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Analysis of Fatal Accidents in New Jersey

Final Report
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16. Abstract

In 2005 there were 691 fatal crashes and 748 fatalities in New Jersey. The data necessary to adequately understand fatal crashes are not readily available to New Jersey policy makers. The research program has developed a pilot system which links fatal crash data with other associated state data files. This research project has considered the following four databases: (1) New Jersey Crash Records, (2) the New Jersey Motor Vehicle Commission Fatal Accident Database, (3) Fatal Analysis Reporting System (FARS), and (4) the New Jersey State Police Fatal Investigations Division database. By linking these databases, there is an opportunity to investigate the root causes of fatalities in ways that are not possible through analysis of a single database. The project has used New Jersey fatal crash data to conduct two case studies, one on teen driver risk and one on elderly driver risk, to demonstrate the value of a linked data system.

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1. Summary

In 2005 there were 691 fatal crashes and 748 fatalities in New Jersey. The data necessary to adequately understand fatal crashes are not readily available to New Jersey policy makers. The research program has developed a pilot system which links fatal crash data with other associated state data files. This research project has considered the following four databases: (1) New Jersey Crash Records, (2) the New Jersey Motor Vehicle Commission Fatal Accident Database, (3) Fatal Analysis Reporting System (FARS), and (4) the New Jersey State Police Fatal Investigations Division database. By linking these databases, there is an opportunity to investigate the root causes of fatalities in ways that are not possible through analysis of a single database. The project has used New Jersey fatal crash data to conduct two case studies, one on teen driver risk and one on elderly driver risk, to demonstrate the value of a comprehensive fatality data system.

Comprehensive Database of NJ Fatalities

The source of all traffic fatality data is the NJTR-1 Police Accident report. The information is sent to the NJMVC, NJDOT Office of Information Technology (OIT) and NJSP depending on the municipality. All the data is eventually stored in the NJSP fatality database and checked for accuracy. The research team concluded that the NJSP database already serves as a comprehensive fatality database. In 2008, a consortium of New Jersey state agencies using highway accident released the NJ CRASH Data Warehouse which contains all NJ Crash Records including those records for fatal crashes.

In addition, the research showed that only a fraction of the data is received by the respective agencies in a timely fashion. The data from the NJTR-1 is supposed to be submitted to NJSP within 24 hours of the crash. This would allow the NJSP to initiate any action necessary if the perpetrator is still at-large. Every effort should be made to send the data to NJSP, NMVC, and NJDOT within the stipulated time outlined in the Fatal Crash reporting protocol.

Younger Driver Crash Fatality Risk

Approximately 100 younger persons (aged 15-20) die each year in New Jersey in traffic crashes. This project investigated the characteristics of these crashes and found the following:

- Most young persons killed in traffic fatalities were occupants of a passenger vehicle (82%) in 2003-2005. Pedestrians accounted for 9% of the fatalities while motorcycle riders accounted for 7% of the fatalities for persons 15-20 years old. Although most safety initiatives rightfully focus on teens and other young persons in their cars, it is important to keep in mind that nearly 1 in 5 young persons is not an occupant of a car or light truck.

- For teens, two-thirds of the fatalities were male. This likely reflects the increased risk taking behavior which is characteristic of many male drivers.

- In 2006, New Jersey belt use rates were 90% - among the highest in the nation. Over half of all fatally injured younger persons were unbelted. Put another way 10% of vehicle occupants account for over half of the fatalities in New Jersey.

- Approximately 20% of younger drivers involved in fatal crashes had been drinking. Drinking is not permitted until age 21 in New Jersey.

- Over 70% of licensed younger drivers involved in fatal crashes had a full license, while over 20% had either a learner's permit or an intermediate GDL license. Lack of a license does not seem to be an issue for these younger drivers: 6% of all younger drivers involved in fatal crashes did not have a license. An additional, 8% of younger drivers involved in fatal crashes were driving on a suspended license.

Older Adult Crash Fatality Risk

In 2006, 134 older adults were fatally injured in traffic crashes in New Jersey. This project investigated the characteristics of these crashes and found the following:

- Older adults comprised less than 8% of all persons exposed to traffic crashes in New Jersey, but accounted for 20% of all New Jersey traffic crash fatalities per year. This underscores the fragility of older persons in traffic crashes.

- Most older adults killed in traffic fatalities were occupants of a passenger vehicle (67%). Fatally-injured older adults in motor vehicles were belted (64%). Surprisingly, more than 1 in 4 (27%) of all fatally-injured older adults were pedestrians.

- Alcohol use does not appear to be less a risk factor for older adult drivers than for young drivers. Only 6% of older adult drivers involved in fatal crashes had been drinking, as compared to 18% of younger drivers.

- Nearly 80% of fatal accidents involving older adult drivers in New Jersey occurred in daylight. This statistic suggests that older drivers may be choosing to avoid driving at night either because of self-regulation or because of licensing restrictions.

- Most fatal accidents involving older adult drivers in New Jersey (46%) occurred at an intersection. In contrast, both teen and adult drivers aged 21-

64 are more likely to be involved in a fatal crash at non-intersections. Older drivers may have an elevated risk of intersection crashes because of a decreased ability to judge the amount of time necessary to clear an intersection.

- Older adult drivers who were involved in fatal crashes were 4.9 times more likely to have been ill or have blacked out than adult drivers aged 21-64. Older adult drivers were 10% more likely to have been drowsy or asleep than adult drivers, and 40% more likely to have been attentive or distracted than adult drivers.

2. Introduction and Background

In 2005 there were 691 fatal crashes and 748 fatalities in New Jersey. Each of these tragic events occurred despite the millions of dollars expended by New Jersey each year on redesigned intersections, aggressive traffic law enforcement, driver education programs, EMS funding, and numerous other safety initiatives. Despite the success of these programs, the belief is that even greater fatality reductions are possible. If there were better data describing the driver-vehicle-road interactions which lead to fatal crashes, highway safety funds could be better targeted to reduce traffic fatalities.

Figure 1. Fatality accidents are complex events. Determining their root causes requires detailed data on driver behavior, vehicle performance, and roadway design.

Unfortunately, the data to adequately understand fatal crashes are simply not readily available to New Jersey policy makers. The encouraging fact is that New Jersey has extensive crash databases, exemplified by the New Jersey Crash Record system which contains summary records of over 300,000 police reported accidents each year. In addition, several state agencies in New Jersey maintain datasets which describe additional facets of the crash event. However, to date, for reasons ranging from privacy concerns to incompatible data formats, these datasets have been seldom linked for a comprehensive perspective of highway safety.

The research program has developed a pilot system which links fatal crash data with other associated state data files. By linking these databases, there is an opportunity to investigate the root causes of fatalities in ways that are not possible through analysis of a single database. This research project has considered the following four databases: (1) NJ Crash Records, (2) NJMVC Fatal Accident Database, (3) Fatal Analysis Reporting System (FARS), and (4) the NJ

State Police Fatal Investigations Division database. The project has conducted two case studies to demonstrate the value of the linked data system.

3. Objective

The goal of this study is to determine the feasibility of an integrated database for the analysis of fatal accidents in New Jersey. The specific objectives are to:

1. Determine how New Jersey fatal accident datasets can be integrated.

2. Demonstrate the value of this integrated database by the system in a series of pilot case studies

4. Current Practice and Experiences in Traffic Database Linkage

Objective

The goal of this section is to address the important issues surrounding data linkage for traffic safety data studies. The discussion which follows will divide the pertinent areas into categories associated with administrative, data and regulatory issues and address them individually. Subsequently, a sampling of some group specific linking systems currently in use will be discussed.

Introduction

Data linkage of highway safety databases can provide new insights into the 10 million motor vehicle crashes in 2005 and 2.5 million crash related injuries which occur each year in the U.S. Data that pertains to traffic safety or conditions is collected in various forms by a number of groups. This data is often tailored to the needs of the specific groups research interests. The potential of these data sets has not fully been realized in many situations. A linkage of data sets can help to improve the quality of regulatory standards and the response to issues in traffic safety.

Effective measures for reducing injuries and fatalities in motor vehicle crashes have been the goal of many transportation based institutions. The National Highway Traffic Safety Administration (NHTSA) has shown measures such as seat belt introduction have been able to reduce traffic fatalities by 45-55% (Johnson et al. 1996). The introduction of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 called for a study on the effect of seat belt and helmet use as well as the increased inclusion of injury data (Johnson et al., 1996). The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was set in motion to encourage state departments of transportation to develop strategic highway safety plans (SHSP). A SHSP is to be designed to provide a data driven approach to creating safer roads throughout the respective states. These plans are intended to integrate important transportation, police and injury data in a manner that provides a perspective on the current traffic safety situations in a given state. However, integration of the diverse datasets is complicated by the fact that the datasets are owned and maintained by separate organizations.

A number of groups both in the United States and internationally have successfully linked databases of varied sorts including, but not limited to, police accident reports, roadway information and hospital records. NHTSA has founded an effort known as The Crash Outcome Data Evaluation System (CODES) which includes the efforts of numerous state Departments of Transportation for linking vehicle, medical and insurance related sources (Johnson et al., 1996). Groups in Australia have been successful in linking their roadway information, traffic volumes, crash records, medical and death certificate records (Rosman, 2001; ARRB, 2006). A number of states have created their own database linkage philosophies and modes of operation, often catering to their specific research interests and as set forth by the SAFETEA-LU (Florida DOT, 2003; Hawaii DOT, 2003; Iowa DOT, 2003; Transportation Research Board, 2007). This has lead to a significant literature resource of associated troubles and successes regarding database linkage. Other literature addresses many of the statistical issues associated with properly linking data as well as the appropriateness of certain statistical techniques. Regulations associated with the release and distribution of certain records, especially medical records are outlined in a number of documents and presented with regards to their effect on data linkage research.

Ethical and Regulatory Discussions of Data Linkage

Often it is assumed that the most pressing issues when forming a linked data system are possibly administrative or data driven. However, it is ultimately the ethical treatment, distribution and collection of the data that are of most importance. The clear goal of data linkage is to provide an increasing view over the range of available relationships within research interests. As researchers, a unique opportunity is given that allows the usage of the linked data to educate the public and guide policy decisions in an enlightened and structured manner that would otherwise be impossible. Although the intentions of the researcher are assumed to be genuine, it is important to have an understating of the sensitivity associated with personally identifiable data in an effort to avoid conflict.

The federal government is aware of the need for ethical consideration when dealing with information regarding personally identifiable information. There is a real concern from the public that their personal information be made only available to those who gain access with the proper consent. In response to this concern, Congress proposed the Health Insurance Portability and Accountability Act (HIPAA) of 1996. This act went through a number or revisions and compliance began in April 2003. The act requires that any information that can relate directly or be traced back to a specific individual regarding their physical or mental health must not be released by the covered entity (Kulynych and Korn, 2002). In order to have access to the resources that contain these identifiable fields, a waiver can be obtained through an Institutional Review Board (IRB). This waiver allows the data to be used only if: (1) the data involves minimal risk to the individuals, (2) the research could not properly be conducted without the waiver, and (3) there are known benefits to those whose information is being used as part of the research (Annas, 2002; Kulynych and Korn, 2002; U.S. Department of Health and Human Services, 2002). Also, there is a long list of identifiers that cannot be included in the disclosed information including names, addresses, telephone numbers, email addresses, social security numbers, and many others (U.S. Department of Health and Human Services, 2002). As a result of these restrictions, the data that can be accessed by the researchers must be sanitized by following certain de-identification procedures. All de-identification must remove the previously mentioned identifiable fields as well as any field that can directly identify an individual. Any information that has any significant risk of reverse-identifying an individual through inferences based on other information released about the individual cannot be included (Kulynych and Korn, 2002; U.S. Department of Health and Human Services, 2002).

When considering how to move forward with research that involves the use of data with personally identifiable data, it should not be seen as a great concern, albeit an area that needs to be taken seriously. The Department of Health and Human Services provides extensive resources on how to approach research of this nature (U.S. Department of Health and Human Services, 2007).

Administrative Issues and Concerns

Data Ownership

The general consensus among the groups who have successfully integrated databases has been that the party who owns the data prior to the linkage retains possession over the data. Once the data has been linked the data may become accessible to other parties but the rights and associated liabilities still belong to the original owner. The CODES project chose to establish advisory committees to discuss the linkage and treatment of the linked data. As part of these committees, representatives from the different data contributors were included in the decision making processes to ensure that each party's opinions were represented (Johnson et al., 1996; Transportation Research Board, 2007; Clark, 2004). It is also important to define the ownership characteristics of the linked data to maintain public support. As stated, privacy is often of great importance to the American public. By maintaining ownership with the original contributor and allowing the contributing parties to have a voice in the accessibility of the data, it easier to express the idea of privacy to any concerned party.

The Maine DOT has recognized issues associated with a lack of inclusion and understanding of data ownership responsibilities. As a result, they have proposed as a basic principle for the future of the project to establish that the official data owners are responsible for the currency, integrity, and availability of data elements (Maine DOT, 2003).The Arizona DOT set up teams of planners and engineers associated with their database linkage system to advise the operational units involved in the project. They worked to explain that those who collected the data were the "owners" and thus, responsible for its integrity, the IT staff is merely to serve as "custodians" of the data, and the data warehouse is to serve only as a tool for accessing the data (Arizona DOT, 2003).

Data Distribution

The CODES project has recognized that once the ownership of the data has been established, it then becomes important to define who should have access to the linked data. It is important to ensure that the contributors to the data linkage also have access to the final product. By allowing access, it helps to show the contributors the value of their participation. It is important to note that because the contributing institutions have their own guidelines for data distribution based on their IRB approval, it is necessary to ensure that all of their regulations are being considered. Therefore, it is up to the database creators to decide who is allowed access to the linked data while including the opinions and guidance of the contributing members (NHTSA, 2001). The Kansas DOT expressed difficulty in expressing the contributing parties to let go of data when the groups felt there was no incentive to sharing and felt that it could increase the opportunities for criticism regarding their data (Kansas DOT, 2003). To help combat this, groups such as the Minnesota DOT has recommended a strong performance-based planning approach for their data linkage project. This will serve to express the fruits of the data linkage and encourage support from the contributing parties (Minnesota DOT, 2003).

The CODES project noted issues that can arise from allowing free access to the data include: (1) lawyers fishing for lawsuits, (2) unethical applications, or (3) improper statistical approaches. Also, contributing institutions are liable for the data that they release so they will not want certain epidemiological or performance information to be released to groups that could possibly use the data for practices mentioned above (NHTSA, 2001). However, the Michigan DOT has recommended the need for a large distribution of data in order to prevent redundant data analysis and database formation (Michigan DOT, 2003).

As mentioned before, it is important to include contributing parties in decision making processes. By allocating seats on the control board for representatives from each contributing party, the specific needs and concerns of all parties can being addressed and facilitate the buy-in of all necessary contributors.

Database Regulation

CODES has found that creating a managing group for the database linkage creates a number of administrative issues. The managing board should include the contributing groups. Members of a large group can feel they have little control over the project and may lose enthusiasm. If groups become uninterested or feel that their contributions are not properly or sufficiently utilized, their concern for the future of the project may increase. To promote the usage of database linkage and maintain the enthusiasm of the associated members, some groups including the CODES teams as well as the Alaska, Florida and Michigan Departments of Transportation have utilized the use of regular letters of agreement signed by members on all levels (Transportation Research Board, 2007; NHTSA, 2001). The Florida DOT (FDOT) for example believe that traffic data linkage, their group expressed that it is especially important to have executive buy-in for the linkage project early on to help promote buy-in form other groups and assure that focus is maintained (Florida DOT, 2003). Regular presentations regarding contemporary research with special emphasis on the importance of the database linkage can help to reinvigorate those involved (NHTSA, 2001).

While maintaining support for the contributing members is significantly important, it is more important to ensure the agency responsible for data linkage is equally enthusiastic about the project. Problems can arise if there is no central control of the data. The agency responsible for maintaining the integrity of the linkage must accept the fact that linked data involves many parties. FDOT found that they had difficulties in relating the cost to benefits even within their own government groups and cited difficulties in gaining support even after the project progressed (Florida DOT, 2003).

Staff Training

The staff required to ensure that the data is being processed and released properly need to be specially trained in the statistical and software issues for effective trouble shooting and understanding. The Hawaii DOT (HDOT) referenced a major difficulty in the differing levels and forms of IT training amongst employees for their traffic linkage project. These differences created issues in language and comprehension with regards to software applications (Hawaii DOT, 2003). Also, staff members need to be aware of changes in linking technology or processes and if changes are needed to improve the project, subsequent training must follow. The CODES project expressed considerable concern with staff issues regarding these areas that were not sorted out in advance and contributed to set backs in the efficiency and utilization of the database (NHTSA, 2001). Hence, decisions about training and responsibility need to be established in before fully undertaking the linkage process. The Delaware DOT (DelDOT) acknowledged the need for continual staff training throughout the creation of their linkage system. As a result, DelDOT worked with the University of Delaware to create a research laboratory and training facility focused on the needs of the linkage system (Delaware DOT, 2003).

Access to Linked Data

The easiest distribution policy for the linked data is through an Internet source. This allows all parties to access and update the data remotely. Unfortunately, not all data is available in electronic format, for example EMS data. Conversion of some of the documents to electronic formats maybe difficult and is an area of discussion when deciding which data to include (NHTSA, 2001). It was also noted that the format in which the linked data was presented can have a positive effect on the partnerships between the governing bodies and contributing members. By creating an interface tailored to the needs of those who utilize and contribute to the database will increase the buy-in to the project and facilitate growth and enthusiasm (Transportation Research Board, 2007).

It is also important to have an understanding of how the information is to be used so the most effective access methods can be set up. CODES indicated that they suffered serious setbacks when they did not allocate enough time to the needs of those who were going to use the database. As a result the original web-site set up for accessing the database was not sufficient. The CODES team was not aware of the dynamic nature that would be required by the users and the specifics in their inquiries. Needless to say, much time and money had to be given to fix the web-based features and make it more suitable for those who needed access. However, the Iowa DOT recognized that the different contributors and users would require different methods for accessing their linked traffic data. They created a number of formats for accessing the data including database reporting tools, a web-based application and access to the data warehouse for certain parties (Iowa DOT, 2003). The Hawaii DOT has implemented their Coordinated Data System/Geographic Information System (CDS/GIS) to utilize geographic references to link data in a web-enabled map-based query system. The system has helped to improve planning and design functions as well as maintenance (Hawaii DOT, 2003).

Data Concerns

Data Consistency

Maintaining the integrity of a linked database relies on the contributing members following the same guidelines for recording and organizing data. A lack of agreement in field names and definitions is common among a number of data linkage groups (NHTSA, 2001; Clark, 2004; ARRB, 2006; Transportation Research Board, 2007). The best policy is to create a list of definitions for data fields, especially those that will be used for linking. Many police reports follow the KABC0 injury severity definitions in their crash reports and this format has been successfully integrated into database linkage systems (Johnson et al., 1996). Also, the Model Minimum Uniform Crash Criteria Guideline (MMUCC) has been established by the Governors Highway Safety Association, NHTSA, FHWA, the Federal Motor Carrier Safety Administration and the Research and Innovative Technology Administration. The MMUCC provides many definitions for crash related fields, specifically to create consistency among different groups. A large collection of various organizations ranging from local police departments to state run departments of transportation are currently working to create a third version of the MMUCC in an effort to further improve the relevance and uniformity among participating groups (MMUCC; Transportation Research Board, 2007).

Confidentiality vs. Linking Variables

As mentioned earlier, de-identification removes personal identifiers from the databases for both ethical and regulatory reasons. However, as a result of these de-identification processes, the most useful and accurate linking elements will be removed. Also, re-identifying must not be possible from the released data; therefore even creating coded fields for the confidential information is not an available option (Annas, 2002; Kulynych and Korn, 2002; U.S. Department of Health and Human Services, 2007). This lack of personal identifiers means that variables which are less than ideal must be used for data linking. Data elements such as location can provide significant linking power without intruding on confidentiality (Rosman, 2001; Florida DOT, 2003; Hawaii DOT, 2003; Iowa DOT, 2003; ARRB, 2006). Often injury types, crash times or dates are included on numerous data records and can serve as powerful linking variables. Based on variables like these, methods can be used to either directly link the data or to attach a certain probability to each linkage.

Data Quality

It has been stated that data quality is more important than data linkage (Clark 2004). The reasoning is; successful data linkage is only as good as the quality of the linking data elements. There are a number of ways that linked databases can lose their integrity, the easiest being through improper recording. Often, records at the crash scene or in the hospital are first recorded on paper forms then later transferred to electronic formats. There is a significant potential for human error in this process. Unfortunately, accounting for and fixing issues arising from these errors can be difficult. Also, many times legacy systems are left in place for organizations to try and convert from paper or older electronic formats (NHTSA, 2001; Clark, 2004). These records are often important when considering a retrospective analysis, but pose problems with data quality that can arise in the conversion to updated formats.

Other problems can arise when data is contributed from unrelated organizations and specialties. As mentioned, different groups may have different definitions for the same variable or different variables to express the same condition (MMUCC; NHTSA, 2001; Clark, 2004). It is important to have a set of definitions for each variable to ensure that each matches properly or can be converted to a proper format accurately. Considerable concern is given to the discussion surrounding the ability to link different variables based on locations. Different organizations utilize different methods of location definitions based on the systems that are currently available. The most common forms include latitude and longitude coordinates or when applicable, a linear reference system (LRS). A LRS is usually based on mile markers along roadways and are assigned codes that designate the specific roadway. Many groups have been successful at combining both latitude – longitude coordinate systems and LRS into a Geographic Information System (GIS) (Rosman, 2001; NHTSA, 2001; Florida DOT, 2003; Hawaii DOT, 2003; Clark, 2004; ARRB, 2006; Transportation Research Board, 2007). This provides a system that is universally acceptable for the contributing parties and in some cases can be beneficial when incorporated into a user interface. A GIS is often based off of GPS systems but requires separate mapping infrastructure to be set in place in order to properly utilize its potential.

Many of the methods used to link data are based on only a few fields which assign the datasets to blocks (Johnson et al., 1996; Blakely and Salmond, 2002; Gomatam, 2002; Clark, 2004). Blocks limit the amount of datasets that will be considered for the final linkage steps based a more general initial linkage. As a result, much influence is given to only a few variables, making it increasingly important that these variables be especially accurate. Insuring the accuracy of these discriminating variables can help to avoid what is known as stratification where increasing influence is given to a variable as its authority is applied to subsequent linkages (Clark, 2004).

Data integrity can also be lost when it is incomplete in its original format. Officers at the scene of a crash understandably give priority to treating the injured, and may not completely or accurately fill out accident reports. Often missing data is filled in later. These missing fields are required to successfully link the data (NHTSA, 2001). Another problem is that duplicates of data may exist as well. For instance when dealing with two vehicles involved in a crash, the crash report may indicate the occupants from both vehicles. When reports are created for both vehicles, this creates two sets of records for either set of occupants. For example, the New South Wales Roads and Traffic Authority (RTA) reported that even with their successful GIS linkage, inaccurate data obtained from their crash reports hindered their ability to accurately link the data (ARRB, 2006). Rosman et al. showed in a study linking crash reports and hospital discharge records that there was an increase in data linkages when improvements in data quality and completeness were made (Rosman, 2001).

Problems can also arise as a result of the size of the databases that are included. A statistical issue arises when more data sets are available, increasing the chances that there will be more than one probabilistic match for a specific variable. Other complications appear when methods either improperly match or fail to match the data. Failing to match records can lead to misidentification of the outcomes for specific cases as well as underestimate the total number of cases. Conversely, falsely matched records can lead to missing data and an overestimation of the total number of cases (Clark, 2004).

<u>Data Formats</u>

Data obtained from multiple sources can often come in many different formats. It has already been mentioned that some data comes in paper format while other comes in electronic formats. However for data within the electronic form there are many possible methods and formats for storing and distributing data. The formats are based on the preferences of the contributing members. It has been recommended by CODES for their own project that all data should be transferred into an data warehouse and that access to the information from that database should be acquired through SAS (NHTSA, 2001).

The problems of converting between formats can be difficult or relatively easy depending on the size and number of databases to be linked. However, it is important to understand upfront what formats will be the most useful and have an understanding of the database software. It is also necessary to provide training for the software or outsource the work to a company who can better handle the data conversions.

Statistical Issues

Deterministic Methods vs. Probabilistic Methods

Deterministic methods use direct matching to link data. In order for a match to be obtained, the data in the fields must match exactly. This method is often applied in smaller data sets. The advantage of deterministic methods is that they provide exact matches often based on distinguishing variables such as a social security number. However, deterministic methods cannot account for error that may be present because of human error or missing data. This can lead to data that is not linked and under-reporting. Often, the data that needs to be linked cannot be done so because it lacks identifying variables such as the case of medical records. Deterministic methods are excellent for accurately linking data however, it lacks the power to link data where exact matches cannot be known (Johnson et al., 1996; Blakely and Salmond, 2002; Gomatam, 2002; Clark, 2004; Transportation Research Board, 2007).

Probabilistic methods are based on variables that can predict linkages. When identifying variables do not exist as is the case with medical data, a system for estimating the probability of a linkage can be created. Computer programs are often utilized to identify the probability of specific linkages based on the available data. To accurately account for human error or missing data, probabilistic methods often apply weights to the variables. The weights assigned to the variables can be designated by their relative importance in linking the data. This determination is decided by the predicting power of the variable as a linking identifier. The weights can also be assigned based on the likelihood of the variable being accurately defined or recorded. The more accurate data will be weighted more to ensure a better chance of correct linkage. Probabilistic thresholds can also be established that determine the likelihood of a correct linkage (Johnson et al., 1996; Blakely and Salmond, 2002; Gomatam, 2002; Clark, 2004; Transportation Research Board, 2007).

The issues with probabilistic methods are often the result of their low positive predictive value. A positive predictive value represents the ability of a method to accurately predict true linkages. The lower positive predictive value often limits the use of probabilistic methods as a possible linkage tool for studies that focus on small sample sizes. However, probabilistic methods provide a high sensitivity. Sensitivity indicates the ability of a method to positively predict the correct number of linkages. Basically, the number of false matches and unmatched pairs cancel out one another so that they can produce a sample of correct linkages. This high sensitivity allows the data to be very useful for large population studies where the individual linkages are not as important as the net outcome (Blakely and Salmond, 2002; Gomatam, 2002; Clark, 2004; Transportation Research Board, 2007).

The differences between deterministic and probabilistic methods are what determine which method should be employed for specific study types. For a large database linkage such as combining DOT data, police reports and hospital records, it is often considered more realistic to employ probabilistic methods (Johnson et al., 1996; Blakely and Salmond, 2002; Gomatam, 2002; Clark, 2004; Transportation Research Board, 2007).

Blocking

Blocking is a method used in conjunction with probabilistic methods to simplify the process of linking large databases. Blocking utilizes the most common and strongest linking variables and utilizes their power to break the data sets into groups with common variable linkages. From these blocks, the data is then linked based on subsequent agreement with other linking variables (Blakely and Salmond, 2002; Gomatam, 2002; Clark, 2004; Transportation Research Board, 2007).

Linking Programs

The differing linking needs for different groups requires that there be a range of software packages available. There are a number of software packages available for probabilistic matching that have shown to be effective for traffic safety linkages. The most common program is AUTOMATCH. This program has been studied in various forms for its accuracy and linking powers. Gomatam et al. (2002) examined the sensitivity of AUTOMATCH for situations where the matches are known. Compared to a stepwise deterministic strategy, the AUTOMATCH software showed a significantly higher sensitivity (0.902 vs. 0.664) but a lower positive predictive value (0.9803 vs. 0.9987), which decreases significantly as errors are introduced. As stated before this shows that a probabilistic software package such as AUTOMATCH would be more appropriate for larger population studies (Gomatam, 2002).

The CODES project began with AUTOMATCH as its primary software package but has since switched to CODES 2000, a probabilistic software package set up to address their specific needs(NHTSA, 2001).

Review of Successful Linkages

Internationally, there have been numerous successful linkages for traffic safety based data. However, the level of integration varies greatly between the organizations. Consequently, there has been a large push from the Federal Highway Administration (FHWA) to promote the linkage of traffic related data for all state DOTs (Vander-Ostrander et al., 2003). The FHWA has since produced a series or reports where different DOTs across the country report their successes with data linkage. Australia has also had a number of reported success stories regarding their own data linkage systems.

Florida DOT – GRIP

In 1999, the Florida DOT (FDOT) set out to create a database linkage system called the Geo-Referenced Information Portal (GRIP). Ultimately, The GRIP project successfully linked data on road conditions, bridge information, roadway characteristics and visual imagery of the geographic areas. All the data sets were connected using GIS technology and applied to a user interface. The system had four: (1) include accurate integrated data (2) handle numerous formats and data sets (3) leverage existing technologies and infrastructures and (4) provide a user friendly interface. As part of their administrative process they assigned tasks to those responsible for the data linkage. There was to be a server to house the data, a data dictionary to define the given variables, metadata was to be recorded, backup copies were to be created, a defined collection processes set in place and provisions were to be made for the future maintenance of the data sets.

The construction of the GRIP system was approached in phases. The first phase involved developing an infrastructure for the system by establishing the functional data requirements, program structure and a GIS based map. Phase 2 was the development of a functional system before the inclusion of large amounts of data. Phase 3 began the integration process by focusing on the priority areas. The fourth phase included making the information available via intranet and through a graphical user interface. Finally, phase 5 included the development of different applications for different users with regards to the graphical user interface.

The GRIP project can allow an unlimited number of groups to access the data in an efficient and practical manner. Personal computers are able to access the intranet server via local area networks. After the successful linkage of the data FDOT reported easier access to data, reduction in complications for decision making and improved data collection and utility (Florida DOT, 2003).

Hawaii DOT – CDS/GIS

The Hawaii DOT (HDOT) recognized a need for a traffic integration system in 1996. The data within contributing DOT divisions was incomplete and there was difficulty associated with the access of the data. This created issues when trying to create state and federally mandated reports. Hawaii's approach for solving problems associated with the existing data problems was to create a linkage system including pavement data, the national bridge inventory, highway inventory data, traffic data and current and historic data projects. From these databases, the system was able to link relational databases, isolated spreadsheets and videolog files. The linkage system is referred to as the Coordinated Data System/Geographic Information System (CDS/GIS). All data is linked by a system of routes and mile posts. Incorporating legacy systems was not much of a difficulty because the linkage system was based on the existing formats. HDOT staff accesses the data through a web-based query interface. Also, HDOT included access to the Highway Performance Monitoring System (HPMS) and Traffic Management System data from the interface. The primary focus of this project was to connect the existing data around the state regarding road conditions and traffic and combine them to aide in policy making, planning and design functions.

The storage of the collected data is housed in a normalized data warehouse. Commercial software including Microsoft Access and Oracle 8.1.7 are used to incorporate and link data. HDOT kept the responsibility of data collection, maintenance and quality with the different groups. This was done so that groups were not hindered in their normal processes and it did not require much change in policy for the respective groups.

Prior to the onset of the project, the ability to identify any probable complications would have been beneficial. The majority of eventual problems were the result of a difference in technical abilities of the HDOT staff, a lack of understanding of the exact needs and importance of such a project, and the use of off the shelf software (Hawaii DOT, 2003).

Traffic Safety Data Linkage in Australia and New Zealand

As of 2006, several Australian states as well as New Zealand have traffic safety database linkage projects in place.The discussion of the different areas of Australia that linked their data on some level revealed that the difference in the ability to link data and the quality of the linked data was usually a function of the GIS technology that was implemented. The New South Wales Roads and Traffic Authority (RTA) was able to spatially link all their data elements. The limiting factor for their linkage was found to be the traffic volume data. The traffic volume data is not collected regularly and is not available on all road types. However the group was very successful at creating a useable graphical user interface (GUI). With their GUI, they created picture tiles available that represented a geographic location linked to their GIS technique. With these tiles, different geometric features of the roadway are enhanced. In the future, the RTA plans to incorporate a tile for crash epidemiology based on individual locations. These tiles will overlay the geometric tile and allow analysis as to the effect of geometric conditions in the roadway as they relate to crash incidence.

In Queensland, Australia the Department of Main Roads (DMR) the group responsible for the data linkage, have also successfully linked their traffic data with their road condition data and crash statistics. However, DMR has reported issues with their intersection definitions. They have found that the way intersections have been defined over time has changed even within the same organizations. Errors like these can affect their ability to perform retrospective studies in relation to intersection types. The group has, however, created a plan to incorporate more accurate intersection definitions with the implementation of GIS technologies to their system.

The South Australia Transport Services Division (TSD) has proven to be a model for large scale traffic data linkage. The TSD has geo-coded all different contributing databases which allows for simple and large scale linkages. The Geo-coding is based on a linear reference system. Also, they have a large network for establishing traffic volumes across the region making it possible to perform more accurate population based studies regarding traffic volumes.

New Zealand has one of the most sophisticated traffic linkage systems. All of New Zealand's 70 Road Controlling Authorities (RCA) keep records on road names and dimensions and most keep records on rarer information including surface water channels, roughness, footpaths, pavement layers and rehabilitation. The Ministry of Transport maintains a map based database of reported crashes. This data is linked to the Road Assessment and Maintenance Management System that contains all the roadway condition information.

All of the transportation groups in Australia and New Zealand that were include in this report stressed the importance of geo-coding and the implementation of GIS for the best linking capabilities. Often this can be one of only a few linking parameters with the ability to bring all the databases together.

The majority of the groups used police crash reports for the crash data and this is supplemented by additional road authority data. Many of the groups focused on successfully linking crash data to road conditions and traffic information. Asset inventory data was used to describe the locations, road classes, surface type, geometric details and speed limits. Automated inventory systems already in place made accessing road inventory data and video-based roadside information easy. Asset condition was also obtained by groups that update the conditions of roadways. Some of this data is saved in the asset inventory database while other groups keep it in standalone databases which require linkage to the asset inventory database. The final linkage was with the traffic volume data. Annual Average Daily Traffic (AADT) is conducted regularly and can provide insight for population studies (ARRB, 2006).

Western Australia Road Injury Database

Rosman et al. (2001) were interested in linking police, hospital and death records for road crashes and injuries. They performed this study by relating police crash reports, hospital discharge record and death registrations from years 1987-1996. The method chosen for linkage was a probabilistic approach that allowed the crash report to be linked using the consequential injury from the crash. A special linkage software platform was used that assigned weights and defined the linking assignments.

The linking process was approached with progressive steps to leading to the final linkages. First, a pilot study was conducted that linked medical discharge and procedural data from within a teaching hospital in Perth (Ferrante et al., 1993). Later, a three year study was performed linking the crash reported data where at least one person was injured with hospital records. Following the previous successes, the death records were included with records from 1993-1994 and 1995-1996. At the same time a comprehensive table was created that linked the costs of injuries based on the injury severity (AIS). This data was obtained by linking injury data to Insurance Claim data. Injury costs could then be calculated for each casualty.

The results of their study were based on logistic regressions from comparing specific variables including age, speed limit, and gender to injury severity. They found that each of the variables were significant and independent in their effect on the probability of severe injury. Severe injury was defined as any casualty with an AIS score greater than 3 and included fatalities. The group did find that there was under-reporting of injuries in the crash reports due to a lack of data accuracy and completeness as reported at the scene. As a result, about 40-45% of the hospital records could not be linked to a crash record. They did however find that the percentage of linked data did increase with time. This increase was attributed to improvements in data quality and completeness. The group noted the known limitations associated with probabilistic linkages, but concluded that a tool such as their Road Injury Database can be powerful when performing population based studies (Rosman, 2001).

CODES

In 1991 a congressional mandate, the ISTEA, required the study of the importance of seat belts and helmet use. As part of this mandate, they allocated 5 million dollars to NHTSA. The ISTEA required that information regarding injury costs, the severity of injuries, rehabilitative costs, mortality and morbidity outcomes be included along with the research on restraint and helmet use (Johnson et al., 1996; Department of Transportation, 1998). These requirements clearly require the use of a number of databases, both governmental and private. From this need came the Crash Outcome Data Evaluation System (CODES).

The CODES system is comprised of a number of state run DOTs that utilize their respective in-state databases to create data linkage. The states that were awarded funding were those with existing linkable databases concerning highway safety, health, and insurance claims. Each state was to create a CODES advisory committee composed of the owners and users of the state data. Differing forms for each category of linkage were represented by the different states. For the most part, states utilized crash reports, vehicle registration data, roadway data, EMS data, ED data, death certificates and insurance claims.

The CODES project utilizes probabilistic methods to determine the appropriate data linkages. The data is first placed into blocks and then weights are assigned to each variable. The weights are determined by the rarity of a given variable. The more rare variables are given the most weight because they possess the most linking power. After linkages are made, a value is assigned to each pair. Pairs with exact matches are given the full weight while non-exact matches are assigned values based on pre-determined match parameters. The attributed weights for each variable linkage are combined to give an overall linkage value. Finally, those whose composite values are in a questionable zone are manually reviewed. On average, each state must manually examine about 10% of their linkages.

The linkages showed that the greater the severity of injury, the more likely it is to be linked. Also, it was noted that Wisconsin had a significantly lower linkage rate because they lacked access to the outpatient data (EMS, ED, vehicle claims). To meet the ISTEA requirements, the CODES data was used to calculate the effectiveness of the belt and helmet use. Previous NHTSA reports had shown seatbelt use was 40-50% effective for preventing death and 45-55% effective at preventing injury. The CODES data did not match up exactly and varied greatly by state. The reported differences were attributed to the over-reporting of belt use in police reports. The discussion of the effect of helmet usage revealed that the CODES data was less consistent than with belts. These differences were attributed to small sample sizes in some states and differences in helmet usage reporting. Other reports were also created regarding relationships in crash injury based on the CODES data including the effects of different restraint types, alcohol and drug use, age, gender and time of day (Johnson et al., 1996).

A number of issues stemming from the introduction of CODES have already been discussed in this review. Administrative and statistical problems are discussed thoroughly in the NHTSA report, “Problems, Solutions and Recommendations for Implementing CODES.” This document can serve as a manual for acknowledging issues and as a guide for improving upon issues that may arise (NHTSA, 2001).

Table 1. Participating CODES stated as of August 2005 (NHTSA, 2005a)

CODES States		
Arizona	Massachusetts	Pennsylvania
Connecticut	Minnesota	Rhode Island
Delaware	Missouri	South Carolina
Georgia	Nebraska	South Dakota
Illinois	Nevada	Tennessee
Indiana	New Hampshire	Texas
Iowa	New York	Utah
Kentucky	North Dakota	Virginia
Maine	Ohio	Wisconsin
Maryland	Oklahoma	

Alaska - MINICODES

Alaska, with the funding of NHTSA and under the guidance of the National Association of Governor's Highway Safety Representatives (NAGHSR), developed a data linkage system under the CODES program whose pilot study was referred to as MINICODES. Alaska used the linked data from this system to evaluate the differences in younger and older drivers.

Computerized crash records from the Highway Analysis System from 1991-1995 were obtained through the Alaska Department of Transportation and Public Facilities (DOT&PF). Hospital discharge records were extracted from the trauma registry. The two different data sources were linked using the MINICODES protocol. Only data where at least one occupant was injured or killed was considered for the study. The driving population was then divided into young drivers, ages 16-20, and older drivers, ages 21-50. All cost estimates were based on the CrashCost Program established by NHTSA and all injuries were categorized by their AIS scaling(Moore, 1998; NHTSA, 2003).

The Alaska MINCODES system was able to determine relationships based on driver age. A sample of their results revealed that young drivers are 2.9 times more likely to be involved in a crash causing injuries resulting in hospitalization and 2.6 more likely to be involved in a fatal crash. Relationships were also established based on sex, time of day, restraint use and alcohol/drug involvement as they relate to older and young drivers.

This study, as well as many others that followed, have shown the increased productivity that can result from database linkage. With all the data contained in one format and in one location, the efforts of research groups, policy maker and contributing organizations can be eased and expedited (Moore, 1998).

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5. Description of New Jersey Fatality Databases

The goal of this research project is to determine the feasibility of an integrated database for the analysis of fatal accidents in New Jersey. This section describes existing fatal crash related databases and datasets in New Jersey. By linking these databases, there is an opportunity to investigate the root causes of fatalities in ways that are not possible through analysis of a single database. The following five databases will be considered in this research project:

- NJ Crash Records
- MVC Fatalities Database
- EMS Records
- Fatal Analysis Reporting System (FARS)
- NJ State Police Fatal Accident Investigations Division

NJ Crash Records

New Jersey Department of Transportation ("NJDOT") makes, maintains and keeps a database of New Jersey Traffic Report (NJTR-1) crash data. New Jersey Motor Vehicle Commission ("NJMVC") by law is the owner of New Jersey Traffic Report (NJTR-1) records pertaining to motor vehicles crashes in this State. The NJDOT database and the information contained in it does not constitute public records and the database information is not required to be released under the New Jersey Open Public Records Act, N.J.S.A. 47:1A-1 et seq., but may be released at the discretion of the NJMVC in such manner as may be determined by the NJMVC Chief Administrator to be administratively appropriate and in accordance with the applicable laws and regulations.

This database contains general information on both the driver and the crash victim. Information such as crash statistics and victim breakdown are also recorded. This information provides factors believed to have caused the crash. Since January 2005, the data has been stored in the form of a Microsoft Excel file. Prior to 2005 information was only available on hardcopy. Currently, the MVC database is not linked with any other state databases. The current use of the MVC database is to keep unsafe drivers off the road. The data fields available in the New Jersey Motor Vehicle Commission Database are listed in the appendices.

Fatal Analysis Reporting System (FARS)

FARS is a comprehensive census of all traffic related fatalities in the U.S. By Federal mandate, all states including New Jersey must collect and provide NHTSA with records of all traffic related fatalities on their highways. FARS data can be obtained by downloading any of the published files from NHTSA at ftp://ftp.nhtsa.dot.gov/FARS. The files are available in SAS, DBF and sequential ASCII file formats. In New Jersey, FARS data is assembled for FARS analysts who supplement the NJTR-1 police accident report with driver history data from MVC and toxicology from NJSP.

NJ State Police Fatal Investigation Unit

The New Jersey State Police Fatal Investigation Unit works with accident reconstructions including estimates of vehicle pre-impact trajectories, impact speeds, and post crash trajectories. Data from these investigations also may include scene measurements, onsite photos, and data retrieved from those crashed vehicles equipped with Event Data Recorders (EDR).

State Police relied upon a system called the Record Management System (RMS)[3]. The State Police were able to pull off the location, the time, if there were any fatalities and if so did they occur at the site. If the accident resulted in a later fatality due to injury the fatality was only on the hardcopy and that information was never transferred over for statistical purposes. Since inconsistencies were a concern of data entry the NJTR-1 was used as an accuracy check. Prior to 2006 the local police used a system called Teletype; information was physically entered from a hard copy. Now NCIC2000 which is more web-based is used by police. Individual municipalities can not electronically enter the accident data and therefore are required to notify the State Police Fatal Investigation Unit within 24 hours of a fatality; however, sometimes municipalities forget and the data is never passed on.[3] The NJSP database was received on March 1, 2007 and is currently being examined to document the data fields.

EMS Records

There are 766 independent Emergency Medical Services (EMS) agencies in New Jersey. Each agency collects data on their unique Emergency Medical Services Form. The state of New Jersey is currently sponsoring a pilot program being conducted by Rutgers University to develop an integrated database called the National Emergency Medical Services Information System (NEMSIS). The databases will be available sometime next year. NJDOT has a data integration team that is working on collecting information to link databases from EMS and NJCrash. NJDOT has told the research team that the EMS database will not be made available to Rowan and Virginia Tech at this time.

Survey of Existing Fatality Databases

A survey was conducted in order to gain information on New Jersey's independent state agencies. A sample of questions was selected in a way to gain the most information from the agencies surveyed. The survey was given to the New Jersey State Police Fatal Units and the New Jersey Motor Vehicle Commission Fatal Units. The survey instrument is presented in the appendices. The results of the survey from of NJMVC and the NJSP Fatal Accident Investigation Unit are provided in Table 2.

Table 2. Responses to Fatality Database Survey

Question	MVC Fatal Accident Unit	NJSP Fatal Accident Investigation Unit
1. What are the agency databases or datasets which involve or supplement crash data?	The NJSP Fatal Accident Units reports are used to develop Motor Vehicles crash data.	The NJSP Fatal Units creates their database primarily based off of the NJTR-1 reports generated in the field
2. What sources are used for data collection?	The NJSP Fatal Accident Units reports are used to develop Motor Vehicles crash data.	The source is from the NJTR-1 report.
3. What are the data collection protocols methods, and forms?	The NJSP Fatal Accident Units reports are used to develop Motor Vehicles crash data.	The form used is the NJTR-1. The NJTR-1 is than confirmed to assure all data is correct before it is input into the NJSP Fatal Units database.
4. What are the data elements in the current database?	The data contains information such as victim information, driver information, etc. A more detailed data library can be seen in the appendix.	The data elements are similar to the ones included in the NJTR-1. The exact elements are going to be analyzed once the database is received.
5. Is the data maintained electronically? If so in what form? What is the physical location of the database? Who has access to it? What is the size of the database?	The current data is now maintained electronically. Prior to 2005 the data was kept as a hardcopy in the form of index cards. The current database uses Microsoft Excel. The physical location of the database is at the NJMVC building in Trenton. The employees of the NJMVC fatal unit have access to the database.	Prior to 2006 the data was teletype into electric format. Now data is sent in electronic format. Also with the change in 2006 an increase in the amount of information collected.

Question	MVC Fatal Accident Unit	NJSP Fatal Accident Investigation Unit
6. What are the current uses of the agency data?	NJMVC Fatal Unit currently uses the data to keep a record of the driver, victim, and the action taken against the driver in a particular fatal accident.	The database is used for prosecution of the individual who caused the fatality. Another use for the database is to develop yearly reports that break down several causes of New Jersey's fatal accidents.
7. Who are the current users of the agency data, i.e., in-agency users, other state agencies, and external organizations?	The only current user is the NJMVC Fatal Unit.	One current user of the database is NJMVC. NJMVC uses the data to create their own database and to figure determine whether action such as driver's license revocation should occur.
8. What additional data would each participant like to have? What other databases would each agency like to access?	NJMVC would like to find a common denominator in fatal accidents in order to be able to reduce accidents.	
9. Are there any data limitations or data quality issues?	The electronic data only dates back to 2005, so information before 2005 cannot be used easily.	The limitations of the NJSP Fatal Unit database are that prior to 2006 fewer details were recorded in the accident reports. Another limitation is the individual municipalities reporting the information to NJSP. Some data quality issues are that some of the fields are still subject to interpretation.

Question	MVC Fatal Accident Unit	NJSP Fatal Accident Investigation Unit
10. Are there any data confidentiality concerns or policies?	Yes. The data contains private information such as driver's license number, so it is important to maintain confidentially.	Yes. The database contains sensitive information
11. Are there any legal constraints on data sharing?	Yes. The data contains private information such as driver's license number, so it is important to maintain confidentially.	Yes.

The responses of the survey provide an invaluable insight about how the data flows between the agencies, how the data is collected and stored, and what each agency does with the data

Interrelationships between Fatality Databases in New Jersey

Following is the interrelationship between the Fatal Accident databases in New Jersey. As seen in Figure 2, the source of all traffic fatality data is the NJTR-1 Police Accident report.

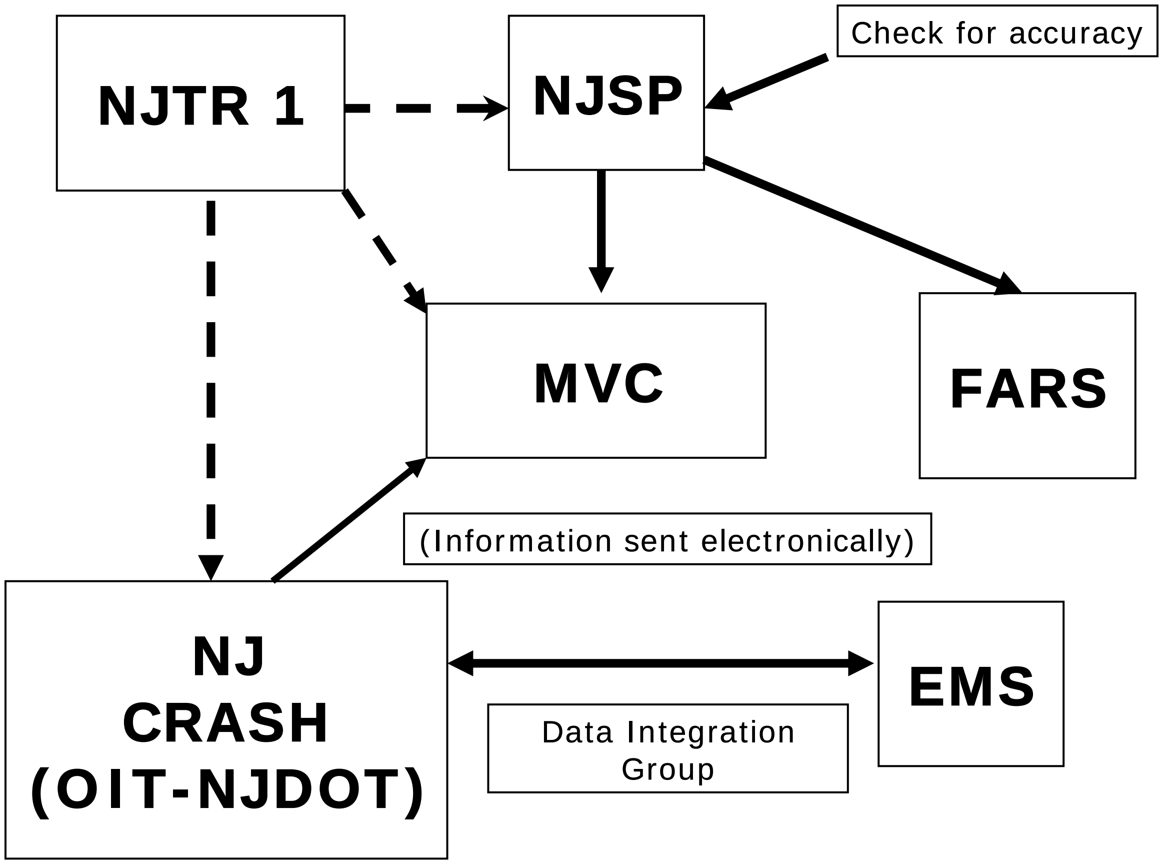

Figure 2. Interrelationships between Fatality Databases in New Jersey

The data from NJTR1 is supposed to be submitted to NJSP within 24 hours. This would allow the NJSP to initiate any action necessary if the perpetrator is still at-large. However, some information is send to NJMVC, OIT-NJDOT and NJSP depending on the municipality. All the data eventually is stored in NJSP and checked for accuracy. The NJSP fatal unit ensures that the data is complete and accurate and could serve as the most comprehensive information about a fatal accident. This information led the research team to believe that any electronic linkage of data from different agencies would not be beneficial, because only NJSP would have the complete information about an accident. The NJSP data could serve as a central database for fatal accidents and the data should be sent to NJSP in a timely fashion.

NJDOT Data Warehouse

In 2008, a consortium of New Jersey state agencies using highway accident released the NJ CRASH Data Warehouse. The consortium, referred to as the NJCRASH co-location group, was coordinated by the NJDOT Bureau of Safety

Programs. The data warehouse itself is maintained by NJDOT Office of Information Technology (OIT).

The CRASH Data Warehouse is a unique data resource for investigating New Jersey fatal accidents. Currently, the data warehouse contains NJ CRASH records and EMS records.

The Office of Information Technology formed the Statewide Traffic Records Coordinating Committee (STRCC). The committee provides a means for all stakeholders that have a need for traffic safety information to provide input regarding improvements to the traffic records system that would benefit their organization and the system as a whole. The STRCC is responsible for approving data elements collected, developing training curricula and manuals for data collectors, adopting requirements for file structure and data integration, assessing capabilities and resources, establishing goals for improving the traffic records system, evaluation the system, developing cooperation and support from stakeholders, and ensuring that high quality data will be available for all users in a timely fashion.

The New Jersey STRCC prepared a Strategic Plan for Traffic Records in 2003 as the result of a recommendation in the 2002 Traffic Records Assessment. The STRCC revised the 2003 Strategic Plan in May 2006. The purpose for this action was to meet the requirements of a NHTSA grant program to improve state traffic safety information systems under Section 2006 of the Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA–LU).

An application for 408 funding was prepared by the STRCC that provides a realistic approach to achieving their vision. Each of the projects identified in the application addresses one of the strategic goals in the Plan. The projects for which funding is being pursued include:

- The Electronic Collection of Emergency Medical (EMS) Data by Volunteer Providers
- Integration of EMS data with Crash Records
- Co-locations of the sections involving Fatal Data Information
- Global Positioning System Units for Police Departments
- Vehicle Identification Number Validation
- Exportation of Blood Alcohol Content (BAC) information

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6. Evaluation of Fatal Crash Reporting in New Jersey

According to NJTR1, the protocol for Fatal Crash Reporting is as follows "*Local Police Dept & medical examiner do preliminary crash investigation.*

1. *Local Police* ***Send NLETS Teletype Message*** *(Incident report)* ***to State Police Fatal Unit within 24 hours*** **on all** ***Fatal crashes***
2. ***Mail a copy of NJTR-1 only to, Motor Vehicle Commission, Fatal Accident Review Board and to NJDOT within 72 hours*** *(whether complete or no*t)"

The problems that we are encountering are that the NJTR-1 and Supervising Officer (SP) reports are not getting done and handed in on time. The time required by law is 72 hours of the accident that the reports have to be done and handed in to the Motor Vehicle Commission, Fatal Accident Review Board and to NJDOT.

The problem is not only that the reports are not being received within the 72 hour law but there is a substantial about of data that is not being recorded; this can be shown in Table 1 by N/A, a value that is close to 42%. The law states that the forms must be handed in within 72 hours whether completed or not. In this case, the forms are exceeding the 72 and not being completed. Less then one percent of the reports are getting handed in within the 72 hour dead line. These results are base solely on the data from the 2005 New Jersey Motor Vehicle Commission.

Table 3. Annual totals of time period that NJTR-1 and SP forms are received

	Annual Totals for 2005			
	NJTR	**SP**	**Total**	**Percentage of total**
Within 3 days	8	0	8	0.64
Within 7 days	18	0	18	1.44
7-14 days	42	0	42	3.37
Within 30 days	42	0	42	3.37
Within 90 days	60	8	68	5.46
Within 180 days	16	160	176	14.13
Within 365 days	7	320	327	26.24
Greater than 365 days	6	36	42	3.37
N/A	429	94	523	41.97
		SUM =	1246	

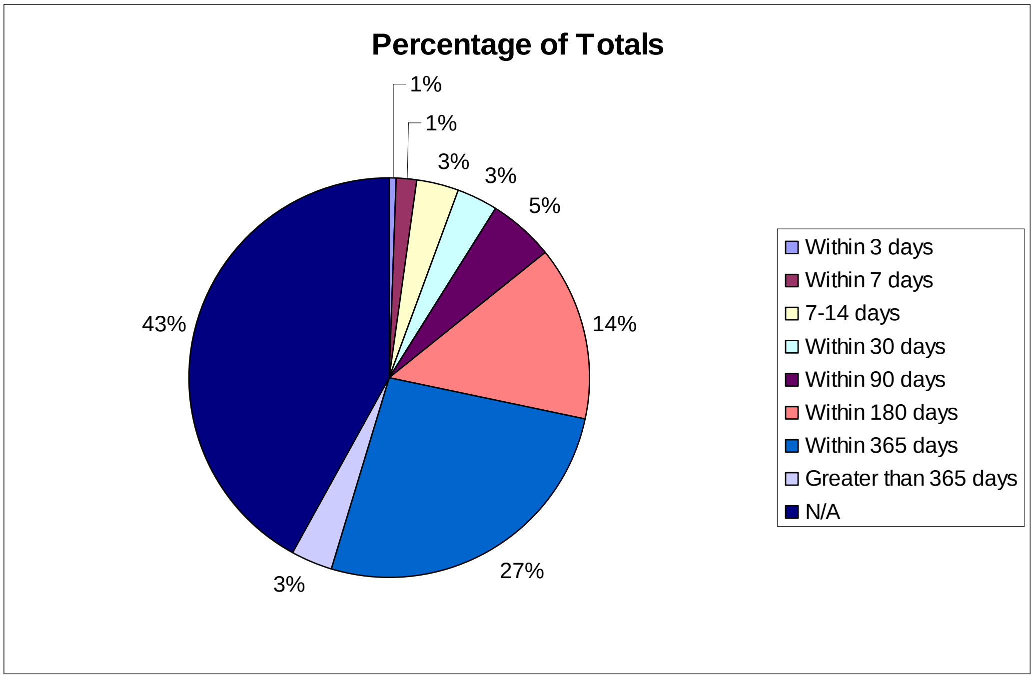

Figure 3. Annual percentages of time period that NJTR-1 and SP forms are received

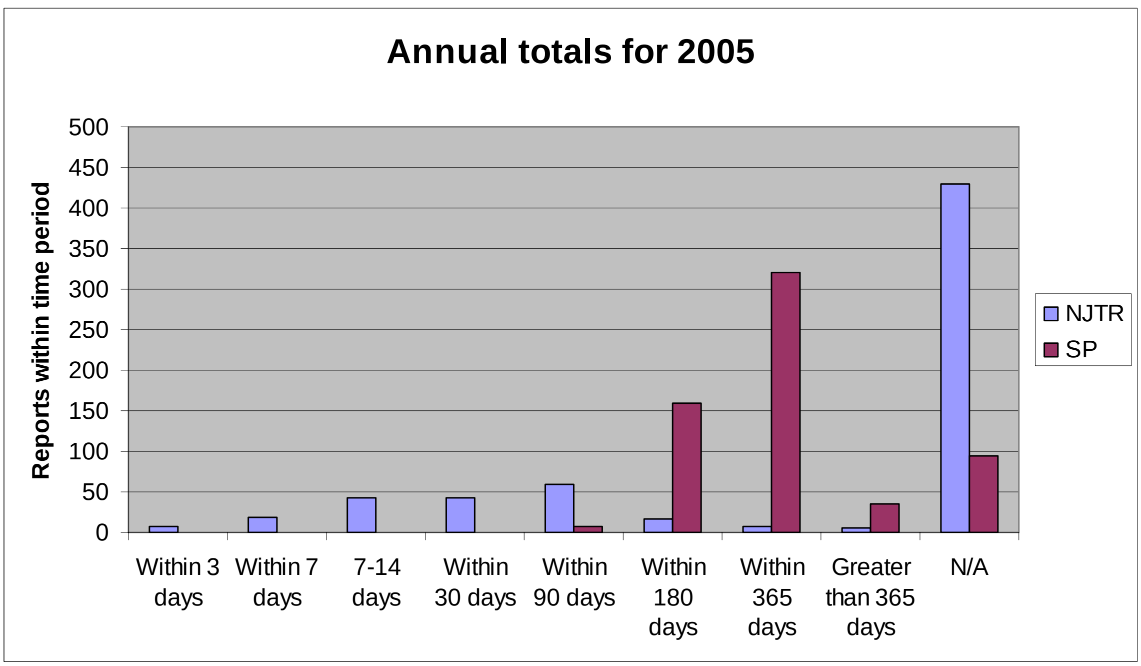

Figure 4. Annual totals of time period that NJTR-1 and SP forms are received

From the table and graphs of the annual numbers for 2005 Motor Vehicle Commission, a very small percentage of the NJTR-1 and SP reports are being received within the 72 hours that the law requires.

7. Preliminary Analysis of Fatal Accidents in New Jersey

Background

Despite intensive efforts to improve highway safety in New Jersey, the number of the number of traffic fatalities in the state has remained relatively constant from 1991-2005. As shown in Figure 5, this has been true for motor vehicle occupants, pedestrians, and other highway users, e.g. bicyclists. During this time period though, the number of registered vehicles and miles traveled on New Jersey highways increased which would suggest that the fatality rate per vehicle mile traveled or per registered vehicle has actually declined.

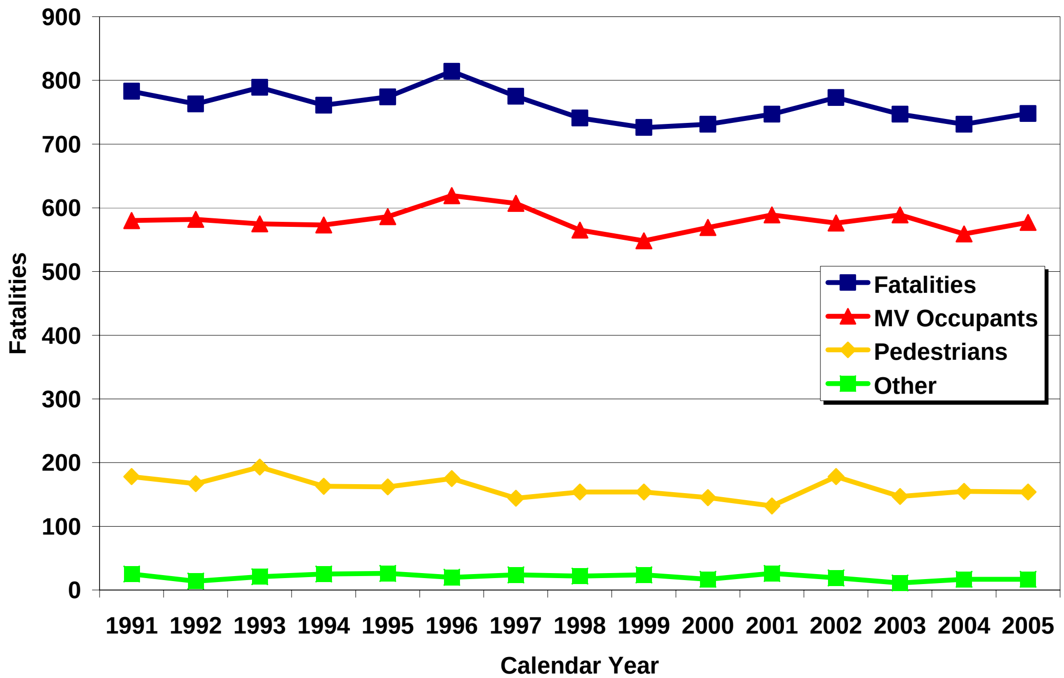

Figure 5. New Jersey Fatalities 1991-2005 (FARS 1991-2005)

The first phase of this project has investigated the feasibility of linking New Jersey fatality data into a single cohesive database to further study this problem.

Objective

The objective of the second phase of this project is to conduct two cases studies to demonstrate the use of linked fatal accident data from New Jersey.

Possible Case Studies

The project initially considered three potential research areas for the case studies:

- Relationship between alcohol-impairment and fatalities
- Fatalities versus safety belt use
- Fatalities versus age of the driver

Early results from each study are shown below.

Case 1: Drinking and Driving

As presented in Figure 6, the number of intoxicated drivers involved in fatal crashes declined sharply from 1988 to 1995. This was the result of aggressive enforcement and driver education about the dangers of drunk driving. Unfortunately, from 1995 to the present the number of intoxicated drivers involved in fatal crashes has remained roughly constant.

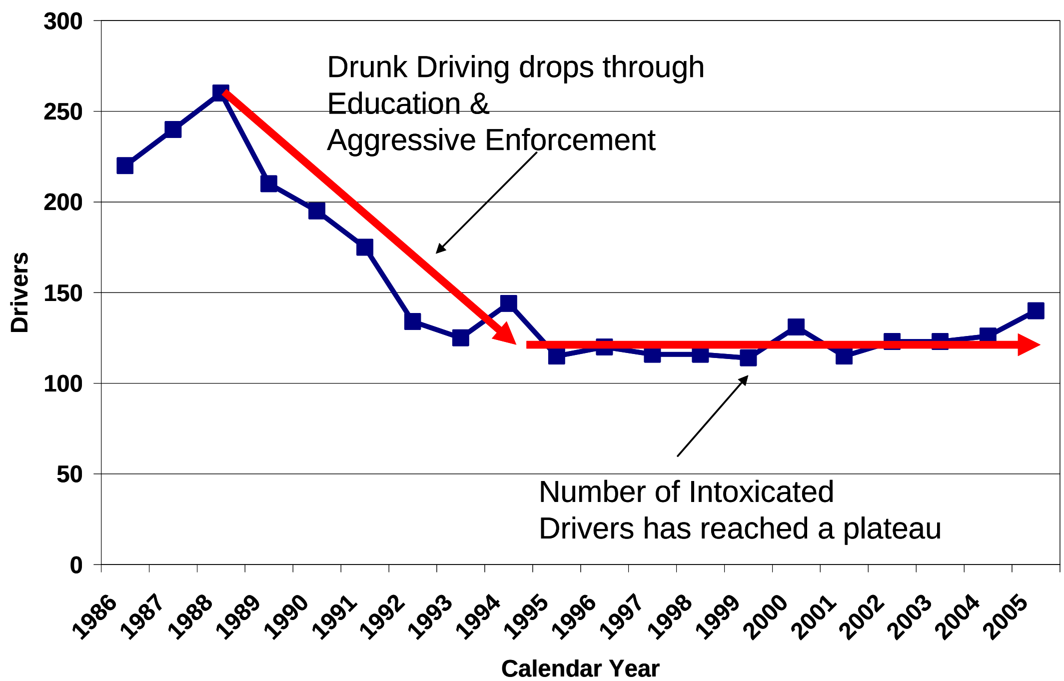

Figure 6. Intoxicated Drivers involved in Fatal Crashes in New Jersey 1986-2005 (NJSP)

The research goal for this case would be to determine who these hardcore drinkers are. The strategy for NJDOT would be then to design a safety improvement program to focus anti-drinking and driving efforts on this hardcore group.

Case 2: Fatalities versus safety belt use

In 2005, the seat belt use rate in New Jersey was 86% - one of the highest rates in the U.S. Figure 7 presents the fraction of occupants involved in motor vehicle crashes by their injury level and seat belt use. The figure is based on analysis of

NJCRASH 2005 data. 98% of the occupants who were uninjured were wearing their belts. As injury severity increases, the fraction of occupants who were wearing their belts decreases. Clearly, there is a benefit to wearing seat belts. Figure 7 shows that 46% of the fatally injured occupants were not wearing their belts. The 16% of occupants who do not wear their belts in New Jersey accounted for almost half of all fatalities. To decrease fatalities, one very clear opportunity is to simply increase belt use.

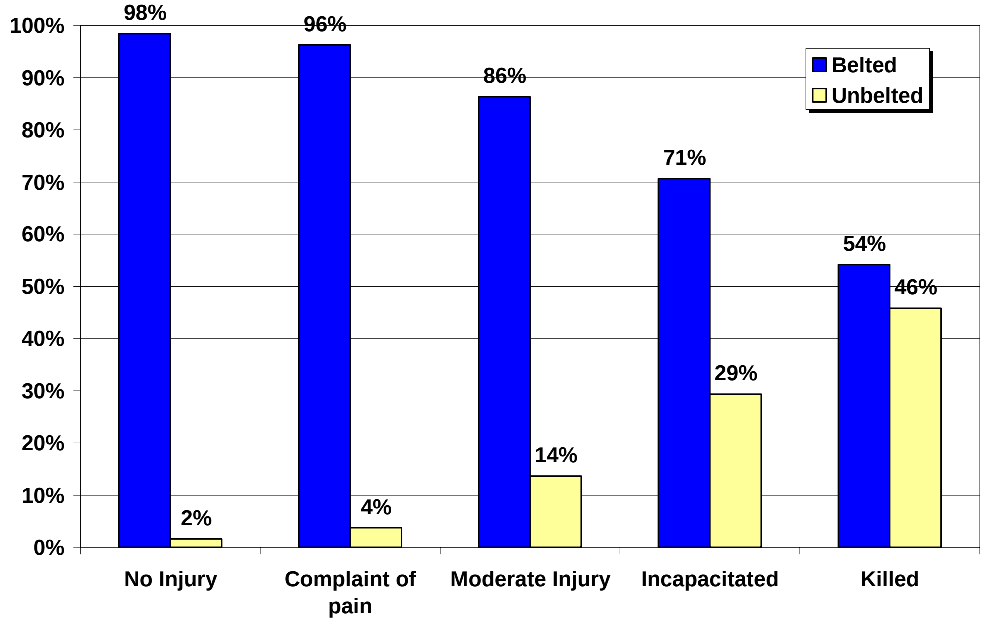

Figure 7. Distribution of Injuries by Safety Belt Use (NJCrash 2005)

<u>Case 3: Fatalities versus Driver Age</u>

Figure 8 presents the distribution of fatally-injured drivers by age. The number of fatalities peaks for younger drivers of age 20-24 and for older driver of age 75+. Both of these driver groups represent an opportunity to reduce fatalities. Younger drivers can benefit from driver education or licensing programs which increase their driving experience. Older drivers can benefit from medical review programs which can identify and correct problems such as impaired vision.

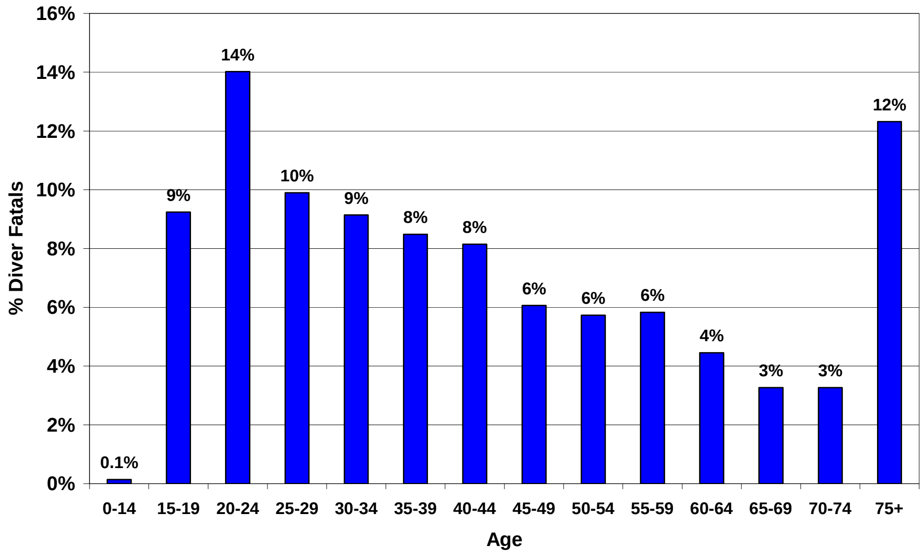

Figure 8. NJ Driver Fatalities by Age, N=2111 (NJCRASH 2005)

Figure 9 shows the number of crashes to which older drivers are exposed by age of the driver. The number of crashes drops off sharply after age 60 presumably because older drivers are driving less.

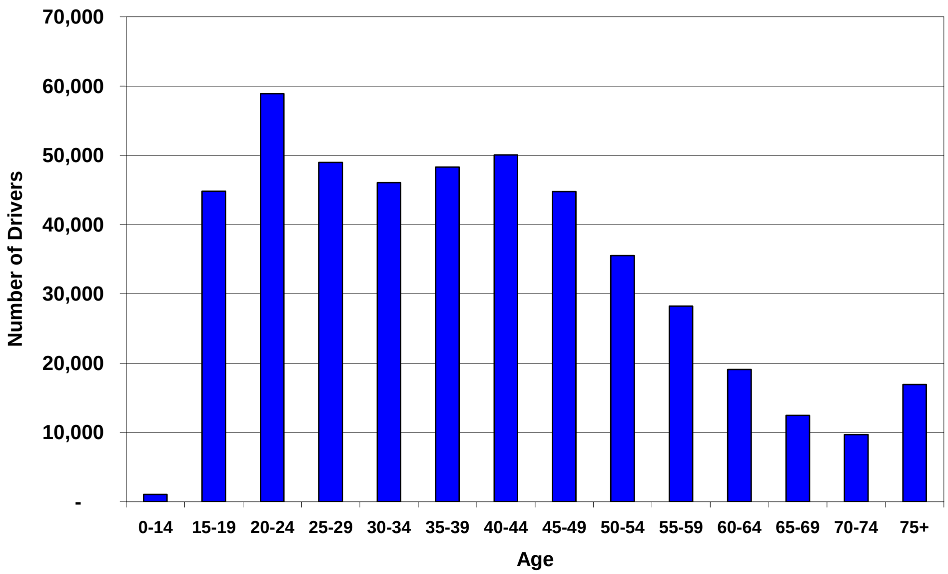

Figure 9. NJ Driver involved in crashes by Age (NJCRASH 2005)

One potential case study would investigate teen or younger drivers. A second possible case study could investigate the special problems which confront elderly drivers.

8. Evaluation of Young Driver Fatality Risk in New Jersey

The objective of this study is to examine the risk of fatalities among young drivers in New Jersey. For this study, young drivers will be defined to from 15-20 years of age.

Approach

The evaluation was based upon the analysis of NJ highway fatality records extracted from the Fatality Analysis Reporting System (FARS) database for years 1991-2006. FARS is a national census of all highway fatalities which is maintained by the National Highway Traffic Safety Administration (NHTSA). Throughout the study which follows, the population has been separated into four age categories: 1) children defined to be 0-14 years of age, 2) young persons defined to be 15-20 years of age, 3) adults defined to be 21-64 years of age, and 4) older adults defined to be 65 years of age and older. We are using the age range of 15-20 years for young persons rather than simply teenagers in order to capture the effect of underage driving. Drinking is not permitted in NJ until age 21.

Results

Figure 10 presents the traffic fatalities in New Jersey from 1991-2006 as a function of the age of the fatally injured persons. Fatalities among young persons have remained around 100 over this 16 year time span. Since 1998, the fatalities among older adults have declined by 29% (from 189 to 134 deaths). Fatalities among adults 21-64 have increased by 4% from 741 to 772 deaths over the same period.

Figure 11 displays the distribution of traffic fatalities for younger drivers by vehicle type. Here the calendar range has been restricted to2003-2005 in order to focus on the most recent trends. Most young persons killed in traffic fatalities were occupants of a passenger vehicle (82%) in 2003-2005. Pedestrians accounted for 9% of the fatalities while motorcycle riders accounted for 7% of the fatalities for persons 15-20 years old. Although most safety initiatives rightfully focus on teens and other young persons in their cars, it is important to keep in mind that nearly 1 in 5 young persons is not an occupant of a car or light truck.

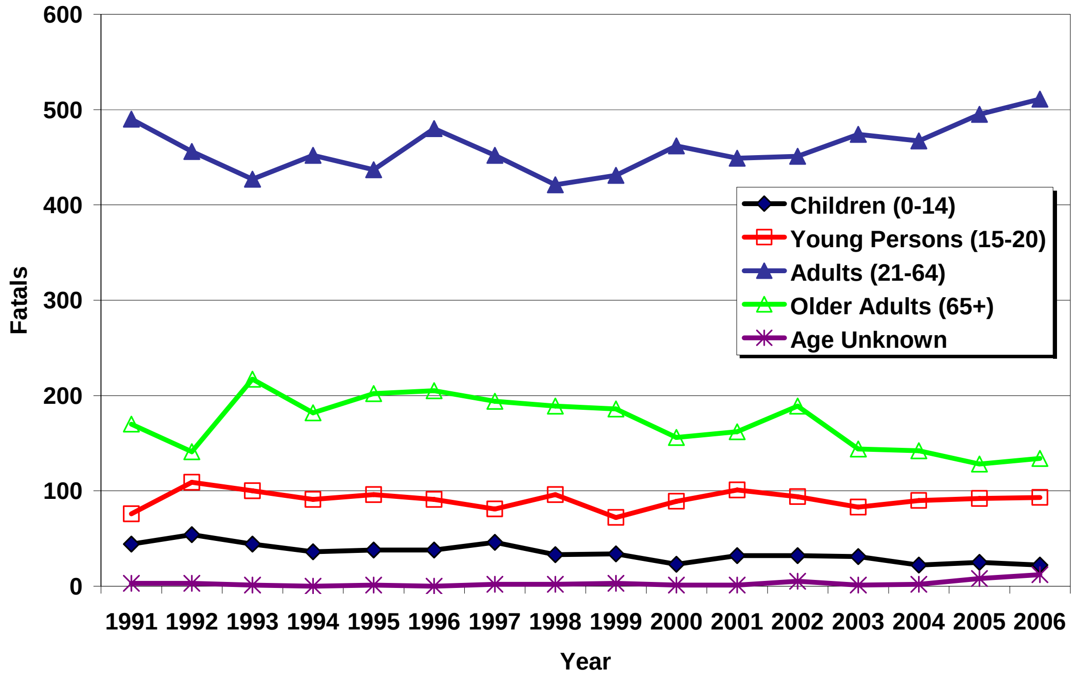

Figure 10. New Jersey Traffic Fatalities from 1991-2005

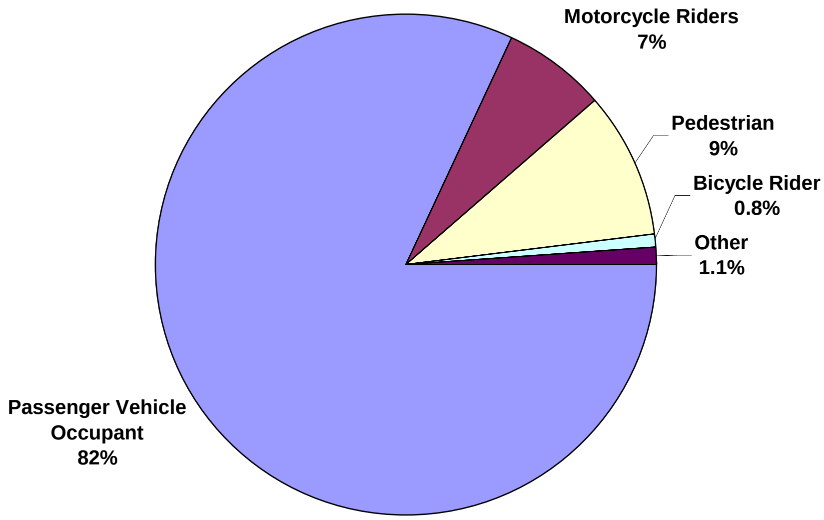

Figure 11. Distribution of NJ Traffic Fatalities incurred by persons 15-20 years old from 2003-2005

Figure 12 presents traffic fatalities for each age group as a function of gender from 2004-2006. For all age groups, a fatality is more likely to be male than female. For teens, two-thirds of the fatalities are male while for adults 21-64 years old over three-fourths of the fatally injured persons are male. This likely reflects the increased risk taking behavior which is characteristic of many male drivers.

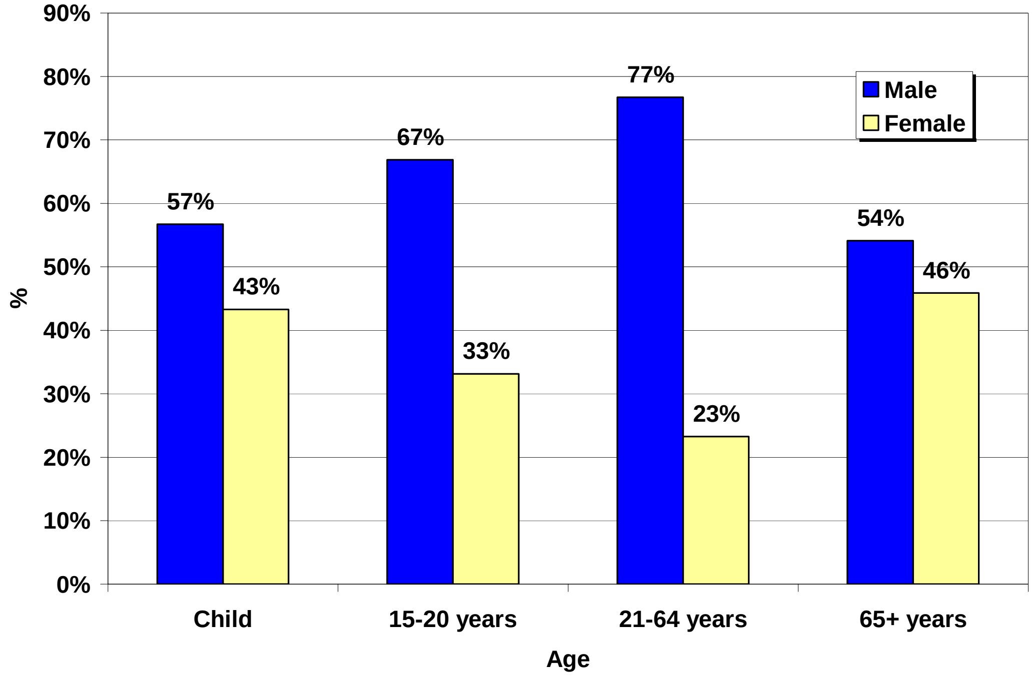

Figure 12. Distribution of NJ Traffic Fatalities by Gender for each age group from 2004-2006

In 2006, New Jersey belt use rates were 90% - among the highest in the nation. However, as shown in Figure 13, over half of all fatally injured younger persons were unbelted. Put another way 10% of vehicle occupants account for over half of the fatalities in New Jersey. This fatality rate was consistent with adults aged 21-64 suggesting that non-belt wearing behavior may carry over from the teen years to adulthood.

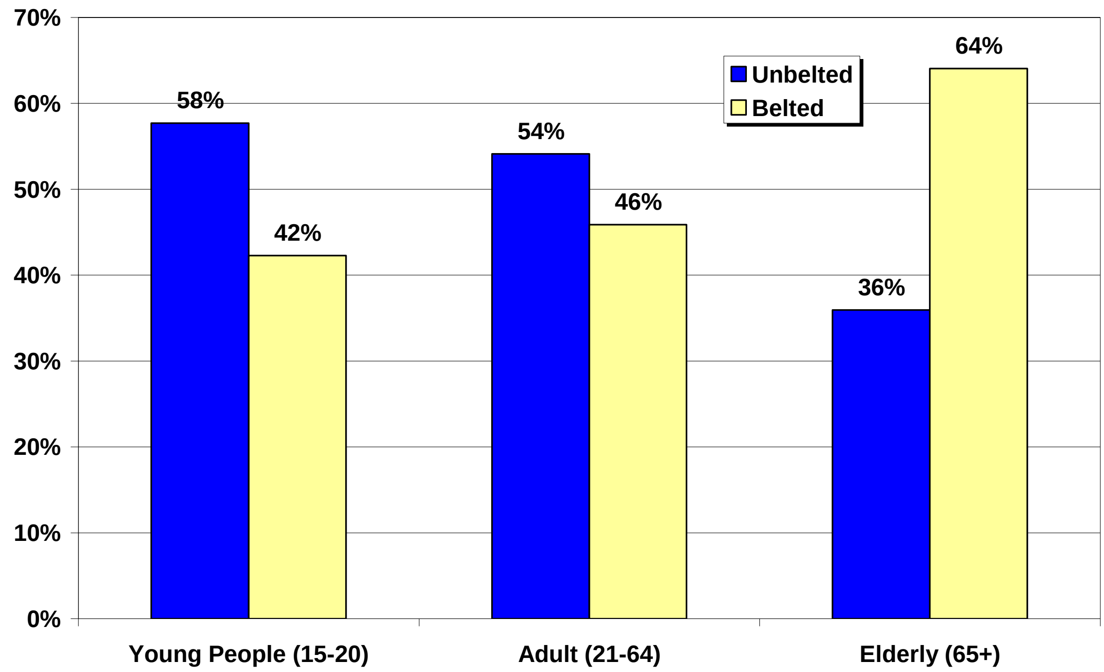

Figure 13. Distribution of NJ Traffic Fatalities by Belt Usage for each age group from 2004-2006

Young Drivers

Because of their inexperience, young drivers may not only be hazardous to themselves as well as other vehicles on the road. This section investigates the behavior of younger drivers involved in fatal crashes. In the analysis which follows, the younger driver was involved in, but not necessarily fatally injured, in the fatal crash.

As shown in Figure 14, approximately 20% of younger drivers involved in fatal crashes had been drinking. This fraction of drivers was consistent with adults aged 21-64. The presence of alcohol was obtained from police accident reports and does not necessarily mean that the driver was intoxicated. Drinking however is not permitted until age 21.

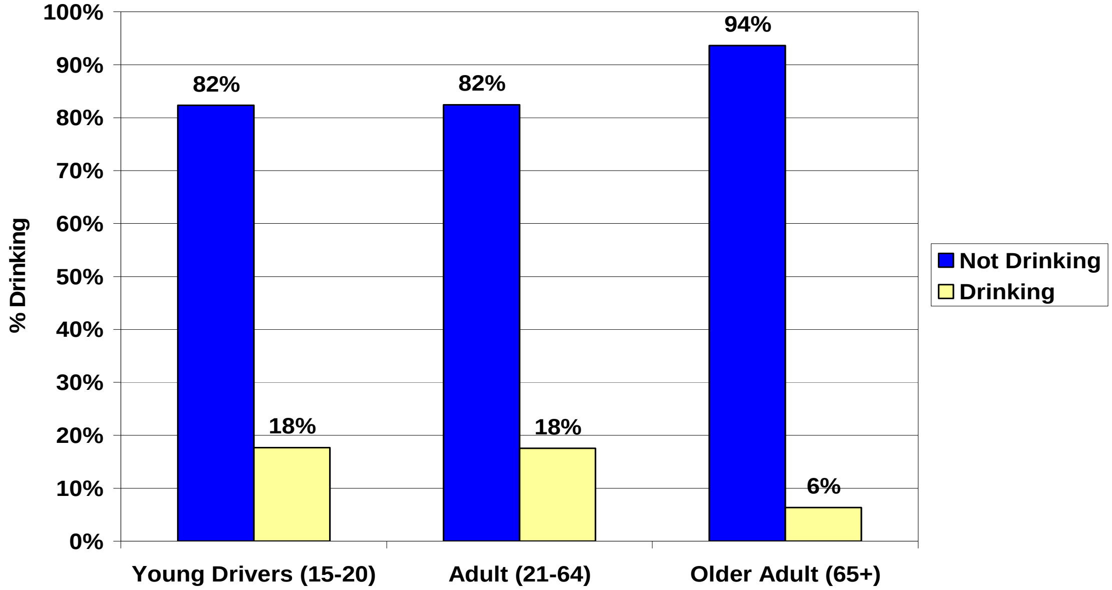

Figure 14. Drivers involved in fatal crashes in NJ by alcohol involvement and age (FARS2004-2006)

Since 2001, New Jersey has maintained a Graduated Driver Licensing (GDL) program to allow teens and younger drivers to safely obtain the experience necessary to become a safe driver. The program has three stages – learner's permit, an intermediate GDL, and a full driver's license. Each stage has a number of restrictions which when successfully met allow the driver to move onto the next licensing stage.

The analysis which follows examines the driver licensing status for younger drivers using data from 2004-2006. As shown in Figure 8, over 70% of licensed drivers involved in fatal crashes had a full license, while over 20% had either a learner's permit or an intermediate GDL license. Lack of a license does not seem to be an issue for these younger drivers: 6% of all younger drivers involved in fatal crashes did not have a license.

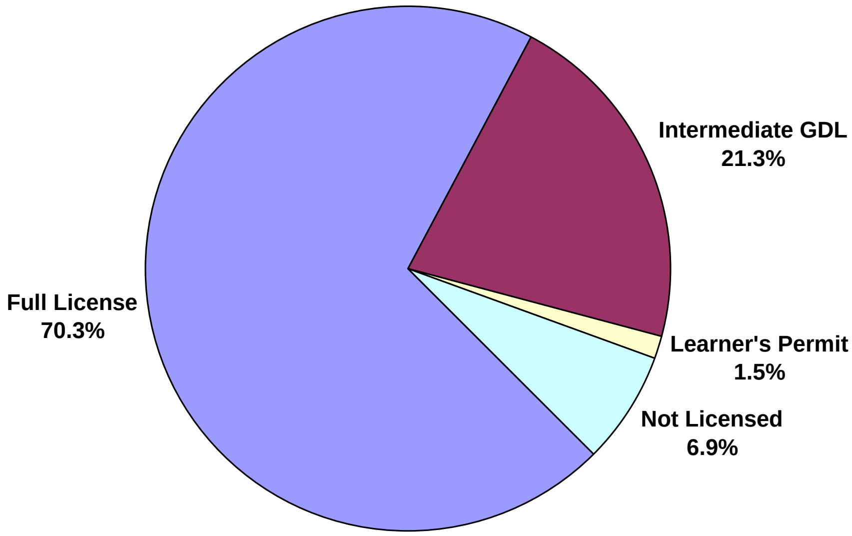

Figure 15. Distribution of License Type carried by Younger Drivers involved in fatal crashes in NJ (FARS2004-2006)

As shown in Figure 16, nearly 7% of all younger drivers involved in a fatal crash were unlicensed while an additional 8% were driving on a suspended license. This distribution is quite different than adults in which only 2% were unlicensed and 7% were driving on a suspended license. Clearly, lack of a valid license does not deter younger drivers from driving. Over 15% of all younger drivers involved in a fatal crash were either driving unlicensed or driving on a suspended license.

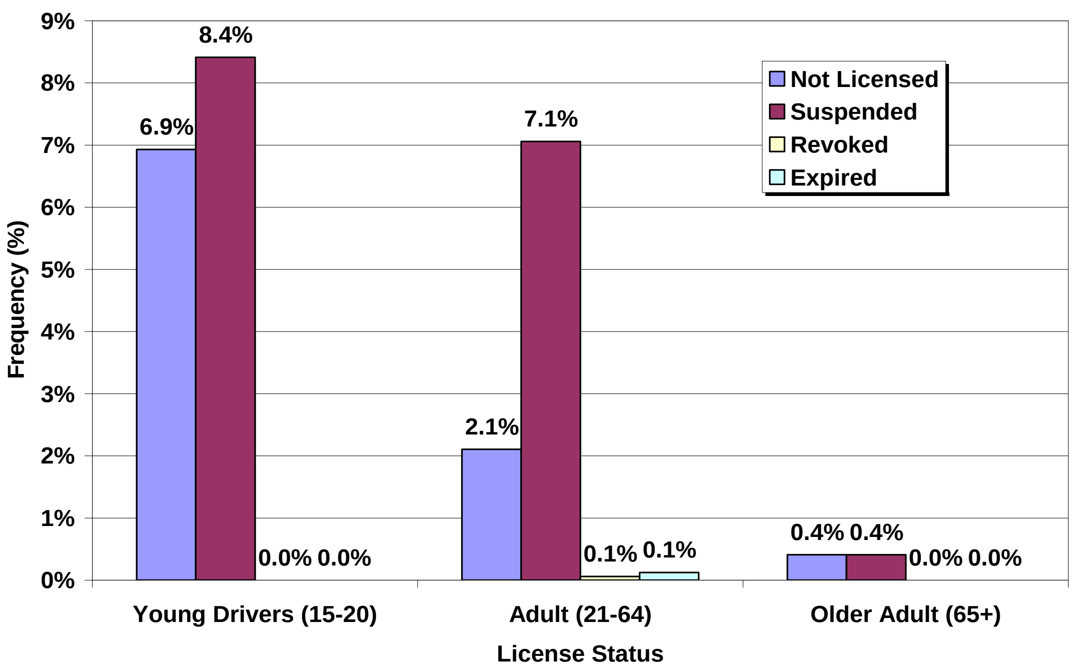

Figure 16. Status of License for Drivers involved in fatal crashes in NJ (FARS2004-2006)

9. Evaluation of the Crash Fatality Risk for Older Adults

Summary

This case study has investigated the fatality risk of older adults involved in traffic crashes in New Jersey. For this study, older adults were defined those individuals 65 years of age or older. The findings were as follows:

- In 2006, 134 older adults were fatally injured in traffic crashes in New Jersey.
- Older adults comprised less than 8% of all persons exposed to traffic crashes in New Jersey, but accounted for 20% of all New Jersey traffic crash fatalities per year. This underscores the fragility of older persons in traffic crashes.
- Most older adults killed in traffic fatalities were occupants of a passenger vehicle (67%). Fatally-injured older adults in motor vehicles were belted (64%). Surprisingly, more than 1 in 4 (27%) of all fatally-injured older adults were pedestrians.
- Alcohol use does not appear to be less a risk factor for older adult drivers than for young drivers. Only 6% of older adult drivers involved in fatal crashes had been drinking, as compared to 18% of younger drivers.
- Nearly 80% of fatal accidents involving older adult drivers in New Jersey occurred in daylight. This statistic suggests that older drivers may be choosing to avoid driving at night either because of self-regulation or because of licensing restrictions.
- Most fatal accidents involving older adult drivers in New Jersey (46%) occurred at an intersection. In contrast, both teen and adult drivers aged 21-64 are more likely to be involved in a fatal crash at non-intersections. Older drivers may have an elevated risk of intersection crashes because of a decreased ability to judge the amount of time necessary to clear an intersection.
- Older adult drivers who were involved in fatal crashes were 4.9 times more likely to have been ill or have blacked out than adult drivers aged 21-64. Older adult drivers were 10% more likely to have been drowsy or asleep than adult drivers, and 40% more likely to have been attentive or distracted than adult drivers.

Introduction and Objective

The objective of this study is to examine the risk of traffic accident-related fatalities among older adults in New Jersey. The specific objectives are to 1) determine the characteristics of fatally-injured older adults in traffic crashes, and 2) identify the factors which lead to fatal crashes involving older adult drivers.

Approach

The evaluation was based upon the analysis of NJ highway fatality records extracted from the Fatality Analysis Reporting System (FARS) database for the years 1991-2006. FARS is a national census of all highway fatalities which is maintained by the National Highway Traffic Safety Administration (NHTSA). Throughout the study which follows, the population has been separated into four age categories: 1) children defined to be 0-14 years of age, 2) young persons defined to be 15-20 years of age, 3) adults defined to be 21-64 years of age, and 4) older adults defined to be 65 years of age and older.

Results

Figure 17. presents the traffic fatalities in New Jersey from 1991-2006 as a function of the age of the fatally injured persons. Since 1993, fatalities among older adults have declined 38% from a peak of 217 in 1993 to 134 fatalities in 2006.

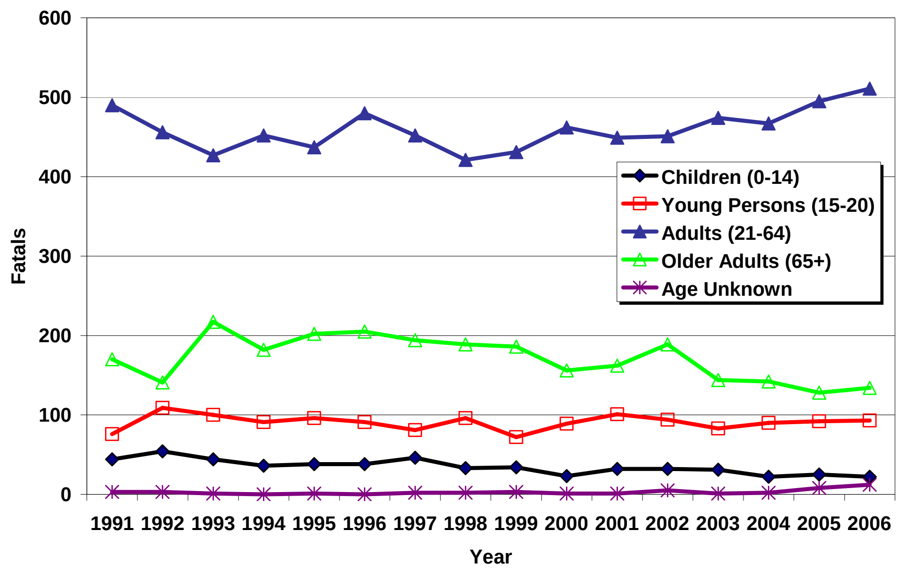

Figure 17. New Jersey Traffic Fatalities from 1991-2005

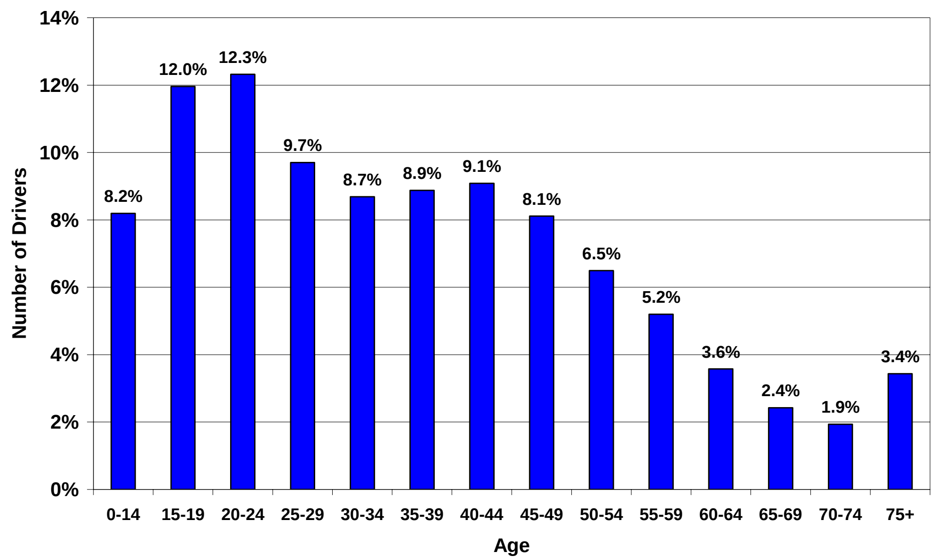

Figure 18. Age Distribution of persons involved in New Jersey traffic accidents (NJCRASH 2005)

As shown in Figure 19, older adults accounted for 7.8% of all persons exposed to New Jersey traffic crashes whether fatal or non-fatal. However, as shown in Figure 19, older adults accounted for 20% of all New Jersey traffic crash fatalities per year. Persons of 75 years age and older comprised only 3% of persons exposed to traffic crashes, but accounted for 13% of all fatally-injured occupants. This underscores the fragility of these older persons in traffic crashes.

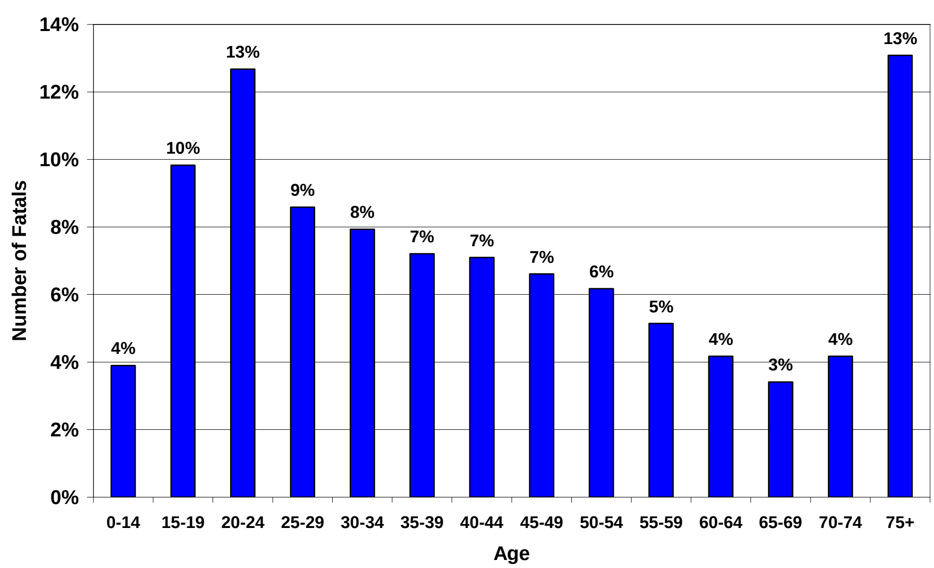

Figure 19. New Jersey Traffic Fatalities by age (FARS 2001-2005)

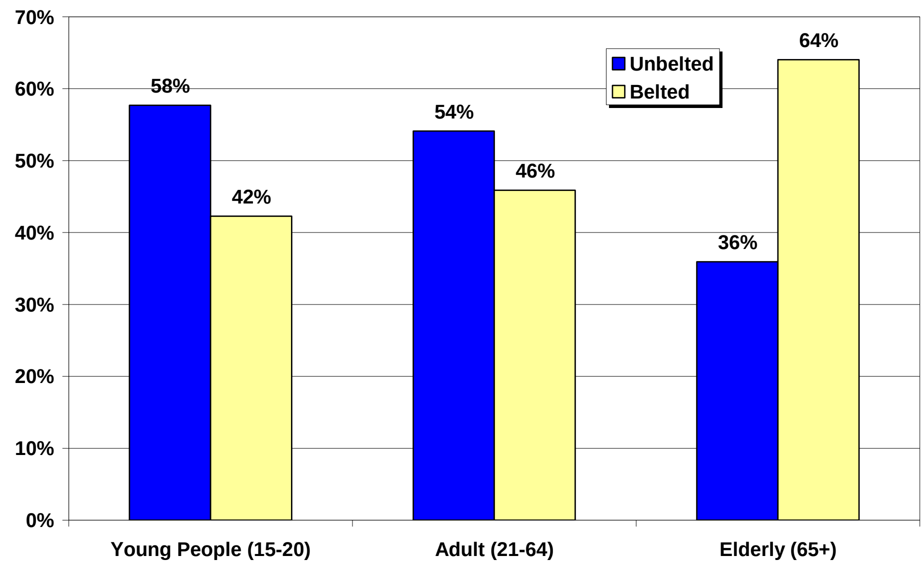

Figure 20. Age Distribution of New Jersey Fatalities by Safety Belt Usage (FARS 2004-2006)

As shown in Figure 20, most fatally-injured older adults (64%) were belted. In contrast, over half of all fatally injured younger persons were unbelted. Even when belted however, the fatality rate among older adults reflects the fact that older adults are less tolerant of injury. These findings are consistent with U.S. experience showing that older adults are more likely to wear seat belts (Nelson et al, 1998).

Figure 21 presents traffic fatalities for each age group as a function of gender from 2004-2006. Fatally-injured older adults were approximately split between male (54%) or female (46%). For younger age groups, a fatality was much more likely to be male than female. For teens, two-thirds of the fatalities are male while for adults 21-64 years old over three-fourths of the fatally injured persons are male.

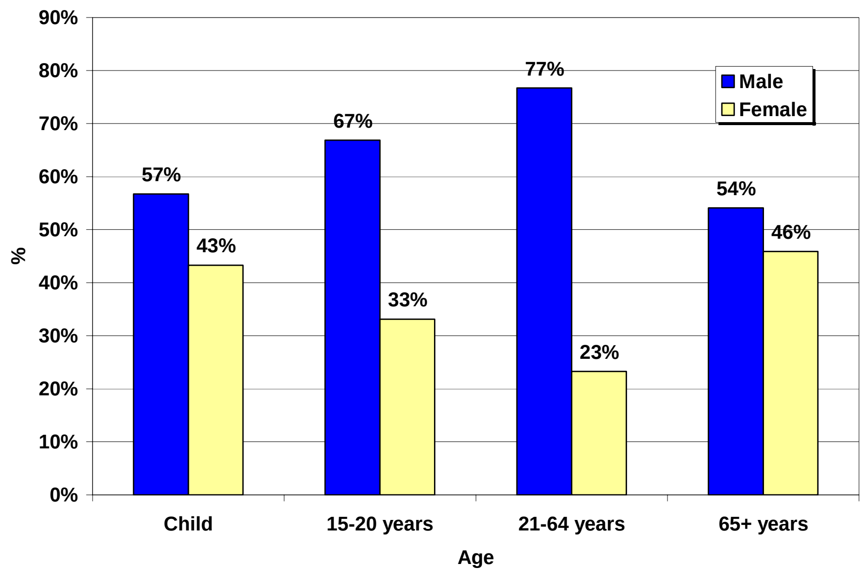

Figure 21. Distribution of NJ Traffic Fatalities by Gender for each age group from 2004-2006

Figure 22 displays the distribution of traffic fatalities from 2002-2006 by the type of vehicle in which the person was a driver or passenger. Note that this figure also contains fatally-injured pedestrians, bicyclists, and motorcyclists. LTV refers to light trucks and vans, e.g. SUVs and pickups. Passenger vehicles include cars and LTVs. Most older adults killed in traffic fatalities were occupants of a passenger vehicle (67%). Surprisingly, more than 1 in 4 (27%) of all fatally-injured older adults were pedestrians. Previous research studies have shown that older adults have decreased perception of the time necessary to walk across an intersection. The elevated number of fatally-injured older pedestrians may be related to the need for older adults to allow more time to cross an intersection.

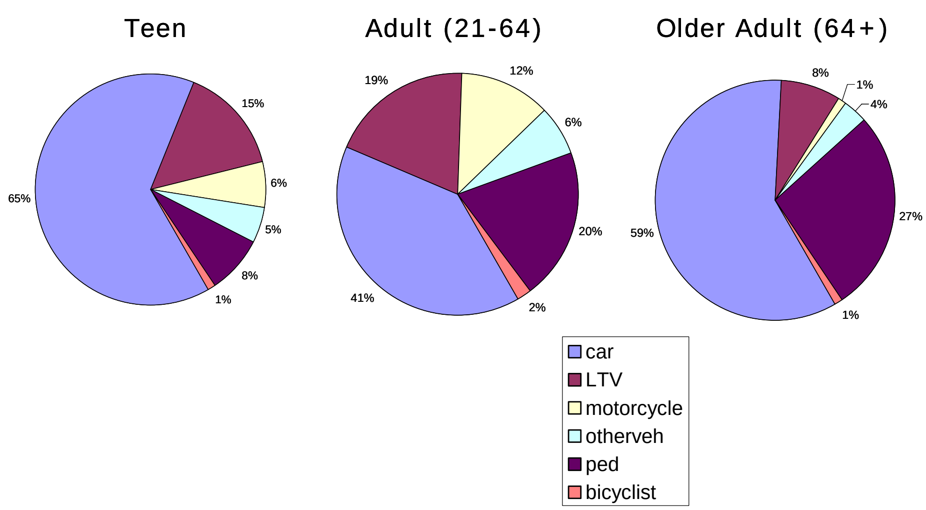

Figure 22. Distribution of NJ Traffic Fatalities incurred by Victim's Vehicle Type (FARS 2002-2006)

Older Adult Drivers

This section investigates the behavior of older adult drivers involved in fatal crashes. In the analysis which follows, the younger driver was involved in, but not necessarily fatally injured, in the fatal crash. Concerns are sometimes raised that older adult drivers who exhibit these symptoms may be hazardous not only to themselves but also to other road users as well. Older adult drivers may be at increased risk of a crash for reasons including slower reaction times (Cooper, 1990; Schlag, 1993), decreased vision (McGwin et al, 2000), medications (Ray et al, 1992), and medical problems, e.g. diabetes, dementia, or syncope.

As shown in Figure 23, 8.4% of all drivers in NJ crashes, both fatal and non-fatal, were 65 years of age or older. Note that 3.6% of drivers in NJ crashes were 75 years of age or older.

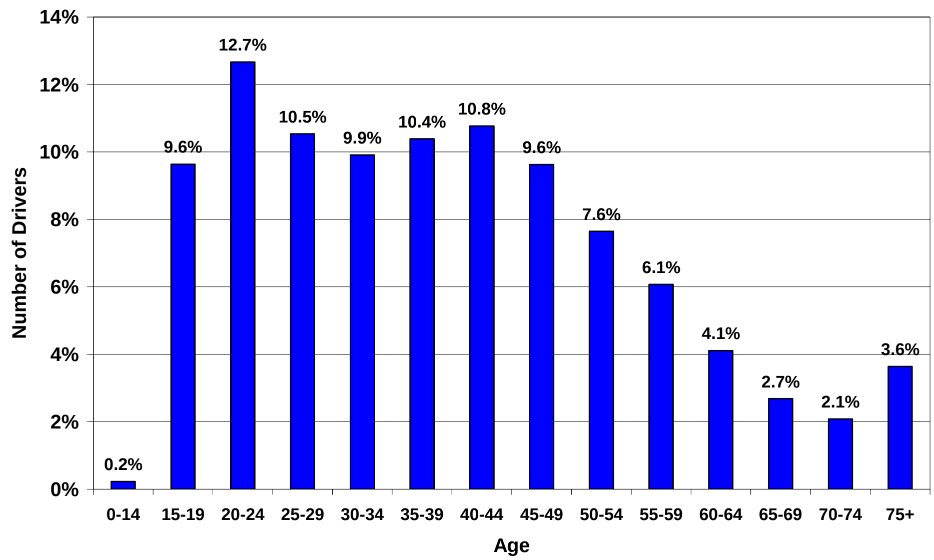

Figure 23. Distribution of Driver Ages in New Jersey Traffic Crashes (NJCRASH 2005)

Alcohol use does not appear to be as prevalent a risk factor for older adult drivers as for young drivers. As shown in Figure 24, 6% of older adult drivers involved in fatal crashes had been drinking. By contrast, approximately 20% of both younger drivers and adult drivers aged 21-64 involved in fatal crashes had been drinking. The presence of alcohol was obtained from police accident reports and does not necessarily mean that the driver was intoxicated.

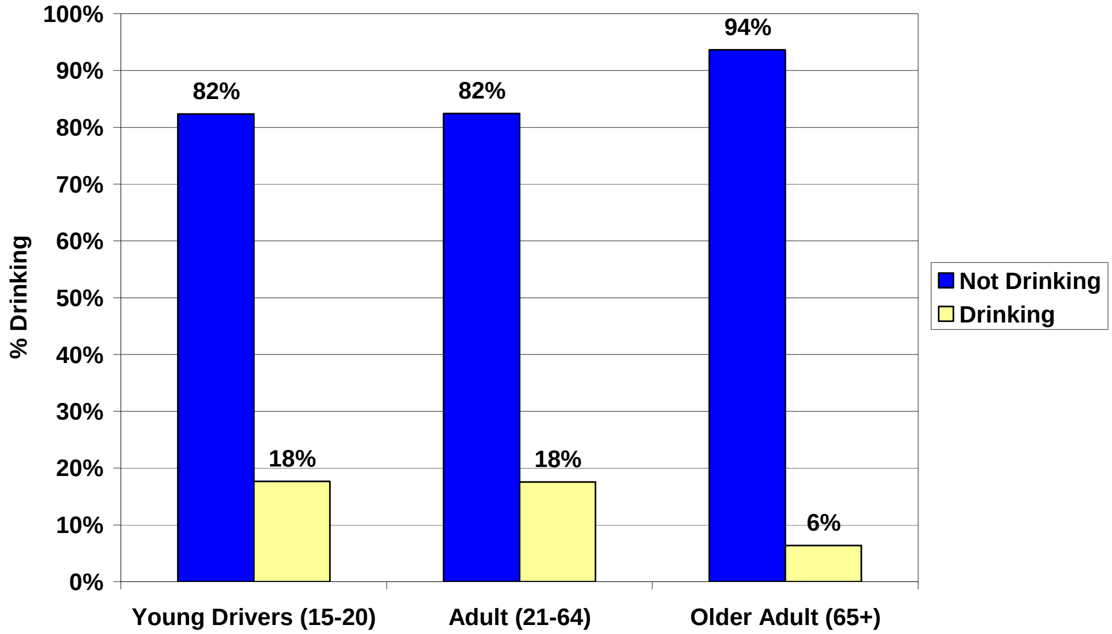

Figure 24. Drivers involved in fatal crashes in NJ by alcohol involvement and age (FARS2004-2006)

The night vision of drivers degrades with age, and can be a crash risk factor for older drivers. Note however that nearly 80% of fatal accidents involving older adult drivers occurred in daylight (Figure 25). This statistic suggests that older drivers may be choosing to avoid driving at night either because of self-regulation or because of licensing restrictions.

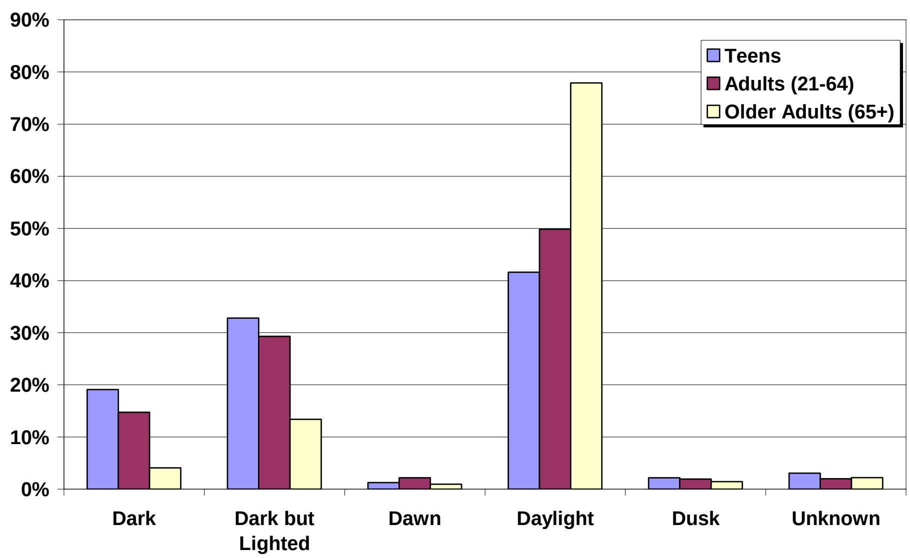

Figure 25. Drivers involved in fatal crashes in NJ by lighting condition at time of accident (FARS2001-2006)

As shown in Figure 26, most fatal accidents involving older adult drivers in New Jersey (46%) occurred at an intersection. An example would be an older driver turning left in front of oncoming traffic. In contrast, both teen and adult drivers aged 21-64 are more likely to be involved in a fatal crash at non-intersections. Many crashes involving teen drivers are single-vehicle run-off road crashes reflecting their relative lack of driving experience or risk taking behavior. Older drivers may have an elevated risk of intersection crashes because of a decreased ability to judge the amount of time necessary to clear an intersection (Preusser et al, 1998).

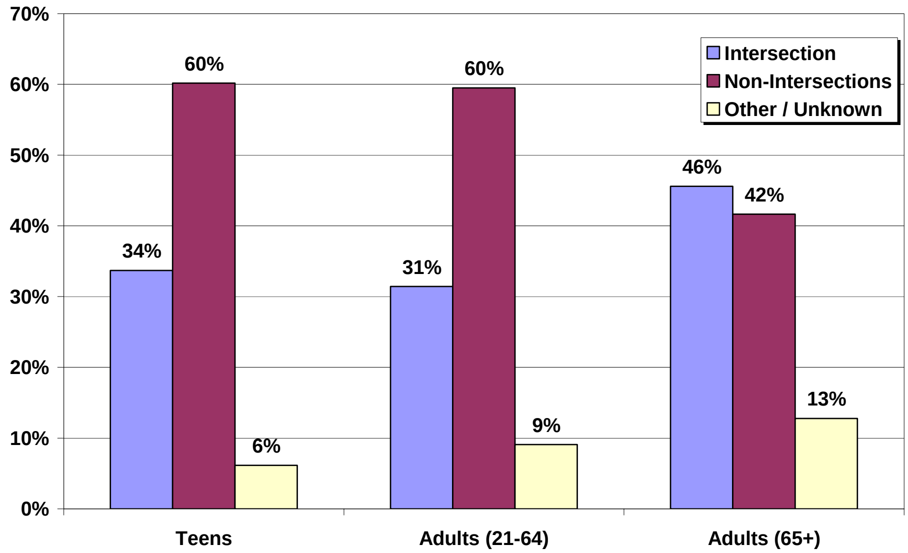

Figure 26. Drivers involved in fatal crashes in NJ by location of accident site to a traffic intersection (FARS2001-2006)

The fraction of fatal crashes as a function of roadway type appears to be independent of age. As shown in Figure 27, most fatal crashes involving all three age groups occurred on urban roads. Nationally, a higher percentage of fatal crashes are experienced on rural roads. The elevated risk in NJ likely simply reflects the fact that NJ is a densely populated state and has a higher percentage of urban roads than elsewhere in the U.S.

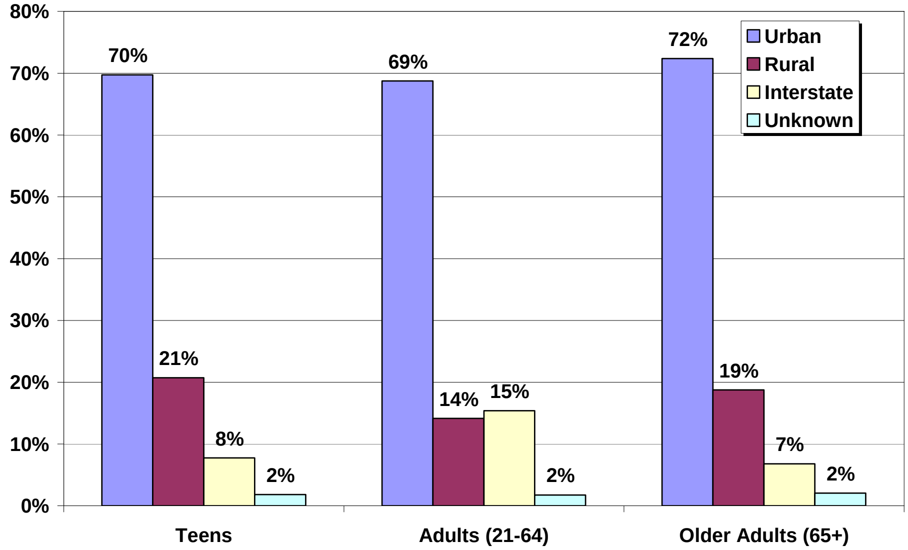

Figure 27. Drivers involved in fatal crashes in NJ by type of roadway (FARS2001-2006)

Factors associated with Elderly Drivers involved in Fatal Crashes

One of our objectives was to explore the factors which may cause older adult drivers to have a elevated risk of being involved in a fatal crash. The analysis which follows was based upon the use of Driver Crash Related Factors variables in FARS. Our analysis explored the following factors:

- Medical risk (ill or passed out)
- Drowsiness
- Inattentiveness
- Medication
- Physical Disabilities

Medical risk includes drivers who blacked-out or who were ill, e.g. from a heart attack. Physical disabilities include drivers identified as being paraplegic, requiring use of a wheelchair, suffering from previous injuries or suffering from any other physical impairment.

In the analysis which follows, we present the proportion of fatal crashes associated with each crash-related factor in comparison with all fatal crashes. This proportion was computed as follows:

$$\text{Proportion Crash Factor - Related} = \frac{\text{Number of Drivers Identified with Factor}}{\text{All Drivers Involved in Fatal Crashes}}$$

As shown in Figure 28, approximately 3% of all older adult drivers involved in fatal crashes either blacked out or was identified ill. This is a small percentage of all older drivers, but is nearly 5 times higher than younger adult drivers. Note that this factor was not a factor in any of the teen driver fatal crashes. Teens are presumably healthier and less prone to this medical risk than older drivers.

A similar approach was followed for the other crash-related factors in our study. In all cases, the percentage of fatal crashes associated with each factor was a relatively small percentage of all fatal crashes. Rather than present these percentages, our analysis presents these proportions relative to the experience of the adult age group (21-64). Figure 29 presents these relative proportions for 1) illness/blackout, 2) inattention, and 3) drowsiness/asleep. Surprisingly the frequency of drivers associated with medication-related or physical disabilities was independent of age (not shown in the figure).

$$\text{Relative Proportion Crash Factor - Related} = \frac{\text{Proportion Crash} - \text{Factor Related in this Age Group}}{\text{Proportion Crash} - \text{Factor Related in Adult Age Group}}$$

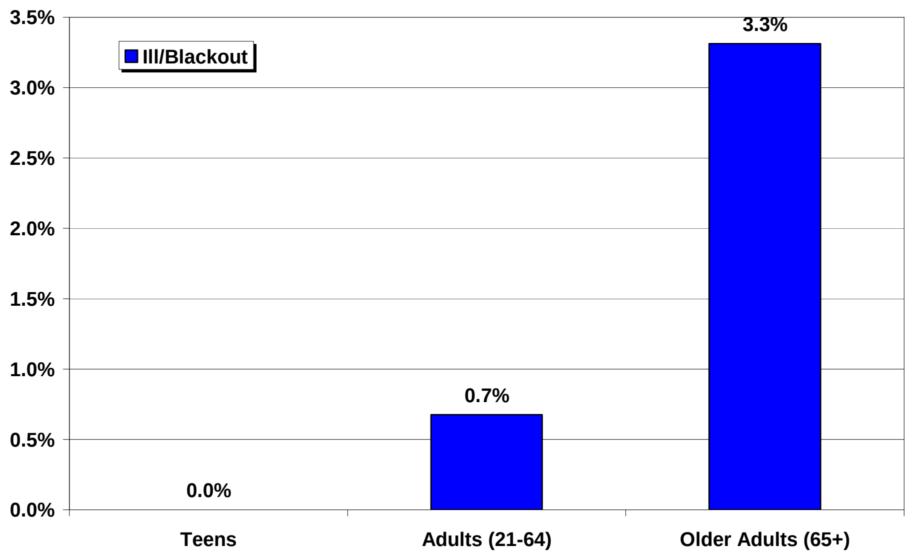

Figure 28. Proportion of Drivers in an age group who blacked-out or who was identified as ill and was involved in a fatal crash (FARS 2002-2006)

Older adult drivers who were involved in fatal crashes were 4.9 times more likely to have been ill or have blacked out than adult drivers aged 21-64. As shown in Figure 28, the fraction of fatal crashes involving an older adult driver with these medical issues is small (3.3%). However, it is these drivers that the Medical Review of the NJ Motor Vehicle Commission seeks to identify and evaluate prior to these fatal crashes.

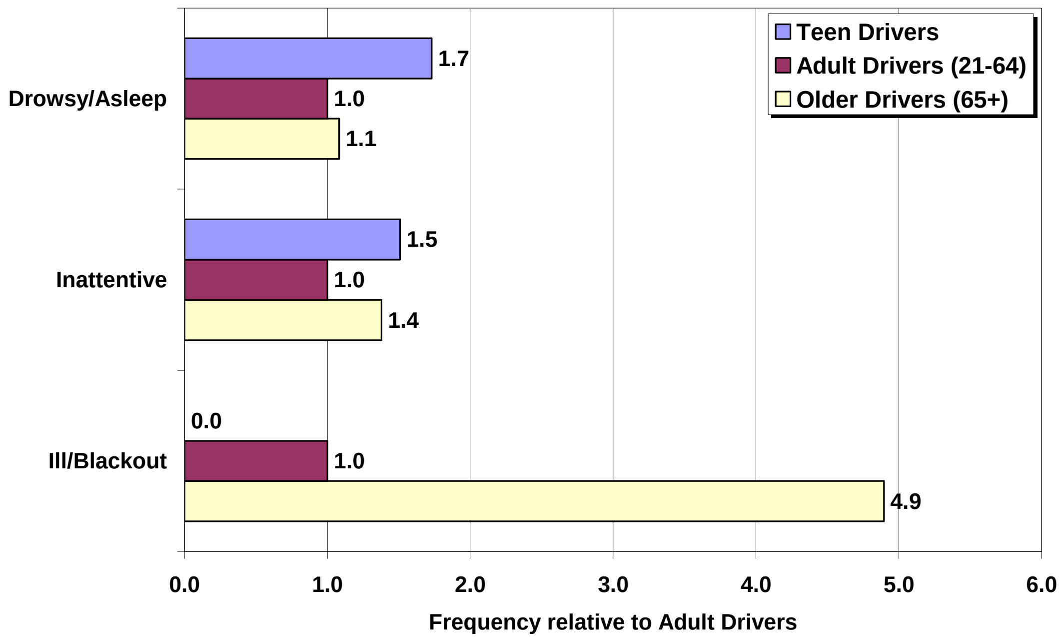

Figure 29. Relative Frequency of Crash-Related Factors for Drivers involved in NJ fatal crashes by Age Group (FARS2001-2006)

As shown in Figure 29, older adult drivers who were involved in fatal crashes were 10% more likely to be drowsy or asleep than adult drivers. Older adult drivers were 40% more likely to have been attentive or distracted than adult drivers. Teen drivers had a parallel experience. Teen drivers who were involved in fatal crashes were 70% more likely to have been drowsy or asleep than adult drivers and 50% more likely to have been attentive or distracted than adult drivers.

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Appendix A – Survey Form on NJ Fatal Accident Databases

Organization: ___________________________________

Questions

1. What are the agency databases or datasets which involve or supplement crash data?

2. What sources are used for data collection?

3. What are the data collection protocols methods, and forms?

4. What are the data elements in the current database?

5. Is the data maintained electronically? If so in what form? What is the physical location of the database? Who has access to it? What is the size of the database?

6. What are the current uses of the agency data?

7. Who are the current users of the agency data, i.e., in-agency users, other state agencies, and external organizations?

8. What additional data would each participant like to have? What other databases would each agency like to access?

9. Are there any data limitations or data quality issues?

10. Are there any data confidentiality concerns or policies?

11. Are there any legal constraints on data sharing?

Appendix B – MVC Fatal File Format

This appendix presents the data elements contained in the Motor Vehicle Commission Fatal File.

Table 4. NJMVC Fatal File

Field Name	Field Description
Date of Accident	Date of Accident
Month	Month of year accident happened
Driver Name	Name of driver
Driver DL	Driver license of driver
Reference #	Number given to accident so it can be found easily
Victim(s)	Names of victims in accident
Municipal/County	Town, county that accident happened
Prosec Office	Prosecutor office has hold on all case material pending Grand Jury indictment
Date NJTR1 Received	Date the NJTR1 data was received by the MVC
SP Report Received	Date the SP data was received by the MVC
Proposal	Motor Vehicle has proposed suspension action against a driver for a period of suspension time
Decision/Disposition	Driver's repercussion due to accident
DRIV	How many drivers were killed
PAS	How many passengers were killed
PED	How many pedestrians were killed
PED CYC	How many pedestrians on a bike were killed
MTR CYC	How many motor cycles were involved
TOT VIC	Total deaths due to accident
CDL	Commercial Driver's License
GDL	Graduated Driver's License
65+	How many people over the age of 65 were killed
DWI	Was driving while intoxicated the cause of the accident
UND DRN	Was underage drinking the cause of the accident
DRG	Were drugs the cause of the accident
H&R	Hit and Run accident .No operator located at this time
LEAV SCEN	Did one of the parties involved in the accident leave the scene
HOMI	Was the accident a homicide
SPED	Was the accident cause by speeding
PRV PROP	Private Property not on highway. Example residence driveway, Business lot etc
DELY DEA	Delayed death .Injured person succumbs at a latter date. NJ State Police only count as fatality, if person succumbs within 30 days from date of accident. MVC does not adhere to the 30 day rule
OUT STATE	Did the accident occur out of the state in which the driver is licensed
340	NJSA (Motor Vehicle Traffic Laws) 39:3-40 Driving while suspended
310	NJSA 39:3-10 Unlicensed Driver
MED	Were medical reasons the cause of the accident

Field Name	Field Description
SLEP	Was sleeping while driving the cause of the accident

Appendix C – NJCRASH Data Elements Exported to MVC-

The following data element are exported by NJDOT from police accident reports and sent to the Motor Vehicle Commission. This data export is run approximately 4 – 5 times per week.

Selection Criteria:

Year = Year entered
Driver_Lic_State = 'NJ' OR (Driver_Lic_State IS NULL AND LENGTH (RTRIM (Driver_Lic_Num)) = 15)

Exported Flat File Header Record

Field No.	Field Description	Right Justify	Source Table	Len	Position	Algorithm
1	Record Prefix			16	1-16	'HEADER N9999DOTA'
2	Time Stamp			6	17-22	hhmmss begin execution time
3	Date Stamp			8	23-30	MMDDYYYY today's date
4	Fill			188	31-218	blanks

Exported Flat File Data Records

Field No.	Field Description	Right Justify	Source Table	Len	Position	Algorithm
1	Record Prefix			9	1-9	'INPUT AA'
2	Accident Control Number		Accidents	8	10-17	DLN
3	Image Control Number		Accidents	12	18-29	'0000' || DLN
4	Accident Date		Accidents	8	30-37	MMDDYYYY
5	Vehicle Number		Vehicles	2	38-39	Vehicle ID (leading zero)
6	First Name		Vehicles	9	40-48	Driver_FName
7	Middle Initial		Vehicles	1	49	Driver_MI
8	Last Name		Vehicles	17	50-66	Driver_LName
9	Address		Vehicles	27	67-93	Driver_Address
10	City		Vehicles	14	94-107	Driver_City
11	State		Vehicles	2	108-109	Driver_State
12	Zip		Vehicles	9	110-118	Driver_Zip
13	Autopic		Vehicles	15	119-133	Driver_Lic_Num first 15 characters
14	DOB		Vehicles	8	134-141	MMDDYYYY
15	Eye Color		Vehicles	1	142	Driver_Eye_Color
16	Sex		Vehicles	1	143	Driver_Sex
17	Vehicle Plate Number		Vehicles	10	144-153	Plate (if blank then 'NO PLATE' inserted without quotes)
18	Case File Number		Accidents	10	154-163	Case first 10 numerics; no characters

19	Police Department		Accidents	10	164-173	Dept_Name first 10 characters
20	Police Station		Accidents	10	174-183	Station first 10 characters
21	Vehicle Plate State		Vehicles	2	184-185	State
22	Insurance Company Code		Vehicles	3	186-188	IF LEN(Ins_Code) = 3 then Ins_code else IF LEN(Ins_Code) = 4 AND SUBSTR(Ins_code) <> '000' then SUBSTR(Ins_code,1,3) else blanks
23	Insurance Policy Number		Vehicles	30	189-218	Ins_Num

Exported Flat File Trailer Record

Field No.	Field Description	Right Justify	Source Table	Len	Position	Algorithm
1	Record Prefix			16	1-11	'TRAILER9999'
2	Time Stamp			6	12-17	hhmmss end execution time
3	Date Stamp			8	18-25	MMDDYYYY today's date
4	Record Count	Y		8	26-33	Number of data records exported
5	Fill			185	188	blanks

Populating the InsuranceRpt Table From Exported Data Record

Field No.	Field Description	Len	Algorithm
1	ID	7	Reccount of record processed
2	DateOfAccident	10	MMDDYYYY
3	Ins_Co_Code	4	IF LEN(Ins_Code) = 3 AND Numeric then 'I' || Ins_code IF LEN(Ins_Code) = 4 AND Numeric then Ins_Code ELSE '0000'
4	PolicyNumber	25	
5	DriversLicenseNumber	25	
6	OwnersName	35	
7	VIN	25	
8	PlateNumber	10	
9	DenialCode	1	Always blank

Appendix D – New Jersey State Police Fatal Database

Table 5. New Jersey State Police Fatal Database Data Element Descriptions

Field Name	Field Description
NUM INVLOVED ID	ID number for involved
TXT FNAME	First name
TXT MNAME	Middle name
TXT LNAME	Last name
CDE SEX	Sex
DTE DOB	Date of Birth
NUM AGE	Age
TXT ADDRESS	Address
TXT CITY	City
TXT ZIP	Zip code
TXT DL NUMBER	Driver's license number
DTE DL EXPIRES	Date driver's license expires
FLG DL SUSPENDED	If driver's license was suspended
DTE DL SUSPENDED	Date Driver's License was suspended
CDE DEATH CLASSIFICATION	Code for death classification
DTE OF DEATH	Date of death
FLAG ALCOHOL TEST	Results of alcohol test
FLAG DRUG TEST	Results of drug test
NUM BLOOD ALCOHOL	Number of Blood Alcohol Content
FLAG HIT RUN	Was the accident a hit and run?
FLAG SEAT BELT REQD	If seatbelt was required
CDE DELTE IND	
DTE CREATED	Date data was created
ID LOGON CREATED	ID number for staff member that created data
DTE LAST UPDATED	Date data was last updated
ID LOGON LAST UPDATED	ID number for staff member that last updated data
FLAG DRUG TEST RESULTS	Drug test results
GPT STATES CDE STATE	Code of state
TIME OF DEATH	Time of death

Field Name	Field Description
NUM INIT INVEST OFF ID	ID number of initial investigation officer
NUM INIT INVEST OFF BADGE	Initial investigation officer badge number
TXT INIT INVEST OFF FNAME	Initial investigation officer first name
TXT INIT INVEST OFF MNAME	Initial investigation officer middle name
TXT INIT INVEST OFF LNAME	Initial investigation officer last name
NUM FATAL INVEST OFF BADGE	Fatal accident investigation officer badge
TXT FATAL INVEST OFF FNAME	Fatal accident investigation officer first name
TXT FATAL INVEST OFF MNAME	Fatal accident investigation officer middle name
TXT FATAL INVEST OFF LNAME	Fatal accident investigation officer last name
NUM AREA ID	ID number for area
CDE ASSIGNED AREA	Code for assigned area
CDE TYPE OF AREA	Code for area type
TXT AREA NAME	Name of Area
FFIONUM FATAL INVEST OFF BADGE	Badge number of fatal accident investigation officer
NUM FATAL ACCIDENT ID	ID Number for fatal accident
TXT CASE NUMBER	Case Number ID
NUM RMS CASE NUMBER	RMS Case number
NUM RMS CASE SEQ	Case sequence for RMS
TXT ORI CASE NUMBER	Case number ID
DTE ACCIDENT	Date of accident
NUM ACCIDENT TIME	Time of accident
CDE INFEST AGENCY	Code of investigation agency
DTE INVEST	Date investigation was assigned

Field Name	Field Description
ASSIGN	
NUM HWY	Highway number where accident occurred
NUM MILE POST	Mile post number where accident occurred
NUM SPEED LIMIT	Speed Limit for road where accident occurred
TXT NAME STREET	Street name where accident occurred
TXT CROSSROAD NAME	Crossroad name where accident occurred
NUM XROAD SPEE LIMT	Speed Limit for crossroad where accident occured
NUM LATTITUDE	Latitude Number
NUM LOGITUDE	Longitude Number
NUM INJURED CNT	Number of injured
TXT NJDOT DLN	New Jersey Department of Transportation DLN
CDE RECORD SOURCE	Code for source of specific record
CDE RECORD STATUS	Code for Status of specific record
TXT FARS NUMBER	Fatal Accident Reporting Systems ID Number
TXT LOC COLOR	Code of Loc Color
TXT GSA COUNTY CODE	GSA Code of County
NUM FARS REPORT NUMBER	Fatal Accident Reporting Systems Report Number
CDE DELTE IND	
DTE CREATED	Date that data was created
ID LOGON CREATED	ID Number of Staff Member that created the data
DTE LAST UPDATED	Date data was last updated
ID LOGOPN LAST UPDATED	ID Number of Staff Member that last updated the data
FFIONUM FATAL INVEST OFF BADGE	Investigation Officer Badge Number
FIIO NUM INIT INVEST OFF ID	Investigation Officer ID Number
GPT MUNICIPALCDE MUNICIPALITY	Code of Municipality
GPT MUNICIPALITY CDE COUNTY	Code of County
AL ORI	

Field Name	Field Description
TXT NARRATIVE	Brief description of what happened during accident
FA NUM FATAL ACCIDENT ID	ID Number for Fatal Accident
FLK NUM LUTYPE KEY ID	ID Number for Lutype Key
NUM FATAL ACC INV VEH ID	
FA NUM FATAL ACCIDENT ID	Number ID for Fatal Accidents
FI NUM INVOLVED ID	Number ID for Involved Vehicle
FV NUM VEHICLE ID	Vehicle ID Number
CDE COUNTY	Code of County
NAM COUNTY	Name of County
NAM MUNICPALITY	Name of Municipality
CDE MUNICPALITY	Code for Municipality
FLK NUMLUTYPE KEY ID	
FI NUM INVOLVED ID	
FL NUM LUTYPE ID	Number for Lutype ID
CDE LUTYPE	Code for Lutype Key
TXT LUTYPE KEY NAME	Name of Lutype Key
NUM LUTYPE KEY ID	ID Number for Lutype Key
TXT LUTYPE APPLIES TO	
TXT LUTYPE NAME	Name of Lutype Key
NUM LUTYPE ID	ID Number for Lutype
FLK NUM LUTYPE KEY ID	ID Number for Lutype Key
FV NUM VEHICLE ID	Vehicle ID Number
GPT STATES CDE STATE	Code for each state
ID LOGON LAST UPDATED	ID number of staff members that last updated that data
DTE LAST UPDATED	Date that data was last updated
ID LOGON CREATED	ID number of staff members that input data
DTE CREATED	Date that data was input

Field Name	Field Description
CDE DELETE IND	
FLAG OVER SIZE WT PERM	
CDE COMM VEH WEIGHT	Code for Commercial Vehicle Weight
TXT VEH PLATE	License Plate Number
NUM YEAR	Year Vehicle was made
NUM VEHICLE ID	Vehicle ID Number
NAM MUNICIPALITY	Name of Municipality
CDE COUNTY	Code of County
CDE MUNICIPALITY	Code of Municipality
NAM STATE	Name of each state
CDE STATE	Code for each state

Appendix E – Fatal Accident Reporting System Database

This appendix presents the data elements contained in the Fatal Accident Reporting System database. This database contains three tables – the Accident table, the Vehicle table, and the Person table. The data elements of each table are described below:

Table 6. FARS Accident Table

Field Name	Field Description
ALIGNMNT	Roadway Alignment (straight, curve, unknown)
ARR_HOUR	EMS Arrival Hour
ARR_MIN	EMS Arrival Minute
CF1	Related Factor 1 (i.e. extenuating circumstances)
CF2	Related Factor 2 (i.e. extenuating circumstances)
CF3	Related Factor 3 (i.e. extenuating circumstances)
CITY	City
COUNTY	County
C_M_ZONE	Construction/Maintenance Zone
DAY	Day of the Month
DAY_WEEK	Day of the Week
DRUNK_DR	Drunk Drivers
FATALS	# of Fatalities
HARM_EV	Type of First Harmful Event
HIT_RUN	Hit and Run
HOSP_HR	EMS Arrival Hour at Hospital
HOSP_MN	EMS Arrival Minute at Hospital
HOUR	Hour of Crash
LATITUDE	Global Position, Latitude
LGT_COND	Light Conditions
LONGITUD	Global Position, Longitude
MAN_COLL	Manner of Collision
MILEPT	Mile Point
MINUTE	Minute of Crash
MONTH	Month of Crash
NHS	National Highway System Designation
NOT_HOUR	EMS Notification Hour
NOT_MIN	EMS Notification Minute
NO_LANES	# of Lanes
PAVE_TYP	Roadway Surface Type
PEDS	# of Non-Motorist Form Submitted
PERSONS	# of Persons Forms Submitted
PROFILE	Roadway Profile (Grade, Flat etc…)
RAIL	Railroad Crossing ID
REL_JUNC	Relation to Junction
REL_ROAD	Relation to Roadway
ROAD_FNC	Roadway Function Class (Rural, Urban, etc..)

Field Name	Field Description
ROUTE	Route Signing
SCH_BUS	School Bus Related
SP_JUR	Special Jurisdiction
SP_LIMIT	Speed Limit
STATE	State
ST_CASE	State Case #
SUR_COND	Surface Condition
TRAF_FLO	Traffic Flow (Divided, Non-Divided, etc..)
TRA_CONT	Traffic Controls
TWAY_ID	Actual Posted Number, Assigned Number, or Common Name
TWAY_ID2	Actual Posted Number, Assigned Number, or Common Name
T_CONT_F	Controls Functioning
VE_FORMS	# of Vehicle Forms Submitted
VE_TOTAL	Vehicle Forms - Submitted All
WEATHER	Atmospheric Conditions
YEAR	Year

Table 7. FARS Vehicle Table

Field Name	Field Description
AVOID	Crash Maneuver (Braking, Steering, etc..)
AXLES	Number of Axels
BODY_TYP	Body Type
BUS_USE	Bus Use
CARGO_BT	Cargo Body Type
CDL_STAT	Commercial Motor Vehicle License Status
DEATHS	# of Fatals
DEFORMED	Extent of Deformation
DR_CF1	Related Factor 1 (i.e. extenuating circumstances)
DR_CF2	Related Factor 2 (i.e. extenuating circumstances)
DR_CF3	Related Factor 3 (i.e. extenuating circumstances)
DR_CF4	Related Factor 4 (i.e. extenuating circumstances)
DR_DRINK	Driver Drinking
DR_HGT	Driver Height
DR_PRES	Driver Presence
DR_WGT	Driver Weight
DR_ZIP	Driver Zip Code
EMER_USE	Emergency Use
FIRE_EXP	Fire Occurrence
FIRST_MO	First Accident-Month
FIRST_YR	First Accident-Year
FLDCD_TR	Truck Fuel Code
GVWR	GVW Rating
HARM_EV	First Harmful Event
HAZ_CARG	Hazardous Cargo
HIT_RUN	Hit and Run

Field Name	Field Description
IMPACT1	Initial Impact (Clock Points)
IMPACT2	Principal Impact (Clock Points)
IMPACTS	Vehicle Role (Striking, Struck, etc..)
J_KNIFE	Jackknife
LAST_MO	Last Accident-Month
LAST_YR	Last Accident-Year
L_COMPL	Drivers License Type and Compliance
L_ENDORS	Compliance w/ License Endorsements
L_RESTRI	Compliance w/ License Restrictions
L_STATE	License State
L_STATUS	Non-CDL License Status
L_TYPE	Non-CDL License Type
MAKE	Vehicle Make
MAK_MOD	Vehicle Model
MAN_COLL	Manner of Collision
MCARR_ID	Motor Carrier ID
MCYCL_DS	CC Displacement
MODEL	Vehicle Model
MOD_YEAR	Model Year
MONTH	Crash Month
M_HARM	Most Harmful Event
OCUPANTS	# of Occupants
OWNER	Registered Vehicle Owner
PREV_ACC	Previous Accidents
PREV_DWI	Previous DWI
PREV_OTH	Previous Other MV Convictions
PREV_SPD	Previous Speeding
PREV_SUS	Previous Suspensions
REG_STAT	Registration State
ROLLOVER	Rollover Status
SEQ1	Event 1
SEQ2	Event 2
SEQ3	Event 3
SEQ4	Event 4
SEQ5	Event 5
SEQ6	Event 6
SER_TR	VIN Series Truck
SPEC_USE	Special Use
STATE	Crash State
ST_CASE	State Case #
TOWAWAY	Manner Leaving the Scene
TOW_VEH	Towed Trailing Vehicle
TRAV_SP	Travel Speed
UNDERIDE	Underride/Override
UNITTYPE	Description of Unit Status at Event
VEH_CF1	Related Factor Vehicle Level 1
VEH_CF2	Related Factor Vehicle Level 2

Field Name	Field Description
VEH_MAN	Vehicle Maneuver
VEH_NO	Vehicle #
VE_FORMS	# of Vehicle Forms
VIN	VIN
VINA_MOD	VIN Model
VIN_1	VIN Field 1
VIN_2	VIN Field 2
VIN_3	VIN Field 3
VIN_4	VIN Field 4
VIN_5	VIN Field 5
VIN_6	VIN Field 6
VIN_7	VIN Field 7
VIN_8	VIN Field 8
VIN_9	VIN Field 9
VIN_10	VIN Field 10
VIN_11	VIN Field 11
VIN_12	VIN Field 12
VIN_BT	VIN Body Type
VIN_LNGT	VIN Length
VIN_WGT	VIN Weight-Auto
VIOLCHG1	Violation Charge 1
VIOLCHG2	Violation Charge 2
VIOLCHG3	Violation Charge 3
V_CONFIG	Vehicle Configuration (Pass. Car, Truck, Bus, etc..)
WGTCD_TR	Truck Weight Code
WHLBS_LG	Wheelbase Long - Auto
WHLBS_SH	Wheelbase Short - Auto

Table 8. FARS Person Table

Field Name	Field Description
AGE	Driver Age
AIR_BAG	Air Bag Availability/Function
ALC_DET	Method of Alcohol Determination (PBT, Behavioral, Breath, etc..)
ALC_RES	Alcohol Test Results
ATST_TYP	Alcohol Test Type (Breathalyzer, Urine, Whole Blood)
BODY_TYP	Vehicle Body Type
CERT_NO	Death Certificate #
COUNTY	County
DAY	Day of the Month
DEATH_DA	Date of Death
DEATH_HR	Hour of Death
DEATH_MN	Minute of Death
DEATH_MO	Month of Death
DEATH_TM	Time of Death
DEATH_YR	Year of Death

Field Name	Field Description
DOA	Dead on Arrival
DRINKING	Alcohol Involvement
DRUGRES1	Drug Test Results-1
DRUGRES2	Drug Test Results-2
DRUGRES3	Drug Test Results-3
DRUGS	Drug Involvement
DRUGTST1	Drug Test Type-1
DRUGTST2	Drug Test Type-2
DRUGTST3	Drug Test Type-3
DRUG_DET	Method of Drug Determination (Evidential, Behavioral, etc..)
EJECTION	Ejection Status
EJ_PATH	Ejection Path (Side Window, Windshield, etc..)
EMER_USE	Emergency Use
EXTRICAT	Extrication
FIRE_EXP	Fire Occurrence
HARM_EV	First Harmful Event
HISPANIC	Hispanic Origin
HOSPITAL	Taken to Hospital
HOUR	Hour of Crash
IMPACT1	Initial Impact (Clock Points)
IMPACT2	Principal Impact (Clock Points)
IMPACTS	Vehicle Role (Striking, Struck, etc..)
INJ_SEV	Injury Severity
LAG_HRS	Crash to Death – Hours
LAG_MINS	Crash to Death – Minutes
LOCATION	Non-motorist Location
MAKE	Vehicle Make
MAK_MOD	Vehicle Model
MAN_COLL	Manner of Collision
MCYCL_DS	Motorcycle CC Displacement
MINUTE	Minute
MOD_YEAR	Model Year
MONTH	Month
N_MOT_NO	Striking Vehicle
PER_NO	Person Number
PER_TYP	Person Type (Driver, Passenger, etc..)
P_CF1	Related Factor - Person1
P_CF2	Related Factor - Person2
P_CF3	Related Factor - Person3
RACE	Race
REST_USE	Restraint System Use
ROAD_FNC	Roadway Function Class
ROLLOVER	Rollover
SCH_BUS	School Bus Related
SEAT_POS	Seating Position
SER_TR	VIN Series Truck
SEX	Sex

Field Name	Field Description
SPEC_USE	Special Use Vehicle
STATE	State
ST_CASE	State Case #
TOW_VEH	Towed Trailing Unit
VEH_NO	Vehicle #
VE_FORMS	# of Vehicle Forms
VINA_MOD	VIN Model
VIN_BT	VIN Body Type
VIN_WGT	VIN Weight-Auto
WGTCD_TR	Truck Weight Code
WHLBS_LG	Wheelbase Long - Auto
WHLBS_SH	Wheelbase Short - Auto
WORK_INJ	Fatal at Work

Appendix E – U.S. and International Roadway or Crash Related Data Linkage Projects

This appendix presents a list of U.S. and International organizations that have participated in roadway or crash related linkages. The tables also include notes regarding their integration approaches, issues, and successful practices.

Table 9. U.S. Roadway or Crash Related Data Linkage Projects

Organization	Data Types Linked	Notes	Reference
Alaska Department of Transportation & Public Facilities (ADOT & PF)	Roadlogs, Traffic, and Accident.[1] Pavement, Bridge, Travel Information, Road Weather, Seasonal Weight Restrictions.[2]	ADOT&PF has built the Maintenance Management System (MMS). The primary archive is the Highway Analysis System (HAS) system containing the linked databases. The MMS also links 7 legacy Systems.[1] The query system allows access by parameters such as CDS route number, road mileage reports, accident reports, or roadway/geographic classifications. ADOT&PF has shown an interest in including more rural information to their database for completeness. All data is linked through a GIS with road-centerline matching and a LRS is used for legacy systems.[2]	[1] p43-47 [2] p21-35
Arizona Department of Transportation (ADOT)	Asset, Maintenance, Finance, Project and Traffic.	The linkage is based on a standard centerline mapping system covering 80% of the public roads. As of 2003, ADOT had planned to create an easily accessible database based on a GIS system.	[1] p48-53
Arizona CODES	Crash, Insurance, Medical.	The Arizona CODES group out of Arizona State University has successfully linked crash and medical data. As of July 2005, the group had received the 2005 crash, ED, and hospital data and were beginning to clean it up and prepare it for linkage.	[3]
California Department of Transportation (Caltrans)	highway, bus, passenger rail, air routes, pipelines, shipping lanes, freight rail, cruise terminals, intermodal freight facilities, ports, tanker terminals, transit, airports, passenger and freight travel, a passenger-mode shift model, census data, and performance measures.	The extensive Intermodal Transportation Management System (ITMS) has undergone four revisions as of 2004 and is composed of 250 supporting organizations on the federal, state, local and private levels. Over 400 standalone datasets are included in the integration. Roughly 600 users access the data for transportation investment alternatives. The database custodial groups include the FHWA, Caltrans, Federal Aviation Commission, the Environmental Protection Agency, the Army Corps of Engineers, and Metropolitan Planning Agencies.	[1] p54-57
Colorado Department of Transportation (CDOT)	Bridge, Pavement, Maintenance, Budget/financial management.	As of 2003, CDOT only has an asset management proposal. An Asset Management Task Force has been created to guide the development of the project. The group plans to integrate an existing Information Technology Resource Team for IT expertise.	[1] p58-63
Delaware Department of Transportation (DelDOT)	Current: Accident, Bridge, high-level capital project. Future: Pavement, video pipe inspection, storm water facility, maintenance, truck permit, equipment and vendor.	The DelTrac Integrated Transportation Management System (ITMS) is designed to support multimodal transportation systems. It stores information from legacy systems and from new system components, including real-time traffic data.	[1] p64-67
Delaware CODES	Crash, Hospital Discharge, and EMS.	The Delaware linkage provides a perspective on the outcome of the crash, the injury scenarios prior to the hospital and the injury outcome after being discharged from the hospital. The Delaware CODES team uses the CODES2000 matching software.	[4]
Florida Department of Transportation (FDOT)	Project development, roadway characteristics inventory system, airports, bridge, pavement,	The FDOT Geo-Referenced Information Portal (GRIP) interactively and visually integrates multiple datasets, navigational tools, has the ability to view imagery files, and provides linkage to the metadata. Business processes made it clear that GRIP	[1] p68-72

Organization	Data Types Linked	Notes	Reference
-GRIP	Background imagery.	administrators would not own data. FDOT data owners were identified and responsibilities were clearly established. The data owners are required to make the data available, have a data dictionary, have metadata and backup copies, use a defined process for collection and QC and provide maintenance.	
Florida Department of Transportation (FDOT) - TEAMS	Facilities, Pavement, Roadway, Structures, Finance and Videolog	The Turnpike Enterprise Asset Management system (TEAMS) was developed to eliminate data duplication and provide a better means of collecting, storing, processing, analyzing, and reporting asset data for the Florida Turnpike Enterprise. Legacy systems were included in the linkage by converting to a GID format.	[1] p73-76
Hawaii Department of Transportation (HDOT)	Bridge, historic pavement data, highway inventory, traffic data, current and historic project data.	The HDOT Coordinated Data System / Geographic Information System (CDS/GIS) was implanted to assist with planning and design functions and has also been supportive for operations and maintenance. HDOT requires that contributing parties collect and maintain data but HDOT is responsible for housing the data.	[1] p77-80
Hawaii CODES	Crash, EMS, Hospital, Insurance.	The data from each field is linked using the AUTOMATCH software and matched to the base map from GPS coordinates based on the address. The data from the database is only released in the form of reports, abstracts, and maps. There is no database access for downloading.	[5] p26-29
Iowa Department of Transportation (IDOT)	Videologs, Pavement, Highway Performance Monitoring System, Accident Location and Analysis System, and GPS.[1]	As of 2003, IDOT had hired a full-time to GIS coordinator to assist in the implementation of their specific goals. The IDOT legacy systems were based on linear reference based geo-references. Their primary objectives focus on integrating these datasets while maintaining the integrity of the data.[1] There are 30 years of roadway data available and 10 years of accident data. As of 2007, IDOT cited that the beneficial additions to their linkage system would include an intersection inventory features and driveways.[2]	[1] p81-86 [2] p41-44
Kansas Department of Transportation (KDOT)	Bridge, Accident Records	The development of the KDOT data linkage was in the planning stages as of 2003. Their plan was to integrate data with a GIS platform. KDOT owns all the data that is to be linked. The data is to be used to support planning, operations, and infrastructure functions.	[1] p87-90
Maine Department of Transportation (Maine DOT)	Roadside Information, Maintenance, Capital Projects, Bridge, Safety Management.	The Transportation Information for Decision Enhancement (TIDE) linked database was established in 1998. The data is linked based on both GIS and Linear reference systems to accommodate both contemporary and legacy data.	[1] p91-94
Maryland CODES	Crash, Insurance, Medical.	A GIS is used to calculate incidence rates and for spatial representation of crash sites. To access the data from the database a request must be submitted to the agency performing the linkage (University of Maryland / Maryland Department of Health and Mental Hygiene as of 2001). Any information regarding personal information must be referred to the CODES Board of Directors and the individual data owner.	[5] p29-31

Organization	Data Types Linked	Notes	Reference
Michigan Department of Transportation (MDOT)	Pavement, Bridge, Congestion, Safety Management, Intermodal Management, Traffic Monitoring.[1]	MDOT found that limiting original data collection, adopting sampling and quality standards, and agreeing on common data and attribute definitions were key to controlling the costs of original collection and eliminating duplicate storage, and supported the development of corporate data standards. All data that was determined to be unimportant was no included in the linked database.[1] All data is linked using two LRS systems and integrated into a GIS. QC programs are in place to ensure the integrity of the data and improve upon its quality. MDOT cited discrete roadway features, intersection features, freeway interchange features, local roadway data, and traffic data as features they would like to include in their linkages. Access to the data includes ad hoc and mapping queries. [2]	[1] p95-101 [2] p45-50
Minnesota Department of Transportation (Mn/DOT)	Highway geometry, railways, navigable waterways.	Mn/DOT has several data integration initiatives underway including the development of a Location Data Model (LDM) and a Transportation Information System GIS tool (TIS Project 274). The LDM creates the location information while the TIS Project 274 works to link data based on GIS. The two systems are combined. As of the 2003 the systems were no fully integrated.	[1] p102-105
Minnesota CODES	Motor Vehicle Crash Database, Minnesota Hospital Association's Hospital injury discharge data	The Minnesota CODES team linked data from 1998 – 2002for roughly 487,000 reported crashes, involving 1.2 million occupants. The data was linked to about 150,000 hospital patients.	[6]
Mississippi Department of Transportation (Mississippi DOT)	Physical Road Geometries, Functional Classes, Route Designations.	All data is to be linked within the next 2 years using a relational data model. All attributes will be linked using county ID, route ID and begin and end mile points. A data warehouse is being created to also include roadway characteristics, traffic volumes, road and city names, crash information and all data will be linked with an LRS.	[2] p51-55
Montana Department of Transportation (MDT)	Maintenance, Pavement, Bridge, Congestion, Traffic, Roadlog, Safety.	As of 2003, the linkage was based on a linear mapping system. The MDT is planning to switch to a GPS based system to avoid issues associated with the linear system. A list of reasons for the project, issues to be addressed and anticipated benefits are given.	[1] p106-110
Nebraska CODES	Hospital Charges, Insurance, EMS, Death Records, and Crash.	Using the CODES data from their successful linkage has allowed the group to organize their data. With this linkage, the group has been able to provide insight into risk factors and specific populations at risk.	[7]
New Hampshire CODES	Crash, Insurance, Medical.	The use of GIS has allowed graphical representations of frequencies and trends as they correspond to real life circumstances. The GIS system was based on an existing Emergency Communications (E-911) system. As of the 2001, the NHDOT was working to fully integrate the CODES data into the existing E-911 system. E-911 utilizes street addresses and local information for linkage. Access to data will be presented in the form of reports, basic queries, and will be determined by user demands and available resources.	[5] p33-36

New Mexico State Highway and Transportation Department (NMSHTD)	Traffic, Accident, Pavement, Bridge, Highway Performance Monitoring System, Strip Maps, County Maps, Road Maps, and Project Evaluation Reports.	The Intranet Decision and Analysis Support System (IDEAS) is being developed to achieve this goal. Once fully implemented, IDEAS will provide graphical, transparent access to legacy information while leveraging historical systems with minimal overhead on the client or server end. It is intended to bridge the data disconnect between the agency's Planning Office, districts, and engineering units. The GIS base map was established during the initial release of IDEAS and has been maintained since then.	[1] p111-114
New York State Department of Transportation (NYSDOT)	Pavement, Bridge, Congestion, Mobility.	NYSDOT uses two linear referencing methods. A field-posted reference marker system is used for most of the highway maintenance, traffic, and accident data. A milepost system is used for inventory and capital project information. GIS route networks for dynamic segmentation have been constructed for each of these systems, using a common base map of highway centerlines. Of primary interest for Asset Management are import of traffic volume and speed histories from roadway sensors into the master highway inventory database via the archived user data service. Of primary interest for traffic management are exports of highway maintenance work orders and traffic management plans for construction projects from transportation operating agencies.	[1] p115-120
Ohio Department of Transportation (ODOT)	Automated Traffic Recording, Bridge, Construction, Culvert Inventory, Overweight Permitting, Highway Safety, Pavement, Project Development, Roadway Inventory, Transportation Management System, and Weigh-in-Motion.[1]	The vision of data integration at the Ohio Department of Transportation (ODOT) is to integrate legacy systems with a common referencing system in order to provide decision makers and policy-makers with better information. This data is accessed through a user-friendly interface. Current uses of the BTRS include developing multi-year district work plans, analyzing statewide highway volume-to capacity ratios, congestion analysis, providing support for ODOT's pavement and bridge management functions, tracking pavement and bridge performance, generating straight-line diagrams, and responding to ad hoc data requests.[1] Currently ODOT has access to crash data but has not included the records in their linkage. [2]	[1] p121-125 [2] p56-61
Oregon Department of Transportation (Oregon DOT)	Crash, Traffic, and Roadway.	There are a number of databases concerning the different areas of linkage but none of them are formally linked. Many of the datasets contain linking abilities based on the highway number and mile marker. The data is accessible from a GIS but the data is not housed in a central database.[2]	[2] p62-68
Pennsylvania Department of Transportation (PennDOT)	Pavement Management, Bridge Management, Maintenance Operations.[1] Crash.[2]	Ownership of the data is split between associated groups but not all data is available in formats that are necessarily beneficial to each participating group. PennDOT was planning to rework the legacy systems as of 2003. Future goals include creating a multimodal integration with the existing system.[1] The traffic data and crash data are housed in different systems but are linkable because they are stored with the same identification key.[2]	[1] p126-132
South Carolina Department of Transportation (SCDOT)	Pavement, Road Inventory, Highway Management, and preconstruction Planning.	SCDOT did not have linkage system in place or legislation to form one as of 2003. They did , however, express a recognition of the benefits that would arise from such an undertaking. Preliminary efforts are underway to investigate the approaches and feasibility of traffic data integration. SC has the fourth largest state highway system in the country.	[1] p133-135
South Carolina CODES	Crash, Insurance, Medical.	The SCDOT CODES team has successfully linked the crash, EMS, ED and hospital data. As of 2001, they were working to update from a GIS to the TIGER GIS system created for the CODES group. The Geocoding is based upon the street address and	[5] p37-40

		street location.	
Tennessee Department of Transportation (TNDOT)	Roadway Inventories, Road Condition, Bridge Condition, Crash Statistics, Traffic, Rail-Highway Grade Crossing, Project, and Photologs.	the Tennessee Roadway Information Management System (TRIMS) is an an enterprise-wide, GIS-based, web-enabled, client/server application accessed by over 800 staff from across the agency. The system integrates data from relational databases, high-resolution photolog data stored on Terrabyte servers, digital plans, and scanned documents. All TRIMS data is geographically referenced using a county-route log-mile point system.	[1] p136-139

Organization	Data Types Linked	Notes	Reference
Utah Department of Transportation (UDOT)	Accident, Bridge, Pavement Management System, Bridge Management System, and Maintenance Management System.	The agency has identified 26 different linear referencing systems in use. All referencing systems have been combined into a GIS system. Legacy systems are to be updated to a standard LRS for easier linkage.	[1] p140-143
Vermont Agency of Transportation (Vtrans)	Pavement, Bridge, Maintenance, Airport Pavements, Facility Management, and Construction Project Management.	Vtrans uses two LRS systems to link their databases. A current project to automate the process of producing route logs will significantly improve integrated access to disparate data sources. This effort has involved developing a GIS-based repository of information on the state highway system.	[1] p144-149
Virginia Department of Transportation (VDOT)	Asset, Infrastructure Inventory.	A number of critical issues were discussed. It was necessary to identify what data was available to work with, evaluating data quality, especially data in legacy systems, the absence of data standards, and the multiple location referencing methods, data was formatted in different projection systems and data formats that required a significant preprocessing effort, and the volume of data for 60,000 miles of roads for the entire state.	[1] p150-155
Washington State Department of Transportation (WSDOT)	Project Planning, Environmental Analysis, Inventory Tracking, Maintenance, Emergency, Transit.	The linking architecture was still in development as of 2003. A bundled approach to data integration, in which data will be collected from a variety of local, state, Federal, and tribal sources and combined into a centerline map.	[1] p156-158
Wisconsin Department of Transportation (WisDOT)	Crash, Citation/-conviction, Driver License, Vehicle Registration, State and Local Roadway Asset, and traffic.	WisDOT is building a WisTransPortal for warehousing the linked data. The WISLR linked data from non-state roadways in Wisconsin utilizes a GIS and when combined with the stat roadway linked data, it provides a comprehensive view of the roadways. Many of the crash records have to be geo-coded before entering into the linkage database.	[2] p73-85

Table 10. International Roadway or Crash Related Data Linkage Projects

Organization	Data Types Linked	Notes	Reference
New South Wales Roads and Traffic Authority (NSW-RTA) -New South Wales, Australia	Road Inventory, Condition, Crash.	The NSW-RTA had not fully integrated their databases, but was aware of the possibility and they were working towards linkage as of 2004. Their current system employs a graphical user interface that allows the user to overlay tiles referencing the roadway section of choice to note relationships between the characteristics. The group plans to include tiles to represent crash locations as well to allow for frequency analysis and relationships between the crash and roadway characteristics.	[8]
VicRoads -Victoria, Australia	Road Inventory, Condition, and crash data.	VicRoads had not linked their data as of 2004, but their noted that the potential was there. The group has already geo-coded all of the information of interest. A integration system was in development at the time of the report to allow for automatic integration.	[8]
Department of Main Roads (DMR) -Queensland, Australia	Crash, Traffic, and Inventory.	The group was in the process of integrating their data as of 2004. The group was held-up by an inability to properly link intersection data. There were varied definitions of intersection types among reported crashes. Also, issues stemmed from an inability to distinguish between the signaled and non-signaled intersections. The group hopes to alleviate this issues through the implementation of a GIS technology.	[8]
Transport Services Division (TSD) - South Australia	Road Inventory, Condition, Traffic, and Crash.	As of 2004, the TSD was a leader in Australia for the implementation of GIS technologies in their linking system. All data was geo-coded through a linear reference system. This data was not linked but it was considered a feasible task due to the high levels of geo-coding.	[8]
Road Asset Maintenance and Management System (RAMM) - New Zealand	Road Characteristics, Traffic Volumes, Surfaces, Drainage, Footpaths, Shoulders, Pavement Layers, Rehabilitation, Traffic Loading, Minor Structure and Crash.	The RAMM is built and maintained by the 70 road controlling authorities across the country. Each contributes to a number of databases that have specific focuses ranging from road lighting to crash analysis. The data is linked via a center-line reference system.	[8]
The Western Australia Road Injury Database	Crash, Hospital, and Death Records	The data linkage covered records for 1987-1996 in Western Australia. The group utilized probabilistic software to match the data from the different groups. The gropu noted an under reporting of injuries from crash data. This lead to a lack of linkage between the hospital records and the crash data.	[9]

1. Vander-Ostrander, A., G. Joseph, and F. Harrison, *Review of Data Integration Practices and Their Applications to Transportation Asset Management: Final Report*. 2003, National Highway Traffic Administration.
2. Transportation Research Board, *Integrating Roadway, Traffic, and Crash Data*, in *Transportation Research Circular*. 2007: Washington, D.C.
3. Arizona CODES., *THE ARIZONA CODES PROJECT UPDATE*, in *http://www.public.asu.edu/~ivanscha/codes/index.htm*. 2006.
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5. National Highway Traffic Safety Administration, *Geographic Information Systems Using CODES Linked Data*. 2001.
6. Minnesota CODES, *Minnesota CODES Project: Project Background Information - September 2005*, in *http://www.dps.state.mn.us/OTS/crashdata/CODES/CODES_Background.pdf*. 2005.
7. Nelson, R.P., et al., *Nebraska 1999 Motor Vehicle Crash Outcome Report*. 2001.
8. ARRB, *Integrating Accident, Road Condition, Asset Management and Traffic Volume Data.* Road Safety Risk Reporter, 2006. **3**.
9. Rosman, D.L., *The Western Australia Road Injury Database (1987-1996): Ten Years of Linked Police, Hospital, and Death Records.* Accident Analysis and Prevention, 2001. **33**: p. 81-88.

Table 11. Summary of State DOT Experiences and Plans for Data Linkage Projects

Organization	Linkage / Administrative Issue	Proposed Solution	Future Plans	Reference
Alaska Department of Transportation & Public Facilities (ADOT & PF)	Multiple Reference Systems for Different Roadways[1]	The Department is working to create a GIS based on a center-line network.[1]	The group hopes to utilize the data for the following: ▪ Alaska Traveler Information System ▪ Vehicle Crash Reporting ▪ Highway Inventory ▪ Legislative Support ▪ Federal Reporting such as HPMS ▪ GIS Development ▪ State Transportation Improvement Program (STIP) ▪ Highway Safety Improvement Program (HSIP).[1]	[1] p43-47 [2] p21-35
	Management Commitment[1]	Commitment is needed to continue funding field data collection equipment acquisition, data collection contracting, data processing and storage hardware/software procurement, and GIS development funding and personnel resources).[1]		
	Different supporting groups started out with different ideas for the use and structure of the database.[1]	—		
	Supporting groups had discussions about the standards of the data collection and the feasibility of incorporating specific fields.[1]	GIS mapping may help to allow more fields to be linked accurately and easily.[1]		
	Not all roads included.[2]	include more traffic maps and include road network updates.[2]		
	Highway assets not included.[2]	Use spatial location for the inclusion of highway assets.[2]		
Arizona Department of Transportation (ADOT)	Data Quality Assurance	The group stressed that data quality is more important than data quantity	▪ Integrate the available photologs. ▪ Include Pavement and Bridge Data. ▪ Include project expenses. ▪ Make presentations to management about how to improve the existing system.	[1] p48-53
	Information Resource Management	Ownership issues and data management standards must be set.		
	Balance between the groups who require the data and those in charge of producing the linked data	The group noted that there needs to be an understanding of the need for data integration at the top levels where it is not as apparent as to those who require the linkage.		
California Department of Transportation	Reliance of outside consulting was necessary	—	▪ Include freight to the database linkage ▪ Increase analytical capabilities of the project.	[1] P54-57
	Complexity of integrating all large	—		

Organization	Linkage / Administrative Issue	Proposed Solution	Future Plans	Reference
(Caltrans)	number of organizations.			
Colorado Department of Transportation (CDOT)	Overcoming the existing mentalities to improve the linkage	A change in the management as a result of turnover has produced a broader vision for the project.	—	[1] p58-63
Delaware Department of Transportation (DelDOT)	Lack of general awareness of the project	Publish brochures and meet with representatives to discuss the relevance of the project	▪ Develop an Integrated Enterprise Environment. ▪ Integrate legacy data. ▪ Expand the project to include a number of additional components.	[1] p64-67
	Allowing for future integration	All data are to adhere to the Traffic Management Data Dictionary developed by the ITS and AASHTO.		
	Maintaining and improving upon existing practices	Continually offer training and support for the implementation and operation of the project.		
Florida Department of Transportation (FDOT) -Geo-Referenced Information Portal (GRIP)	Maintain Support	Determine the actual benefits to the project and secure continual support.	▪ Update existing system to include GIS products.	[1] p68-72
	Maintaining Focus	Continual training as well as ensuring careful planning, cooperation, and coordination.		
Florida Department of Transportation (FDOT) - Turnpike Enterprse Asset Management (TEAMS)	Obtaining buy-in from a large number of groups.	The use of focus group meetings, surveys, and interviews were utilized to determine user need.	▪ Fully integrate Turnpike utility and toll information.	[1] p73-76
	Develop and document the detailed processes associated with the linkage.	Maintain a detailed schedule and the regularly report and communicate results to stakeholders.		

Organization	Linkage / Administrative Issue	Proposed Solution	Future Plans	Reference
Hawaii Department of Transportation (HDOT)	Wide mix of IT experience among the staff.	—	▪ Incorporate new applications as they develop. ▪ Development of a comprehensive pavement management system.	[1] p77-80
	Software	The group found the off-the-shelf software worked very well for their needs.		
	Acquiring Interest	It was discovered that interest is easily attainable after the construction of the database so that concrete examples are available.		
Iowa Department of Transportation (IDOT)	Implementation challenges due to the inclusion of separate agencies[1]	Develop standardized protocols, standard languages and a database centric design.[1]	▪ The inclusion of other organizations such as the Des Moines metropolitan counties. ▪ Use the resulting linkages for effective responses to the patterns and applicable relationships that become apparent.[1]	[1] p81-86 [2] p41-44
	Lack of roadway and traffic data timeliness.[2]	increase accessibility [2]		
	Inaccurate crash data[2]	Working to improve consistency [2]		
Kansas Department of Transportation (KDOT)	Middle Management Resistance	Ensure that all levels of management are included in the management structure.	▪ Develop a web-based information portal. ▪ Utilize a GIS.	[1] p87-90
	More systems to link than expected and complex relationships between databases and technologies.	Hire consultants to provide knowledge, advice and mentoring.		
Maine Department of Transportation (Maine DOT)	A single location-based linkage approach did not support all parties needs.	Utilize methods of location synchronization and cross-referencing with different methods.	▪ Transfer all data from existing system to an updated system with stronger spatial relating capabilities	[1] p91-94
	Maintaining data integrity	Use electronic collection to limit the introduced errors.		
Michigan Department of Transportation (MDOT)	The linkage was stalled by a lack of software availability.[1]	The group developed their own software solutions.[1]	▪ Legislation is mandating the adoption of Asset Management concepts. ▪ Development of web-based fronts.[1]	[1] p95-101 [2] p45-50
	Developing a linked system and maintaining the system are separate.[1]	Commitments must be made to ensure that the linkages are kept up. Also, appropriate training and continued education on the topic areas are necessary. [1]		
	Lack of local road data.[2]	Standardization is to be implemented for local roads as well.[2]		

Organization	Linkage / Administrative Issue	Proposed Solution	Future Plans	Reference
	Gaps in the roadway feature data.[2]	Paper records need to be included in the electronic database.[2]		
Minnesota Department of Transportation (Mn/DOT)	Finding a practical approach to the linkage process	Develop a phased approach with manageable increments and defined deliverables. Use a performance based approach	▪ Incorporate more data to cover the entire set of transportation data.	[1] p102-105
	Maintaining enthusiasm	Frequent meetings between contributors and users.		
Mississippi Department of Transportation (Mississippi DOT)	Storage and administration separation[2]	Ensure that all groups are following the same referencing standards[2]	▪ Create a data warehouse to store the roadway characteristics, traffic volumes, road and city name alias tables. ▪ Improve GIS capabilities[2]	[2] p51-55
Montana Department of Transportation (MDT)	Maintaining staff training	Create a training plan.	▪ They are moving towards systems that will not confine them to only one software type. This is to allow for changes that may be necessary.	[1] p106-110
	Enforcing data management standards	Meetings within the agency can serve to ensure and inquire about data management.		
New Mexico State Highway and Transportation Department (NMSHTD)	Developing early buy-in	NMSHTD was able to obtain buy-in by releasing the results of a pilot study early on to show relevance.	▪ Support for the project has fallen off so a move to restore support has been put in place.	[1] p111-114
New York State Department of Transportation (NYSDOT)	There has been difficulty in applying the linked data to a cost – benefit analysis	—	▪ Complete applications for highway and bridge data ▪ Move to integrate other components as well; i.e. pavement, safety, and congestion data.	[1] p115-120
	Understanding the context of the linked data	It was noted that the linked data did not necessarily replace existing systems, but could serve to supplement those systems.		

Organization	Linkage / Administrative Issue	Proposed Solution	Future Plans	Reference

Ohio Department of Transportation (ODOT)	Developing a data warehouse[1]	To account for varying legacy systems, a common referencing system was established, development procedures were installed and work with contributors to develop their data for the new system[1]	▪ Adopt goals for pavement improvements ▪ Strategy for congestion management ▪ Addition of more systems to the data warehouse ▪ Customize GIS tools ▪ Implement a marketing effort to facilitate integration further[1]	[1] p121-125 [2] p56-61
	Prevalence of proprietary views of legacy systems[1]	a cross-disciplinary committee was assigned to recommend policies and standards. [1]		
	Planning and administration	Implementation plans should be developed and executive support must be secured		
	Temporal issues[2]	Account for and be aware of roadway changes with time. [2]		
	No local data[2]	Integrate the local data into the existing system. [2]		
Oregon Department of Transportation (Oregon DOT)	Lack of Data definition	Create common data definitions and database standards	▪ Include local roads data	[2] p62-68
	Lack of IT resources	Improve IT resources to develop required links between data sets		
Pennsylvania Department of Transportation (PennDOT)	Balance[1]	An understanding regarding the strategic plan, practicality and maintenance must be established[1]	▪ Reengineer their Roadway Management System ▪ Develop an Enterprise Model ▪ Develop a reference management system ▪ Integrate more systems into a GIS[1]	[1] p126-132 [2] p69-72
	Maintenance[1]	Project objectives should include changing technologies and situations[1]		
	Relationships[1]	Develop contractor relationships to promote training and technology. [1]		
	No inclusion of local roads[2]	Develop a system to integrate the roadway data. [2]		
South Carolina Department of Transportation	Coordinating management systems	Assure that data integration is accomplished with regard to the needs of the participating groups.	▪ Integrate two existing systems ▪ Inventory all state-maintained roads with GPS	[1] p133-135

(SCDOT)	Maintain support	The release of an Annual Accountability Report.		

Organization	Linkage / Administrative Issue	Proposed Solution	Future Plans	Reference
Tennessee Department of Transportation (TNDOT)	Making timely and informed decisions	Develop a system that is geared towards mission specific goals.	▪ Addition of automated inventory processes ▪ Linkage of additional systems ▪ Tailor off-the-shelf systems ▪ Streamline the most popular features	[1] p136-139
	Undertaking a set of challenges.	Introduce the linkage in steps. This can reduce risk and is easier to manage.		
Utah Department of Transportation (UDOT)	Organizational decisions.	Make all decisions prior to IT work	▪ Create an asset manager position ▪ Integrate pavement and bridge data	[1] p140-143
Vermont Agency of Transportation (Vtrans)	Developing a common understanding of asset management.	A committee to address these issues can be formed and a forum can be set up to determine the differences in management.	▪ Document current planning, programming and budget process ▪ Develop a list of data and analysis requirements ▪ Reinforce existing GIS by documenting its critical nature	[1] p144-149
	Fully integrating management systems .for decision making.	—		
	Integrating data from different sources in a manner that supports management.	—		
Virginia Department of Transportation (VDOT)	Choosing software.	The software choice should be based on the data model.	▪ Embracing web-based services ▪ Interested in implementing the National Spatial Data Infrastructure Framework Project ▪ Develop an open systems approach to account for changing technologies	[1] p150-155
	Administrative.	Define the requirements and rules for the data model.		
	Feasibility.	Approach the initial stages will small data sets.		
Washington State	Stalled out projects.	Developing a business plan before approaching the technical side.	▪ Proceed with pilot studies ▪ Continue to view the project with respect	[1] p156-158

Department of Transportation (WSDOT)	Lack of experience.	Bringing in outside contractors can help with specific issues.	to the overall goals ▪ Create a list of GIS applications as development continues	
	What issues to address.	A committee can help to evaluate and rank each need and provide the appropriate approach to addressing them.		
Wisconsin Department of Transportation (WisDOT)	System stability and data quality.	Employ or build a GIS-client system (i.e. WISLR).	▪ Link road geometry and crash data ▪ Automatically link crash data for state and non-state datasets ▪ Establish and utilize crash location reference standards	[2] p73-85
	Ensuring success of data integration.	Focus on the accident data collection and the crash coding process.		

References

1. Vander-Ostrander, A., G. Joseph, and F. Harrison, *Review of Data Integration Practices and Their Applications to Transportation Asset Management: Final Report*. 2003, National Highway Traffic Administration.
2. Transportation Research Board., *Integrating Roadway, Traffic, and Crash Data*, in *Transportation Research Circular*. 2007: Washington, D.C.

Table 12. Summary of CODES Experiences with Data Linkage Projects: Issues

Category	Topic	Major Issue	Solution
Data Access	EMS Data	Lack of electronic data	A data operator computerized all run sheets
		Varying quality within EMS data	CODES applied for additional funding to aid the EMS agency to perform data entry
	Missing Data	Difficulty in convincing hospitals to release outpatient data	Worked with State Association of Healthcare and Hospital Information Management Association to develop effective means of data acquisition
		Difficulty matching data due to a lack of personal identifiers	Use AUTOMATCH software for probabilistic linkages.
	Data Access Delays	Lack of knowledge about the data set	Dedicated time for educating the CODES team on crash data files
		Gaining permission to the databases	Show a clear purpose for access.
Data Quality	Crash data	Separate crash data files	The data was cleaned up and variables were re-named to maintain uniformity
		Information not available for non-injured occupants	Encourage the officials in charge of collecting data to start collecting the non-injury data
	EMS Data	EMS data often incomplete	A new reporting form was created
	Hospital Data	Data ownership changes	Meetings were set up by new data owners to help with the reporting requirements
		Low use of e-codes	Increased use of bodily injury location and type of injury for linkage
		Standardizing unlike hospital records	A standard template was created with the help of the Hospital Information Management Association
Data Linkage	Probabilistic Techniques	Assuring consistency	A consultant was hired to help build a software package that would accept multiple formats
		Huge file sizes	The linkage was to be kept simple
	Failure to Link	inconsistent time variables	new yyyymmdd formats were put in place
		Lack of strong patient identifiers	Additional geographic indicators were included
		Non-uniform data between hospital and EMS	new 3-digit injury variables were created
Application	Statistical Issues	Need for improved spatial integration	software was implemented to help with mapping and geo-coding
		Missing Data – under reporting	In some cases, records were removed where fields were missing
		The importance of covariates	Common models were created to analyze the importance of covariates

Category	Topic	Major Issue	Solution
		Statistical methodology	A number of approaches were considered including logistic regression, SAS, and log linear analysis

Category	Topic	Major Issue	Solution
	Personnel Issues	Shortage of on-staff expertise for traffic safety	Relationships with safety experts across the sates were vital for supporting the project
		The use of the data	All reports and studies from the CODES linkage has been the result of a need expressed from the community, government or citizen.
	Confidentiality	Confidentiality policies	Exclude all identifiers and data that may be used for making comparisons
		Distributing information without impeding privacy	Worked with the Association of Healthcare Organizations and the Hospital Information Management Association for the production of guidelines
	Limitations for Case Study	Lack of clearly defined variables	Close discussion between contributing parties to have a strong understanding of the field definitions
	Production Issues	Lack of Planning	The first iteration was not planned well. The groups began to plan well ahead of time to anticipate any issues that may arise
		Keeping up with the demand or the CODES data	A full time staff employee has dedicated his time to the CODES project to answer requests.
	Web-Site Development	Underestimating the cost	Development required a prior knowledge of the data users needs
			Anticipate the need for changes base on user needs
			Note the hardware, software, and staffing requirements for meeting the needs of the users

Table 13. Summary of CODES Experiences with Data Linkage Projects: Issues

Category	Topic	Recommendations
Administrative	Board of Directors	The board must be expandable
		Obtain interagency trust
		Develop ownership regulations
		Produce written explanations for data release and notify involved parties when releasing data
		Have an understanding of how the data will be used
	Collaboration	A written commitment from all parties can help to maintain support
		Give credit where it is due
		Express the value of the project to the contributors
		Utilize available assets such as existing groups that can work to establish regulations.
	Priorities	Develop strategies for releasing the data before beginning while in the planning stages
		Include those who will use the data in the decision making processes
	Communication	Maintain the focus and allow for change within the project
		Include upper management and keep them up to date on the project as changes are made
		Always include and inform data contributors
		Invite those interested to become involved
	Project Management	Hire a fulltime project manager
		Be able to adapt

Category	Topic	Recommendations
Linkage	Data Access	Understand the structure of the datasets
		Create a dream list of the desired datasets. Express to the holders of these datasets the importance of their inclusion into the project
		Create a plan and time-line for acquiring datasets. Understand the potential and feasibility associated with the respective dataset linkages
		Negotiate the use and dissemination of data with the contributing parties
		Accept all formats, but make recommendations
		Ask for all possible identifying variables, even if it is thought that access may not be granted
		Assure that al parties are in agreement with all aspects of the project
		Be aware of changes that may occur within the contributing datasets
	Data Quality	Have an understanding of the time commitment associated with preparing the data
		Ensure that software choices are suitable for the proposed uses and datasets
		Check for completeness of the datasets as they are delivered or as they are integrated into the system
		Assess the compatibility of the injury data between data sets
		develop knowledge of the fields and recognize any variation in consistency and reliability
	Probabilistic Linkage	know the limits of the data for integration and pass this knowledge on to the data owners to establish an understanding of the importance of accurate and sufficient data
Application	Statistical	Utilize the same processing an and analyzing from year to the next
		Always remember that accurate analyses are more dependent on data quality than quantity
		Beware of any bias that may exist in the data (i.e. over reporting of belt use)
	Decision Making	Use the fruits of the project to assist the contributing parties in enhancing their own practices
		Use the data as feedback to the parties that are contributing to the project
	Production	Define a policy for requested reports and data release
		Keep all data contributors happy
		Try to maintain the timeliness of all studies
		work with advocacy groups to establish studies regarding their interest

References

1. National Highway Traffic Safety Administration, *Problems, Solutions and Recommendations for Implementing CODES (Crash Outcome Data Evaluation System)*. 2001.