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# ANALYSIS OF SPEED AND OTHER UNSAFE DRIVING ACTS

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16. Abstract

The objective of this project is to support the development of effective enforcement strategies to reduce crashes resulting from speeding and other unsafe driving acts associated with speeding. A census dataset of crash-involved traffic units from 11 states was built for the analyses. The 11-state dataset had a total of 3,421,258 crash-involved traffic units available for analysis, of which 1,905,179 had at least one unsafe driving act (UDA) recorded (55.7%). Of cases where a UDA was coded, 1,512,904 had only one UDA recorded (44.2% of all cases). Only 392,275 of all cases had more than one UDA recorded (11.5%). Speed was coded as a contributing factor in 337,440 of the cases (9.9%). A second UDA was coded in addition to speeding in 103,300 of the cases in which speed was coded (3.0% of all cases, 30.6% of cases where speed was also coded). The conditional probability of a specific UDA being reported when speeding was also reported in a given crash is low. However, analyses of likelihood ratios of other UDAs occurring with speeding found excessive speed to be related to improper lane use, improper passing, driving the wrong way, driving left of center, driver inattention, and alcohol/drug involvement. We found little evidence to support the development or implementation of *significant* new strategies for deploying enforcement personnel or targeting and observing unsafe driving actions that contribute to crashes. We did find evidence to support continuing efforts for enforcing speed laws. In addition, we found evidence to support enhancing speed enforcement efforts on road segments with an uphill or downhill grade or curved road segments by having officers also be alert for drivers who may be exhibiting general improper lane use or specifically, vehicles driving left of center.

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# CONTENTS

# LIST OF TABLES

# 1 REVIEW OF THE LITERATURE

## 1.1 Crash Causation

### *1.1.1 Behaviors and unsafe driving acts related to crash causation*

Hazardous driving behaviors have been consistently identified as a major cause of traffic crashes. Among the unsafe driving acts (UDAs) most closely examined and regulated is excessive driving speed. However, unsafe driving acts have generally been examined independently of each other. That is, the extent to which speed, following too closely, turning into oncoming traffic, or other unsafe acts are related to the incidence of vehicle crash have been examined without considering how these unsafe driving acts are related.

Lohman, Leggett, Stewart, and Campbell (1976) examined the relative risk of vehicle crash associated with the commission of various unsafe driving acts. These researchers examined data from vehicle crash reports and traffic citations to determine the frequency of various unsafe acts and violations. These frequencies were then combined using Bayes formula to calculate relative risk of crash given the occurrence of a particular unsafe driving act. These analyses showed that turning in front of oncoming traffic was the riskiest behavior, followed by pulling in front of oncoming traffic, following too closely, running a traffic control, driving left of center, and speeding.

Lohman et. al. point out that enforcement efforts to reduce unsafe driving acts should be based not only on absolute risk of a crash given a particular unsafe act, but also the frequency with which the act is committed. Before enforcement efforts are implemented we must consider whether it is more desirable to focus resources on attempting to attack the unsafe act that produces the most crashes in terms of absolute number or to attack an unsafe act which is relatively rare but extremely risky.

Building on the work of Lohman et al. (1976), Joscelyn and Jones (1980) examined enforcement procedures directed at violations of laws related to three unsafe driving actions (i.e., speeding, following too closely, and driving left of center). Using definitions developed in a concurrent project (Jones, Treat, and Joscelyn, 1981), Joscelyn and Jones reexamined the relative risk of crash for the three unsafe acts identified. Results of these new analyses differed somewhat from those conducted by Lohman et al.

As described in Joscelyn and Jones (1980), a speed-related unsafe driving act occurs when a vehicle is travelling above or below an appropriately established limit, or when a vehicle's speed is less than the fifth percentile speed of traffic or greater than the ninety-fifth percentile speed of traffic. Following-too-closely was defined as occurring when a vehicle follows another at a distance such that the time separation between the two vehicles is so short that the level of crash risk is unacceptably short (defined as time separations of less than one to two seconds). Driving left-of-center was defined to occur when a vehicle crosses the centerline of a two-way road when not passing or turning. The study found following-too-closely UDAs were a causal factor in only about one percent of crashes. Driving-left-of-center UDAs were found to be "moderately prevalent," but for most instances drivers did not act in an unsafe manner consciously or intentionally. The speed-related UDAs were found to be the most prevalent of the three examined with 28% of crashes nationwide being caused at least in part by speed-related UDAs.

A study to identify unsafe driving acts most associated with crashes and to assess the feasibility of observing their frequency in the course of normal driving was conducted by Charlesworth and Cairney (1988) in Australia. The study was carried out in three stages. First, previous studies were reviewed to identify the most common unsafe driving acts. Second, a flow chart for assigning unsafe driving acts was developed and the relative incidence of unsafe driving acts was determined from a representative sample of crashes in Victoria and South Australia. Third, techniques for observing the incidence of unsafe driving acts were piloted. Observations of traffic conflicts at intersections were backed up by video recordings. Also tested was a technique involving observations from a moving vehicle.

Results from the first stage indicate the most frequent unsafe driving acts to be (in decreasing order of frequency): assumed no conflicting traffic movements, failed to see, visual obstruction, distraction, excessive speed, inadequate control, inappropriate evasive action, misjudged speed or position, and pedestrian ran into road. Findings from the second stage were inconclusive due to the inability of coders to extract sufficient information from crash records. Testing of techniques for observation of unsafe driving acts revealed that reliability between manual observation and video was poor. The authors point out that only an in-car observation technique has the capacity to measure whether most of the unsafe driving acts listed on the flow chart occurred. They caution, however, that such obtrusive techniques may influence the driver behavior under study.

Quimby (1988) tested an in-car observation technique to measure the frequency of different unsafe driving acts and assess their relative crash risk. Observed conflicts and seriousness of unsafe driving acts were used to determine relative crash risk in the absence of observed crashes in the study. Unsafe driving acts and conflicts were rated by observers as slight or serious based on perceived likelihood of causing a crash. Three unsafe driving acts made up over half of all such acts observed: (1) following too closely (20.5%), (2) positioning while turning (which occurred when turning at an intersection and included pulling out too far when waiting to emerge and being too far to left or right when turning; 17.4%), and (3) too fast for conditions (16.3%). However, the latter two acts (positioning while turning and driving too fast for conditions), while relatively frequent, were more likely to be rated as slight and resulted in relatively few conflicts. In contrast, unsafe acts involving the acceptance of gaps in conflicting streams of traffic (such as emerging or turning across approaching traffic) while not very frequent, comprised a high proportion of those acts judged to be serious or to result in conflicts and were responsible for over three quarters of all the serious conflicts observed.

The relationship between following headway in high flow freeway traffic and crash involvement was the focus of a study by Evans and Wasielewski (1982). The authors observed following headway (defined as time interval between a vehicle and the preceding vehicle in the same lane) and obtained records of crash involvement and traffic violations of drivers through photographs of license plates of observed vehicles. Crash involved drivers were more likely to follow with short headways (less than 1 second) than crash free drivers. A similar effect was found in comparing drivers with and without traffic violations. The authors interpret following headway as a measure of driver risk and conclude that crash involved drivers and traffic violators exhibit higher levels of risk in everyday driving than crash free and violation free drivers.

Risser (1985) used traffic conflicts rather than traffic crashes to examine differences in driver behavior. He defined a traffic conflict as "an observable event which would end in an accident unless one of the involved parties slows down, changes his direction, or accelerates to avoid a collision" (p. 180) and hypothesized that conflicts are the result of definable errors in driving behavior, the result of poor communication, and are the pre-stages of crashes. To identify typical errors leading to frequent traffic conflicts, Risser observed 201 subjects driving along a standardized route. Information about past crash involvement was based on self-reports by the subjects and insurance company data. The author found a statistically significant relationship between driving errors and traffic conflicts. Further, the sum of errors, independent of their type, was significantly related to both conflicts and self-reported crash involvement. However, only two specific types of errors, badly adapted speed and too short following distance, appeared to be pre-stages of both traffic conflicts and self-reported crash involvement. Speeding, risky passing maneuvers, and unlawful behavior at traffic signals showed statistically significant relationships with self-reported crash involvement but not traffic conflicts. Other errors were associated with conflicts but not crash involvement (late, hesitant, or risky lane changing, cutting curves or corners, taking others' right-of-way, jerky steering, inadequate lateral distance, absence of precaution at intersection, and insisting on one's own right-of-way).

Several studies have focused on driving behavior associated with overtaking. Hauer (1971) began with the thesis that overtakings and crashes on rural roads between intersections are related, that a driver's traveling speed determines the total number of overtakings he will experience during a trip of fixed length, and consequently, that the probability of crash is closely related to the rate at which overtakings occur. According to Hauer's theory, the probability of a crash is smallest when a driver travels close to the median speed on a given road.

Hauer's proposed relationship between overtaking and crash involvement is supported by findings of Kemper, Huntington, and Byington (1972). The authors make a distinction between overtaking (defined as when a vehicle comes up behind a slower moving lead vehicle) and passing (defined as when the following vehicle goes around the slower moving vehicle). Based on examination of 182 crashes occurring in one year on 35 miles of two-lane rural highway in Virginia, the authors concluded that 43% of all crashes on rural two-lane highways involve overtaking and passing maneuvers (23% and 20%, respectively).

Summala (1980) examined the effect of prohibiting overtaking on safety margins. Overtaking was temporarily prohibited on a busy stretch of highway and the time headway for every vehicle passing the site in a certain direction was measured at two points between within the prohibited overtaking area. The lateral position of each vehicle was also recorded. Findings suggest that temporary prohibition of overtaking does have some favorable effects on safety margins. The author concludes that waiting for the opportunity to pass increases crash risk by inducing short following distances and driving near the center line.

Results of on-the-scene investigations of 22 crashes using a multidisciplinary team approach to identify human, vehicular, and environmental factors contributing to crash initiation were described by Wright (1972). Two or more causative factors were identified in 20 of the 22 crashes and three or more were identified in six crashes. Human factors comprised the majority of the contributing factors identified (63%); most of these were driving errors. Most common were inattention to the driving task and improper reaction. Failure to exercise due caution and excessive speed were also common contributing factors but appeared less frequently.

Beckett, Shea, and Brenton (1985) found the role of human factors in crash causation to be more limited. The authors examined police reported crash data in Newfoundland, focussing solely on human factors associated with traffic crashes and concluded that human factors contributed to only 37% of crashes. However, human factors played an increasingly important role as the severity of the crash increased; human factors contributed to 36% of property damage only, 42% of personal injury, and 63% of fatal crashes. Similar to Wright (1972), driver inattention was the most frequently identified human factor contributing to crashes overall (31%). The authors did not examine the effect of specific unsafe driver acts such as excessive speed.

Studies of unsafe driving acts have generally concentrated on a single act (such as speeding) or have examined several acts independent of one another. Little information is available about how these unsafe driving acts relate to each other, the driving environment, and crash involvement. Comparisons across studies are complicated because of differing definitions of the unsafe driving acts and methods used to measure them. Finally, the ability to examine relationships between unsafe driving acts and crash involvement has been limited in experimental studies by the relative absence of crashes, while analyses of crash records often have not yielded enough detailed information to reach meaningful conclusions.

### *1.1.2 Effects of driver characteristics on crash causation*

Several researchers have attempted to identify the effect of driver characteristics on specific unsafe driving acts rather than overall crash involvement. Summala, Näätänen, and Väisänen (1984) conducted a study in Finland to determine to what extent a single deviant driving speed (either faster or slower than the average of the traffic flow) represented drivers' usual speed choice and whether such deviant drivers differed from other drivers. Drivers were categorized as fast (at least 10km/h faster than the mean speed), median, or slow (at least 10km/h slower than the mean speed) based on radar measurement and interviewed at the roadside to determine driver, trip, and vehicle characteristics. Information about drivers' previous driving convictions was obtained later from driver records. The authors found that a single speed observation, particularly for those driving at high speed, strongly correlates with the drivers' former speeding convictions and can be used to predict future convictions. They identified a "fast driver type" who drives frequently (often professionally), takes long trips, and has difficulties in conforming to speed limits when time savings are possible. They found that safety does not weigh much in the trade-off between time and safety.

Rothengatter and de Bruin (1988) used radar, license plate observations, and questionnaire survey methods to examine the effects of drivers' attitudes and vehicle characteristics on speed choice in the Netherlands. They found that four motivational factors satisfactorily predict speed choice on highways: pleasure of driving, risk, travel costs, and travel time. Vehicle performance affected perceived pleasure while driving, but not perceived risk from speeding. While vehicle characteristics (such as top speed) correlated with registered speed, they did not add to the prediction of speed choice over the four motivational factors. Finally, speed choice was not significantly affected by age, sex, years of driving experience, or level of education.

Speeding behavior of drivers was also examined by Hirsh (1986). Drivers in Israel were interviewed before entering a freeway and vehicle speeds were later measured by observers using radar. A disaggregate analysis of drivers' speeding behavior identified several factors significantly affecting speed choice including vehicle characteristics (vehicle age and engine volume), trip characteristics (trip purpose and number of passengers) and vehicle ownership. Drivers' speeding records and other characteristics such as age and education were not found to significantly affect speed choice.

Marks, McNair, Jones, and Joscelyn (1982) developed and tested procedures to identify drivers' motivations for committing four unsafe driving acts (speeding, following too closely, running a stop sign, and pulling in front of/turning left in front of traffic). Results of the test program supported the feasibility of using roadside survey methods to collect information about such motivations. According to subjects in the test program, motivating factors for speeding included driver-related factors (e.g., perception of enforcement, mood, alcohol use), vehicle-related factors (e.g., type and condition of car), and roadway-related factors (e.g., road localities and conditions). Motivating factors for following too closely and running a stop sign included driver-related factors (e.g., distractions, mood, presence of passengers) and roadway-related factors (e.g., traffic flow). The unsafe driving act of pulling in front of/turning left in front of traffic was only affected by roadway factors (e.g., knowledge of past crashes, weather conditions, visibility).

McDonald (1977) examined characteristics and crash producing errors of crash and traffic violation prone drivers. Analyzing data from the "Tri-level Study of the Causes of Traffic Accidents" (Institute for Research in Public Safety, 1974), crash and traffic conviction repeaters and nonrepeaters were compared on the basis of driver characteristics and 23 different causes attributable to either the driver, vehicle, or environment. Both crash repeaters and traffic conviction repeaters were more frequently young (20-24), male, single, and attended but did not graduate from college than nonrepeaters. Crash repeaters caused crashes more frequently because of improper evasive actions compared to noncrash repeaters, while traffic conviction repeaters caused more crashes more frequently due to excessive speed or alcohol impairment compared to nonconviction repeaters. Both groups of repeaters were more frequently exposed to crash risk, however, which may explain these effects. Finally, nonrepeaters were as likely as repeaters to be considered the cause of the crash.

## 1.2 Countermeasures to Reduce Crashes

Traynor, Searcy, and Tarrants (1982) examined effectiveness and efficiencies of police traffic services. Police services include training, management, selective enforcement, accident investigations, hazardous condition control, planning, and evaluation intended to reduce motor vehicle crashes and the injuries associated with those crashes. The authors group police traffic service programs into four areas: (1) programs proven to be effective, (2) programs with a significant potential for reducing crashes, (3) those which have an efficiency increasing or cost reducing potential for reducing crashes, and (4) those which appear to justify consideration for future funding. Selective enforcement programs are considered foremost among programs proven to be effective. Selective enforcement refers to enforcement programs proportional to traffic accidents with respect to time and place, with heaviest emphasis on crash-related violations. Selective enforcement focuses on three classes of unlawful driving behavior including speeding, driving under the influence of alcohol or drugs, and other unsafe driving acts.

In selective speed enforcement programs, crash data are used to identify sections of roadway, days of the week, and times of day during which speed is a primary contributing factor to crashes. Police enforcement activity (involving either normal or special patrols) is then targeted to those areas and times identified as having speed-related problems. Special patrols, in which personnel are assigned full-time to speed enforcement on the identified problem section of roadway, increase motorists' perceived risk of apprehension, thereby reducing the number of vehicles exceeding the speed limit and reducing the crash potential.

Selective enforcement efforts aimed at reducing other unsafe driving acts are similar to speed enforcement programs. Unsafe driving acts identified by the authors in descending order of frequency include following too closely, making unsafe entry into traffic flow, backing into traffic, turning in front of oncoming traffic, driving too fast for traffic or weather conditions, running a stop sign or light, changing lanes or merging in front of traffic, driving to the left of the center line or on the center line, turning too widely or sharply, and passing improperly. The authors note that unsafe driving acts (not including speed-related UDAs) are causally related to 58% of all crashes and 37% of fatal crashes.

The authors provide examples of several effective selective enforcement programs with clearly demonstrated impacts on crashes. They conclude that selective enforcement is clearly effective in reducing crashes and associated injuries. Speed enforcement, in particular, is considered one of the single most effective safety measured ever implemented.

In a later work, Tarrant (1984) summarized several selective enforcement projects judged to be noteworthy by NHTSA in terms of their contribution to traffic safety. Most focused on hazardous moving violations. All involved increased enforcement activities targeted at high crash sites combined with public information and education efforts. All resulted in significant increases in enforcement activity as measured by citations issued and reductions in total crashes and/or injury crashes. Tarrants notes that results from most other selective traffic enforcement programs have shown similar significant improvements. He concludes that there is substantial evidence that such programs are highly cost-beneficial and have the potential for significantly reducing motor vehicle injuries and fatalities in high crash locations.

A manual for developing and implementing selective traffic enforcement programs was prepared by Franey, Darwick, and Roberson (1972). They identified key elements of selective enforcement as the traffic crash data base, traffic crash analysis, training for selective enforcement, and technical implementation. Technical implementation consists of selection and training of personnel, enforcement techniques, assignment techniques, use of traffic crash analysis, and evaluation of selective enforcement efforts. In discussing specific enforcement techniques, the authors point out that traffic patrol for selective enforcement should be active and visible. Active and visible patrol results in better supervision of traffic and an increased deterrent effect, due to greater area coverage. Maintenance of visible patrol during peak crash periods leads to reductions in both crash-causing violations and crashes.

Joscelyn and Jones (1980) studied police enforcement strategies for unsafe driving acts, identifying four functional areas of police traffic services including deployment, surveillance and detection, apprehension, and presanctioning/sanctioning. They emphasize that deployment of police is the first step in the enforcement process. They found that most departments make deployment decisions subjectively, using primarily their own experience which may then be supported by violation and/or crash data. When more formal deployment methods were used, usually some form of selective enforcement scheme was employed.

As part of the study of enforcement strategies described above, Jones, Marks, Ruschmann, Bennett, Fennessy, Joscelyn, and Komoroske (1980) reviewed the literature on police enforcement procedures for speeding, following too closely, and driving left of center. They found no pertinent literature for driving left of center and only one document specifically for following too closely. However, they identified several distinctions between enforcement of speed laws and laws related to following too closely and driving left of center. Speed law enforcement is generally characterized by specific resource allocation strategies, specially designed measurement devices, targeting of efforts to specific locations and times associated with high crash experience, issuance of traffic tickets to non-crash-involved as well as crash-involved drivers, and proactive activities involving the use of both general and special deterrence strategies. Enforcement of laws related to following too closely and driving left of center tends to be carried out as part of the general police traffic function. Officers on routine patrol may observe such violations and take enforcement action at their own discretion. Enforcement of laws related to following too closely and driving left of center is characterized by issuance of tickets following a crash, reactive actions occurring as part of a crash investigation, and almost total reliance on special deterrence strategies.

The authors conclude that: (1) overt police presence has a clearly demonstrated effect on traffic flow behavior, (2) effects of other enforcement procedures on reducing unsafe driving acts and crash incidence have not been objectively established, (3) enforcement strategies are limited by constraints imposed by the criminal law system, resulting in a labor-intensive approach to enforcement, (4) existing police personnel levels are insufficient to achieve large effects on traffic behavior, (5) driver perceptions of risk of apprehension are more important than actual enforcement efforts in shaping driver behavior, although over time perception will more accurately reflect reality, and (6) general deterrence is apparently preferred by police over special deterrence. Special deterrence is generally used only enough to create a credible perception of enforcement.

Shinar and McKnight (1985) also point to the importance of drivers' perceived risk of apprehension in effective enforcement of traffic laws. They reviewed strategies for achieving compliance with traffic laws and present several conclusions regarding perceived risk of apprehension: (1) perceived risk requires a minimum level of objective risk, (2) enforcement units must be highly visible, (3) visible enforcement must appear threatening, (4) uncertainty can extend the range of perceived risk, (5) and enforcement efforts must be publicized. The authors note a number of factors which influence enforcement strategies including cost/benefit, cost constraints, equipment, roadway environment, traffic density, other environmental constraints such as heavy fog, dense traffic, and darkness, and manpower availability. Finally, they emphasize the need to further study strategies aimed at achieving higher compliance with traffic laws through increased risk of apprehension which combine public information and enforcement.

A review of literature on police traffic law enforcement by Armour (1984) indicated that enforcement can result in reduced incidence of traffic crashes, given the right circumstances and correct type of site. Selective enforcement appeared more effective than a general increase in enforcement. In examining effects on driver behavior, the author found evidence that the presence of an enforcement vehicle will reduce driving speeds and that these lowered speeds can be maintained for some time after vehicles have passed the enforcement vehicle. A memory effect may also be produced by such concentrated enforcement. The author cautions that the possibility of a memory effect has only been demonstrated in highway situations.

To assess the effect of police presence on urban driving speeds, a field study was conducted in New South Wales (Armour, 1986). Findings from the study indicate that the presence of an enforcement vehicle on an urban road may reduce the number of vehicles exceeding the speed limit by approximately two-thirds. A memory effect lasting at least two days after the police presence was removed was also found. The author notes, however, that drivers returned to their normal driving behavior very soon after passing the enforcement vehicle, indicating that enforcement may be most suitable for treating particular problem sites.

Jones, Treat, and Joscelyn (1981) concentrated on speed-too-fast unsafe driving acts in developing countermeasure programs. Using a risk management framework (which attempts to balance the utilities and disutilities drivers' associate with unsafe driving acts), they present a number of countermeasure elements which potentially can reduce speed-too-fast UDAs. These elements are then incorporated into three recommended countermeasure programs including increased enforcement and punitive sanctions, automatic detection devices with civil-law sanctions, and on-board detection and warning of speed-related unsafe driving acts. The authors caution that considerable design work would be necessary before these programs could be implemented. However, the programs do offer a point of departure for developing more specialized programs.

Successful implementation of countermeasures to reduce crashes and associated injuries depends on public acceptability as well as technical efficiency. Vayda and Crespi (1981) assessed public attitudes toward proposed highway safety countermeasures using focus group, questionnaire survey, and key-informant interview methods. Conventional speed detection measures ranked fairly high in acceptability. Radar was most widely favored (70%), followed by speedometer method (66%) and Vascar (63%). Use of automatic speed enforcement received less support (40%).

Understanding relationships between unsafe driving acts themselves as well as characteristics of the driving environment is important for developing enforcement strategies to reduce crashes resulting from speeding and other unsafe driving acts. Unfortunately, there is little information available describing relationships between unsafe driving acts and subsequent crash involvement. Given the extent to which speed-related UDAs contribute to crash involvement, it would be extremely valuable to understand the relationship between speed-related UDAs and other unsafe driving acts such as following to closely or running through a traffic control device. If these relationships can be determined, it may be possible to create countermeasure strategies to deter multiple unsafe driving acts which may be committed together or in some regular sequence.

If enforcement activities are focused on times and places where speeding and other unsafe driving acts are commonly associated with each other, the probability of detecting at least one of these behaviors is increased. Police could better allocate resources by targeting enforcement activities to identified problem areas and times. In addition, the deterrence value of police enforcement is increased as the perceived probability of apprehension increases. To achieve these ends, we investigated the relationship between speed and other unsafe driving acts as precursors to motor vehicle crash.

# 2 METHODS

The objective of this project is to support the development of effective enforcement strategies to reduce crashes resulting from speeding and other unsafe driving acts associated with speeding. This objective is achieved in two ways: (1) determining relationships between speeding and other unsafe driving acts, and (2) suggesting more effective enforcement strategies based on these relationships.

## 2.1 Data Collection

Several census and statistically sampled vehicle crash databases were considered for assessing relationships between speeding and other unsafe driving actions. From UMTRI's Data Center, several state census files are available including Michigan, Texas, Missouri, and Washington, as well as federally sponsored databases including Fatal Accident Reporting System (FARS), National Accident Sampling Survey (NASS), and the six state CARDFile. The Computing Center at the National Institute of Health (NIH) in Bethesda, Maryland, houses NHTSA's state data program. The remaining source of vehicle crash data is directly soliciting candidate state's computerized Police Accident Reports (PARS).

When identifying candidate data sources, is important to consider not only the content of the data (i.e., are the data necessary to perform the desired analyses available), but also the quality and representativeness of the data. Conducting analyses on databases which are exclusive (e.g., including crashes of a particular type or severity) limit the general applicability of the findings. The FARS database was not chosen for the analyses because it includes only fatal crashes.

The minimum criterion for considering a dataset for inclusion in this project database was the availability of multiple unsafe driving codes for each crash-involved traffic unit. It was also desirable that unsafe driving codes be recorded according to their temporal sequence. The CARDFile developed under the auspices of NHTSA was not selected for use in the analyses because of the absence of multiple driver error (unsafe driving action) codes necessary for the analyses.

Data from the NHTSA state data program were chosen as the resource for the project database to be used for the analyses. The list of candidate states overlap the states maintained by UMTRI providing a reliable backup to NHTSA's data sets. Elements crucial to the analyses are present in the NASS data set, though the unsafe driving acts are not necessarily recorded sequentially. Data from candidate states in NHTSA's state data program are also not necessarily recorded sequentially, but the large sample size and ease of analyses using a census of crash data from several states was deemed to be preferable to the relatively small sample size and complex statistical survey of NASS.

There are 26 states which are included in the NHTSA state data program. Data from each state's PAR are typically coded into a state-based computing system and then sent to NHTSA's Mathematical Analysis Division. This group converts the state data, which can include several files for a given year (e.g., accident, vehicle, occupant levels), to SAS (Statistical Analysis System) format using the NIH Computing Center where the SAS data files are maintained. The NIH Computing Center WYLBUR operating system was used for accessing the NHTSA maintained data.

Every participating state's inventory file was extracted and reviewed. For a given state, each file for the most recent year available was noted and a SAS PROC CONTENTS run to obtain the variable listing for that particular file. From this, thirteen candidate states were selected as having all or most of the pertinent elements needed for analyses: Arizona, Florida, Kansas, Maryland, Minnesota, Missouri, New Mexico, Ohio, Pennsylvania, Tennessee, Texas, Utah, and Washington. It was thought this candidate list did not adequately represent the northeastern and southern states. States not available in the NHTSA state data program were contacted and queried about the contents and availability of their computerized PARS databases. Of all those contacted, only Vermont proved to have the necessary elements for inclusion in the analyses and was willing to make the data available for our use. A data tape and documentation materials were mailed upon request.

For proper interpretation of the states' datasets, codebooks which describe all elements within the datasets were obtained for each selected state. PAR forms were obtained for those states whose data codebooks inadequately described the data elements. All of the states along with the variables present in the NHTSA state files are presented in Table 2.1.

| Table 2.1: Variable Availability by State | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | AZ | FL | KS | MD | MN | MO | NM | OH | PA | TN | TX | UT | WA |
| Road class | X | X | X | X | X | X | X | X | X | X | X | | X |
| Number of lanes | X | X | X | | X | | X | | X | X | | | |
| Report type | X | | X | | X | | X | X | X | X | X | X | X |
| Intersection related | X | X | X | X | X | | X | X | X | X | X | | X |
| Locality | X | | | X | | | | | | X | | X | |
| Vehicle defects | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Vehicle type | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Road alignment | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Road grade | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Alcohol contributing | X | X | X | X | X | | X | X | X | X | X | X | X |
| Speed: Posted | X | X | X | X | X | X | | X | X | X | | X | |
| Vehicle | X | X | X | | | | | X | X | | | X | X |
| Safe | X | | | | | | | | | | | | |
| Unsafe Driving Acts | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Citation | | X | | X | | | | | | | | X | |
| Hour | X | X | X | X | | X | X | X | X | X | X | X | X |
| Day of week | X | X | X | X | X | X | X | X | X | X | X | X | X |

The code values for each variable were listed for each state. A uniform coding was derived for every element (state by element recodes will be made available upon request). Some univariate runs demonstrated the presence of spurious codes for variables. In one case, a query to the Mathematical Analysis Division resulted in the necessity for a rebuild of the Florida driver level data set to correct a variable in the SAS file. Other coding problems were resolved by direct contact with the group within a state's department responsible for maintaining the crash data.

Most variable values could be easily recoded one-for-one. For example, Tennessee coded "improper passing" as "03" which was recoded for the 11-state dataset to "improper passing" coded "13." Most states also had some idiosyncratic codes which had no equivalents in other states. These idiosyncratic codes were generally combined in a single "other" category. In the case of unsafe driving act variables (often categorized by states as contributing circumstances), some states included not only driver behaviors but also vehicle and road defects which may have contributed to the crash. The unsafe driving act variable had categories to capture both contributing circumstances "other than driver behavior" as well as idiosyncratic "other driver behavior" codes. While specific definitions of some variable values differed slightly from state-to-state, values were recoded based on their similarity to the group of values at large. Citation recodes were generated by categorizing specific violations according to their more general unsafe driving act equivalents.

Coding missing data and data with undefined values presented an interesting challenge. Most data elements had "true" missing data codes present in the original data. Also available for many variables were values for "unknown." Because some states did not have a given variable we generated a new value "not available." There were also many invalid codes scattered throughout the original data for which no valid value exists. For these cases, the variable was coded as "not available" so these data would not be confused with true unknown or missing codes.

Job Control Language (JCL) and SAS commands were written up for building the files with the variables of interest for transfer to magnetic computer tape using the proper coding information, PROC CONTENTS results, and univariate runs. As a requirement of the NIH Computing Facility, NIH system tapes were requested for the project's computer account. All of the states' necessary datasets were built onto these tapes, one state per tape. In one case, a system tape was incorrectly labeled and the build had to be resubmitted when the Computing Center error was corrected. Special (non-NIH tapes) were submitted to copy the datasets built at NIH onto tapes to be used at the University of Michigan (UM) computing facility. The NIH Computing Center assisted by mailing the completed non-NIH tapes back to Ann Arbor. The Output Distribution Services of the NIH Computing Facility were exemplary in their service and turnaround on mailing requests.

Upon receipt from NIH, the data tapes were submitted for use on the UM computing system. As a point of verification, the Michigan Terminal System (MTS) *LABELSNIFF facility was used to check on the label contents and data files on the tapes. This allowed for confirmation of the dataset names used in the NIH builds as well as the output format and record count. The first 100 records from each data set were printed for verification and programming purposes. SAS will generally right align output, but in some cases variables appeared to be left aligned (e.g., the citation variable for Utah). Since FORTRAN was used for the next database build, column specific placement of the variables was essential. The 100 records listing was sufficient to discern the proper placement of variables.

The Vermont tape was also submitted for use on MTS. It was apparent from the *LABELSNIFF results that the tape's format was not standard and the records listing revealed the data unreadable in a strict ASCII format. Further contact was made with the appropriate staff in Vermont, another tape sent, as well as the proper codebook (the one sent initially was for keypunching purposes and different from the final computerized version). The data fields in questionable format were found to be in a COBOL packed decimal format. Programming resource allocations necessary to decode the Vermont tape were so high that Vermont had to be dropped from the candidate state list. Given the relatively small contribution of this state to the overall sample size, the loss in explanatory power by dropping this state was not great.

System subroutines, ADAAS (Automated Data Access and Analysis System) developed blocked tape and field translation routines, and FORTRAN routines were used to build a vehicle level dataset for each state with a uniform format across all states. The code used to build the individual state vehicle level file would have to account for missing records on each of the file levels it was merging. ADAAS was used for data management and analysis because it is capable of handling multiple files across multiple tapes as **one** dataset.

Pennsylvania and New Mexico had serious problems with their datasets. Specifically, there were discrepancies between the number of records available and the expected number of records in the different file levels for each state. The problems with the data from these two states prohibited an accurate merge of data from different dataset levels using the data as originally coded. Because of the relatively high cost in cpu time and staff hours required for the necessary rebuilds of those two state's data, these states were not included in the final dataset. Similar problems were found for Texas and Washington. However, because these databases are maintained at UMTRI, the problems were easily overcome using the UMTRI datasets and the states were retained. The total number of cases (one traffic unit per case) included for each state in the analyses dataset are provided in Table 2.2.

| Table 2.2: Number of Cases for the Analysis Data Set by State | | |
|---|---|---|
| State | Year of Data | Number of Cases |
| Arizona | 1986 | 189,066 |
| Florida | 1987 | 517,980 |
| Kansas | 1988 | 110,535 |
| Maryland | 1988 | 215,680 |
| Missouri | 1987 | 314,153 |
| Minnesota | 1988 | 189,880 |
| Ohio | 1988 | 703,920 |
| Tennessee | 1987 | 174,128 |
| Texas | 1988 | 705,268 |
| Utah | 1988 | 76,885 |
| Washington | 1988 | 223,763 |
| TOTAL | | 3,421,258 |

## 2.2 Data Analysis

Data analysis strategies were developed to answer the three central research questions for the project. Each question presented its own unique challenges and the analysis plan is presented in the following subsections by research question.

### *2.2.1 What proportion of unsafe driving acts occur by themselves and what proportion occur with speeding?*

The solution to this research question was divided into several portions. We wanted to determine: (1) the proportion of crash-involved traffic units (cases) in which an unsafe driving act was coded as having contributed to the crash, (2) the proportion of cases where only one unsafe driving act was coded to have contributed to the crash (overall and broken down by unsafe driving act), and (3) the proportion of cases where an unsafe driving act other than speeding was recorded as contributing to the crash given speeding was also recorded as contributing (overall and broken down by unsafe driving act).

The answers to these research questions were provided by generating several one-way and two-way frequency tables of the unsafe driving act variables applying ADAAS programming to the 11-state dataset. After establishing the total number of cases in the complete dataset, we filtered out those cases in which an unsafe driving act was coded in only one of the seven unsafe driving act variables available for analysis. In a separate analysis we filtered cases based on the occurrence of speed as one of the unsafe driving acts, and generated two-way tables of these cases to obtain data on the frequency with which speed and other unsafe driving acts were coded together.

### *2.2.2 For those unsafe driving acts which occur with speeding, is there a pattern in the sequence in which the acts occur?*

At this point we should note some of the strengths and weaknesses of these data for addressing the questions posed for this contract. One strength is that the data represent a geographically diverse group of locations with similarly diverse driving environments. Thus, information is available which is reasonably representative of the U.S. as a whole. A second strength of the data is that they are gathered from crash reports, allowing us to analyze driving acts which have been reported to have contributed to each crash. Each crash involved traffic unit was coded as a single case along with the pertinent data for that case. Thus, unsafe driving acts and other crash relevant data are available for each traffic unit at the case level.

Unfortunately, the strength of having data collected from crash reports also contributes to the most significant weakness of the data. Because these data are taken from crash reports, they are the subjective impressions of crashes generated after the fact by the individual who completed the report (usually the police officer who responded to the crash). To identify what actions may have contributed to each crash, officers have to rely on observations of the post-crash scene, their personal and professional experiences, as well as the unsworn testimony of the involved parties and other witnesses. Clearly there are many shortcomings to data collected in such a manner. Even in cases where the post-crash scene remains unchanged from the time of the crash to the time the officer arrives at the scene, the physical evidence available may provide conflicting or ambiguous information about events which led to the crash. Crash involved individuals may not be fully forthcoming with information about events immediately prior to a crash. They may be motivated by a need to avoid blame or they may simply not be able to clearly recall events immediately prior to a crash. Witnesses are generally not attending to each of the crash participants' actions as interested or trained observers, but are only bystanders who report those actions which they happened to see and recall. Also, officers differ in their levels of skill and training in crash investigation. The majority of officers have little detailed training in crash investigation. The most significant weakness of the data is that it is gathered after a crash has occurred, and thus it is only speculation as to what specific behaviors the crash-involved individuals may have been performing prior to a crash (regardless of source of the speculation).

Although there may be spaces available on a crash form for multiple unsafe driver actions which may contribute to a crash, officers may decide to record only the action they believe was most responsible for the crash or they may omit factors which they believe may have contributed to the crash but do not have sufficient evidence to include in their report. Often officers record UDAs according to the officer's judgement of the UDA's relative contribution to the crash (e.g., code the most proximal cause first, etc.). Contributing factors may be recorded in their order according to their perceived causal sequence, however such coding would be post-hoc speculation on the part of the reporting officer. In addition, some states (e.g., Texas) have a predetermined hierarchy of UDAs on the crash form eliminating the possibility of determining a causal sequence from the order of UDAs reported on the form. Because of the speculative and post-hoc nature of the data, assessing true *causal* relationships between speed, other unsafe driving acts, and crash involvement is not possible from crash data. Instead we must rely on assessing the probabilities of various unsafe driving acts being recorded with speed in crash reports.

We examined the relationships between speed and other unsafe driving acts reported in crash data in two ways. First, we assessed the conditional probability of a given unsafe driving act being reported given speed was also reported as a contributing factor for crashes. By applying Bayes' Theorem we calculate these conditional probabilities using the formula:

$$P(UDA|Speed) = \frac{P(Speed|UDA) * P(UDA)}{P(Speed)}$$

The value P(Speed|UDA) is the probability that speed was reported as a contributing factor given a specific UDA was also reported (calculated by dividing the number of cases where speed and the specific unsafe driving act were coded together by the total number of cases). P(UDA) is the overall probability of the specific UDA being reported as a contributing factor (calculated by dividing the number of cases where the specific unsafe driving act was reported by the total number of cases). P(Speed) is the overall probability that speed was reported as a contributing factor (calculated by dividing the number of cases where speeding was reported by the total number of cases).

Second, we assessed the likelihood ratio of a given unsafe driving act being recorded with speed. This likelihood ratio is the probability of speeding being recorded when a specific unsafe driving act was recorded divided by the probability of speeding being recorded if the specific unsafe driving act was not recorded. The larger the likelihood ratio the greater the association is between the unsafe driving act and speed relative to the absence of the given UDA. The formula for calculating the likelihood ratio is:

$$\frac{P(\text{Speed}|\text{UDA}) * P(\text{n-Speed})}{P(\text{n-Speed}|\text{UDA}) * P(\text{Speed})}$$

The value P(Speed|UDA) is the probability that speed was reported as a contributing factor given a specific UDA was also reported (calculated by dividing the number of cases where speed and the specific unsafe driving act were coded together by the total number of cases). P(n-speed) is the overall probability that speed was not reported as a contributing factor (calculated by subtracting the number of cases where speeding was recorded from the total number of cases and dividing the result by the total number of cases). P(n-speed|UDA) is the probability that speed was not reported as a contributing factor given a specific UDA was reported (calculated by subtracting the number of cases where speeding and the specific UDA were reported together from the total number of cases where the specific UDA was reported and dividing the result by the total number of cases). P(Speed) is the overall probability that speed was reported as a contributing factor (calculated by dividing the number of cases where speed was reported by the total number of cases).

### 2.2.3 *Are there specific characteristics identified with unsafe driving acts related to speeding which would allow enforcement personnel to apprehend speeding violators in a more effective way?*

The analyses conducted to answer this question were one-way ADAAS frequency tables of the following characteristics: (1) day of week, (2) time of day, (3) road class, (4) number of lanes, (5) relationship of the crash to an intersection, (6) road curvature, and (7) road grade. For the purpose of comparison, separate analyses were conducted for all crashes, crashes where speeding was identified as the sole unsafe driving act, and the unsafe driving act-speeding pairs identified in the probability analyses.

# 3 RESULTS

A codebook describing the univariate frequencies for each variable contained in the 11-state dataset can be found in the appendix. Results of the analyses designed to answer each of the specific research questions posed in this contract are detailed in the following sections.

## 3.1 Distribution of Unsafe Driving Acts

The 11-state data set had a total of 3,421,258 total crash-involved traffic units available for analysis. Of these cases, 1,905,179 had at least one unsafe driving act (UDA) recorded (55.7%), and 1,512,904 had only one UDA recorded (44.2%, see Table 3.1). Only 392,275 of all cases had more than one UDA recorded (11.5%).

We examined the first and second unsafe driving acts coded for each case to determine which unsafe driving acts were associated with speed.[1] Speed was coded as a contributing factor to a vehicle's involvement in a crash in 337,440 of the cases (9.9%). A second UDA was coded in addition to speeding in 103,300 of the cases in which speed was coded (3.0% of all cases, 30.6% of cases where speed was also coded, see Table 3.2).

We also examined data in the three states where information was available on moving violations which were issued to crash involved drivers (i.e., Maryland, Florida, and Utah). Of the 810,545 total cases available from these three states, only 173,003 cases had a moving violation recorded (21.3%). Only 15,008 of all the cases had more than one moving violation recorded (1.8%). Of the 22,340 cases where speed was recorded as the first or second moving violation, only 2,119 cases had a second moving violation recorded in addition to the speed violation (9.5%, see Table 3.3). While these proportions are much smaller than those of the UDA contributing factors, this is not unexpected. Officers may be reluctant to issue citations for offenses they did not observe directly or those lacking other direct evidence to support the citation (as would be the case in the majority of crashes). This problem is confounded in cases

[1]The total number of cases with speed as a contributing factor for the third through seventh UDA variables constituted only 0.6% of the total number of speeding UDAs found in the first and second UDA variables. Because of the extremely large data set used in this study, the third through seventh UDA variables were excluded from these analyses because prohibitively high computing costs would have been incurred if they were included.

of possible multiple citations. It is not uncommon for officers to issue only the most serious citation they believe is warranted. The relatively high number of cases where alcohol involvement and speeding were both charged may be due to the detrimental effects intoxication has on driver behavior. In addition, multiple citations support the alcohol impairment charge by providing evidence that a driver's judgement or behavior was impaired as evidenced by the unsafe act, and for this reason police may be more likely to issue additional citations to alcohol offenders.

**Table 3.1: Vehicles with Only One Unsafe Driving Act by UDA**

| Unsafe Driving Act | Frequency | % of single UDA total |
|---|---|---|
| Speed | 256,266 | 16.9 |
| Following too close | 155,845 | 10.3 |
| Improper turn | 45,373 | 3.0 |
| Improper passing | 23,895 | 1.6 |
| Disregard traffic signal | 76,021 | 5.0 |
| Failure to yield | 292,243 | 19.3 |
| Left of center | 18,832 | 1.2 |
| Improper lane change | 22,240 | 1.5 |
| Improper lane use | 23,575 | 1.6 |
| Failure to control vehicle | 43,013 | 2.8 |
| Driver inattention | 99,439 | 6.6 |
| Careless driving | 88,131 | 5.8 |
| Improper backing | 33,375 | 2.2 |
| Wrong way | 3,785 | 0.2 |
| Improper signal | 3,196 | 0.2 |
| Improper lookout | 8,255 | 0.5 |
| Alcohol/drugs | 48,493 | 3.2 |
| Other driver behavior | 270,927 | 17.9 |
| **TOTAL** | **1,512,904** | **100.0** |

**Table 3.2: Vehicles with Speed Coded as a Contributing Factor by UDA**

| Unsafe Driving Act | Frequency | % of Speed UDA Cases |
|---|---|---|
| Following too close | 8,156 | 2.4 |
| Improper turn | 1,244 | 0.4 |
| Improper passing | 2,995 | 0.9 |
| Disobey signal | 3,538 | 1.0 |
| Failure to yield | 3,783 | 1.1 |
| Left of center | 3,320 | 1.0 |
| Improper lane change | 436 | 0.1 |
| Improper lane use | 2,595 | 0.8 |
| Failure to control vehicle | 190 | 0.05 |
| Inattention | 21,770 | 6.4 |
| Careless driving | 5,592 | 1.7 |
| Improper backing | 197 | 0.05 |
| Wrong way | 554 | 0.2 |
| Improper signal | 55 | 0.02 |
| Improper lookout | 443 | 0.1 |
| Alcohol/drugs | 26,176 | 7.8 |
| Other driver behavior | 22,256 | 6.6 |
| **TOTAL** | **103,300** | **30.6** |

| Table 3.3: Vehicles with Speed Cited as a Moving Violation by UDA | | |
|---|---|---|
| Unsafe Driving Act | Frequency | % of Speed UDA Cases |
| Failure to yield | 53 | 0.2 |
| Following too close | 37 | 0.2 |
| Improper turn | 13 | 0.06 |
| Disobey signal | 121 | 0.5 |
| Improper passing | 37 | 0.2 |
| Wrong way | 6 | 0.03 |
| Alcohol (DUI) | 1,278 | 5.7 |
| Reckless driving | 402 | 1.8 |
| Improper lane use | 81 | 0.4 |
| Speed | 91 | 0.4 |
| **TOTAL** | **2,119** | **9.5** |

## 3.2 Relationships between Speeding and Other Unsafe Driving Acts

We examined the relationships between speed and other unsafe driving acts reported in crash data in two ways. First, we assessed the conditional probability of a given unsafe driving act being reported given speed was also reported as a contributing factor for crashes. Second, we assessed the likelihood ratio of a given unsafe driving act being recorded with speed. The larger the likelihood ratio the greater the association is between the unsafe driving act and speed relative to the absence of the given UDA. Table 3.4 provides the frequency with which each unsafe driving act was recorded when speed was also recorded (for the first and second unsafe driver action variables), the total frequency with which each unsafe driving act was recorded, the conditional probability of each unsafe driving act being recorded with speed (P[UDA|Speed]), and the likelihood ratio for each unsafe driving act being recorded with speed.

| Table 3.4: Probabilities of Other Unsafe Driving Acts Reported with Speed | | | | |
|---|---|---|---|---|
| Unsafe Act | # UDA with Speed | # UDA Total | P (UDA\|Speed) | Likelihood Ratio |
| Following too close | 8,156 | 266,738 | 0.00188 | 0.288 |
| Improper turn | 1,244 | 69,256 | 0.0000746 | 0.167 |
| Improper passing | 2,995 | 35,333 | 0.0000917 | 0.846 |
| Disregard signal | 3,538 | 114,491 | 0.000351 | 0.291 |
| Failure to yield | 3,783 | 397,173 | 0.00130 | 0.0879 |
| Left of center | 3,320 | 33,324 | 0.0000958 | 1.0112 |
| Improper lane change | 436 | 33,400 | 0.0000126 | 0.121 |
| Improper lane use | 2,595 | 33,559 | 0.0000754 | 0.766 |
| Failure to control | 190 | 62,638 | 0.0000103 | 0.0278 |
| Driver inattention | 21,770 | 186,022 | 0.00351 | 1.211 |
| Careless driving | 5,592 | 105,068 | 0.000509 | 0.514 |
| Improper backing | 197 | 42,127 | 0.00000719 | 0.0429 |
| Wrong way | 554 | 5,785 | 0.00000278 | 0.968 |
| Improper signal | 55 | 4,476 | 0.000000213 | 0.114 |
| Improper lookout | 443 | 12,097 | 0.00000464 | 0.347 |
| Alcohol/drugs | 26,176 | 81,335 | 0.00184 | 4.337 |
| Other driver behavior | 22,256 | 380,336 | 0.00733 | 0.568 |
| SPEED | 2,590 | 337,440 | 0.000757 | 0.0707 |

It is clear from Table 3.4 that the conditional probability of any specific UDA occurring with speed in a crash is quite small. That is, the probability is very low that speed and a given UDA will occur together for a given crash-involved vehicle. However, six unsafe acts had likelihood ratios approaching or exceeding 1.0 (i.e., improper lane use (.77), improper passing (.85), driving the wrong way (.97), driving left of center (1.01), driver inattention (1.21), and alcohol or drug involvement (4.34)). This result suggests these six UDAs as possible targets for enforcement intervention because their occurrence with speed in crashes is about as likely or more likely than all other UDAs (or the lack thereof) occurring with speed.

We should note, however, that driver inattention may serve as a "catch-all" category for unsafe driving when an officer believes the driver's behavior was somehow deficient but can't pinpoint a specific deficiency. Also, driver inattention may be often given as an excuse for a crash by involved persons (e.g., "I don't know what happened officer. I guess I just wasn't paying attention to what I was doing"). While driver inattention and alcohol or drug involvement are reported as contributing circumstances in many crash reports, it can be safely assumed that some other specific unsafe driving action(s) actually caused the crashes. Inattention and alcohol or drug impairment do not cause crashes, but rather these conditions impair driver decision making and subsequent behavior and it is poor behavior choice not inattention or impairment which are the most proximate cause of crashes. However, it is not possible for enforcement personnel to directly identify individuals who are inattentive or intoxicated. Instead, they must rely on behavioral cues to indicate these driver conditions.

## 3.3 Crash Site Characteristics

Given the conditional probability and likelihood ratio results, we now examine the characteristics of crash sites where speeding and specific unsafe driving acts are most likely to occur so that enforcement efforts can be directed efficiently. To determine when and where enforcement efforts to reduce crashes involving speed and other unsafe driving acts resulting in crashes should be targeted, we examined characteristics of all crashes, crashes involving speed alone, and crashes where speed was associated with improper lane use, improper passing, driving the wrong way, driving left of center, and driver inattention. The speed and other UDA combinations examined are those with likelihood ratios above .75 described in the previous subsection.

While it may be desirable to have these proportions also consider some measure of exposure such as vehicle miles traveled or traffic volume, accurate and specific exposure data for the cells are not available. When considering assigning officers to the field to prevent the greatest number of crashes, it is probably more important to examine the proportion of crashes occurring given a certain characteristic than the rate of these actions per mile travelled. Rate per mile travelled would serve as an indicant of why there are disproportionately high crash frequencies at certain times and locations and would assist in determining areas and times where crash risk is disproportionately high given exposure. However, if the goal is to allocate enforcement resources to affect the greatest number of crashes it may be more productive to assign staff to high crash frequency areas and times than to areas where the risk is greater per mile travelled but the total crash frequencies are low. These types of analysis and allocation decisions have been a perplexing issue for many years and we do not feel they can be easily resolved. Because the central focus of this study is to affect total crash frequencies based on driver actions (rather than to identify risky situations based on exposure), we compare frequency distributions of cases across each crash characteristic and driver action category. Problem times and sites are identified based on the distribution of cases in each category without explicitly calculating exposure rates.

When cases were examined by day of week the crashes occurred, we find few differences in the distributions between overall crash involvement, speed as the sole UDA, and the speed-specific UDA cases (Table 3.5). However, crashes involving speed and other UDAs seem to be more common on weekends (particularly Sunday) than the overall crash distribution. While proportions differed little from the overall crash distribution and the UDA distributions for Friday and Saturday, a high proportion of cases also occurred on these days.

Examinations of crashes by time of day are more complex because of the high number of hourly cells considered (Table 3.6). The "rush" hours of 3:00 p.m. through 6:00 p.m. generally had the highest proportion of crashes. Smaller peaks can also be found around the noon rush. This is particularly true for crashes where speeding was reported with improper lane use. For the speed-improper lane use category, high crash proportions actually extended from 10:00 a.m. through 1:00 p.m. Early morning "rush hour" (7:00 a.m. through 9:00 a.m.) also contributed relatively large proportions of crashes compared to the remaining nonpeak times. Much of these effects are probably due to exposure and crowded traffic conditions existing during these times. A higher proportion of crashes seem to occur during the noon rush than the early morning rush period across all UDA categories.

As expected, the highest proportions of cases were found on streets (Table 3.7). One notable exception was found in cases where speeding was reported with driving left of center. These cases were most prevalent on county roads. The proportion of cases occurring on interstate and interstate loops were highest for cases where speeding was the sole UDA and when speeding was recorded with driver inattention. An unfortunately high proportion of cases where speeding was associated with improper lane use occurred where road class data were unavailable, complicating the interpretation of this speed-UDA combination.

Data describing the number of lanes the trafficway on which a crash occurred were unavailable for the majority of cases (Table 3.8). For those cases where these data were available, most occurred on two-lane trafficways. This is consistent with the finding that large proportions of crashes occurred on streets rather than multilane highways. Four lane trafficways were the next most prevalent category for all cases where the number of lanes was known.

Differences were found for crash related driving acts when their relationship to an intersection was examined (Table 3.9). Among all crashes, intersection and nonjunction crashes were found to occur in about the same proportions. Cases in which speeding was the sole UDA reported and cases where speeding was reported with driving left of center were predominantly found in nonjunction crashes (although a significant proportion of cases where speeding was the sole UDA were also found to be intersection related). Cases in which speeding and driving the wrong way were both reported were most prevalent at intersections, as were cases where speeding and driver inattention were reported together. A plurality of cases in which speeding was reported with improper passing were nonjunction crashes, followed by crashes at intersections and driveways. Speeding-improper passing was the only category to contain such a high proportion of crashes at driveways. Once again a large proportion of cases involving speeding and improper lane use had missing data for this variable.

Road curve also differed greatly by contributing factors (Table 3.10). Cases involving straight road alignment were the majority for all cases examined together, cases where speed was the sole UDA reported, and cases where speeding was reported with improper passing. Cases involving straight and curved road segments were evenly divided when speeding was reported with improper lane use. More cases in which speeding was reported with driving left of center involved curved road segments, but a significant proportion also involved straight segments. High rates of road alignment nonreporting for cases where speed was associated with driving the wrong way or driving inattention were observed; however, for those cases where curvature data were available, crashes were more likely to have occurred on straight road segments for cases where speeding was reported with either driving the wrong way or driver inattention.

Level road segment cases were the clear majority for all crashes examined together, speeding as the sole UDA, as well as speeding reported with improper passing, driving the wrong way, or driver inattention (Table 3.11). While a plurality of cases in which speed was reported with improper lane use or driving left of center also occurred on level road segments, large proportions of crashes involving these speed-UDA combinations occurred on road segments with an uphill or downhill grade.

| Table 3.5: Vehicles Involved in Crashes by Day of Week | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day of Week | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Sunday | 352,324 | 10.3 | 31,356 | 12.2 | 406 | 15.6 | 385 | 12.9 | 85 | 15.3 | 496 | 14.9 | 2,539 | 11.7 |
| Monday | 473,446 | 13.8 | 33,446 | 13.1 | 323 | 12.4 | 360 | 12.0 | 72 | 13.0 | 413 | 12.4 | 3,063 | 14.1 |
| Tuesday | 472,776 | 13.8 | 32,721 | 12.8 | 289 | 11.1 | 379 | 12.7 | 60 | 10.8 | 402 | 12.1 | 2,935 | 13.5 |
| Wednesday | 476,196 | 13.9 | 33,392 | 13.0 | 266 | 10.3 | 412 | 13.8 | 60 | 10.8 | 416 | 12.5 | 2,860 | 13.1 |
| Thursday | 503,043 | 14.7 | 35,096 | 13.7 | 316 | 12.2 | 406 | 13.6 | 68 | 12.3 | 440 | 13.3 | 3,037 | 14.0 |
| Friday | 625,438 | 18.3 | 46,854 | 18.3 | 465 | 17.9 | 566 | 18.9 | 83 | 15.0 | 535 | 16.1 | 3,850 | 17.7 |
| Saturday | 515,224 | 15.1 | 43,341 | 16.9 | 530 | 20.4 | 487 | 16.3 | 126 | 22.7 | 617 | 18.6 | 3,477 | 16.0 |
| Missing | 708 | 0.0 | 23 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.0 | 8 | 0.0 |
| Not available | 2,103 | 0.1 | 37 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.0 |

| Table 3.6: Vehicles Involved in Crashes by Time of Day | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time of Day | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| 0000-0059 | 62,786 | 1.8 | 8,260 | 3.2 | 43 | 1.7 | 42 | 1.4 | 28 | 5.1 | 83 | 2.5 | 361 | 1.7 |
| 0100-0159 | 56,827 | 1.7 | 7,947 | 3.1 | 57 | 2.2 | 55 | 1.8 | 51 | 9.2 | 96 | 2.9 | 413 | 1.9 |
| 0200-0259 | 52,506 | 1.5 | 7,719 | 3.0 | 30 | 1.2 | 30 | 1.0 | 22 | 4.0 | 87 | 2.6 | 294 | 1.4 |
| 0300-0359 | 28,598 | 0.8 | 4,213 | 1.6 | 19 | 0.7 | 20 | 0.7 | 17 | 3.1 | 48 | 1.4 | 191 | 0.9 |
| 0400-0459 | 18,558 | 0.5 | 2,715 | 1.1 | 16 | 0.6 | 7 | 0.2 | 6 | 1.1 | 33 | 1.0 | 144 | 0.7 |
| 0500-0559 | 22,137 | 0.6 | 2,816 | 1.1 | 10 | 0.4 | 19 | 0.6 | 5 | 0.9 | 28 | 0.8 | 173 | 0.8 |
| 0600-0659 | 57,128 | 1.7 | 5,614 | 2.2 | 25 | 1.0 | 52 | 1.7 | 7 | 1.3 | 57 | 1.7 | 378 | 1.7 |
| 0700-0759 | 140,604 | 4.1 | 11,837 | 4.6 | 28 | 1.1 | 92 | 3.1 | 16 | 2.9 | 130 | 3.9 | 677 | 3.1 |
| 0800-0859 | 129,492 | 3.8 | 10,417 | 4.1 | 22 | 0.8 | 94 | 3.1 | 15 | 2.7 | 104 | 3.1 | 511 | 2.3 |
| 0900-0959 | 105,418 | 3.1 | 7,515 | 2.9 | 11 | 0.4 | 77 | 2.6 | 6 | 1.1 | 105 | 3.2 | 404 | 1.9 |
| 1000-1059 | 147,955 | 4.3 | 9,451 | 3.7 | 154 | 5.9 | 130 | 4.3 | 12 | 2.2 | 113 | 3.4 | 967 | 4.4 |
| 1100-1159 | 180,425 | 5.3 | 11,330 | 4.4 | 180 | 6.9 | 140 | 4.7 | 20 | 3.6 | 118 | 3.6 | 1,112 | 5.1 |
| 1200-1259 | 213,269 | 6.2 | 13,290 | 5.2 | 199 | 7.7 | 160 | 5.3 | 26 | 4.7 | 105 | 3.2 | 1,273 | 5.8 |
| 1300-1359 | 176,156 | 5.1 | 11,062 | 4.3 | 31 | 1.2 | 118 | 3.9 | 13 | 2.3 | 120 | 3.6 | 818 | 3.8 |
| 1400-1459 | 198,264 | 5.8 | 12,695 | 5.0 | 34 | 1.3 | 164 | 5.5 | 19 | 3.4 | 155 | 4.7 | 912 | 4.2 |
| 1500-1559 | 247,716 | 7.2 | 15,980 | 6.2 | 46 | 1.8 | 182 | 6.1 | 20 | 3.6 | 207 | 6.2 | 1,269 | 5.8 |
| 1600-1659 | 265,416 | 7.8 | 17,753 | 6.9 | 66 | 2.5 | 211 | 7.0 | 23 | 4.2 | 216 | 6.5 | 1,283 | 5.9 |
| 1700-1759 | 268,253 | 7.8 | 18,233 | 7.1 | 34 | 1.3 | 220 | 7.3 | 33 | 6.0 | 202 | 6.1 | 1,359 | 6.2 |
| 1800-1859 | 191,290 | 5.6 | 14,076 | 5.5 | 43 | 1.7 | 196 | 6.5 | 34 | 6.1 | 165 | 5.0 | 884 | 4.1 |
| 1900-1959 | 144,555 | 4.2 | 10,972 | 4.3 | 32 | 1.2 | 159 | 5.3 | 29 | 5.2 | 176 | 5.3 | 631 | 2.9 |
| 2000-2059 | 113,173 | 3.3 | 9,385 | 3.7 | 36 | 1.4 | 121 | 4.0 | 22 | 4.0 | 164 | 4.9 | 579 | 2.7 |
| 2100-2159 | 111,306 | 3.3 | 9,694 | 3.8 | 43 | 1.7 | 124 | 4.1 | 37 | 6.7 | 149 | 4.5 | 581 | 2.7 |
| 2200-2259 | 96,579 | 2.8 | 9,475 | 3.7 | 41 | 1.6 | 91 | 3.0 | 28 | 5.1 | 174 | 5.2 | 615 | 2.8 |
| 2300-2359 | 87,265 | 2.6 | 9,459 | 3.7 | 39 | 1.5 | 75 | 2.5 | 37 | 6.7 | 181 | 5.5 | 609 | 2.8 |
| Unknown | 17,148 | 0.5 | 218 | 0.1 | 18 | 0.7 | 6 | 0.2 | 0 | 0.0 | 15 | 0.5 | 78 | 0.4 |
| Missing | 22,879 | 0.7 | 334 | 0.1 | 0 | 0.0 | 7 | 0.2 | 4 | 0.7 | 12 | 0.4 | 0 | 0.0 |
| Not available | 265,555 | 7.8 | 13,806 | 5.4 | 1338 | 51.6 | 403 | 13.5 | 24 | 4.3 | 277 | 8.3 | 5254 | 24.1 |

| Table 3.7: Vehicles Involved in Crashes by Road Class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Road Class | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Interstate or loop | 247,987 | 7.2 | 33,579 | 13.1 | 138 | 5.3 | 219 | 7.3 | 11 | 2.0 | 75 | 2.3 | 2,665 | 12.2 |
| Street | 1,305,262 | 38.2 | 78,312 | 30.6 | 138 | 5.3 | 743 | 24.8 | 408 | 73.6 | 736 | 22.2 | 8,624 | 39.6 |
| Turnpike/tollway | 200 | 0.0 | 1 | 0.0 | 0 | 0.0 | 4 | 0.1 | 0 | 0.0 | 9 | 0.3 | 0 | 0 |
| Other fully controlled | 5,500 | 0.2 | 314 | 0.1 | 0 | 0.0 | 28 | 0.9 | 0 | 0.0 | 15 | 0.5 | 416 | 1.9 |
| U.S. route | 9,096 | 0.3 | 1,199 | 0.5 | 47 | 1.8 | 145 | 4.8 | 38 | 6.9 | 196 | 5.9 | 1,370 | 6.3 |
| State route | 104,868 | 3.1 | 6,614 | 2.6 | 100 | 3.9 | 237 | 7.9 | 44 | 7.9 | 347 | 10.5 | 1,483 | 6.8 |
| County road | 327,566 | 9.6 | 18,831 | 7.3 | 6 | 0.2 | 324 | 10.8 | 8 | 1.4 | 1,068 | 32.2 | 1,068 | 4.9 |
| Other interstate, U.S., or state route | 308,438 | 9.0 | 32,231 | 12.6 | 1 | 0.0 | 305 | 10.2 | 0 | 0.0 | 471 | 14.2 | 6 | 0.0 |
| Other | 300,904 | 8.8 | 38,715 | 15.1 | 358 | 13.8 | 440 | 14.7 | 13 | 2.3 | 242 | 7.3 | 957 | 4.4 |
| Missing | 378,461 | 11.1 | 21,664 | 8.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Not available | 41,793 | 1.2 | 1,789 | 0.7 | 1,807 | 69.6 | 550 | 18.4 | 32 | 5.8 | 161 | 4.8 | 5,181 | 23.8 |

**Table 3.8: Vehicles Involved in Crashes by Number of Lanes**

| Number of Lanes | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| One | 13,095 | 0.4 | 263 | 0.1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 0.1 | 0 | 0.0 |
| Two | 384,650 | 11.2 | 9,559 | 3.7 | 416 | 16.0 | 408 | 13.6 | 25 | 4.5 | 593 | 17.9 | 1,732 | 8.0 |
| Three | 16,061 | 0.5 | 163 | 0.1 | 4 | 0.2 | 8 | 0.3 | 0 | 0.0 | 3 | 0.1 | 17 | 0.1 |
| Four | 259,921 | 7.6 | 3,991 | 1.6 | 92 | 3.5 | 121 | 4.0 | 11 | 2.0 | 94 | 2.8 | 1,151 | 5.3 |
| Five or more | 90,574 | 2.6 | 1,092 | 0.4 | 0 | 0.0 | 25 | 0.8 | 2 | 0.4 | 3 | 0.1 | 252 | 1.2 |
| One way | 10,048 | 0.3 | 151 | 0.1 | 18 | 0.7 | 4 | 0.1 | 0 | 0.0 | 1 | 0.0 | 51 | 0.2 |
| Other | 106,604 | 3.1 | 2,234 | 0.9 | 253 | 9.7 | 75 | 2.5 | 0 | 0.0 | 12 | 0.4 | 1,076 | 4.9 |
| Missing | 225,642 | 6.6 | 22,853 | 8.9 | 1 | 0.0 | 250 | 8.3 | 484 | 87.4 | 0 | 0.0 | 9,113 | 41.9 |
| Not available | 2,314,663 | 67.7 | 215,960 | 84.3 | 1,811 | 69.8 | 2,104 | 70.3 | 32 | 5.8 | 2,611 | 78.6 | 8,378 | 38.5 |

| Table 3.9: Vehicles Involved in Crashes by Intersection | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Intersection | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Nonjunction | 1,124,476 | 32.9 | 125,127 | 48.8 | 386 | 14.9 | 967 | 32.3 | 26 | 4.7 | 2620 | 78.9 | 4,117 | 18.9 |
| At intersection | 977,214 | 28.6 | 34,784 | 13.6 | 86 | 3.3 | 657 | 21.9 | 390 | 70.4 | 242 | 7.3 | 6,817 | 31.3 |
| Intersection related | 378,752 | 11.1 | 48,244 | 18.8 | 71 | 2.7 | 226 | 7.5 | 10 | 1.8 | 185 | 5.6 | 1,457 | 6.7 |
| Driveway | 273,246 | 8.0 | 13,508 | 5.3 | 0 | 0.0 | 390 | 13.0 | 3 | 0.5 | 67 | 2.0 | 248 | 1.1 |
| Other specific (RR, ramp, alley) | 35,100 | 1.0 | 1,167 | 0.5 | 130 | 5.0 | 58 | 1.9 | 0 | 0.0 | 22 | 0.7 | 601 | 2.8 |
| Unknown/not stated | 137,554 | 4.0 | 1,401 | 0.5 | 115 | 4.4 | 62 | 2.1 | 0 | 0.0 | 12 | 0.4 | 107 | 0.5 |
| Other | 4,913 | 0.1 | 63 | 0.0 | 0 | 0.0 | 1 | 0.0 | 2 | 0.4 | 4 | 0.1 | 0 | 0.0 |
| Not available | 490,003 | 14.3 | 31,972 | 12.5 | 1,807 | 69.6 | 634 | 21.2 | 123 | 22.2 | 168 | 5.1 | 8,423 | 38.7 |

| Table 3.10: Vehicles Involved in Crashes by Road Curve | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Road Curve | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Curve | 258,962 | 7.6 | 45,239 | 17.7 | 1,271 | 49.0 | 302 | 10.1 | 17 | 3.1 | 1,639 | 49.4 | 2,295 | 10.5 |
| Straight | 2,821,581 | 82.5 | 183,697 | 71.7 | 1,302 | 50.2 | 2,227 | 74.1 | 79 | 14.3 | 1,001 | 30.2 | 6,909 | 31.7 |
| Not reported | 187,986 | 5.5 | 22,543 | 8.8 | 0 | 0.0 | 245 | 8.2 | 458 | 82.7 | 0 | 0.0 | 9,027 | 41.5 |
| Unknown | 59,307 | 1.7 | 610 | 0.2 | 14 | 0.5 | 11 | 0.4 | 0 | 0.0 | 0 | 0.0 | 133 | 0.6 |
| Missing | 2,786 | 0.1 | 330 | 0.1 | 8 | 0.3 | 210 | 7.0 | 0 | 0.0 | 680 | 20.5 | 3,406 | 15.6 |
| Not available | 88,361 | 2.6 | 3,799 | 1.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

| Table 3.11: Vehicles Involved in Crashes by Road Grade | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Road Grade | All Crashes | | Speeding as sole UDA | | Speeding with Improper Lane Use | | Speeding with Improper Passing | | Speeding with Driving Wrong Way | | Speeding with Driving Left of Center | | Speeding with Driver Inattention | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Level | 2,723,904 | 79.6 | 207,770 | 81.1 | 1,341 | 51.7 | 2,277 | 76.0 | 411 | 74.2 | 1,473 | 44.4 | 13,674 | 62.8 |
| Uphill | 29,939 | 0.9 | 1,451 | 0.6 | 37 | 1.4 | 31 | 1.0 | 36 | 6.5 | 0 | 0.0 | 464 | 2.1 |
| Downhill | 41,493 | 1.2 | 2,975 | 1.2 | 65 | 2.5 | 44 | 1.5 | 76 | 13.7 | 0 | 0.0 | 700 | 3.2 |
| Grade | 421,819 | 12.3 | 34,317 | 13.4 | 995 | 38.3 | 363 | 12.1 | 17 | 3.1 | 1,100 | 33.1 | 2,860 | 13.1 |
| Crest | 32,275 | 0.9 | 3,734 | 1.5 | 104 | 4.0 | 42 | 1.4 | 6 | 1.1 | 38 | 1.1 | 325 | 1.5 |
| Unknown | 73,443 | 2.1 | 1,262 | 0.5 | 33 | 1.3 | 22 | 0.7 | 5 | 0.9 | 0 | 0.0 | 270 | 1.2 |
| Sag or dip | 4,933 | 0.1 | 580 | 0.2 | 12 | 0.5 | 6 | 0.2 | 3 | 0.5 | 29 | 0.9 | 70 | 0.3 |
| Missing | 2,786 | 0.1 | 330 | 0.1 | 8 | 0.3 | 210 | 7.0 | 0 | 0.0 | 680 | 20.5 | 3,407 | 15.6 |
| Not available | 88,391 | 2.6 | 3,799 | 1.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

# 4 DISCUSSION

While we found that more than half (55.7%) of all the cases examined in the 11-state dataset had at least one unsafe driving act recorded, only a small fraction of all cases (11.5%) had more than one UDA recorded. The small number of cases with multiple UDAs recorded does not necessarily mean that multiple UDAs seldom precede crashes. It is likely that this result is due in part to problems officers in the field have in recording multiple unsafe driving acts (as discussed earlier). However, we have little evidence to suggest that the proportion of crashes in which multiple unsafe driving acts truly contribute to crashes would increase substantially if crash investigation and data collection procedures were improved. Of course this is an empirical question which cannot be answered in this contract.

Discussions with district court personnel who handle traffic violations suggest that multiple moving violation citations are issued infrequently (either as the result of a crash investigation or from normal traffic patrol). The anecdotal reports from these court officials were verified by our analysis of the crash data. Only 21.3% of all the cases available from states with citation data were coded as having a moving violation issued, and only 1.8% of all the cases from these states had more than one moving violation recorded.

While the likelihood ratio results suggest that excessive speed is related to improper lane use, improper passing, driving the wrong way, driving left of center, driver inattention, and alcohol or drug involvement as contributing factors in crashes, it is important to speculate about possible causal relationships between speed and these other UDAs. It is unlikely that speed per se actually causes many other unsafe driving acts, however it is likely that speeding creates conditions favorable for other unsafe acts to occur.

Speeding probably creates opportunities for improper lane use and improper passing. These UDAs may be made more likely by an individual travelling at excessive speed as that driver encounters other vehicles, obstacles in the road, or weaves through slower traffic trying to maintain a high rate of speed. The relationships between speeding and driving the wrong way or left of center are not as simple to hypothesize. Perhaps drivers who are speeding drive left of center to avoid obstacles impeding their swift progress, as hypothesized for improper lane use and improper passing. It may also be true that some drivers travelling at excessive speed have difficulty controlling their vehicles and thus may stray left of center. Speeding and driving left of center may both be related to inattentiveness; that is, drivers may be paying insufficient attention to either their speed or remaining on the correct side of the center line. It is difficult to envision what circumstances lead to an individual driving the wrong way. Perhaps drivers travelling at excessive speed are unable to or fail to take the time to determine what the correct traffic flow for a particular road segment is. A second hypothesis is that drivers may select to take a short cut by travelling the wrong way for a limited stretch and try to reduce the amount of time spent going the wrong way by speeding. A third hypothesis is that speeding and driving the wrong way are both related to the more general phenomenon of inattentiveness. Similar to the hypothesis for driving left of center, inattentive drivers may both travel at excessive speeds and travel the wrong way on a road segment simply because they are not paying attention to the driving task. As alluded to earlier, driver inattention and alcohol or drug involvement are not symptoms of excessive speed, but these UDAs are more probably causes of excessive speed.

Given the empirical findings and hypothesized causal relationships we turn to exploring enforcement options to prevent these unsafe acts and subsequent crashes. We are skeptical about the utility of targeting unsafe driving acts associated with speed for developing new special enforcement programs. As shown in Table 3.4, the conditional probability of a specific UDA being reported when speeding was also reported in a crash is extremely low. This suggests that targeting enforcement efforts to specifically identify driving acts which may be associated with speed would probably contribute little above efforts targeting speed or given unsafe driving acts alone.

However, speed enforcement programs may be enhanced by targeting programs at times and locations where unsafe driving acts associated with speed were found to be different from times and locations of speeding alone. For example, while speeding as the sole UDA reported was most prevalent on straight road segments, speeding-driving left of center UDA combinations were most prevalent on curved road segments. Thus, when monitoring speeding on curved road segments officers should also be alert to drivers travelling left of center. A similar relationship was found for speeding-improper lane use. Differences between the characteristics of crashes where speed was the sole UDA and select speeding-UDA were also found by road grade. Cases where speeding was the sole UDA were most prevalent on level road segments, but a relatively small proportion of speeding as sole UDA cases occurred on road segments with uphill or downhill grades. While large proportions of cases for each of the speeding-other UDA combinations were also found to occur on level road segments, equally large proportions of cases where speeding was reported with improper lane use and driving left of center were reported on road segments with uphill and downhill grades. Therefore, when monitoring speeding on road segments with uphill or downhill grades officers should also be alert for drivers exhibiting general improper lane use or specifically, driving left of center.

Unfortunately the two most promising speed-other UDA relationships were with UDAs which can better be described as driver conditions rather than behaviors (i.e., inattention and alcohol or drug involvement). Each of these conditions constituted a relatively large number of cases and had quite high likelihood ratios indicating strong relationships with speed. However, as described earlier, it is difficult to observe driver conditions independent of the driver's behavior. It is therefore logical that efforts to reduce crashes associated with these driver conditions be targeted toward general speed reduction, employing proven speed reduction strategies.

The unsafe acts of following too close and failure to yield were found to contribute to high proportions of crashes (similar to the proportion accounted for by speeding). We found the relationship between speeding and these unsafe driving acts to be quite weak. We therefore cannot recommend that special attention be paid by officers to identify these UDAs with the hope of also affecting speed related crashes or visa versa.

In sum, we found little evidence to support the development or implementation of *significant* new strategies for deploying enforcement personnel or targeting and observing unsafe driving actions that contribute to crashes. We did find evidence to support continuing efforts for enforcing speed laws. In addition, we found evidence to support enhancing the crash preventive effects of speed enforcement efforts on road segments with an uphill or downhill grade or curved road segments by having officers also be alert for drivers who may be exhibiting general improper lane use or specifically, vehicles driving left of center.

Evidence from previous special enforcement efforts (i.e., selective traffic enforcement programs) has demonstrated these programs are effective for reducing the number of vehicles violating traffic laws and reducing crash potential. These programs have also proven to be cost-effective strategies for reducing violations and crashes. The suggested enhancement of the programs on road segments with curves and uphill or downhill grades would not increase program costs because no additional resources beyond those necessary for effective selective enforcement programs would be required. Benefits measured in terms of reductions in violations and crashes may increase due to heightened diligence in observing and citing these additional unsafe acts associated with speed and subsequent crashes.

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# APPENDIX

# 11-STATE CRASH DATA CODEBOOK

| Variable 1 | **CASENO** | MD1: None | Field Width: 19 |
|---|---|---|---|
| | | MD2: None | Type: Alphabetic |

| Variable 2 | **VEHNO** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

| Variable 3 | **STATE** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

| FREQ | Prcnt | STATE |
|---|---|---|
| 189066 | 5.5 | 04. Arizona |
| 517980 | 15.1 | 12. Florida |
| 110535 | 3.2 | 20. Kansas |
| 215680 | 6.3 | 24. Maryland |
| 189880 | 5.6 | 27. Minnesota |
| 314153 | 9.2 | 29. Missouri |
| 703920 | 20.6 | 39. Ohio |
| 174128 | 5.1 | 47. Tennessee |
| 705268 | 20.6 | 48. Texas |
| 76885 | 2.2 | 49. Utah |
| 223763 | 6.5 | 53. Washington |

| Variable 4 | **YEAR** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

| Variable 5 | **MONTH** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

| Variable 6 | **WEEKDAY** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

| FREQ | Prcnt | WEEKDAY |
|---|---|---|
| 352324 | 10.3 | 1. Sunday |
| 473446 | 13.8 | 2. Monday |
| 472776 | 13.8 | 3. Tuesday |
| 476196 | 13.9 | 4. Wednesday |
| 503043 | 14.7 | 5. Thursday |
| 625438 | 18.3 | 6. Friday |
| 515224 | 15.1 | 7. Saturday |
| 708 | 0.0 | 8. Missing |
| 2103 | 0.1 | 9. Not available |

Variable 7 **HOUR** MD1: None Field Width: 2
MD2: None Type: Numeric

| FREQ | Prcnt | HOUR |
|---|---|---|
| 62786 | 1.8 | 01. 0000-0059 |
| 56827 | 1.7 | 02. 0100-0159 |
| 52506 | 1.5 | 03. 0200-0259 |
| 28598 | 0.8 | 04. 0300-0359 |
| 18558 | 0.5 | 05. 0400-0459 |
| 22137 | 0.6 | 06. 0500-0559 |
| 57128 | 1.7 | 07. 0600-0659 |
| 140604 | 4.1 | 08. 0700-0759 |
| 129492 | 3.8 | 09. 0800-0859 |
| 105418 | 3.1 | 10. 0900-0959 |
| 147955 | 4.3 | 11. 1000-1059 |
| 180425 | 5.3 | 12. 1100-1159 |
| 213269 | 6.2 | 13. 1200-1259 |
| 176156 | 5.1 | 14. 1300-1359 |
| 198264 | 5.8 | 15. 1400-1459 |
| 247716 | 7.2 | 16. 1500-1559 |
| 265416 | 7.8 | 17. 1600-1659 |
| 268253 | 7.8 | 18. 1700-1759 |
| 191290 | 5.6 | 19. 1800-1859 |
| 144555 | 4.2 | 20. 1900-1959 |
| 113173 | 3.3 | 21. 2000-2059 |
| 111306 | 3.3 | 22. 2100-2159 |
| 96579 | 2.8 | 23. 2200-2259 |
| 87265 | 2.6 | 24. 2300-2359 |
| 17148 | 0.5 | 96. Unknown |
| 0 | 0.0 | 97. Other |
| 22879 | 0.7 | 98. Missing |
| 265555 | 7.8 | 99. Not available |

Variable 8 **ROADCLAS** MD1: None Field Width: 2
MD2: None Type: Numeric

| FREQ | Prcnt | ROAD CLASS |
|---|---|---|
| 247987 | 7.2 | 01. Interstate or loop |
| 1305262 | 38.2 | 02. Street |
| 200 | 0.0 | 03. Arterial |
| 0 | 0.0 | 04. Collector |
| 5500 | 0.2 | 05. Turnpike/highway |
| 9096 | 0.3 | 06. Other fully controlled |
| 104868 | 3.1 | 07. US route |
| 327566 | 9.6 | 08. State route |
| 308438 | 9.0 | 09. County road |
| 300904 | 8.8 | 10. Other interstate, US or state route |
| 378461 | 11.1 | 97. Other |
| 41793 | 1.2 | 98. Missing |

| FREQ | Prcnt | Var 8 ROADCLAS |
|---|---|---|
| 391183 | 11.4 | 99. Not available |

Variable 9 **REPTTYPE** MD1: None Field Width: 1
MD2: None Type: Numeric

| FREQ | Prcnt | REPORT TYPE |
|---|---|---|
| 1288622 | 37.7 | 1. Police |
| 37816 | 1.1 | 2. Citizen |
| 623453 | 18.2 | 3. Office report |
| 63881 | 1.9 | 4. Not investigated |
| 176747 | 5.2 | 5. Investigated |
| 95273 | 2.8 | 6. Report taken at scene |
| 7071 | 0.2 | 7. Other |
| 65705 | 1.9 | 8. Missing |
| 1062690 | 31.1 | 9. Not available |

Variable 10 **NUMLANE1** MD1: None Field Width: 1
MD2: None Type: Numeric

Number of Lanes - Response 1

| FREQ | Prcnt | NUMLANE1 |
|---|---|---|
| 13095 | 0.4 | 1. One |
| 384650 | 11.2 | 2. Two |
| 16061 | 0.5 | 3. Three |
| 259921 | 7.6 | 4. Four |
| 90574 | 2.6 | 5. Five or more |
| 10048 | 0.3 | 6. One way |
| 106604 | 3.1 | 7. Other |
| 225642 | 6.6 | 8. Missing |
| 2314663 | 67.7 | 9. Not available |

Variable 11 **NUMLANE2** MD1: None Field Width: 1
MD2: None Type: Numeric

Number of Lanes - Response 2

| FREQ | Prcnt | NUMLANE2 |
|---|---|---|
| 0 | 0.0 | 1. One |
| 2 | 0.0 | 2. Two |
| 0 | 0.0 | 3. Three |
| 57 | 0.0 | 4. Four |

| FREQ | Prcnt | Var 11 NUMLANE2 |
|---|---|---|
| 0 | 0.0 | 5. Five or more |
| 1247 | 0.0 | 6. One way |
| 15146 | 0.4 | 7. Other |
| 157676 | 4.6 | 8. Missing |
| 3247130 | 94.9 | 9. Not available |

| Variable 12 | **INTRSCTN** | MD1: | None | Field Width: | 1 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

| FREQ | Prcnt | INTERSECTION |
|---|---|---|
| 1124476 | 32.9 | 1. Non-junction |
| 977214 | 28.6 | 2. At intersection |
| 378752 | 11.1 | 3. Intersection related |
| 273246 | 8.0 | 4. Driveway |
| 35100 | 1.0 | 5. Other specific (rr, ramp, allley) |
| 137554 | 4.0 | 6. Unknown/not stated |
| 4913 | 0.1 | 7. Other |
| 0 | 0.0 | 8. Missing |
| 490003 | 14.3 | 9. Not available |

| Variable 13 | **LOCALTY1** | MD1: | None | Field Width: | 1 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Locality - Response 1

| Variable 14 | **LOCALTY2** | MD1: | None | Field Width: | 1 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Locality - Response 2

| Variable 15 | **LOCALTY3** | MD1: | None | Field Width: | 1 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Locality - Response 3

| Variable 16 | **VEHDEF1** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Vehicle Defect - Response 1

| Variable 17 | **VEHDEF2** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Vehicle Defect - Response 2

| Variable 18 | **VEHDEF3** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Vehicle Defect - Response 3

| Variable 19 | **VEHDEF4** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Vehicle Defect - Response 4

| Variable 20 | **VEHDEF5** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Vehicle Defect - Response 5

| Variable 21 | **VEHTYPE** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

| FREQ | Prcnt | VEHICLE TYPE |
|---|---|---|
| 1285661 | 37.6 | 01. Passenger |
| 28627 | 0.8 | 02. Motorcycle/motorized cycle |
| 575057 | 16.8 | 03. Truck |
| 9858 | 0.3 | 04. Emergency vehicle |
| 207 | 0.0 | 05. Towed vehicle |
| 33258 | 1.0 | 06. Unknown |
| 39424 | 1.2 | 07. Other |
| 1633 | 0.0 | 08. Pedestrian |
| 12272 | 0.4 | 09. Bicycle |
| 20040 | 0.6 | 98. Missing |
| 1415221 | 41.4 | 99. Not available |

Variable 22 **ROADCURVE** MD1: None Field Width: 1
MD2: None Type: Numeric

| FREQ | Prcnt | ROAD ALIGNMENT |
|---|---|---|
| 258962 | 7.6 | 1. Curve |
| 2821581 | 82.5 | 2. Straight |
| 187986 | 5.5 | 3. Not reported |
| 59307 | 1.7 | 6. Unknown |
| 2786 | 0.1 | 7. Other |
| 88361 | 2.6 | 8. Missing |
| 2275 | 0.1 | 9. Not available |

Variable 23 **ROADGRAD** MD1: None Field Width: 2
MD2: None Type: Numeric

| FREQ | Prcnt | ROAD GRADE |
|---|---|---|
| 2723904 | 79.6 | 01. Level |
| 29939 | 0.9 | 02. Uphill |
| 41493 | 1.2 | 03. Downhill |
| 421819 | 12.3 | 04. Grade |
| 32275 | 0.9 | 05. Crest |
| 73443 | 2.1 | 06. Unknown |
| 4933 | 0.1 | 07. Sag or dip |
| 2786 | 0.1 | 97. Other |
| 88391 | 2.6 | 98. Missing |
| 2275 | 0.1 | 99. Not available |

Variable 24 **POSTSPED** MD1: None Field Width: 3
MD2: None Type: Numeric

Posted Speed Limit

Variable 25 **VEHSPEED** MD1: None Field Width: 3
MD2: None Type: Numeric

Reported Vehicle Speed

Variable 26 **SAFSPEED** MD1: None Field Width: 3
MD2: None Type: Numeric

Officer's Estimated Safe Speed

Variable 27 **CITATN1** MD1: None Field Width: 2
MD2: None Type: Numeric

Citation Issued - Response 1

| FREQ | Prcnt | CITATN1 |
|---|---|---|
| 504146 | 14.7 | 01. None |
| 20561 | 0.6 | 02. Speeding |
| 49283 | 1.4 | 03. Failure to yield |
| 5318 | 0.2 | 04. Following too close |
| 20242 | 0.6 | 05. Improper turn |
| 2807 | 0.1 | 06. Disobey stop sign/light |
| 2833 | 0.1 | 07. Disobey other traffic signal |
| 4589 | 0.1 | 08. Improper lookout |
| 7616 | 0.2 | 09. Improper passing |
| 114 | 0.0 | 10. Wrong way |
| 12277 | 0.4 | 11. DUI |
| 4474 | 0.1 | 12. Reckless driving |
| 5878 | 0.2 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 114094 | 3.3 | 95. Miscellaneous other |
| 2511 | 0.1 | 96. Other nonmoving viol. |
| 4388 | 0.1 | 97. Other moving viol. |
| 49375 | 1.4 | 98. Missing |
| 2610752 | 76.3 | 99. Not available |

Variable 28 **CITATN2** MD1: None Field Width: 2
MD2: None Type: Numeric

Citation Issued - Response 2

| FREQ | Prcnt | CITATN2 |
|---|---|---|
| 670831 | 19.6 | 01. None |
| 1870 | 0.1 | 02. Speeding |
| 1518 | 0.0 | 03. Failure to yield |
| 188 | 0.0 | 04. Following too close |
| 671 | 0.0 | 05. Improper turn |
| 73 | 0.0 | 06. Disobey stop sign/light |
| 218 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 407 | 0.0 | 09. Improper passing |
| 33 | 0.0 | 10. Wrong way |

| FREQ | Prcnt | Var 28 CITATN2 |
|---|---|---|
| 8257 | 0.2 | 11. DUI |
| 1766 | 0.1 | 12. Reckless driving |
| 682 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 46864 | 1.4 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |
| 282 | 0.0 | 98. Missing |
| 2687598 | 78.6 | 99. Not available |

Variable 29 **CITATN3** MD1: None Field Width: 2
MD2: None Type: Numeric

Citation Issued - Response 3

| FREQ | Prcnt | CITATN3 |
|---|---|---|
| 500969 | 14.6 | 01. None |
| 158 | 0.0 | 02. Speeding |
| 306 | 0.0 | 03. Failure to yield |
| 28 | 0.0 | 04. Following too close |
| 187 | 0.0 | 05. Improper turn |
| 0 | 0.0 | 06. Disobey stop sign/light |
| 0 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 91 | 0.0 | 09. Improper passing |
| 0 | 0.0 | 10. Wrong way |
| 2236 | 0.1 | 11. DUI |
| 0 | 0.0 | 12. Reckless driving |
| 122 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 13883 | 0.4 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |
| 0 | 0.0 | 98. Missing |
| 2903278 | 84.9 | 99. Not available |

Variable 30 **CITATN4** MD1: None Field Width: 2
MD2: None Type: Numeric

Citation Issued - Response 4

| FREQ | Prcnt | CITATN4 |
|---|---|---|
| 517980 | 15.1 | 01. None |
| 0 | 0.0 | 02. Speeding |
| 0 | 0.0 | 03. Failure to yield |

| FREQ | Prcnt | Var 30 CITATN4 |
|---|---|---|
| 0 | 0.0 | 04. Following too close |
| 0 | 0.0 | 05. Improper turn |
| 0 | 0.0 | 06. Disobey stop sign/light |
| 0 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 0 | 0.0 | 09. Improper passing |
| 0 | 0.0 | 10. Wrong way |
| 0 | 0.0 | 11. DUI |
| 0 | 0.0 | 12. Reckless driving |
| 0 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 0 | 0.0 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |
| 0 | 0.0 | 98. Missing |
| 2903278 | 84.9 | 99. Not available |

| Variable 31 | **CITATN5** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Citation Issued - Response 5

| FREQ | Prcnt | CITATN5 |
|---|---|---|
| 517980 | 15.1 | 01. None |
| 0 | 0.0 | 02. Speeding |
| 0 | 0.0 | 03. Failure to yield |
| 0 | 0.0 | 04. Following too close |
| 0 | 0.0 | 05. Improper turn |
| 0 | 0.0 | 06. Disobey stop sign/light |
| 0 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 0 | 0.0 | 09. Improper passing |
| 0 | 0.0 | 10. Wrong way |
| 0 | 0.0 | 11. DUI |
| 0 | 0.0 | 12. Reckless driving |
| 0 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 0 | 0.0 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |
| 0 | 0.0 | 98. Missing |
| 2903278 | 84.9 | 99. Not available |

| Variable 32 | CITATN6 | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Citation Issued - Response 6

| FREQ | Prcnt | CITATN6 |
|---|---|---|
| 517980 | 15.1 | 01. None |
| 0 | 0.0 | 02. Speeding |
| 0 | 0.0 | 03. Failure to yield |
| 0 | 0.0 | 04. Following too close |
| 0 | 0.0 | 05. Improper turn |
| 0 | 0.0 | 06. Disobey stop sign/light |
| 0 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 0 | 0.0 | 09. Improper passing |
| 0 | 0.0 | 10. Wrong way |
| 0 | 0.0 | 11. DUI |
| 0 | 0.0 | 12. Reckless driving |
| 0 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 0 | 0.0 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |
| 0 | 0.0 | 98. Missing |
| 2903278 | 84.9 | 99. Not available |

| Variable 33 | CITATN7 | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Citation Issued - Response 7

| FREQ | Prcnt | CITATN7 |
|---|---|---|
| 517980 | 15.1 | 01. None |
| 0 | 0.0 | 02. Speeding |
| 0 | 0.0 | 03. Failure to yield |
| 0 | 0.0 | 04. Following too close |
| 0 | 0.0 | 05. Improper turn |
| 0 | 0.0 | 06. Disobey stop sign/light |
| 0 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 0 | 0.0 | 09. Improper passing |
| 0 | 0.0 | 10. Wrong way |
| 0 | 0.0 | 11. DUI |
| 0 | 0.0 | 12. Reckless driving |
| 0 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 0 | 0.0 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |

| FREQ | Prcnt | Var 33 CITATN7 |
|---|---|---|
| 0 | 0.0 | 98. Missing |
| 2903278 | 84.9 | 99. Not available |

| Variable 34 | **CITATN8** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Citation Issued - Response 8

| FREQ | Prcnt | CITATN8 |
|---|---|---|
| 517980 | 15.1 | 01. None |
| 0 | 0.0 | 02. Speeding |
| 0 | 0.0 | 03. Failure to yield |
| 0 | 0.0 | 04. Following too close |
| 0 | 0.0 | 05. Improper turn |
| 0 | 0.0 | 06. Disobey stop sign/light |
| 0 | 0.0 | 07. Disobey other traffic signal |
| 0 | 0.0 | 08. Improper lookout |
| 0 | 0.0 | 09. Improper passing |
| 0 | 0.0 | 10. Wrong way |
| 0 | 0.0 | 11. DUI |
| 0 | 0.0 | 12. Reckless driving |
| 0 | 0.0 | 13. Improper lane |
| 0 | 0.0 | 14. Unsafe lane change |
| 0 | 0.0 | 95. Miscellaneous other |
| 0 | 0.0 | 96. Other nonmoving viol. |
| 0 | 0.0 | 97. Other moving viol. |
| 0 | 0.0 | 98. Missing |
| 2903278 | 84.9 | 99. Not available |

| Variable 35 | **ALCOHOL1** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Alcohol Involvement - Response 1

| Variable 36 | **ALCOHOL2** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Alcohol Involvement - Response 2

| Variable 37 | **ALCOHOL3** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Alcohol Involvement - Response 3

| Variable 38 | **ALCOHOL4** | MD1: None | Field Width: 1 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Alcohol Involvement - Response 4

| Variable 39 | **UNSFACT1** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Unsafe Driving Act Contributing to Crash - Response 1

| FREQ | Prcnt | UNSFACT1 |
|---|---|---|
| 1557141 | 45.5 | 01. None |
| 26721 | 0.8 | 02. Exceed speed limit |
| 171833 | 5.0 | 03. Unsafe speed |
| 22997 | 0.7 | 04. Illegal or unsafe speed |
| 64783 | 1.9 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 31198 | 0.9 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 128107 | 3.7 | 11. Following too close |
| 61841 | 1.8 | 12. Improper turn |
| 24428 | 0.7 | 13. Improper passing |
| 25589 | 0.7 | 14. Disregard red light |
| 46891 | 1.4 | 15. Disregard stop sign |
| 29049 | 0.8 | 16. Disregard other traffic signal |
| 357432 | 10.4 | 17. Failure to yield right-of-way |
| 21913 | 0.6 | 18. Left of center |
| 31374 | 0.9 | 19. Improper lane change |
| 10436 | 0.3 | 20. Failure to remain w/in lane |
| 18254 | 0.5 | 21. Improper lane use |
| 62599 | 1.8 | 22. Failure to control |
| 116585 | 3.4 | 23. Driver inattention |
| 101660 | 3.0 | 24. Careless driving |
| 38400 | 1.1 | 25. Improper backing |
| 4538 | 0.1 | 26. Wrong way |
| 1968 | 0.1 | 27. Improper signal |
| 9093 | 0.3 | 28. Improper lookout |
| 27986 | 0.8 | 93. Drugs-alcohol |
| 71426 | 2.1 | 94. Other than driver behav. |
| 10599 | 0.3 | 95. Not stated |
| 119549 | 3.5 | 96. Unknown |
| 162788 | 4.8 | 97. Other driver behavior |
| 63329 | 1.9 | 98. Missing |

| FREQ | Prcnt | Var 39 UNSFACT1 |
|---|---|---|
| 751 | 0.0 | 99. Not available |

| Variable | 40 | **UNSFACT2** | MD1: | None | Field Width: | 2 |
|---|---|---|---|---|---|---|
| | | | MD2: | None | Type: | Numeric |

Unsafe Driving Act Contributing to Crash - Response 2

| FREQ | Prcnt | UNSFACT2 |
|---|---|---|
| 1434813 | 41.9 | 01. None |
| 3319 | 0.1 | 02. Exceed speed limit |
| 11948 | 0.3 | 03. Unsafe speed |
| 3544 | 0.1 | 04. Illegal or unsafe speed |
| 1050 | 0.0 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 2637 | 0.1 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 158026 | 4.6 | 11. Following too close |
| 7608 | 0.2 | 12. Improper turn |
| 11040 | 0.3 | 13. Improper passing |
| 5268 | 0.2 | 14. Disregard red light |
| 3571 | 0.1 | 15. Disregard stop sign |
| 4691 | 0.1 | 16. Disregard other traffic signal |
| 63785 | 1.9 | 17. Failure to yield right-of-way |
| 11594 | 0.3 | 18. Left of center |
| 2036 | 0.1 | 19. Improper lane change |
| 1859 | 0.1 | 20. Failure to remain w/in lane |
| 3307 | 0.1 | 21. Improper lane use |
| 45 | 0.0 | 22. Failure to control |
| 71210 | 2.1 | 23. Driver inattention |
| 3435 | 0.1 | 24. Careless driving |
| 3886 | 0.1 | 25. Improper backing |
| 1247 | 0.0 | 26. Wrong way |
| 2543 | 0.1 | 27. Improper signal |
| 3043 | 0.1 | 28. Improper lookout |
| 53575 | 1.6 | 93. Drugs-alcohol |
| 15781 | 0.5 | 94. Other than driver behav. |
| 101 | 0.0 | 95. Not stated |
| 291653 | 8.5 | 96. Unknown |
| 223545 | 6.5 | 97. Other driver behavior |
| 798540 | 23.3 | 98. Missing/No Additional UDAs |
| 222558 | 6.5 | 99. Not available |

| Variable 41 | **UNSFACT3** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Unsafe Driving Act Contributing to Crash - Response 3

| FREQ | Prcnt | UNSFACT3 |
|---|---|---|
| 511882 | 15.0 | 01. None |
| 995 | 0.0 | 02. Exceed speed limit |
| 876 | 0.0 | 03. Unsafe speed |
| 171 | 0.0 | 04. Illegal or unsafe speed |
| 3 | 0.0 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 105 | 0.0 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 243 | 0.0 | 11. Following too close |
| 486 | 0.0 | 12. Improper turn |
| 287 | 0.0 | 13. Improper passing |
| 22 | 0.0 | 14. Disregard red light |
| 364 | 0.0 | 15. Disregard stop sign |
| 522 | 0.0 | 16. Disregard other traffic signal |
| 888 | 0.0 | 17. Failure to yield right-of-way |
| 712 | 0.0 | 18. Left of center |
| 123 | 0.0 | 19. Improper lane change |
| 131 | 0.0 | 20. Failure to remain w/in lane |
| 205 | 0.0 | 21. Improper lane use |
| 0 | 0.0 | 22. Failure to control |
| 7364 | 0.2 | 23. Driver inattention |
| 405 | 0.0 | 24. Careless driving |
| 39 | 0.0 | 25. Improper backing |
| 233 | 0.0 | 26. Wrong way |
| 56 | 0.0 | 27. Improper signal |
| 0 | 0.0 | 28. Improper lookout |
| 1836 | 0.1 | 93. Drugs-alcohol |
| 601 | 0.0 | 94. Other than driver behav. |
| 0 | 0.0 | 95. Not stated |
| 173094 | 5.1 | 96. Unknown |
| 2759 | 0.1 | 97. Other driver behavior |
| 713042 | 20.8 | 98. Missing/No Additional UDAs |
| 2003814 | 58.6 | 99. Not available |

| Variable 42 | **UNSFACT4** | MD1: None | Field Width: 2 |
|---|---|---|---|
| | | MD2: None | Type: Numeric |

Unsafe Driving Act Contributing to Crash - Response 4

| FREQ | Prcnt | UNSFACT4 |
|---|---|---|
| 1 | 0.0 | 01. None |
| 0 | 0.0 | 02. Exceed speed limit |
| 0 | 0.0 | 03. Unsafe speed |

| FREQ | Prcnt | Var 42 UNSFACT4 |
|---|---|---|
| 0 | 0.0 | 04. Illegal or unsafe speed |
| 0 | 0.0 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 7 | 0.0 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 8 | 0.0 | 11. Following too close |
| 13 | 0.0 | 12. Improper turn |
| 1 | 0.0 | 13. Improper passing |
| 0 | 0.0 | 14. Disregard red light |
| 1 | 0.0 | 15. Disregard stop sign |
| 27 | 0.0 | 16. Disregard other traffic signal |
| 60 | 0.0 | 17. Failure to yield right-of-way |
| 0 | 0.0 | 18. Left of center |
| 0 | 0.0 | 19. Improper lane change |
| 4 | 0.0 | 20. Failure to remain w/in lane |
| 21 | 0.0 | 21. Improper lane use |
| 0 | 0.0 | 22. Failure to control |
| 782 | 0.0 | 23. Driver inattention |
| 0 | 0.0 | 24. Careless driving |
| 1 | 0.0 | 25. Improper backing |
| 8 | 0.0 | 26. Wrong way |
| 2 | 0.0 | 27. Improper signal |
| 0 | 0.0 | 28. Improper lookout |
| 161 | 0.0 | 93. Drugs-alcohol |
| 15 | 0.0 | 94. Other than driver behav. |
| 0 | 0.0 | 95. Not stated |
| 174025 | 5.1 | 96. Unknown |
| 57 | 0.0 | 97. Other driver behavior |
| 536850 | 15.7 | 98. Missing/No Additional UDAs |
| 2709214 | 79.2 | 99. Not available |

| Variable 43 | **UNSFACT5** | MD1: | None | Field Width: | 2 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Unsafe Driving Act Contributing to Crash - Response 5

| FREQ | Prcnt | UNSFACT5 |
|---|---|---|
| 0 | 0.0 | 01. None |
| 0 | 0.0 | 02. Exceed speed limit |
| 0 | 0.0 | 03. Unsafe speed |
| 0 | 0.0 | 04. Illegal or unsafe speed |
| 0 | 0.0 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 0 | 0.0 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 1 | 0.0 | 11. Following too close |
| 0 | 0.0 | 12. Improper turn |
| 0 | 0.0 | 13. Improper passing |

| FREQ | Prcnt | Var 43 UNSFACT5 |
|---|---|---|
| 0 | 0.0 | 14. Disregard red light |
| 0 | 0.0 | 15. Disregard stop sign |
| 2 | 0.0 | 16. Disregard other traffic signal |
| 11 | 0.0 | 17. Failure to yield right-of-way |
| 0 | 0.0 | 18. Left of center |
| 0 | 0.0 | 19. Improper lane change |
| 0 | 0.0 | 20. Failure to remain w/in lane |
| 11 | 0.0 | 21. Improper lane use |
| 0 | 0.0 | 22. Failure to control |
| 112 | 0.0 | 23. Driver inattention |
| 0 | 0.0 | 24. Careless driving |
| 0 | 0.0 | 25. Improper backing |
| 0 | 0.0 | 26. Wrong way |
| 2 | 0.0 | 27. Improper signal |
| 0 | 0.0 | 28. Improper lookout |
| 28 | 0.0 | 93. Drugs-alcohol |
| 3 | 0.0 | 94. Other than driver behav. |
| 0 | 0.0 | 95. Not stated |
| 174106 | 5.1 | 96. Unknown |
| 13 | 0.0 | 97. Other driver behavior |
| 313992 | 9.2 | 98. Missing/No Additional UDAs |
| 2932977 | 85.7 | 99. Not available |

| Variable 44 | **UNSFACT6** | MD1: | None | Field Width: | 2 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Unsafe Driving Act Contributing to Crash - Response 6

| FREQ | Prcnt | UNSFACT6 |
|---|---|---|
| 0 | 0.0 | 01. None |
| 0 | 0.0 | 02. Exceed speed limit |
| 0 | 0.0 | 03. Unsafe speed |
| 0 | 0.0 | 04. Illegal or unsafe speed |
| 0 | 0.0 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 1 | 0.0 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 0 | 0.0 | 11. Following too close |
| 0 | 0.0 | 12. Improper turn |
| 0 | 0.0 | 13. Improper passing |
| 0 | 0.0 | 14. Disregard red light |
| 0 | 0.0 | 15. Disregard stop sign |
| 0 | 0.0 | 16. Disregard other traffic signal |
| 0 | 0.0 | 17. Failure to yield right-of-way |
| 0 | 0.0 | 18. Left of center |
| 0 | 0.0 | 19. Improper lane change |
| 0 | 0.0 | 20. Failure to remain w/in lane |
| 2 | 0.0 | 21. Improper lane use |

| FREQ | Prcnt | Var 44 UNSFACT6 |
|---|---|---|
| 0 | 0.0 | 22. Failure to control |
| 0 | 0.0 | 23. Driver inattention |
| 0 | 0.0 | 24. Careless driving |
| 0 | 0.0 | 25. Improper backing |
| 0 | 0.0 | 26. Wrong way |
| 0 | 0.0 | 27. Improper signal |
| 0 | 0.0 | 28. Improper lookout |
| 0 | 0.0 | 93. Drugs-alcohol |
| 0 | 0.0 | 94. Other than driver behav. |
| 0 | 0.0 | 95. Not stated |
| 174120 | 5.1 | 96. Unknown |
| 5 | 0.0 | 97. Other driver behavior |
| 0 | 0.0 | 98. Missing/No Additional UDAs |
| 3247130 | 94.9 | 99. Not available |

| Variable 45 | **UNSFACT7** | MD1: | None | Field Width: | 2 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Unsafe Driving Act Contributing to Crash - Response 7

| FREQ | Prcnt | UNSFACT7 |
|---|---|---|
| 0 | 0.0 | 01. None |
| 0 | 0.0 | 02. Exceed speed limit |
| 0 | 0.0 | 03. Unsafe speed |
| 0 | 0.0 | 04. Illegal or unsafe speed |
| 0 | 0.0 | 05. Speed too great for conditions |
| 0 | 0.0 | 06. Other speed |
| 0 | 0.0 | 07. General speeding |
| 0 | 0.0 | 08. Speed too slow |
| 0 | 0.0 | 11. Following too close |
| 0 | 0.0 | 12. Improper turn |
| 0 | 0.0 | 13. Improper passing |
| 0 | 0.0 | 14. Disregard red light |
| 0 | 0.0 | 15. Disregard stop sign |
| 0 | 0.0 | 16. Disregard other traffic signal |
| 0 | 0.0 | 17. Failure to yield right-of-way |
| 0 | 0.0 | 18. Left of center |
| 0 | 0.0 | 19. Improper lane change |
| 0 | 0.0 | 20. Failure to remain w/in lane |
| 0 | 0.0 | 21. Improper lane use |
| 0 | 0.0 | 22. Failure to control |
| 0 | 0.0 | 23. Driver inattention |
| 0 | 0.0 | 24. Careless driving |
| 0 | 0.0 | 25. Improper backing |
| 0 | 0.0 | 26. Wrong way |
| 0 | 0.0 | 27. Improper signal |
| 0 | 0.0 | 28. Improper lookout |
| 0 | 0.0 | 93. Drugs-alcohol |

| FREQ | Prcnt | Var 45 UNSFACT7 |
|---|---|---|
| 0 | 0.0 | 94. Other than driver behav. |
| 0 | 0.0 | 95. Not stated |
| 174127 | 5.1 | 96. Unknown |
| 1 | 0.0 | 97. Other driver behavior |
| 0 | 0.0 | 98. Missing/No Additional UDAs |
| 3247130 | 94.9 | 99. Not available |

Variable 46 **SEX** MD1: None Field Width: 1
MD2: None Type: Numeric

Variable 47 **AGE** MD1: None Field Width: 2
MD2: None Type: Numeric

Variable 48 **BELTS** MD1: None Field Width: 1
MD2: None Type: Numeric

Variable 49 **NUMVEH** MD1: None Field Width: 2
MD2: None Type: Numeric

Number of Vehicles Involved

Variable 50 **NUMKILL** MD1: None Field Width: 2
MD2: None Type: Numeric

Number Killed in Crash

Variable 51 **NUMINJ** MD1: None Field Width: 2
MD2: None Type: Numeric

Number Injured in Crash

| Variable 52 | **NUMNINJ** | MD1: | None | Field Width: | 2 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Number not Injured in Crash

| Variable 53 | **SEVERITY** | MD1: | None | Field Width: | 1 |
|---|---|---|---|---|---|
| | | MD2: | None | Type: | Numeric |

Worst Outcome of Crash