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# An Evaluation of Medical And Financial Outcomes Of Motor Vehicle Crash/Injuries In Connecticut

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AIS ........ Abbreviated Injury Score
CAAI ........ Collision Analysis Auxiliary Input Files
CHA ........ Connecticut Hospital Association
CHIME® ........ Connecticut Health Information and Management Exchange
CHREF ........ Connecticut Healthcare Research and Education Foundation, Inc.
CTMDS ........ Connecticut State Mortality Data Set
DOT........ Department of Transportation
ED........ Emergency Department
ICD-9-CM........ International Classification of Disease, 9th Edition Clinical Modification
ICF ........ Intensive Care Facility
ISS........ Injury Severity Score
LOS ........ Length of Stay
MVC........ Motor Vehicle Crash
SNF ........ Skilled Nursing Facility

# ABSTRACT

A deterministic algorithm was developed which allowed data from Department of Transportation motor vehicle crash records, state mortality registry records, and hospital admission and emergency department records to be linked for analysis of the financial and medical impact of motor vehicle crashes in Connecticut in 1995. There were 132,918 motor vehicle crash records (individual vehicles or pedestrians) involving 183,358 persons, 18.9% of whom were associated with one or more linked medical records, resulting in a total of 34,778 hospital visits. Of these, 91.7% were treated and released from the emergency department, with the rest being admitted to hospital with median length of stay of 3 days. About 77% of the persons treated in the emergency department or admitted as hospital inpatients had been identified as injured by the traffic safety officer at the scene of the crash. Median total hospital charges for these hospital visits was $405. Home discharge constituted 97% of the hospital discharges; mean total charges for those discharged to skilled nursing or intensive care facilities were 10 times greater than for those discharged home. There were 329 mortality registry records linked with these crashes, of which 46.8% occurred at the crash site. Logistic regression analysis determined that higher risk of fatal or serious injury was associated with head on collisions, motorcycle riding, driver illness, violating traffic control, and being at fault (according to the investigating traffic officer). Also associated with higher risk of fatal or serious injury were striking a tree, utility pole, or other object off the road, and multivehicle collisions. Weather conditions associated with increased risk of fatal or serious injury were blowing sand, soil, or snow, or no adverse weather conditions.

# INTRODUCTION

This report examines motor vehicle crashes occurring in Connecticut during 1995, using several linked data sets. The findings reported herein illustrate the usefulness of using linked data sets to perform these types of analyses. Alone, each data set could not provide the type and depth of information provided by the group of linked data sets.

Data sets used for the studies include:

- The CHIME® database, including Inpatient and Emergency Department data
- Ambulatory Surgery data from 31 general acute care facilities
- State of Connecticut, Department of Transportation (DOT) crash file
- State of Connecticut Mortality Data Set (CTMDS).

The CHIME® dataset identifies all people involved in a MVC (motor vehicle crash) who had inpatient, emergency, or ambulatory surgery treatment at a Connecticut facility regardless of the state in which the MVC occurred. The DOT dataset identifies all MVCs and people involved in a crash, regardless of whether or not they had treatment at a hospital. The mortality dataset identifies deaths from MVCs. It includes all deaths from MVCs in Connecticut, whether the fatality was a resident of Connecticut or not, in addition to deaths of Connecticut residents who died in MVCs outside Connecticut which were reported by the state where they died.

Linking these data sets allows in-depth analysis of medical and financial outcomes of crash injuries occurring in Connecticut. For instance, analysis of medical and financial outcomes of crash injuries occurring in Connecticut is enabled by the linking of multiple data sets. Medical and financial consequences of the acute care provided, obtained from the CHIME® database, are linked with the DOT dataset, allowing multivariate analysis of the impact of MVCs occurring in Connecticut.

What follows are a description of the linking, a statistical analysis of the data, and a summary of our findings.

This study was funded in part by the National Highway Traffic Safety Administration as part of the CODES demonstration project[1], and performed in collaboration by the Connecticut Healthcare Research and Education Foundation (CHREF, a non-profit affiliate of the Connecticut Hospital Association), the State of Connecticut Department of Transportation (DOT), and Hartford Hospital.

# METHODS

## DATA SOURCES

### Motor Vehicle Crash (MVC) Data

The MVC data were obtained from the 1995 Collision Analysis Auxiliary Input (CAAI) Files. This is a database of motor vehicle crash data, owned by the State of Connecticut Department of Transportation.

There are six different record formats in the DOT files, described as follows:

- Record Type 1: Crash Summary Record
- Record Type 2: Traffic Unit Information Record
- Record Type 3: Traffic Unit Pen-Based Only Record
- Record Type 4: Involved Person Record
- Record Type 5: Property Damage Record
- Record Type 6: Crash Narrative Record.

Record Types 1, 2 and 4 were used for this analysis. Record Type 1 contains information pertinent to the crash as a whole, such as date and time, location and other crash-specific information. Record Type 2 identifies each traffic unit involved in a crash, defined as a vehicle involved in a crash or a pedestrian who was struck by a vehicle involved in a crash. Record Type 4 contains information about vehicle operators, struck pedestrians, passengers, and witnesses. If more than four persons were involved in a crash, more than one person-record was created[2]. Table 1 summarizes the number of records in these files.

**Table 1. Summary Of 1995 Collision Analysis Input Files**

| File Type | Number of Records |
|---|---:|
| Type 1: Crash Summary Records | 72,677 |
| Type 2: Traffic Unit Information Records | 136,165 |
| Type 4: Included Person Records (1 - 4 persons each) | 79,931 |

The working MVC data file was constructed based on Type 1, 2 and 4 records in the DOT file. Type 1 records were merged with Type 2 records, to produce a file of one record per vehicle or pedestrian involved in a crash. The Type 4 records were converted from one record for each 1 to 4 involved persons into one record per involved person (*i.e.*, if there were 4 people involved in a crash, the original file had one Type 4 record but the converted file has 4 records), then merged with the file of involved vehicles or pedestrians. This process produced one record for each involved person, containing all the data describing that person, as well as the specific crash and the specific vehicle. Table 2 categorizes the records contained in the DOT file.

**Table 2. DOT MVC File Crash Records, by Category**

| | Number | Percent of Total |
|---|---|---|
| Drivers | 132.918 | 72.5% |
| Passengers | 48.919 | 26.7% |
| Pedestrians | 1.518 | 0.8% |
| Witnesses | 3 | 0.0% |
| **Total** | **183,358** | **100.0%** |

## Hospital Claim Data

The CHIME® database was used for this analysis. Included in the CHIME® database is demographic, clinical and financial information about each patient visit occurring in Connecticut acute care hospitals.

Data were extracted from this database in a two step process. In the first step, an index file containing information about Connecticut hospital ED visits, ambulatory surgery visits, and inpatient stays during 1995 was created for all patients having an ICD-9-CM code ranging from E810 to E819 (motor vehicle traffic crash E-codes), as detailed in Table 3.

**Table 3. CHIME® Database Records, by Motor Vehicle E-Code Category**

| E-Code Category | Number | Percent of Total |
|---|---|---|
| Motor Vehicle, Driver | 23,219 | 56.79% |
| Motor Vehicle, Passenger | 11,659 | 28.52% |
| Motorcyclist | 1,191 | 2.91% |
| Other, Unspecified | 2,430 | 5.94% |
| Pedalcyclist | 697 | 1.70% |
| Pedestrian | 1,687 | 4.13% |
| **Total** | **40,883** | **100%** |

In the second step, a medical history file containing the previous year's hospital visit information for those patients having an MVC in the index year was created. There were 40,883 records in the index CHIME® database and 12,280 records in the history CHIME® database.

### Mortality Data

Mortality data for victims of motor vehicle crashes were derived from the State of Connecticut Mortality Database (CTMDS). This database is offered to individuals and institutions from the State of Connecticut Department of Public Health, Office of Planning & Evaluation, Vital Records Bureau, and offers a comprehensive view of primary causes of mortality in Connecticut.

There were a total of 390 records selected from the state of Connecticut 1995 mortality database as possessing a motor vehicle crash related cause of death. Table 4 details these records by location of residency and location of crash.

**Table 4. CT Mortality Database MVC Records, by Location of Crash and Location of Residency**

| Residency | Location of MVC | Number | Percent of Total |
|---|---|---|---|
| Connecticut | Connecticut | 321 | 82% |
| Connecticut | Out of State | 51 | 13% |
| Out of State | Connecticut | 18 | 5% |
| **Total** | **Total** | **390** | **100%** |

## LINKING /MERGING PROCESS

A proprietary deterministic matching algorithm was developed in the FOCUS language to merge these databases. Key variables used to link the crash and hospital data were date of crash, date of birth, date of ED visit, date of inpatient admission(s), date of death, gender, and towncode of crash. Because passenger DOT records do not specify a gender, three steps of merging were employed. The first step included only driver and pedestrian records, with gender identified in the DOT database. The second step included passenger records from the DOT database, for which gender cannot be used as a linking variable. The third step included all unmatched records from the first and second steps. This algorithm did not allow for fuzzy or probabilistic linking; however, since crash date and ED or inpatient admission date would not always be expected to match exactly, four levels of date window were allowed within each matching step.

One hundred percent complete linkage is not expected when linking the DOT crash database to the CHIME® database; for instance, if a motor vehicle crash occurred outside the state of Connecticut and the victim was taken to a Connecticut emergency room, or admitted to a Connecticut hospital, the patient would be included in the CHIME® database but not the DOT database. Conversely, anyone who had a crash occurring in the state of Connecticut and was admitted to a hospital or ED outside of Connecticut would be included in the DOT database but not in the CHIME® database. The result of this slight disjunction between the underlying pools of subjects is that the maximum linkage rate attainable will be reduced below 100% by an unknown amount, since we do not have a count of persons involved in either out of state crashes, or out of state hospital visits.

The mortality registry contains some records of Connecticut residents who die in other states, dependent on the other state's reporting them. Therefore, similarly to the above, Connecticut residents who die out of state in a crash might appear in the mortality database, but not in the DOT or CHIME® databases. Conversely, a person injured in a crash in Connecticut and admitted to a Connecticut hospital, but who eventually dies out of state, might appear in the DOT and CHIME® databases, but not in the mortality registry. Again, this would reduce the maximum attainable rate of linkage to the mortality registry, by an amount that we are not able to predict.

Table 5 describes the matching steps and levels in the merging algorithm. The output linked-dataset was inspected to verify the quality of the match.

**Table 5. Merge Algorithm for DOT and CHIME® Database**

| Level | Matching Strategy |
|---|---|
| | **First Step: Merge Driver Or Pedestrian Records Which Include Gender** |
| **1** | Matching variables: birth date, gender, town code<br>date adjustment window of 0 days (date of hospital visit equal to date of crash). |
| **2** | Matching variables: birth date, gender, town code<br>date adjustment window of +7 days (date of hospital visit within 7 days after date of crash). |
| **3** | Matching variables: birth date, gender, town code<br>date adjustment window of +30 days (date of hospital visit within 30 days after date of crash). |
| **4** | Matching variables: birth date, gender, town code<br>date adjustment window of +30/-1 days (date of hospital visit within 30 days after or 1 day before date of crash). |
| | **Second Step: Merge Passenger Records Which Do Not Include Gender** |
| **5** | Matching variables: birth date, town code<br>date adjustment window of 0 days (date of hospital visit equal to date of crash). |
| **6** | Matching variables: birth date, town code<br>date adjustment window of +7 days (date of hospital visit within 7 days after date of crash). |
| **7** | Matching variables: birth date, town code<br>date adjustment window of +30 days (date of hospital visit within 30 days after date of crash). |
| **8** | Matching variables: birth date, town code<br>date adjustment window of +30/-1 days (date of hospital visit within 30 days after or 1 day before date of crash). |
| | **Third Step: Merge Records With Gender Unknown Or Missing** |
| **9** | Matching variables: birth date, town code<br>date adjustment window of 0 days (date of hospital visit equal to date of crash). |
| **10** | Matching variables: birth date, town code<br>date adjustment window of +7 days (date of hospital visit within 7 days after date of crash). |
| **11** | Matching variables: birth date, town code<br>date adjustment window of +30 days (date of hospital visit within 30 days after date of crash). |
| **12** | Matching variables: birth date, town code<br>date adjustment window of +30/-1 days (date of hospital visit within 30 days after or 1 day before date of crash). |

## STUDIES AND PHASES

This study was divided into two phases. The first phase analyzed all eligible DOT records to determine the distribution of the variables under examination and identify significant predictors of these variables and their odds ratios. The second phase was restricted to cases that successfully linked or merged, with a primary goal of determining the clinical events after MVCs.

## OUTCOME AND INDEPENDENT VARIABLES

### Outcome Variables

The outcome variable for the first phase was frequency of severe injury, determined as either fatal or incapacitating (injury types K or A from the DOT Type 4 record). The outcome variables for the second phase of the study included: severity of injury, mortality, length of stay, discharge disposition, total hospital charges, and Injury Severity Score (ISS). Due to the inclusion of emergency department data and the high frequency of zero length of stay cases, inpatient admissions were analyzed separately for length of stay analysis. Similarly, for some analyses of cost, only records with hospital charges of at least one dollar were selected.

Drivers' age was categorized into five subgroups: age less than 25 years, 25 to 44, 45 to 64, 65 to 74, and greater than 74 years. Length of stay was categorized into three groups: ED treated and released, inpatient with length of stay equal to 1 day, and inpatient with length of stay greater than 1 day. Total hospital charge was calculated on an unadjusted basis only, due to lack of cost/charge ratio information. Mortality was categorized as died at the crash site, Emergency Department death (died in hospital with zero length of stay), died as inpatient (died in hospital with length of stay equal to or greater than 1 day), and died after discharge. Type of injury was categorized into 5 levels (K, fatal injury; A, incapacitating injury, B, non-incapacitating injury; C, possible injury; and N, no injury), based on the DOT file's injury classification code. This classification was made at the time of the crash, based on either an involved person's self-report or the investigator's visual assessment; however, persons involved in a crash but categorized as not injured may seek treatment, and, conversely, persons categorized as injured may never appear at a hospital for treatment.

ISS is calculated from a mapping of ICD-9-CM codes to patient injury severity values for each trauma patient, through a two step process. The first step is to define the highest Abbreviated Injury Score (AIS) for each of six body regions: Head, Face, Chest, Abdomen, Appendages, and Skin; these AIS values range from 0 (no trauma injury), to 6 (trauma injury incompatible with life). In cases where multiple wounds exist in the same body region, the highest AIS value prevails. Thus, a skull vault fracture with AIS value of 4 prevails over a scalp abrasion with AIS value of 1. The second step is to calculate the ISS from the AIS values, by taking the three most injured body areas as described by their AIS values, squaring each of those values, then adding those squared values together. For instance, a trauma patient with a skull vault fracture (AIS value of 4), plus a lacerated liver (AIS value of 3), plus a fractured femur (AIS value of 2), plus a skin abrasion (AIS value of 1), would receive an ISS score of $(4^2) + (3^2) + (2^2)$, or 29 (only the highest three terms are used). The maximum ISS value of 75 is assigned to any patient receiving an AIS value of 6, indicating a trauma incompatible with life.[3]

### Independent Variables

Independent variables in this study were drawn from two sources, the DOT data file and the CHIME® database. Those variables included demographic, geographic, subjective, and objective factors, road and weather/season condition, police judgment/investigation, and clinical variables. Demographic variables included age (categorized into five age groups as described above), and gender (female or male). Geographic variables included location of the crash and location of the fixed object struck. Subjective factors included speeding, following too closely, violating traffic controls, unsafe use of highway by pedestrian, etc. Objective factors included driver illness, vehicle involved in emergency, etc. Road condition included construction and road surface. Weather/seasonal variables included snow and rain. Police judgment/investigation included whether or not the driver had been drinking, and lighting conditions. Clinical variables included having at least one hospital visit with a motor vehicle crash related E-code within the past 1 year or 6 months. Other variables included type of motor vehicle, collision type, and injury classification. All categorical variables were converted into binary variables as required for the analysis.

## STATISTICAL ANALYSIS

For the first phase of the study, the frequency for each outcome in the studied cohort was determined. The bivariate associations with outcome of road condition, weather/season condition, police judgment/investigation, demographic, geographic, subjective, objective, and clinical variables were evaluated, then a stepwise logistic regression model with a group of independent variables was developed, to find the significant predictors. Candidate independent variables were selected from the variables identified in the bivariate analysis as having an association with $p < 0.10$.

All stepwise models were constructed with an entry significance level of 0.01 and an exit significance level of 0.05, chosen to identify a parsimonious set of independent variables in the models. Partial residual plots were used to evaluate potential problematic areas of fit[4]. Goodness-of-fit was evaluated by comparing fitted probabilities with observed value of dependent variables within deciles of probability, and calculating the corresponding observed chi-square statistic. In addition, an area under the receiver operator curve for logistic models was calculated to evaluate the predictive power of the models[5].

An adjusted odds ratio was derived in which each odds ratio was adjusted for all other independent variables listed. An odds ratio less than 1 indicates that a crash event with that characteristic has a lower likelihood of association with the outcome variable than without that characteristic, while an odds ratio higher than 1 indicates that a crash event with that characteristic has a higher likelihood of association with the outcome variable than without that characteristic. For each of the studies, the logistic regression model's odds ratios and 95 percent confidence intervals for predictors were reported. In addition, a chi-square test or non-parametric test was performed for each bivariate analysis.

All calculations were performed using the software systems SAS® 6.12 (SAS Institute, Cary, NC) and STATA® 3.0 (STATA Corporation, College Station, TX).

# RESULTS

## LINKING AND MERGING

### CHIME® Database

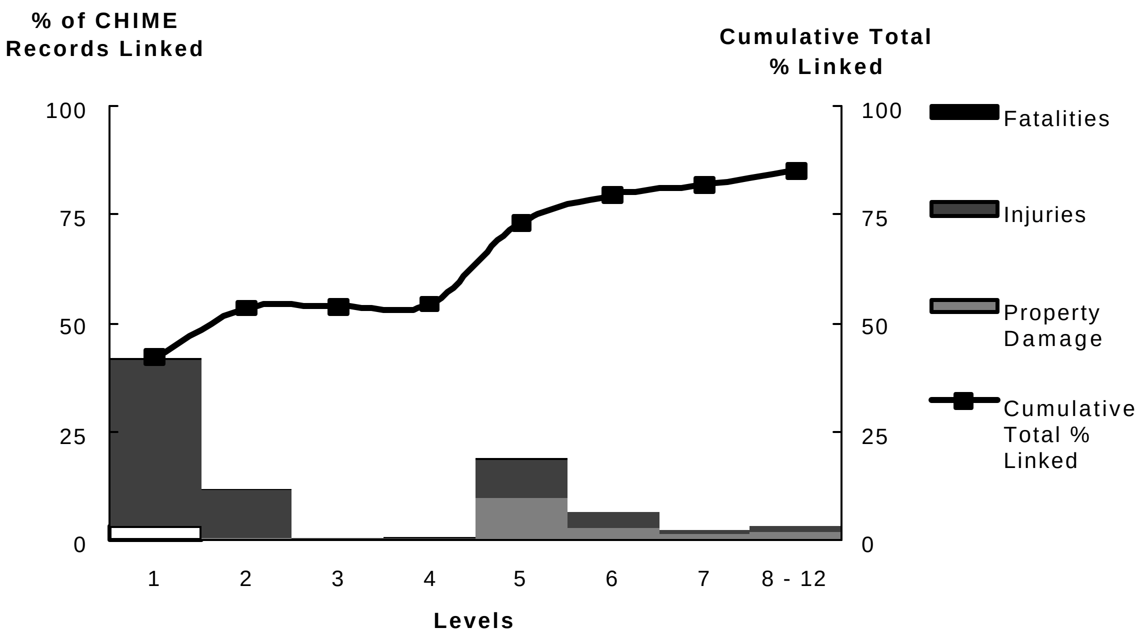
There were 40,883 records selected from the CHIME® data set as having motor vehicle crash related E-codes, as detailed in Table 3. Of these, 35,832 records (87.6%) were linked and merged. After deleting duplicate records (1,054, 2.9%), 34,778 records remained (85.1%). Of these records, 364 (1%) were excluded from future analysis due to unreliable key variables.

Table 6 and Figure 1 show the linkage/merging rate of CHIME® records for each of the linkage levels described in Table 5, classified by crash severity index in the Type 1 record of the DOT file. Since gender is such a useful linking variable, levels 1 through 4 link drivers and pedestrians only; levels 5 through 12 link passengers (who do not have gender recorded by the DOT) and individuals with gender unrecorded by reason of incomplete or defective records.

Table 6. Linkage Rates (CHIME® and DOT)

| Level | Fatality Records Linked as % of CHIME® Records | Injury Records Linked as % of CHIME® Records | Property Damage Records Linked as % of CHIME® Records | Number Linked | Cumulative Total Linked | Cumulative Linkage Rate (%) |
|---|---|---|---|---|---|---|
| **1** | 0.5 | 38.1 | 3.4 | 17.158 | **17.158** | **42.0** |
| **2** | 0.2 | 10.7 | 0.6 | 4.726 | **21.884** | **53.5** |
| **3** | 0.0 | 0.4 | 0.0 | 144 | **22.028** | **53.9** |
| **4** | 0.0 | 0.4 | 0.1 | 202 | **22.230** | **54.4** |
| **5** | 0.1 | 9.0 | 9.6 | 7.690 | **29.920** | **73.2** |
| **6** | 0.1 | 3.6 | 2.8 | 2.633 | **32.553** | **79.6** |
| **7** | 0.0 | 1.1 | 1.2 | 923 | **33.476** | **81.9** |
| **8 - 12** | 0.0 | 1.2 | 2.0 | 1,302 | **34,778** | **85.1** |

**Figure 1. Linkage Rate, by Linkage Level and Crash Severity**




One hundred percent complete linkage is not expected when linking DOT files to all Connecticut hospital and emergency department discharges, since, if a motor vehicle crash occurred outside the state of Connecticut and the victim was hospitalized or admitted to a Connecticut hospital, the patient would be included in the CHIME® database but not the DOT database. Conversely, anyone who had a crash occurring in the state of Connecticut and was admitted to a non-Connecticut hospital or ED would be included in the DOT database but not in the CHIME® database. If both such cases could be eliminated, the final linked and merged rate would be higher than the current 85.1%.

### CTMDS File

A total of 329 records (84% of the 390 motor vehicle crash related fatalities) from the Connecticut Mortality dataset were successfully linked and merged with the DOT and CHIME® files.

## OVERALL MOTOR VEHICLE CRASHES IN CONNECTICUT

Overall, there were a total of 72,639 motor vehicle crashes reported to the DOT in the state of Connecticut during calendar 1995 (38 records of the total 72,677 were excluded due to duplication), involving 136,165 vehicles or pedestrians and 183,358 individual persons (Table 1 and Table 2); of the total persons involved in a crash, 34,778 (19%) were successfully linked to an ED visit or hospitalization (Table 6), and 329 to a mortality entry.

**Figure 2. Percentage of Crashes in Connecticut, 1995, by Town or City**

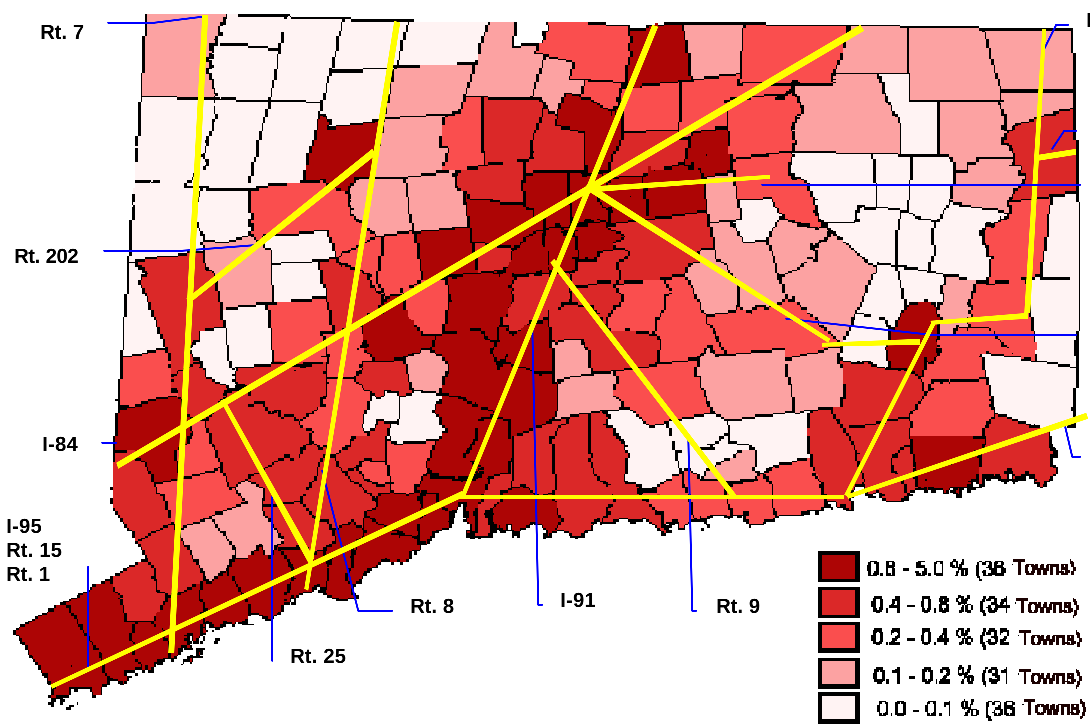



Figure 2 shows a geographical view of the percentage of total crashes by town or city, calculated as the number of crashes in the index town or city divided by total crashes in the state. As can be seen, the highest rates occur in towns and cities surrounding Interstate 91 (I-91), Interstate 95 (I-95) between the New York border and New Haven, Route 15, Interstate 84 (I-84), and Interstate 395 (I-395) between I-95 and Route 6.

There are 169 towns or cities recorded in the DOT files, with crash rates ranging from 0.01% to 5.1%. The five lowest towns or cities were Lyme (0.01%), Warren (0.01%), Colebrook (0.02%), Hampton (0.02%), and Hartland (0.02%), while the five highest were New Haven (5.07%), Hartford (5.00%), Bridgeport (4.81%), Stamford (3.20%), and Norwalk (2.93%). Appendix A details the crash rates by town.

**Figure 3. Rate of Injury for CT Motor Vehicle Crashes, by Town or City**

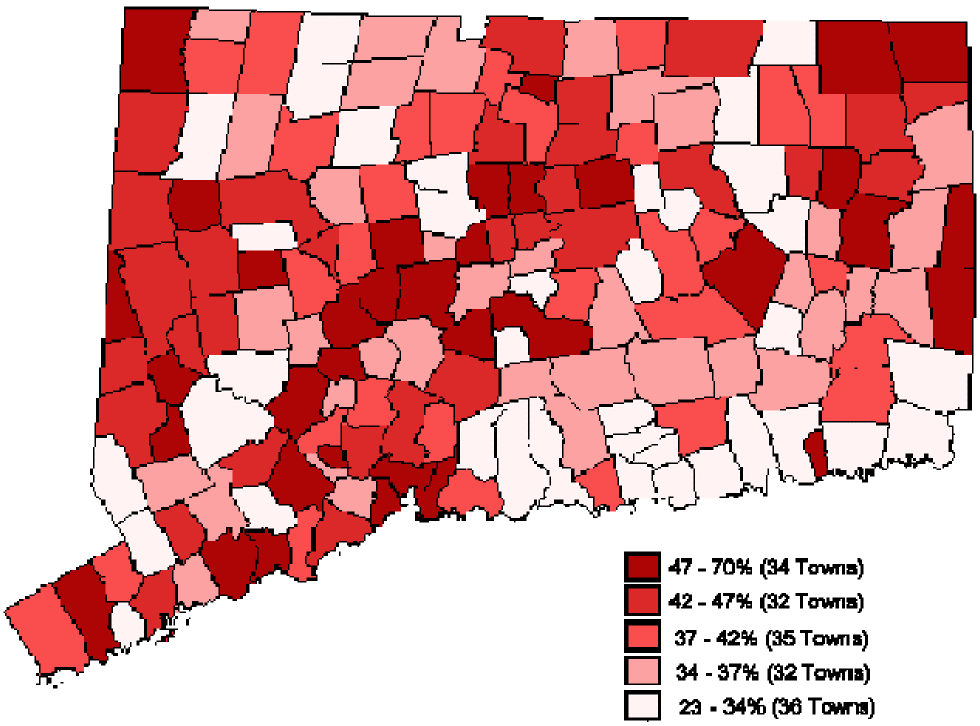



Figure 3 shows the rate of injury by town or city in the state of Connecticut. Presence of injury was determined from the DOT Type 1 record injury severity code, including fatalities or any type of injuries, but excluding property damage only. Rate of injury was determined as number of injured people divided by total crashes in the index town or city.

Overall, the injury rate ranged from 23% to 70%; the five lowest town or cities were Old Lyme (22.89%), Madison (23.71%), Chester (25.00%), Essex (25.25%), and Guilford (27.17%), while the five highest were Sterling (69.57%), Hartford (63.38%), Hampton (62.50%), Windsor Locks (60.81%), and New Haven (59.82%). Appendix A contains detailed data for Figure 3.

**Figure 4. Mortality by Position in Motor Vehicle and Place of Death**

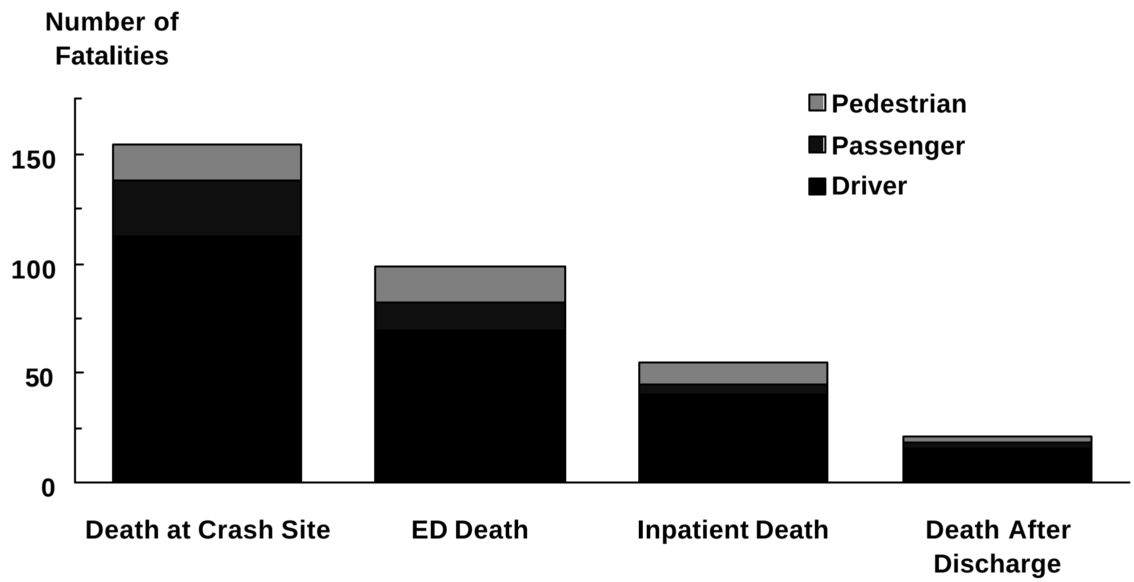



Figure 4 and Table 7 show mortality by position in vehicle (driver, passenger, or pedestrian) and place of death (at the crash site, emergency department [LOS = 0], inpatient [LOS > 0], or after discharge).

**Table 7. Mean Age and Mortality by Position in Motor Vehicle and Place of Death**

| | Death at Crash Site | ED Death | Inpatient Death | Death After Discharge | Total |
|---|---|---|---|---|---|
| **Driver** | 112 | 70 | 40 | 16 | **238** |
| **Passenger** | 26 | 12 | 5 | 2 | **45** |
| **Pedestrian** | 16 | 17 | 10 | 3 | **46** |
| **Total** | **154** | **99** | **55** | **21** | **329** |
| **Mean age** | 38.7 | 41.2 | 53.8 | 38.5 | **42.0** |

**Figure 5. Mean Age of Fatalities by Place of Death**

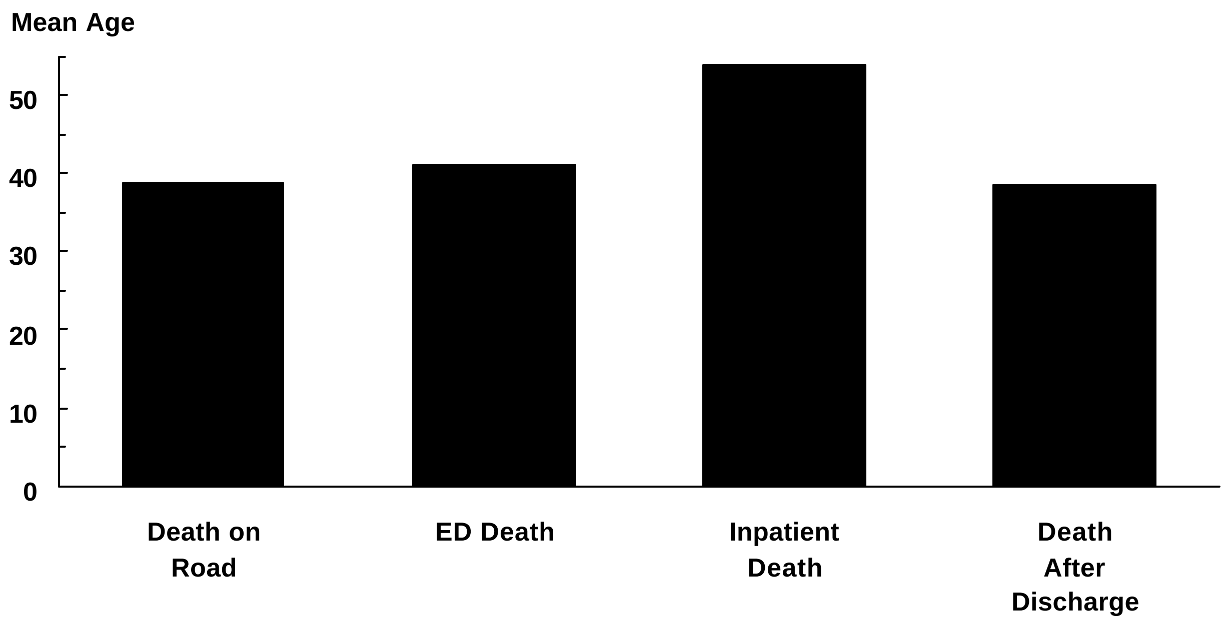



Figure 5 and Table 7 show mean age of fatalities by place of death. Inpatient deaths tended to be older than the other classes of fatalities. There was no significant difference between males and females.

**Figure 6. Fatality Rate of Motor Vehicle Crashes by Town or City**

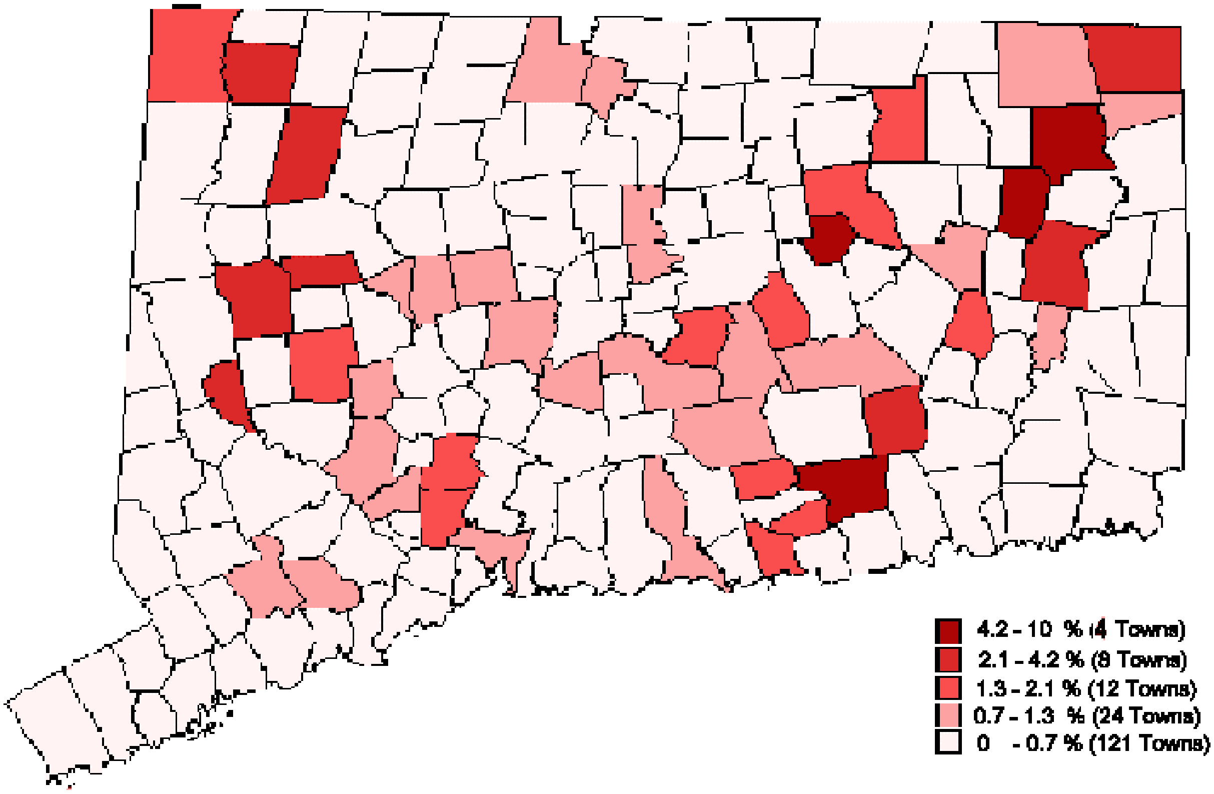



Figure 6 shows fatality rate of crashes by town or city, determined as the number of deaths divided by number of crashes in each town or city. The mortality rate ranged from 0 to 10%, the five highest areas being Lyme (10%, 1 killed in 10 crashes), Hampton (6.25%, 1 killed in 16 crashes), Andover (4.76%, 2 killed in 42 crashes), Pomfret (4.23%, 2 killed in 71 crashes), and Canaan (4.12%, 1 killed in 24 crashes).

**Figure 7. Percentage of Total Mortality by Town or City**

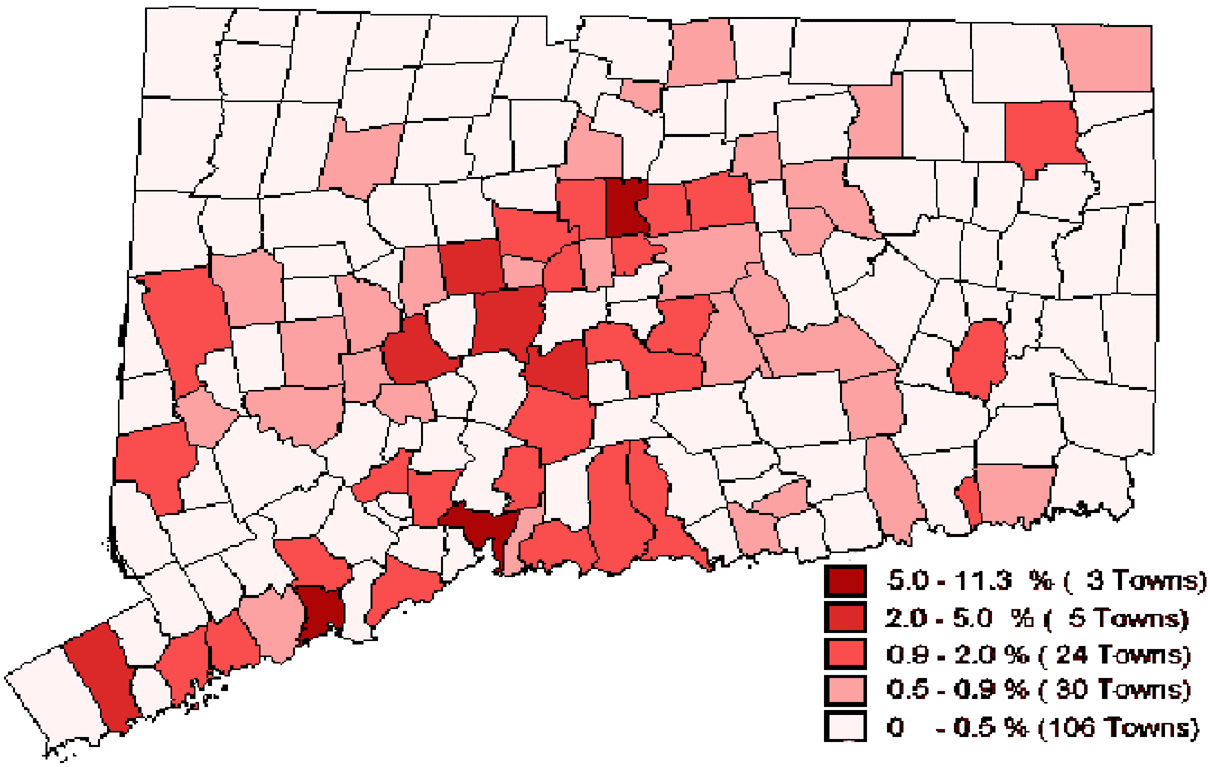



Figure 7 shows mortality by town or city where crash occurred, as a percent of total state mortality. By this measure, Hartford, New Haven, Bridgeport, Waterbury, and Bristol accounted for 29.5% of total state mortality. There were 59 towns or cities where mortality was zero (no one killed by crashes in those areas during 1995).

# PHASE ONE

## Study Sample

Table 8 summarizes by DOT injury classification the 132,918 drivers included in this study.

**Table 8. Number of Driver Injuries, by DOT Injury Classification**

| DOT Injury Classification | Number | % of Total |
|---|---|---|
| Fatal Injury | 206 | 0.2% |
| Incapacitating Injury | 3,801 | 2.9% |
| Non-Incapacitating Injury | 8,741 | 6.6% |
| Possible Injury | 20,381 | 15.3% |
| No Injury | 99,789 | 75.1% |
| **Total** | **132,918** | **100%** |

## Results

Appendix B shows the bivariate analysis of injury classification association with predictor variables. Table 9 shows the odds ratios of characteristics associated with fatal or incapacitating injury, based on multiple logistic regression with backward stepwise selection. Adjusted odds ratio was derived from a multiple regression analysis in which each odds ratio was adjusted for all other independent variables listed. An odds ratio less than 1 indicates that a crash event with that characteristic has a lower likelihood of association with fatal or incapacitating injury, while an odds ratio higher than 1 indicates that a crash event with that characteristic has a higher likelihood of association with fatal or incapacitating injury.

**Table 9. Characteristics Associated with Fatal or Incapacitating Injury**

| Characteristics | Lower 95% Confidence Limit | Odds Ratio | Upper 95% Confidence Limit |
|---|---|---|---|
| Collision type: head-on | 3.15 | 6.50 | 13.42 |
| Vehicle type: motorcycle | 4.12 | 5.08 | 6.25 |
| Contributing factor: driver illness | 2.78 | 3.66 | 4.81 |
| Weather: blowing sand/soil/ dirt or snow | 1.14 | 3.23 | 9.13 |
| Weather: no adverse condition | 1.25 | 3.01 | 7.24 |
| At-fault traffic unit #1 | 1.67 | 2.79 | 4.68 |
| 1st object struck: tree | 2.03 | 2.54 | 3.17 |
| Object location: off road and shoulder | 1.99 | 2.38 | 2.84 |
| 1st object struck: utility pole | 1.69 | 2.10 | 2.60 |
| Airbag deployed | 1.78 | 2.01 | 2.28 |
| 2nd object struck | 1.71 | 1.99 | 2.31 |
| Involved more than 3 vehicles | 1.61 | 1.81 | 2.03 |
| At-fault traffic unit #2 | 1.05 | 1.77 | 2.97 |
| Object location: on median divider | 1.06 | 1.47 | 2.05 |
| Contributing factor: violated traffic control | 1.20 | 1.42 | 1.66 |
| 1st object struck: curbing | 1.22 | 1.31 | 1.40 |
| Other roadway feature: intersection with private roadway | 0.69 | 0.79 | 0.89 |
| 1st object struck: highway sign/post/delineator | 0.42 | 0.64 | 0.96 |
| Construction | 0.43 | 0.61 | 0.87 |
| Light condition: dark-not lighted | 0.35 | 0.59 | 0.99 |
| Contributing factor: following too closely | 0.42 | 0.50 | 0.58 |
| 1st object struck: metal beam guide rail | 0.35 | 0.48 | 0.65 |
| 1st object struck: Jersey barrier | 0.28 | 0.48 | 0.84 |
| 1st object struck: wire rope guide rail | 0.31 | 0.43 | 0.60 |
| Vehicle type: automobile | 0.37 | 0.42 | 0.48 |
| Vehicle type: passenger van | 0.32 | 0.41 | 0.53 |
| No indication drinking | 0.31 | 0.37 | 0.43 |
| Road surface: sand/mud/dirt or oil | 0.15 | 0.36 | 0.87 |
| Road surface: ice | 0.15 | 0.35 | 0.83 |
| Road surface: snow/slush | 0.14 | 0.34 | 0.81 |
| Vehicle type: truck | 0.25 | 0.31 | 0.37 |
| Collision type: backing | 0.13 | 0.31 | 0.71 |
| Collision type: sideswipe-same direction | 0.13 | 0.27 | 0.55 |
| Collision type: moving object | 0.03 | 0.09 | 0.26 |

**Based on multiple logistic regression with backward stepwise selection**

Head on collisions, riding a motorcycle, driver illness, being at fault, and violating traffic control were risk factors for significantly increased risk of fatal or incapacitating injury. Factors associated with a significantly decreased risk of fatal or incapacitating injury included backing up, no indication of drinking, dark conditions, following too closely, construction, and intersection with a private drive. Striking a first object of tree, utility pole, or other object off the road and shoulder or on the median, striking two or more vehicles, or involving more than three vehicles were associated with a significantly higher risk of fatal or incapacitating injury; while striking as a first object a highway sign or post, wire or metal beam guide rail, Jersey barrier, or moving object, or sideswiping a vehicle traveling in the same direction were associated with a significantly lower risk of fatal or incapacitating injury. Weather conditions associated with significantly increased risk of fatal or incapacitating injury were blowing sand, soil, or snow, or, conversely, no adverse weather conditions, while sandy, muddy, oily, icy, snowy, or slushy road surfaces were associated with significantly decreased risk of fatality or incapacitating injury.

## PHASE TWO

### Study Sample

This study was limited to the 34,778 persons in the merged file that resulted from linking the DOT file with the CHIME® database file. Of these, 364 (1%) had unreliable key variables and were excluded from analysis. The mean age of the remaining 34,414 was 32 years with a standard deviation of 15.8 years; 44% were females, 56% males, and 9 cases had gender unrecorded. Since this study focused on medical and financial consequences of crashes, records from all involved persons were included in the analysis, rather than just drivers. Of the 34,414 records, 25,184 (73%) were drivers, 8,446 (25%) were passengers, and 783 (2%) were pedestrians, with 1 position unrecorded.

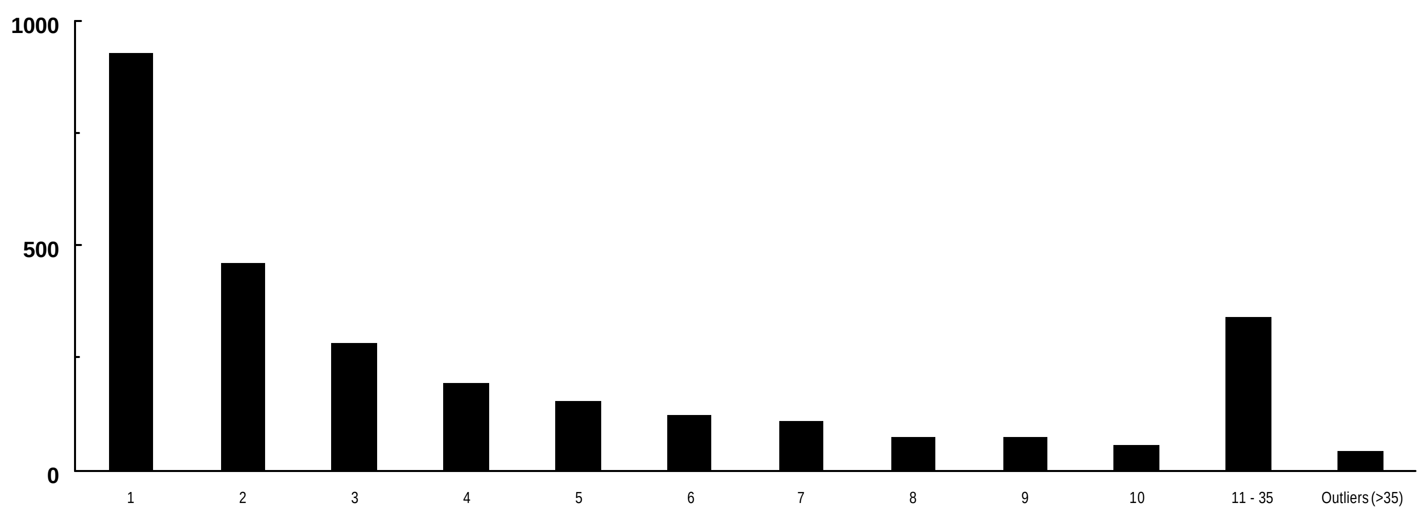
## Results

Of the 34,414 in the study, 31,570 (91.7%) were treated and released from the ED (Table 10). Of the remaining 2,844 admitted as inpatients, 2,800 had length of stay less than or equal to 35 days; median length of stay for this group was 3 days (Figure 8).

**Table 10. Distribution of Length of Stay**

| LOS in Days | Number | Percent |
|---|---|---|
| 0 | 31,570 | 91.74 |
| 1 | 930 | 2.70 |
| 2 | 462 | 1.34 |
| 3 | 281 | 0.82 |
| 4 | 193 | 0.56 |
| 5 | 155 | 0.45 |
| 6 | 122 | 0.35 |
| 7 | 110 | 0.32 |
| 8 | 75 | 0.22 |
| 9 | 73 | 0.21 |
| 10 | 56 | 0.16 |
| 11 - 35 | 343 | 1.00 |
| Outliers (>35) | 44 | 0.13 |

**Figure 8. Distribution of Inpatient Length of Stay (LOS > 0)**



Of these inpatients, 2,152 had been classified at the scene of the crash as injured or possibly injured, consistent with their being admitted to a hospital. The remaining 648 included 49 classified as fatally injured and 599 as not injured (Table 11), for whom hospital admission would not have been predicted. Thus, about 77% of the hospitalizations had been identified as injured by the traffic safety officer at the scene.

**Table 11. Mean LOS by DOT Injury Classification (for Inpatients)**

| DOT Injury Classification | Mean LOS | Standard Deviation | Number | Percent of Total |
|---|---|---|---|---|
| **K = Fatal Injury** | 3.61 | 5.07 | 49 | 2% |
| **A = Incapacitating Injury** | 6.23 | 7.62 | 1,040 | 37% |
| **B = Non-Incapacitating** | 3.84 | 4.25 | 731 | 26% |
| **C = Possible Injury** | 3.14 | 3.57 | 381 | 14% |
| **N = No Injury** | 4.51 | 5.43 | 599 | 21% |
| **Overall** | **4.79** | **5.56** | **2,800** | **100%** |

Note that the 599 people classified as “No Injury” at the time of crash had a longer mean length of stay than those recorded as “Possible Injury” or “Non-Incapacitating Injury”, indicating a substantial hospitalization burden incurred by individuals with no immediate signs of injury.

Table 12 details by DOT injury classification the number of hospital inpatient and Emergency Department records, as well as Mortality Registry records, which linked to DOT crash records. Again, it can be seen that of 48,901 persons classified by the traffic safety officer as injured or possibly injured, 22,616 (46%) were seen by an Emergency Department, and 25,110 (51%) were admitted to hospital as inpatients. Since there is substantial but not 100% overlap between those seen in the Emergency Department and those admitted as inpatients, the total percentage of those classified as injured or possibly injured who receive some sort of hospital care is higher than either of these percentages.

**Table 12. Number of Linked Hospital, ED, and Mortality Records as Percentage of DOT Records, by DOT Injury Classification**

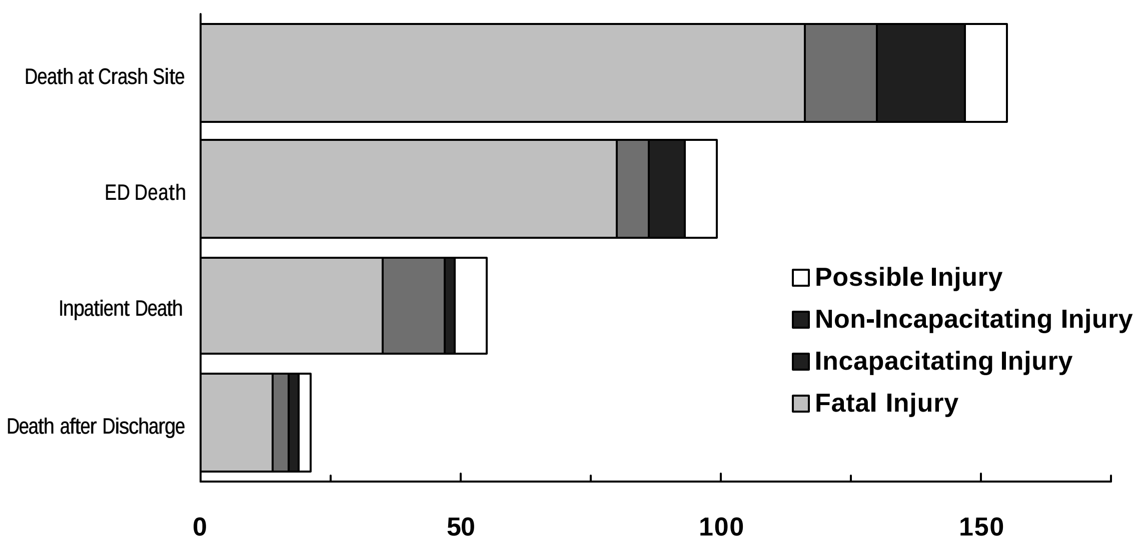
| | Record Source | | | | | | |
|---|---|---|---|---|---|---|---|
| DOT Injury Classification | DOT | CHIME | | ED | | MORTALITY | |
| **K = Fatal Injury** | 322 | 169 | 52% | 106 | 33% | 259 | 80% |
| **A = Incapacitating Injury** | 5,628 | 4,366 | 78% | 3,048 | 54% | 7 | 0% |
| **B = Non-Incapacitating** | 12,598 | 7,604 | 60% | 6,780 | 54% | 3 | 0% |
| **C = Possible Injury** | 30,675 | 13,140 | 43% | 12,788 | 42% | 0 | 0% |
| **N = No Injury** | 141,168 | 5,999 | 4% | 5,815 | 4% | 4 | 0% |

Fatalities listed in the Connecticut Mortality Registry as having a motor vehicle related cause of death were linked to the CHIME® and DOT datasets to identify persons who died outside of the hospital, either at the crash site or subsequent to discharge. There were 329 matches. Table 13 and Figure 9 detail mortality by DOT injury classification at the crash site, and actual place of occurrence of death.

**Table 13. Mortality by DOT Injury Classification and Place of Death**

| | Actual Place of Death | | | | |
|---|---|---|---|---|---|
| **DOT Injury Classification** | **Death at Crash Site** | **ED Death** | **Inpatient Death** | **Death After Discharge** | **Total** |
| **K = Fatal Injury** | 116 | 80 | 35 | 14 | **244** |
| **A = Incapacitating Injury** | 14 | 6 | 12 | 3 | **35** |
| **B = Non-Incapacitating Injury** | 17 | 7 | 2 | 2 | **28** |
| **C = Possible Injury** | 8 | 6 | 6 | 2 | **22** |
| **N = No Injury** | 0 | 0 | 0 | 0 | 0 |
| **Total** | **154** | **99** | **55** | **21** | **329** |

**Figure 9. Mortality by Injury Classification and Admission Status**



The total hospital charge including emergency department and inpatient cases, for the 34,341 patients who had at least $1 in charges, ranged from $3 to $491,062, with median $405, mean $1,779, and standard deviation $8,995 (Table 14).

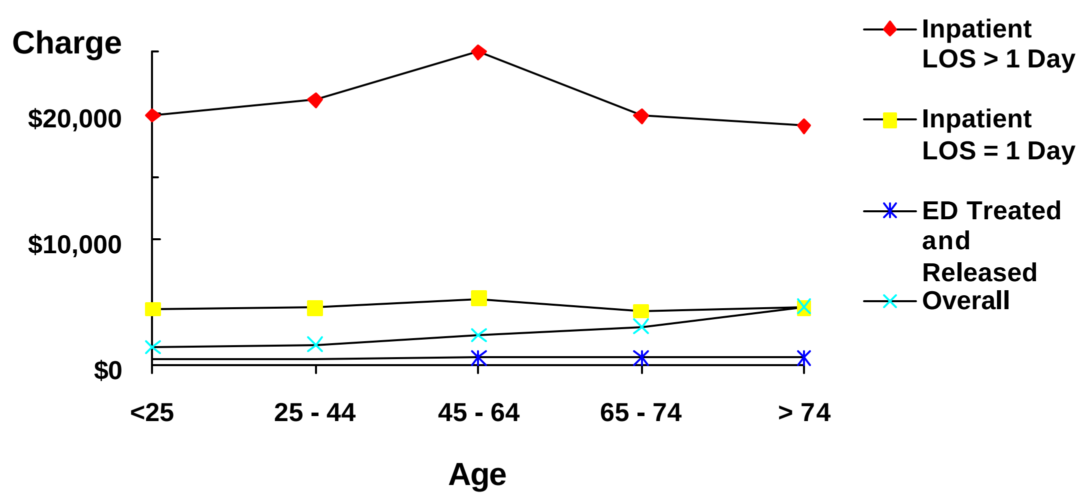
**Table 14. Total Average Charge by DOT Injury Classification**

| DOT Injury Classification | Mean Charge | Standard Deviation | Number |
|---|---|---|---|
| **K = Fatal Injury** | $8,957.77 | $17,529.57 | 149 |
| **A = Incapacitating Injury** | $6,725.59 | $20,254.84 | 3,686 |
| **B = Non-Incapacitating** | $1,752.34 | $4,923.75 | 6,524 |
| **C = Possible Injury** | $748.42 | $2,566.52 | 11,634 |
| **N = No Injury** | $1,201.69 | $8,401.92 | 12,348 |
| **Overall** | **$1,779.30** | **$8,994.60** | **34,341** |

At least one dollar charge.

The mean total charge for those who had an ED visit and were treated and released was $529; for those who stayed one day as inpatient $4,608; and for those who stayed more than one day as inpatient, $21,140 (Figure 10 and Table 15). Overall, mean total charge increased with the patient's age. The highest mean total charge was for those aged 45 to 64 with length of stay greater than one day (Figure 10 and Table 15).

**Figure 10. Mean Total Hospital Charge by Age Group and Length of Stay**



### Table 15. Mean Total Hospital Charge by Age Group and Length of Stay

| Age | ED Treated and Released | | | Inpatient | | | | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LOS = 1 Day | | | LOS > 1 Day | | | | | |
| | Mean $ | STD $ | Number | Mean $ | STD $ | Number | Mean $ | STD $ | Number | Mean $ | STD $ | Number |
| **< 25** | 496 | 590 | 12.160 | 4.458 | 2.298 | 378 | 19.892 | 25.027 | 566 | 1.448 | 6.579 | 13.104 |
| **25 - 44** | 536 | 609 | 13.649 | 4.574 | 2.146 | 369 | 21.104 | 32.561 | 734 | 1.661 | 8.564 | 14.752 |
| **45 - 64** | 574 | 613 | 4.200 | 5.286 | 3.272 | 120 | 24.923 | 43.953 | 325 | 2.400 | 13.196 | 4.645 |
| **65 - 74** | 582 | 618 | 978 | 4.298 | 2.809 | 38 | 19.813 | 36.473 | 145 | 3.105 | 14.353 | 1.161 |
| **> 74** | 617 | 631 | 509 | 4.575 | 3.965 | 25 | 19.031 | 19.005 | 144 | 4.674 | 11.548 | 678 |
| **Overall** | **529** | **603** | **31,496** | **4,608** | **2,476** | **930** | **21,140** | **32,387** | **1,914** | **1,788** | **9,027** | **34,340** |

**At least 1 dollar charge.**

Mean length of stay and total charge by individual providers varied widely (data not shown); mean length of stay ranged from 2.0 to 6.4 days, and mean total charges ranged from $497 to $6,559.

Of the 34,414 people in the study sample, 97% were discharged home. Figure 11 details the discharges by DOT injury classification.

**Figure 11. Discharge Dispositions by DOT Injury Classification, Excluding Discharged Home**

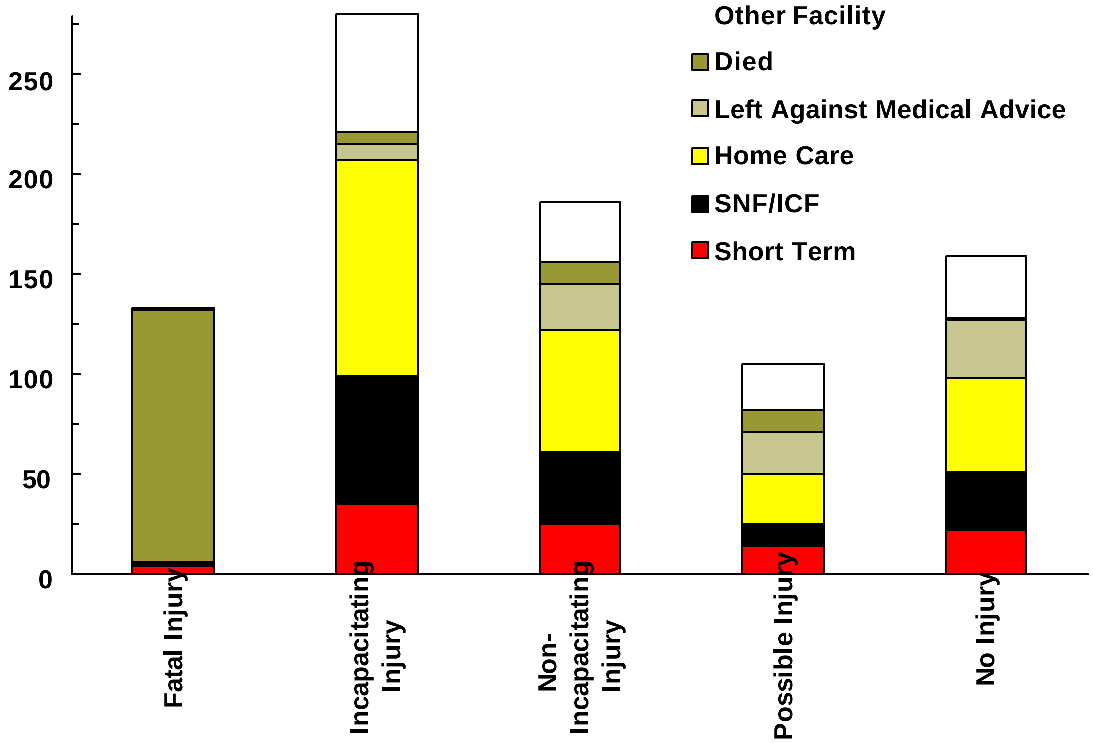



Figure 12 and Table 16 show discharge disposition by length of stay groups. Mortality tends to decrease with increasing length of stay, while discharges to home care become more significant at longer lengths of stay.

**Figure 12. Discharge Dispositions by Length of Stay, Excluding Discharged Home**

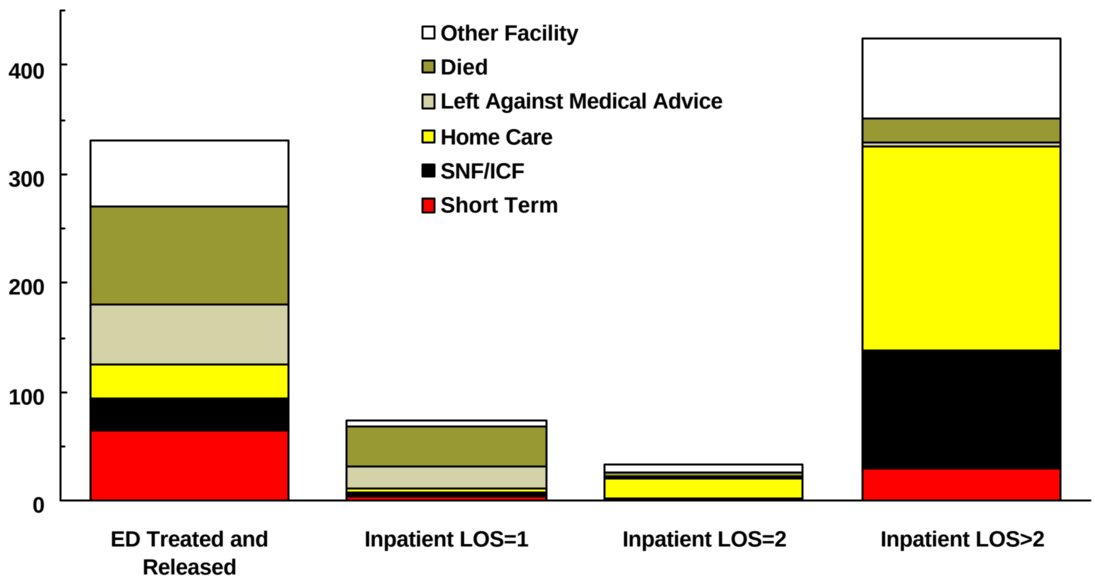
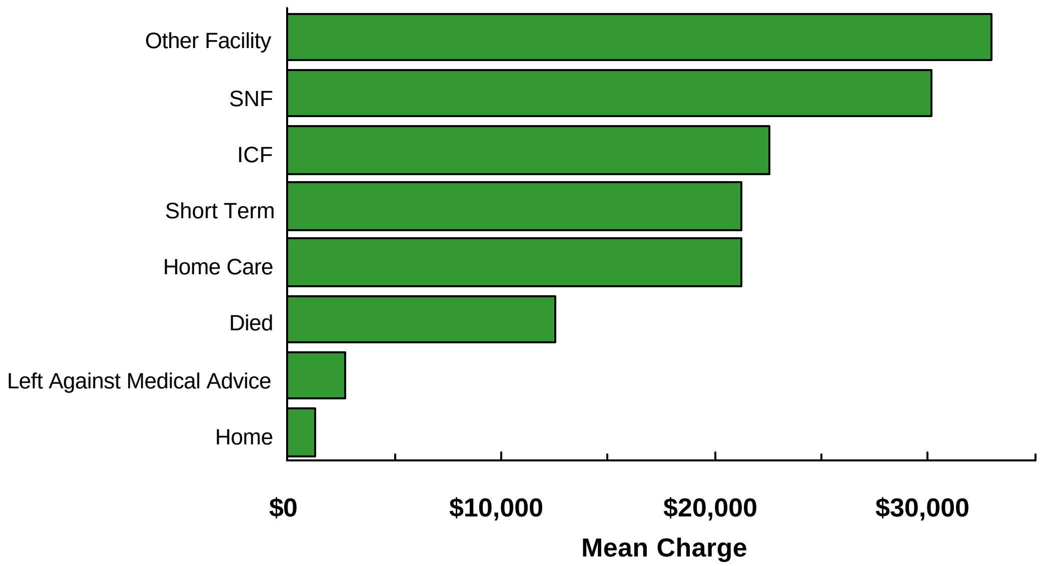



**Table 16. Discharge Dispositions by Length of Stay**

| | ED Treated and Released | Inpatient LOS=1 | Inpatient LOS=2 | Inpatient LOS>2 | Total |
|---|---|---|---|---|---|
| **Home** | 31.238 | 857 | 428 | 1.027 | **33.550** |
| **Other Facilitv** | 61 | 4 | 7 | 73 | **145** |
| **Died** | 90 | 38 | 4 | 23 | **155** |
| **Left Against Medical Advice** | 55 | 19 | 3 | 4 | **81** |
| **Home Care** | 32 | 4 | 18 | 187 | **241** |
| **SNF/ICF** | 29 | 4 | 1 | 108 | **142** |
| **Short Term** | 65 | 4 | 1 | 30 | **100** |
| **Total** | **31,570** | **930** | **462** | **1,452** | **34,414** |

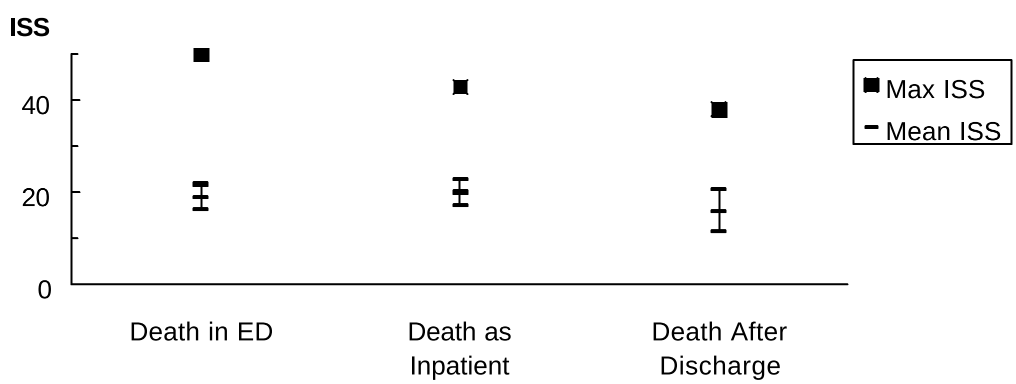
Total hospital charge varied widely between discharge dispositions. For those discharged to SNF or ICF, charges were 10 times greater than for those discharged home (Figure 13).

**Figure 13. Total Charge by Discharge Disposition**




For the 34,414 cases in the study sample, the Injury Severity Score (ISS) ranged from 0 (10%) to 50 (0.01%), with a 99th percentile of 17. For those without traumatic injury, the ISS can be low or zero. Figure 14 shows the maximum, mean and 95% confidence limits of the ISS for fatalities associated with hospital records (ISS were not calculated for those who died at the crash site). The highest ISS observed was 50, for a case of a death on arrival to hospital. The mean ISS for death in ED, death as inpatient, and death after discharge were not significantly different.

**Figure 14. ISS of Fatalities, by Admission Status**



# DISCUSSION

This project demonstrated that the individual data sets (CAAI data, CHIME® database, ED data, and CTMDS data) can be successfully linked together, permitting sophisticated analyses that would otherwise be impossible.

Overall, there were 72,639 motor vehicle crashes in the state of Connecticut during 1995, involving more than 135,000 vehicles or pedestrians and more than 183,000 individual people, killing more than 300 people and costing approximately 12,173 years of lost life, causing more than 30,000 hospitalized injuries, and leaving more than 3,500 people with incapacitating injury. On the average, a crash occurs every 7 minutes, involving 2.5 people and 1.9 vehicles or pedestrians, killing almost one person every day. Hospital charges for 1995 motor vehicle crashes in Connecticut, including both emergency department and inpatient episodes, ranged from $3.30 to $491,062 with an average charge of $1,779; however, the total cost to the health care system would need to include rehabilitation charges, and subsequent life-long care. About 92% of the individuals had an ED visit and were treated and released on the same day; however, some of them will continue to visit a doctor as a result of the crash. The linkage performed in this study allows following the progress of their care to determine more completely the average length and cost of treatment per crash for those individuals, as well as identifying more accurately the extent of the long term morbidity and mortality.

The capability of linking different databases makes possible numerous important and interesting investigations. The medical database generates useful information on the type and severity of injury to organ systems that have been damaged, as well as the length of stay in the Emergency Department, the Intensive Care Units, and the hospital. It can also be used to determine what, if any, chronic diagnoses the patient had at the time of hospitalization; since certain conditions, *e.g.* cardiovascular disease and diabetes, can be identified as predating the crash, the linked data allow for study of how patients with differing baseline medical status fare with respect to specific types of crash injuries. The value and utility of the medical database are greatly enhanced by the ability to identify and correlate specific environmental elements, such as road conditions and time of day or night, physical conditions such as type of car and type of object struck, personal conditions such as the use of seat belts or air bags, and specific injuries to the people involved. It is now possible to examine the impact of environmental and physical variables and determine the differences in cost and outcome.

Linked data can make possible substantial progress in the design and safety improvement of motor vehicles. The relative risks and consequences of the placement and design of seat belts, air bags, dashboards, and intrusions into the passenger space can be quantified by coupling the data to the crash outcomes in terms of personal injury, loss of independence, and cost. A carefully performed study, controlling for environmental and physical factors, utilizing linked data to compare outcomes of different types and severities of crash with reference to mortality, length of stay, ICU stay, rehabilitation, and cost, could be extremely helpful in generating specific prevention and public policy recommendations. For instance, the type and usage of frontal air bags, side air bags, and rear seat restraints, and how these factors affect type of injury, outcome, cost, and rehabilitation, could be very helpful to both legislative bodies and vehicular design and manufacturing interests.

These larger data base linkage initiatives allow for evaluating data from the public health, hospital, and posthospital domains, in order to identify problems and potential solutions in the prehospital, traffic, and public safety areas. It is essential to be sure that the basic tenets upon which this linkage work is based are accurate. Because of the size of the cohorts involved in this large population based study, important inferences can be made which may well be the basis for generating public policy, laws and regulations, and financial reimbursement strategies which will be used in prevention and medical intervention issues. The design of the analysis protects the confidentiality of the individuals, evaluating groups or cohorts of patients and not attempting to render judgments on individuals.

Databases of prehospital information typically contain data entered by public safety officials not sophisticated in medical diagnosis, *e.g.* traffic control officers; linking the information with a medical data base is very useful for maintaining data quality, as it allows this prehospital highway safety data to be directly compared to highly sophisticated medical outcomes data. The prehospital database requires that the traffic safety officer at the scene of the incident make a series of observations, which result in classifying the victims into one of five categories:

- Fatal injury
- Incapacitating injury
- Non-incapacitating injury
- Possible injury
- No injury.

There may be subtle injuries not obvious to the traffic safety officer at the scene, *e.g.* a transected aorta, as well as hidden underlying pre-existing conditions that become aggravated and result in hospitalization or death, *e.g.* previous myocardial infarctions. It is possible and desirable to test the validity of the prehospital reports by using the linked data to determine the accuracy of these determinations. For example, there should be relatively few persons classified as fatalities at the crash site who visit a hospital and are discharged home. Similarly, there should be few patients classified as “No injury” who are admitted to the Intensive Care Unit and ultimately die. Following generally accepted principles of quality improvement, it would be useful to analyze the statistical distribution of these misclassifications and establish what rates are acceptable. If a given group of officers has significantly higher error rates, a targeted educational program could be established for that group and the accuracy of their classification followed over time to determine the efficacy of the intervention.

The linked dataset makes additional analyses possible. Currently, a project is underway to construct a geographical interface to this data, providing for analysis of specific locations with high frequency or severity of motor vehicle crashes, either because of roadway design, traffic flow, or factors related to post-crash issues. Identification of such areas would enable intervention in terms of roadway design or modification, traffic control or enforcement, or changes in delivery of emergency services.

Acquisition and linkage of additional medical data, such as pharmacy utilization and rehabilitation and long-term care, will extend even further our ability to correlate the baseline medical status of the persons involved and the probability and outcomes of motor vehicle crashes, both in general and with reference to specific criteria. In addition to the medical/surgical utilization analyzed here, pharmacy utilization is the other large piece of the acute medical costs; linkage of this data will greatly enhance the accuracy of this type of study. In the long term, rehabilitative and long-term care costs could eventually grow to dominate the total costs resulting from a crash; acquisition and linkage of this data would enable analysis of the total impact of motor vehicle crashes, both in aggregate, and broken down by various classifications.

## SUMMARY

This data linkage project has demonstrated that large databases from the highway safety domain and the medical domain can be linked successfully. It has shown that mortality, morbidity, cost, and outcome data can be integrated with environmental and physical crash data to yield important information. This information can be helpful in shaping public policy relative to injury prevention.

An essential next step is to test the validity of the triage criteria and the accuracy of the data generated. These elements are critical to validating information that will be used to generate public policy and safety recommendations.

Further analysis of the linked database in terms of geographic data, and acquisition of additional data types such as pharmacy and long-term care data, can enhance the utility of this linked dataset even more.

# RECOMMENDATIONS

- Evaluate and improve the coding accuracy of traffic safety officers in classifying injuries at the scene of the crash.
- Acquire pharmaceutical utilization data and link it with the merged traffic safety and medical/surgical procedure and outcomes data.
- Analyze the linked database in terms of geographical variables to identify problematic areas.

# APPENDIX A

## CRASHES AND INJURIES, BY TOWN OR CITY

**Table 17. Crashes and Injuries, By Town or City**

| Town or City | Total Crashes | Crashes as Percent of State Total | Injuries | Injuries as Percent of Crashes |
|---|---|---|---|---|
| Andover | 42 | 0.06% | 14 | 33% |
| Ansonia | 175 | 0.24% | 99 | 57% |
| Ashford | 77 | 0.11% | 30 | 39% |
| Avon | 305 | 0.42% | 86 | 28% |
| Barkhamsted | 63 | 0.09% | 22 | 35% |
| Beacon Falls | 60 | 0.08% | 21 | 35% |
| Berlin | 475 | 0.65% | 170 | 36% |
| Bethany | 60 | 0.08% | 25 | 42% |
| Bethel | 182 | 0.25% | 101 | 55% |
| Bethlehem | 30 | 0.04% | 16 | 53% |
| Bloomfield | 423 | 0.58% | 181 | 43% |
| Bolton | 118 | 0.16% | 39 | 33% |
| Bozrah | 38 | 0.05% | 11 | 29% |
| Branford | 718 | 0.99% | 274 | 38% |
| Bridgeport | 3,496 | 4.81% | 1,975 | 56% |
| Bridgewater | 39 | 0.05% | 18 | 46% |
| Bristol | 1,263 | 1.74% | 622 | 49% |
| Brookfield | 400 | 0.55% | 190 | 48% |
| Brooklyn | 86 | 0.12% | 39 | 45% |
| Burlington | 86 | 0.12% | 34 | 40% |
| Canaan | 24 | 0.03% | 10 | 42% |
| Canterbury | 37 | 0.05% | 20 | 54% |
| Canton | 229 | 0.32% | 88 | 38% |
| Chaplin | 37 | 0.05% | 17 | 46% |
| Cheshire | 649 | 0.89% | 242 | 37% |
| Chester | 60 | 0.08% | 15 | 25% |
| Clinton | 166 | 0.23% | 64 | 39% |
| Colchester | 249 | 0.34% | 95 | 38% |
| Colebrook | 15 | 0.02% | 5 | 33% |
| Columbia | 82 | 0.11% | 34 | 41% |
| Cornwall | 42 | 0.06% | 12 | 29% |

## Table 17 continued. Crashes And Injuries, By Town Or City

| Town or City | Total Crashes | Crashes as Percent of State Total | Injuries | Injuries as Percent of Crashes |
|---|---|---|---|---|
| Coventry | 138 | 0.19% | 61 | 44% |
| Cromwell | 423 | 0.58% | 131 | 31% |
| Danbury | 1,616 | 2.22% | 707 | 44% |
| Darien | 726 | 1.00% | 240 | 33% |
| Deep River | 57 | 0.08% | 17 | 30% |
| Derby | 421 | 0.58% | 146 | 35% |
| Durham | 113 | 0.16% | 39 | 35% |
| East Granby | 86 | 0.12% | 36 | 42% |
| East Haddam | 92 | 0.13% | 33 | 36% |
| East Hampton | 187 | 0.26% | 64 | 34% |
| East Hartford | 1,229 | 1.69% | 516 | 42% |
| East Haven | 530 | 0.73% | 271 | 51% |
| East Lyme | 355 | 0.49% | 98 | 28% |
| East Windsor | 231 | 0.32% | 99 | 43% |
| Eastford | 32 | 0.04% | 13 | 41% |
| Easton | 107 | 0.15% | 40 | 37% |
| Ellington | 154 | 0.21% | 54 | 35% |
| Enfield | 760 | 1.05% | 286 | 38% |
| Essex | 99 | 0.14% | 25 | 25% |
| Fairfield | 896 | 1.23% | 423 | 47% |
| Farmington | 680 | 0.94% | 210 | 31% |
| Franklin | 56 | 0.08% | 21 | 38% |
| Glastonbury | 374 | 0.51% | 173 | 46% |
| Goshen | 35 | 0.05% | 12 | 34% |
| Granby | 104 | 0.14% | 37 | 36% |
| Greenwich | 1,308 | 1.80% | 513 | 39% |
| Griswold | 199 | 0.27% | 71 | 36% |
| Groton | 872 | 1.20% | 296 | 34% |
| Guilford | 449 | 0.62% | 122 | 27% |
| Haddam | 126 | 0.17% | 43 | 34% |
| Hamden | 1,368 | 1.88% | 618 | 45% |
| Hampton | 16 | 0.02% | 10 | 63% |
| Hartford | 3,635 | 5.00% | 2,304 | 63% |
| Hartland | 11 | 0.02% | 4 | 36% |
| Harwinton | 94 | 0.13% | 33 | 35% |
| Hebron | 92 | 0.13% | 36 | 39% |
| Kent | 45 | 0.06% | 19 | 42% |

**Table 17 continued. Crashes And Injuries, By Town Or City**

| Town or City | Total Crashes | Crashes as Percent of State Total | Injuries | Injuries as Percent of Crashes |
|---|---|---|---|---|
| Killingly | 355 | 0.49% | 129 | 36% |
| Killingworth | 55 | 0.08% | 19 | 35% |
| Lebanon | 67 | 0.09% | 40 | 60% |
| Ledyard | 242 | 0.33% | 99 | 41% |
| Lisbon | 91 | 0.13% | 32 | 35% |
| Litchfield | 176 | 0.24% | 74 | 42% |
| Lyme | 10 | 0.01% | 4 | 40% |
| Madison | 291 | 0.40% | 69 | 24% |
| Manchester | 1,037 | 1.43% | 554 | 53% |
| Mansfield (Storrs) | 435 | 0.60% | 153 | 35% |
| Marlborough | 115 | 0.16% | 37 | 32% |
| Meriden | 906 | 1.25% | 470 | 52% |
| Middlebury | 262 | 0.36% | 91 | 35% |
| Middlefield | 117 | 0.16% | 37 | 32% |
| Middletown | 571 | 0.79% | 326 | 57% |
| Milford | 1,386 | 1.91% | 645 | 47% |
| Monroe | 364 | 0.50% | 157 | 43% |
| Montville | 406 | 0.56% | 150 | 37% |
| Morris | 35 | 0.05% | 11 | 31% |
| Naugatuck | 324 | 0.45% | 157 | 48% |
| New Britain | 1,018 | 1.40% | 571 | 56% |
| New Canaan | 294 | 0.40% | 119 | 40% |
| New Fairfield | 129 | 0.18% | 55 | 43% |
| New Hartford | 83 | 0.11% | 28 | 34% |
| New Haven | 3,686 | 5.07% | 2,205 | 60% |
| New London | 605 | 0.83% | 296 | 49% |
| New Milford | 486 | 0.67% | 221 | 45% |
| Newington | 676 | 0.93% | 304 | 45% |
| Newtown | 397 | 0.55% | 130 | 33% |
| Norfolk | 35 | 0.05% | 14 | 40% |
| North Branford | 292 | 0.40% | 91 | 31% |
| North Canaan | 54 | 0.07% | 20 | 37% |
| North Haven | 940 | 1.29% | 377 | 40% |
| North Stonington | 222 | 0.31% | 70 | 32% |
| Norwalk | 2,127 | 2.93% | 955 | 45% |
| Norwich | 1,166 | 1.60% | 438 | 38% |
| Old Lyme | 166 | 0.23% | 38 | 23% |

## Table 17 continued. Crashes And Injuries, By Town Or City

| Town or City | Total Crashes | Crashes as Percent of State Total | Injuries | Injuries as Percent of Crashes |
|---|---|---|---|---|
| Old Saybrook | 270 | 0.37% | 76 | 28% |
| Orange | 797 | 1.10% | 294 | 37% |
| Oxford | 120 | 0.17% | 65 | 54% |
| Plainfield | 280 | 0.39% | 106 | 38% |
| Plainville | 511 | 0.70% | 181 | 35% |
| Plymouth | 232 | 0.32% | 90 | 39% |
| Pomfret | 71 | 0.10% | 33 | 46% |
| Portland | 182 | 0.25% | 70 | 38% |
| Preston | 184 | 0.25% | 70 | 38% |
| Prospect | 96 | 0.13% | 33 | 34% |
| Putnam | 115 | 0.16% | 50 | 43% |
| Redding | 123 | 0.17% | 44 | 36% |
| Ridgefield | 447 | 0.62% | 140 | 31% |
| Rocky Hill | 447 | 0.62% | 168 | 38% |
| Roxbury | 27 | 0.04% | 12 | 44% |
| Salem | 73 | 0.10% | 26 | 36% |
| Salisbury | 65 | 0.09% | 32 | 49% |
| Scotland | 28 | 0.04% | 10 | 36% |
| Seymour | 356 | 0.49% | 149 | 42% |
| Sharon | 45 | 0.06% | 20 | 44% |
| Shelton | 503 | 0.69% | 253 | 50% |
| Sherman | 42 | 0.06% | 20 | 48% |
| Simsbury | 370 | 0.51% | 150 | 41% |
| Somers | 93 | 0.13% | 36 | 39% |
| South Windsor | 292 | 0.40% | 132 | 45% |
| Southbury | 316 | 0.43% | 104 | 33% |
| Southington | 813 | 1.12% | 424 | 52% |
| Sprague | 30 | 0.04% | 12 | 40% |
| Stafford | 178 | 0.24% | 83 | 47% |
| Stamford | 2,327 | 3.20% | 1,254 | 54% |
| Sterling | 23 | 0.03% | 16 | 70% |
| Stonington | 501 | 0.69% | 158 | 32% |
| Stratford | 1,227 | 1.69% | 489 | 40% |
| Suffield | 177 | 0.24% | 80 | 45% |
| Thomaston | 134 | 0.18% | 58 | 43% |
| Thompson | 93 | 0.13% | 44 | 47% |
| Tolland | 210 | 0.29% | 78 | 37% |

## Table 17 continued. Crashes And Injuries, By Town Or City

| Town or City | Total Crashes | Crashes as Percent of State Total | Injuries | Injuries as Percent of Crashes |
|---|---|---|---|---|
| Torrington | 713 | 0.98% | 274 | 38% |
| Trumbull | 392 | 0.54% | 125 | 32% |
| Union | 62 | 0.09% | 21 | 34% |
| Vernon | 610 | 0.84% | 239 | 39% |
| Voluntown | 42 | 0.06% | 21 | 50% |
| Wallingford | 1,056 | 1.45% | 451 | 43% |
| Warren | 6 | 0.01% | 3 | 50% |
| Washington | 62 | 0.09% | 28 | 45% |
| Waterbury | 2,798 | 3.85% | 1,603 | 57% |
| Waterford | 584 | 0.80% | 197 | 34% |
| Watertown | 477 | 0.66% | 195 | 41% |
| West Hartford | 1,154 | 1.59% | 592 | 51% |
| West Haven | 1,070 | 1.47% | 594 | 56% |
| Westbrook | 145 | 0.20% | 47 | 32% |
| Weston | 74 | 0.10% | 33 | 45% |
| Westport | 1,118 | 1.54% | 385 | 34% |
| Wethersfield | 616 | 0.85% | 271 | 44% |
| Willington | 113 | 0.16% | 37 | 33% |
| Wilton | 481 | 0.66% | 157 | 33% |
| Winchester (Winsted) | 277 | 0.38% | 114 | 41% |
| Windham (Willimantic) | 499 | 0.69% | 203 | 41% |
| Windsor | 682 | 0.94% | 277 | 41% |
| Windsor Locks | 148 | 0.20% | 90 | 61% |
| Wolcott | 179 | 0.25% | 89 | 50% |
| Woodbridge | 222 | 0.31% | 104 | 47% |
| Woodbury | 141 | 0.19% | 50 | 35% |
| Woodstock | 85 | 0.12% | 46 | 54% |
| **Statewide** | **72,667** | **100%** | **32,882** | **45%** |

# APPENDIX B

## BIVARIATE ANALYSIS OF CHARACTERISTICS BY DOT INJURY CLASSIFICATION

**Table 18. Bivariate Analysis of Characteristics with DOT Injury Classification**

(N=132918, Driver only)

| Characteristic | Total | Incapacitating Injury | Non-Incapacitating Injury | Possible Injury | Fatal Injury | No Injury | P value |
|---|---|---|---|---|---|---|---|
| | N | N=3801 | N=8741 | N=20381 | N=206 | N=99789 | |
| | | % | % | % | % | % | |
| Mon. | 18280 | 2.84 | 6.73 | 15.18 | 0.19 | 75.05 | 0.564 |
| Tues. | 18009 | 2.98 | 6.84 | 15.2 | 0.21 | 74.78 | 0.135 |
| Thurs. | 19343 | 2.8 | 6.12 | 15.39 | 0.16 | 75.54 | 0.08 |
| Fri. | 20775 | 2.7 | 6.34 | 15.19 | 0.09 | 75.68 | 0.016 |
| Wed | 18450 | 2.79 | 6.92 | 15.56 | 0.17 | 74.57 | 0.195 |
| Weekend | 38061 | 2.97 | 6.57 | 15.41 | 0.14 | 74.91 | 0.45 |
| No indication drinking | 130853 | 2.77 | 6.34 | 15.37 | 0.09 | 75.43 | <0.001 |
| At-fault driver | 70332 | 2.96 | 7.66 | 14.95 | 0.23 | 74.21 | <0.001 |
| Female | 49672 | 3.13 | 6.53 | 20.33 | 0.1 | 69.89 | <0.001 |
| Age > 64 years | 11212 | 3.24 | 6.46 | 14.81 | 0.19 | 75.3 | <0.001 |
| Age missing | 5946 | 0.96 | 2.42 | 5.77 | 0.02 | 98.8 | <0.001 |
| At-fault traffic unit #1 | 77924 | 3.7 | 8.07 | 15.92 | 0.23 | 72.08 | <0.001 |
| At-fault traffic unit #2 | 48310 | 1.74 | 4.63 | 14.22 | 0.05 | 79.36 | <0.001 |
| At-fault traffic unit #3 | 5268 | 1.16 | 3.4 | 16.12 | 0.02 | 79.31 | <0.001 |
| Collision type: pedestrian | 1385 | 0.07 | 0.94 | 0.65 | 0 | 98.34 | <0.001 |
| Involved more than 3 vehicles | 16026 | 2.98 | 5.35 | 18.34 | 0.11 | 73.22 | <0.001 |
| Involved more than 1 pedestrians | 1513 | 0.13 | 1.39 | 1.39 | 0 | 97.09 | <0.001 |
| Collision type: angle | 8842 | 6.19 | 10.4 | 22.03 | 0.1 | 61.28 | <0.001 |
| Collision type: backing | 2195 | 0.91 | 2.23 | 10.52 | 0 | 86.33 | <0.001 |
| Collision type: jackknife | 113 | 2.65 | 9.73 | 7.96 | 0 | 79.65 | 0.183 |
| Collision type: head-on | 1329 | 18.13 | 21.07 | 22.12 | 2.18 | 36.49 | <0.001 |
| Collision type: overturn | 791 | 9.23 | 27.69 | 19.72 | 6.32 | 37.04 | <0.001 |
| Collision type: parking | 827 | 1.45 | 2.42 | 9.31 | 0 | 86.82 | <0.001 |
| Collision type: rear-end | 49600 | 1.44 | 3.47 | 17.21 | 0.04 | 77.83 | <0.001 |

**Table 18 continued. Bivariate Analysis Of Characteristics With DOT Injury Classification**

| Characteristic | Total | Incapacitating Injury | Non-Incapacitating Injury | Possible Injury | Fatal Injury | No Injury | P value |
|---|---|---|---|---|---|---|---|
| | N | N=3801 | N=8741 | N=20381 | N=206 | N=99789 | |
| | | % | % | % | % | % | |
| Collision type: sideswipe-same direction | 13376 | 0.76 | 2.51 | 7.41 | 0.04 | 89.27 | <0.001 |
| Collision type: turning-same direction | 5551 | 2.05 | 4.34 | 11.51 | 0.11 | 81.99 | <0.001 |
| Median barrier: no median barrier | 122315 | 3 | 6.63 | 15.53 | 0.16 | 74.68 | <0.001 |
| Median barrier: no penetration | 9487 | 1.3 | 5.42 | 12.94 | 0.01 | 80.33 | <0.001 |
| Collision type: fixed object | 15443 | 4.66 | 15.68 | 15.19 | 0.4 | 64.07 | <0.001 |
| Construction | 2584 | 1.24 | 3.95 | 11.34 | 0.04 | 83.44 | <0.001 |
| Contributing factor: driving/entered on wrong side of road | 1921 | 10.57 | 15.36 | 19.21 | 0.16 | 54.71 | <0.001 |
| Contributing factor: driver illness | 449 | 16.26 | 21.16 | 29.62 | 1.11 | 31.85 | <0.001 |
| Contributing factor: speed too fast | 12242 | 3.15 | 10 | 16.79 | 0.19 | 69.87 | <0.001 |
| Contributing factor: violated traffic | 8775 | 5.64 | 9.14 | 19.37 | 0.08 | 65.77 | <0.001 |
| Contributing factor: failed to grant right | 24746 | 3.84 | 7.39 | 16.47 | 0.04 | 72.26 | <0.001 |
| Contributing factor: following too closely | 41907 | 1.21 | 2.8 | 16.85 | 0.01 | 79.13 | <0.001 |
| Collision type: turning-intersecting paths | 16370 | 3.19 | 6.16 | 15.37 | 0.04 | 75.24 | <0.001 |
| At intersection | 65651 | 3.06 | 6.1 | 16.39 | 0.06 | 74.38 | <0.001 |
| Light condition: dark - lighted | 25956 | 3.66 | 8.47 | 15.91 | 0.23 | 71.73 | <0.001 |
| Light condition: dark-not lighted | 6980 | 2.79 | 10.85 | 14.53 | 0.59 | 71.25 | <0.001 |
| Light condition: dawn | 1045 | 2.58 | 9.95 | 15.22 | 0.77 | 71.48 | <0.001 |
| Light condition: daylight | 95335 | 2.64 | 5.73 | 15.21 | 0.09 | 76.32 | <0.001 |
| Light condition: dusk | 2919 | 2.81 | 5.93 | 15.93 | 0.27 | 75.06 | 0.252 |
| Collision type: moving object | 2290 | 0.44 | 2.71 | 3.01 | 0 | 93.84 | <0.001 |
| Non collision | 117 | 1.71 | 9.4 | 3.42 | 0 | 85.47 | 0.005 |
| Object location: on shoulder | 1010 | 3.37 | 13.47 | 14.85 | 0.1 | 68.22 | <0.001 |
| Object location: off road and shoulder | 12555 | 6.73 | 18.7 | 18.12 | 0.8 | 55.64 | <0.001 |
| Object location: in roadway | 2737 | 1.35 | 4.42 | 4.86 | 0.04 | 89.33 | <0.001 |
| Object location: on median divider | 2856 | 1.47 | 9.35 | 15.97 | 0.67 | 72.55 | <0.001 |
| Collision type: sideswipe-opposite | 2918 | 5.59 | 11.86 | 17.72 | 0.48 | 64.36 | <0.001 |

**Table 18 continued. Bivariate Analysis Of Characteristics With DOT Injury Classification**

| Characteristic | Total | Incapacitating Injury | Non-Incapacitating Injury | Possible Injury | Fatal Injury | No Injury | P value |
|---|---|---|---|---|---|---|---|
| | N | N=3801 | N=8741 | N=20381 | N=206 | N=99789 | |
| | | % | % | % | % | % | |
| direction | | | | | | | |
| Collision type: turning-opposite direction | 11566 | 4.72 | 9.27 | 17.49 | 0.04 | 68.48 | <0.001 |
| Other roadway feature: intersection with public roadway | 55771 | 3.27 | 6.38 | 16.99 | 0.06 | 73.3 | <0.001 |
| Other roadway feature: intersection with private roadway | 30911 | 2.36 | 5.36 | 14.77 | 0.04 | 77.46 | <0.001 |
| 1st object struck: animal other than deer | 1159 | 5.44 | 20.88 | 22.43 | 1.21 | 50.04 | <0.001 |
| 1st object struck: curbing | 1700 | 11.53 | 19.76 | 19.41 | 1 | 48.29 | <0.001 |
| 1st object struck: deer | 942 | 0.85 | 4.35 | 3.18 | 0 | 91.61 | <0.001 |
| 1st object struck: highway sign post, delineator | 684 | 3.95 | 14.62 | 11.55 | 0.58 | 69.3 | <0.001 |
| 1st object struck: Jersey barrier | 1391 | 1.01 | 11.29 | 19.77 | 0.14 | 67.79 | <0.001 |
| 1st object struck: metal beam guide rail | 2991 | 1.27 | 7.36 | 13.54 | 0.7 | 77.13 | <0.001 |
| 1st object struck: tree | 1443 | 9.98 | 28.27 | 22.18 | 1.52 | 38.05 | <0.001 |
| 1st object struck: utility pole | 1658 | 10.86 | 30.7 | 22.62 | 0.78 | 35.04 | <0.001 |
| 1st object struck: wire rope guide rail | 2144 | 1.77 | 8.54 | 9.84 | 0.37 | 79.48 | <0.001 |
| 2nd object struck | 4588 | 8.91 | 23.19 | 19.66 | 1.44 | 46.8 | <0.001 |
| Road surface: other | 199 | 6.03 | 9.55 | 21.61 | 0.5 | 62.31 | <0.001 |
| Road surface: sand, mud, dirt or oil | 1129 | 3.72 | 11.25 | 20.19 | 0.18 | 64.66 | <0.001 |
| Road surface: snow/slush | 6361 | 1.75 | 4.76 | 13.93 | 0.09 | 79.47 | <0.001 |
| Road surface: dry | 93540 | 2.98 | 6.72 | 15.04 | 0.16 | 75.1 | <0.001 |
| Road surface: ice | 2921 | 2.23 | 7.57 | 16.47 | 0.21 | 73.54 | 0.013 |
| Road surface: wet | 28134 | 2.7 | 6.23 | 16.25 | 0.14 | 74.67 | <0.001 |
| Weather: sleet, hail | 737 | 1.76 | 6.11 | 14.93 | 0.27 | 76.93 | 0.351 |
| Weather: blowing sand, soil | 454 | 3.08 | 3.3 | 19.82 | 0 | 73.79 | 0.006 |
| Weather: fog | 955 | 2.3 | 11.1 | 14.76 | 0.52 | 71.31 | <0.001 |
| Weather: other | 785 | 2.55 | 8.66 | 17.71 | 0 | 71.08 | 0.023 |

Table 18 continued. Bivariate Analysis Of Characteristics With DOT Injury Classification

| Characteristic | Total | Incapacitating Injury | Non-Incapacitating Injury | Possible Injury | Fatal Injury | No Injury | P value |
|---|---|---|---|---|---|---|---|
| | N | N=3801 | N=8741 | N=20381 | N=206 | N=99789 | |
| | | % | % | % | % | % | |
| Weather: rain | 20349 | 2.41 | 6.06 | 16.57 | 0.09 | 74.87 | <0.001 |
| Weather: snow | 5423 | 1.38 | 4.59 | 12.3 | 0.15 | 81.58 | <0.001 |
| Weather: severe cross winds | 141 | 2.84 | 5.67 | 13.48 | 0 | 78.01 | 0.928 |
| Weather: no adverse condition | 103326 | 3.04 | 6.75 | 15.21 | 0.17 | 74.83 | <0.001 |
| Vehicle type: automobile | 109031 | 2.76 | 6.4 | 16.33 | 0.13 | 74.39 | <0.001 |
| Vehicle type: motorcycle | 975 | 23.9 | 40.31 | 17.85 | 3.18 | 14.77 | <0.001 |
| Vehicle type: truck | 12092 | 1.72 | 4.81 | 10.25 | 0.15 | 83.07 | <0.001 |
| Vehicle type: passenger van | 4012 | 2.27 | 3.91 | 13.11 | 0.15 | 80.56 | <0.001 |
| Airbag deployed | 3995 | 8.14 | 21.78 | 27.46 | 0.5 | 42.13 | <0.001 |
| MVC within past 1 year | 1214 | 10.54 | 20.51 | 32.37 | 0.33 | 36.24 | <0.001 |
| MVC within past 6 months | 451 | 13.08 | 20.4 | 31.71 | 0.44 | 34.37 | <0.001 |

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