities, fuel, oil, and maintenance. Personnel costs are separated in the table below into the fixed cost of the chief pilot and secretary and the hourly costs of the 14 police officers who are the pilots:

Operating Cost	Item
Fixed	Chief pilot and secretary
	Hangar and office insurance
	Charts and other
Variable	Pilot salaries
	Depreciation
	Fuel and oil
	Periodic maintenance
Ground support officers	Drivers
	Assistants

Excluded from the cost of the police officers is their training and supervision on the basis that these same costs would be incurred if they were not flying. On the other hand, costs for pilot training are included. Finally, the costs of ground support are added. Such support is required to cite a traffic violation, investigate a disabled vehicle, or handle an accident reported by a pilot.

Fixed costs for the ISP aerial patrol in FY 81 (July 1, 1980 to June 30, 1981) were $83 950. Approximately 50 percent of those costs were for personnel. Variable costs added another $594 750, for a total annual cost of $678 700. Of the variable costs, 38.3 percent were costs for pilots. During FY 81, the seven aircraft in the fleet were flown 7080 h in law enforcement. More than 1000 additional hours were flown for maintenance, proficiency checks, training, and meetings, but these are considered a fixed cost of operation. Thus, based on the 7080 h of operation, Table 1 shows an average hourly cost of $95.80.

Added to the costs of operating the aircraft are those of ground assistance associated with enforcing

Table 1. Summary of airplane costs (FY 1981).

Cost	Total ($)	Cost per Hour of Law Enforcement ($)	Percentage of Total
Fixed	83 950	11.86	12.4
Variable			
Pilots	227 970	32.20	33.5
Depreciation	72 290	10.21	10.7
Fuel and oil	166 340	23.49	24.5
Periodic maintenance	128 150	18.10	18.9
Total	678 700	95.86	