U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

People Saving People
http://www.nhtsa.dot.gov

DOT HS 808 971
NHTSA Report

September 1999

PB2000-100227

Using Linked Data to Evaluate Motor Vehicle Crashes Involving Elderly Drivers in Connecticut

Crash Outcome Data Evaluation System (CODES)

This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 808 971		

4. Title and Subtitle	5. Report Date
Using Linked Data to Evaluate Motor Vehicle Crashes Involving Elderly Drivers in Connecticut	September 1999
	6. Performing Organization Code
7. Author(s) Gerald Zuckier Lenworth Jacobs, Lorna Thibeault	8. Performing Organization Report No.
9. Performing Organization Name and Address The CT Healthcare Research and Education Foundation, Inc. 110 Barnes Road, P.O. Box 90 Wallingford, CT 06492	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTNH-22-96-R-07266
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, DC 20590	13. Type of Report and Period Covered Research Study 14. Sponsoring Agency Code

15. Supplementary Notes

16. 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 impact of motor vehicle crashes on the elderly (65 years of age and over) population. Elderly drivers were involved in 8.4% of the motor vehicle crashes in Connecticut in 1995. Elderly drivers were associated with 5.2% of the linked medical records and 3.2% of the fatalities. Of the elderly drivers with linked hospital visits, 81% were treated in the emergency department and discharged; the rest were admitted to hospital, with median length of stay of 4 days. Geographically, crashes involving elderly drivers showed a bias towards more rural areas and away from the areas showing the highest overall motor vehicle crash rates. Logistic regression showed that, compared to the general population, crashes involving elderly drivers were more frequently correlated with driver illness (as reported by traffic enforcement personnel), a construction zone, violating traffic control, or failing to grant right of way, and less frequently with drinking or aggressive or dangerous driving. Conditions of diminished visibility were not identified as a significant factor, but elderly drivers were significantly more likely to be in a crash involving striking a deer.

17. Key Words	18. Distribution Statement
CODES, linked data, motor vehicle crashes, Connecticut, elderly drivers	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

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 impact of motor vehicle crashes on the elderly (65 years of age and over) population. Elderly drivers were involved in 8.4% of the motor vehicle crashes in Connecticut in 1995. Elderly drivers were associated with 5.2% of the linked medical records and 3.2% of the fatalities. Of the elderly drivers with linked hospital visits, 81% were treated in the emergency department and discharged; the rest were admitted to hospital, with median length of stay of 4 days. Geographically, crashes involving elderly drivers showed a bias towards areas that are more rural and away from the areas showing the highest overall motor vehicle crash rates. Logistic regression showed that, compared to the general population, crashes involving elderly drivers were more frequently correlated with driver illness (as reported by traffic enforcement personnel), a construction zone, violating traffic control, or failing to grant right of way, and less frequently with drinking or aggressive or dangerous driving. Conditions of diminished visibility were not identified as a significant factor, but elderly drivers were significantly more likely to be in a crash involving striking a deer.

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 this type of analysis. 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 study 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 motor vehicle crashes involving the elderly driver. For instance, using the Department of Transportation data set alone, we would be able to identify elderly drivers and the location of those crashes; however, no information would be available to analyze the medical outcomes and mortality stemming from the crash, or the individual and total charges to the hospital system. Linking to the CHIME® and mortality databases allowed these analyses.

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 vehicle or pedestrian 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, towncode date adjustment window of 0 days (date of hospital visit equal to date of crash).
2	Matching variables: birth date, gender, towncode date adjustment window of +7 days (date of hospital visit within 7 days after date of crash).
3	Matching variables: birth date, gender, towncode date adjustment window of +30 days (date of hospital visit within 30 days after date of crash).
4	Matching variables: birth date, gender, towncode 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, towncode date adjustment window of 0 days (date of hospital visit equal to date of crash).
6	Matching variables: birth date, towncode date adjustment window of +7 days (date of hospital visit within 7 days after date of crash).
7	Matching variables: birth date, towncode date adjustment window of +30 days (date of hospital visit within 30 days after date of crash).
8	Matching variables: birth date, towncode 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, towncode date adjustment window of 0 days (date of hospital visit equal to date of crash).
10	Matching variables: birth date, towncode date adjustment window of +7 days (date of hospital visit within 7 days after date of crash).
11	Matching variables: birth date, towncode date adjustment window of +30 days (date of hospital visit within 30 days after date of crash).
12	Matching variables: birth date, towncode 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 the frequency of elderly drivers (defined as a driver 65 years of age or older) in MVCs and injuries. Outcome variables for the second phase of the study included length of stay (LOS), total hospital charge, mortality, and severity of injury.

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 decline to seek hospital treatment.

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 were 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 1 MVC and a hospital visit and admission diagnosis codes within 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[3]. 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[4].

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

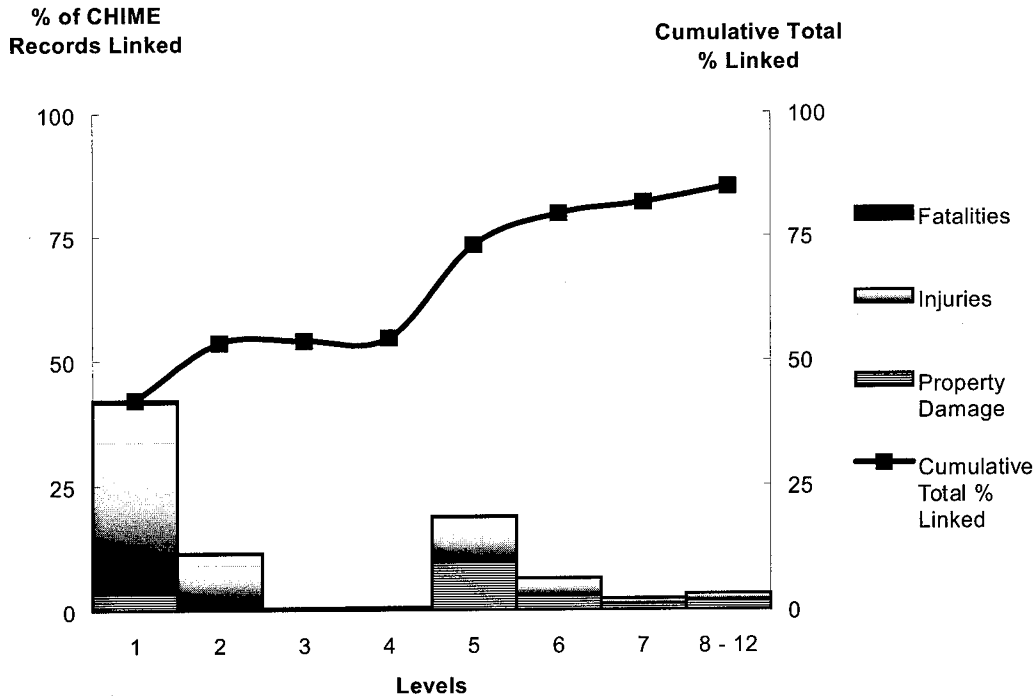
There were 40,883 records selected from the CHIME® data set as having motor vehicle crash related E-codes, as detailed in Table 3. Of these, 35,832 records (87.6%) were linked and merged. After deleting duplicate records (1,054, 2.9%), 34,778 records remained (85.1%). Of these records, 364 (1%) were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



As discussed in the Methods section, one hundred percent complete linkage is not expected when linking DOT, CHIME® database, and mortality registry files. Without a measure of the incidence of out of state crashes, hospitalizations, and deaths, the maximum possible linkage rate cannot be determined for comparison with the observed rate of 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 crashes, 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

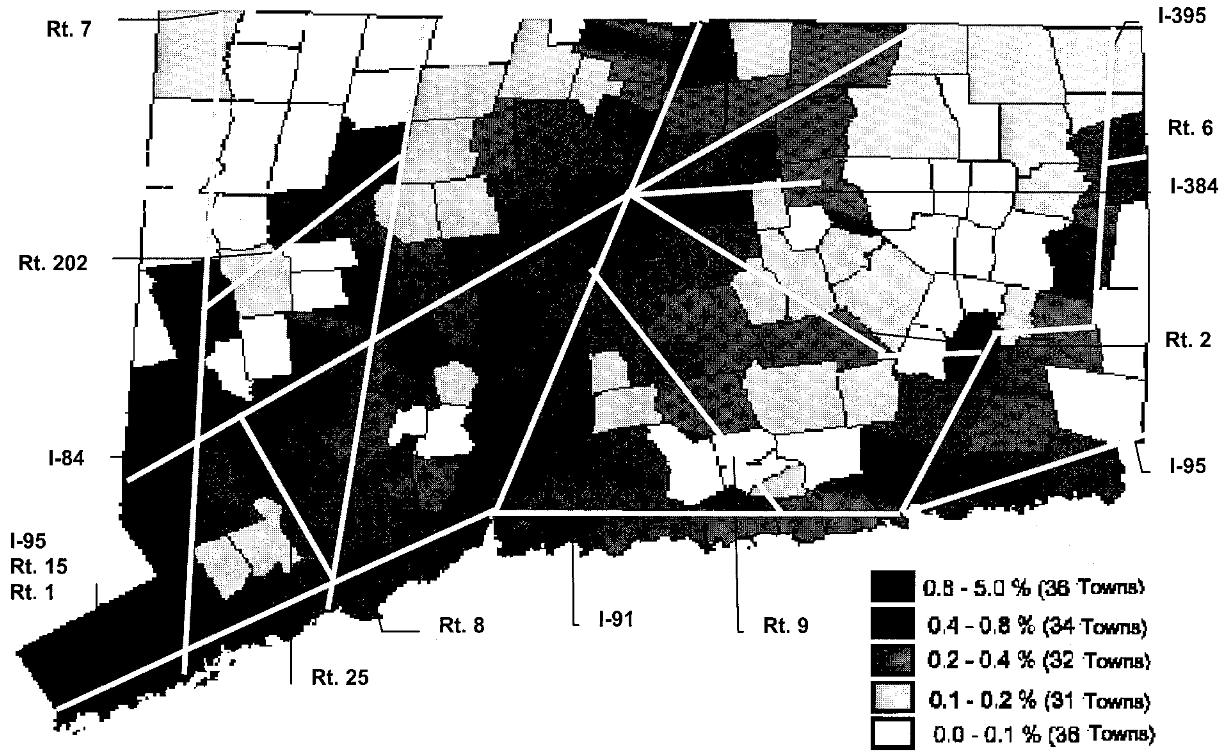
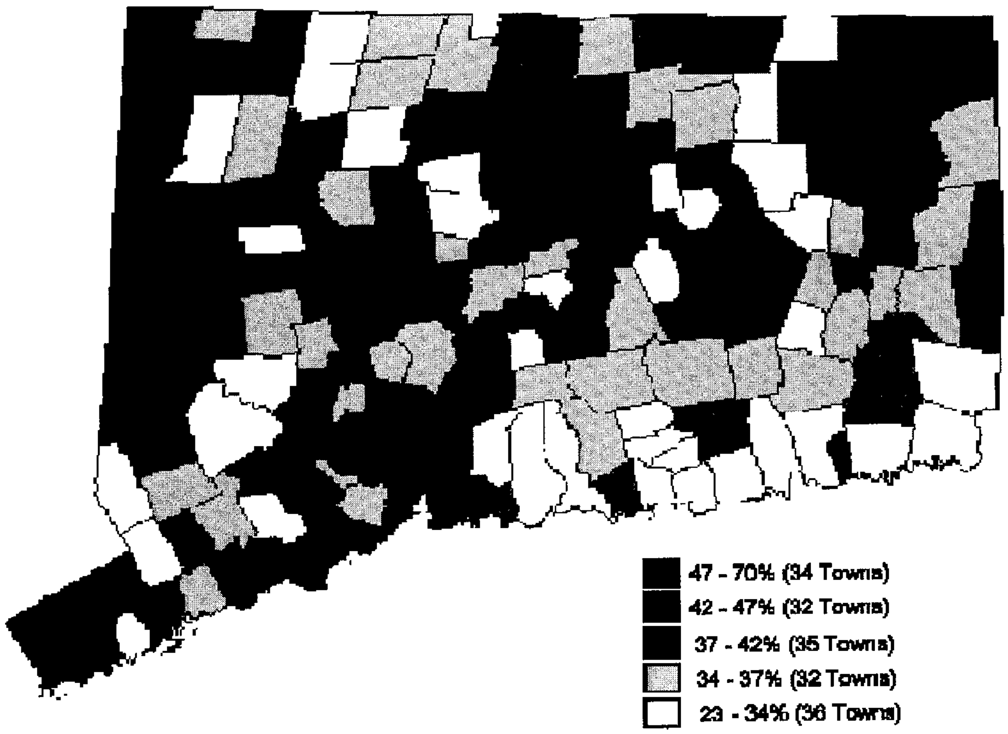


Figure 2 shows a geographical view of the percentage of total crashes by town or city, calculated as the number of crashes in the index town or city divided by total crashes in the state. As can be seen, the highest rates occur in towns and cities surrounding Interstate 91 (I-91), Interstate 95 (I-95) 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%).

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



Rate of injury was determined as number of injuries divided by total crashes in the index 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.

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%).

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

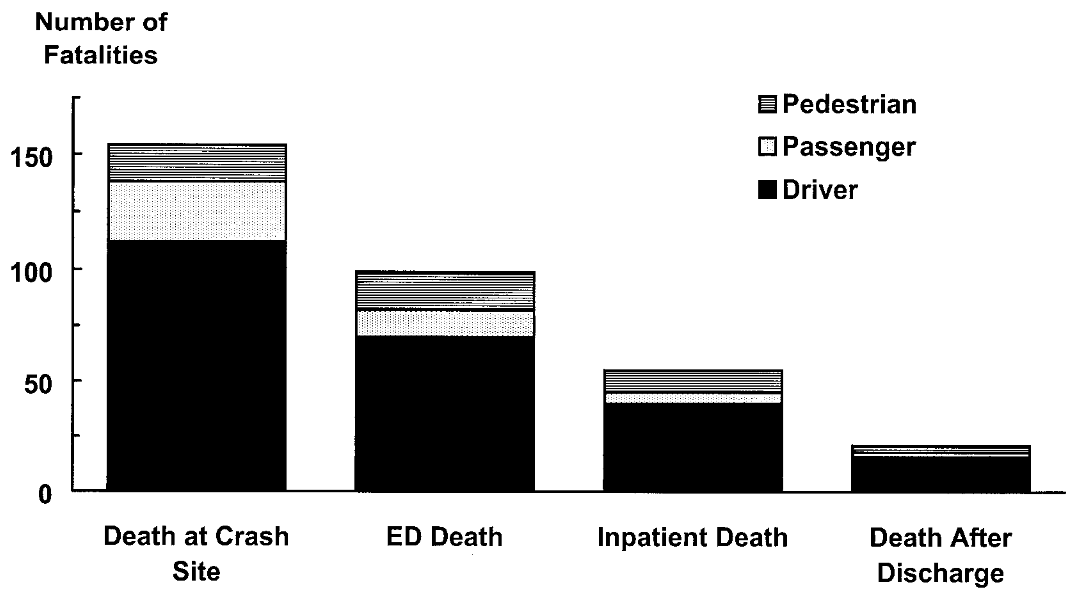


Figure 4 and Table 7 show mortality by position in vehicle (driver, passenger, or pedestrian) and place of death (at the crash site, emergency department [LOS = 0], inpatient [LOS > 0], or after discharge).

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

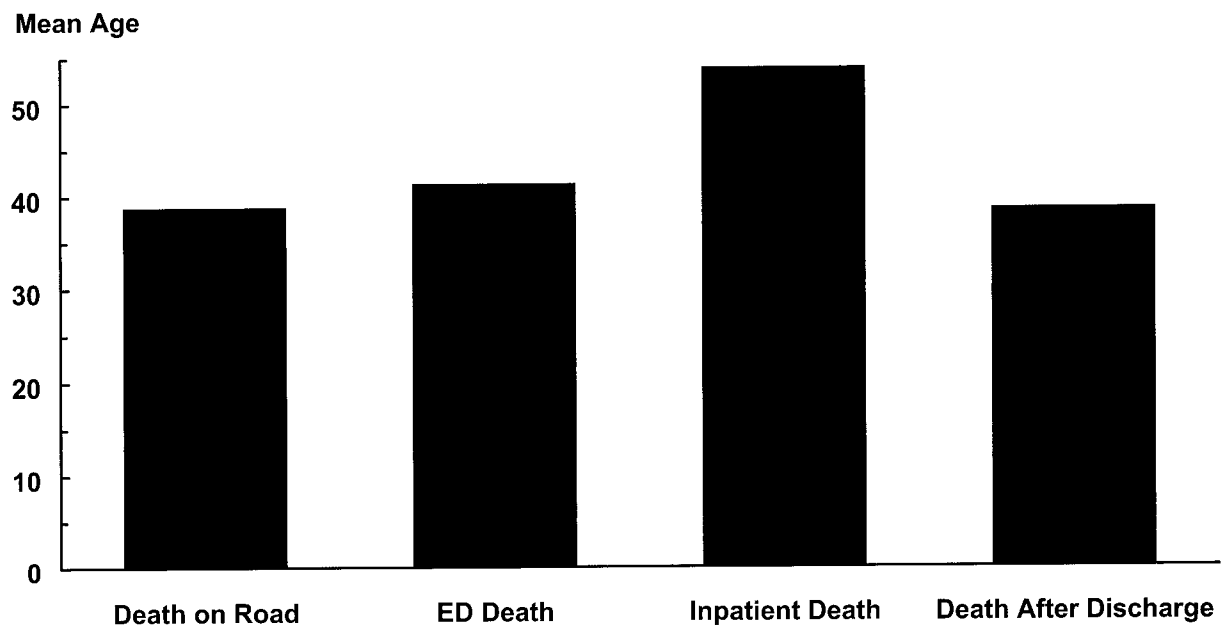


Figure 5 and Table 7 show mean age of fatalities by place of death. Inpatient deaths tended to be older than the other classes of fatalities. There was no significant difference between males and females.

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

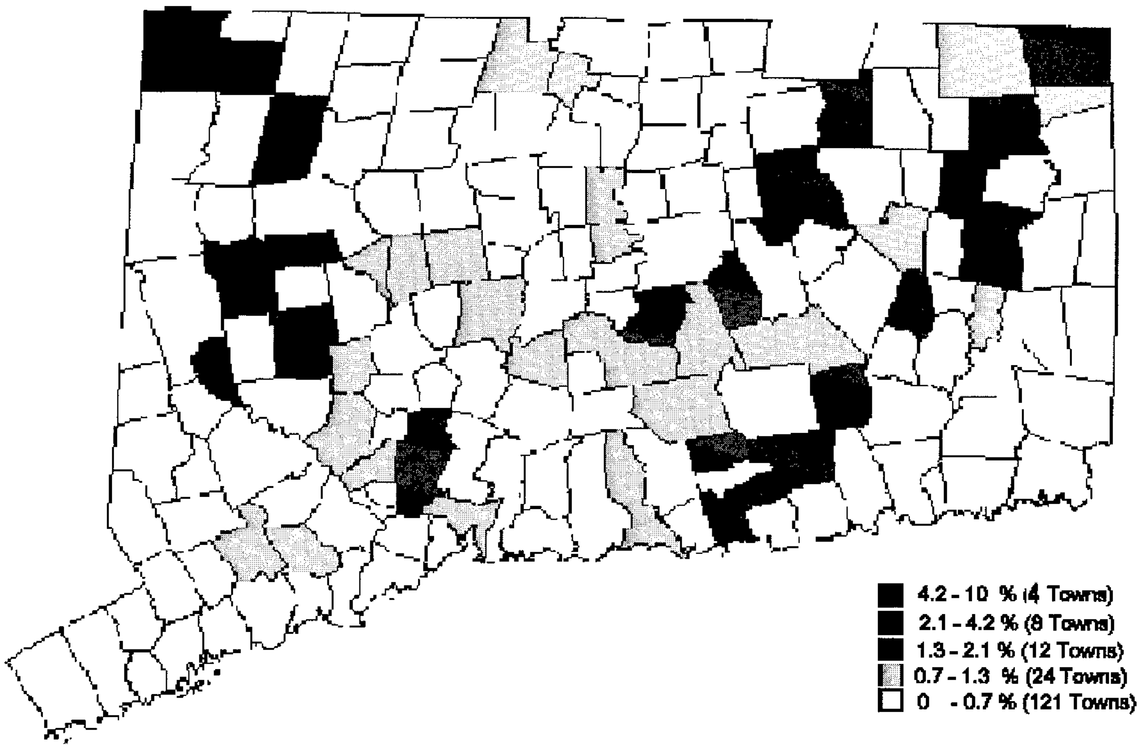


Figure 6 shows fatality rate of crashes by town or city, determined as the number of deaths divided by number of crashes in each town or city. The mortality rate ranged from 0 to 10%, the five highest areas being Lyme (10%, 1 killed in 10 crashes), Hampton (6.25%, 1 killed in 16 crashes), Andover (4.76%,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

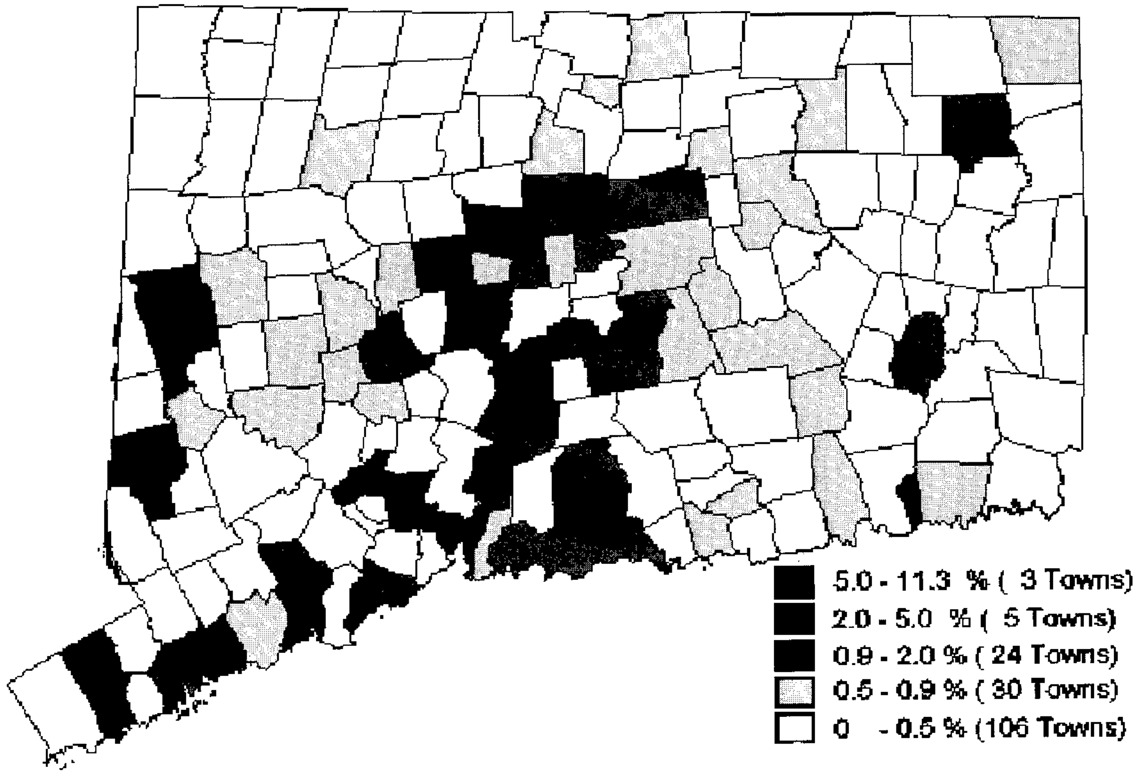


Figure 7 shows mortality by town or city where crash occurred, as a percent of total state mortality. By this measure, Hartford, New Haven, Bridgeport, Waterbury, and Bristol accounted for 29.5% of total state mortality. There were 59 towns or cities where mortality was zero (no one killed by crashes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

Phase One

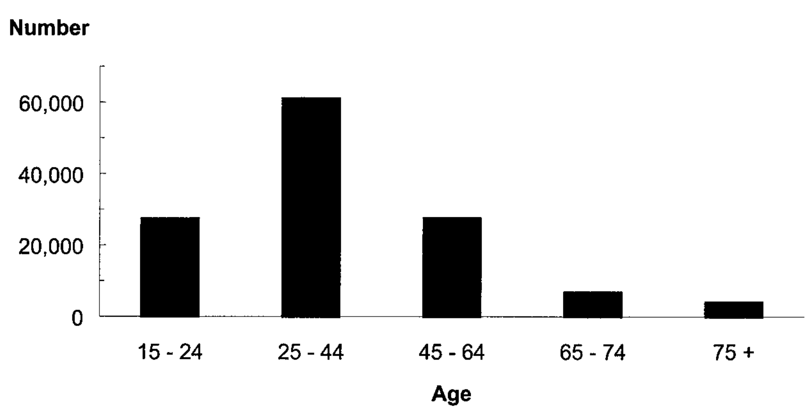
Study Sample

There were a total of 132,918 drivers in the DOT crash database; 6,543 (5%) did not have age recorded, leaving 126,375 for study. Their age distribution is broken down in Table 8 and Figure 8. There were 48,915 (39%) female drivers, and 77,460 (61%) male; overall, there were no significant differences in distribution of driver's age groups between males and females. Elderly drivers were defined as drivers with age greater than 64 years (10,615, 8.4%), for this study.

Table 8. Total Crashes by Driver's Age Group

Age Group	Number	Percent
15 - 24	27,317	21.6%
25 - 44	61,009	48.3%
45 - 64	27,434	21.7%
65 - 74	6,664	5.3%
75 +	3,951	3.1%
Total	**126,375**	**100.0%**

Figure 8. Total Crashes by Driver's Age Group



Results

The bivariate associations between the age groups and the independent variables are detailed in Appendix . Table 9 shows the odds ratios of the independent variables (significant variables only), based on a stepwise logistic model derived from a multiple regression analysis in which each odds ratio was adjusted for all other independent variables listed. Characteristics listed are taken from the DOT motor vehicle crash reports. The odds for finding each characteristic associated with a crash involving elderly drivers (defined as 65 years of age or older) were compared against the odds for drivers 64 years of age or younger. An odds ratio less than 1 indicates that a crash event with that characteristic has a lower likelihood of association with an elderly driver, while an odds ratio higher than 1 indicates that a crash event with that characteristic has a higher likelihood of association with an elderly driver.

Table 9. MVC Characteristics Associated with Elderly Drivers

Characteristic	Lower 95% Confidence Limit	Odds Ratio	Upper 95% Confidence Limit
Vehicle type: automobile	3.893	4.612	5.465
Contributing factor: driver illness	2.542	3.208	4.048
No indication drinking	1.829	2.411	3.178
1st object struck: deer	1.209	1.734	2.488
Vehicle type: truck	1.425	1.723	2.084
Light condition: daylight	1.092	1.593	2.324
Vehicle type: passenger van	1.261	1.591	2.008
At-fault traffic unit #1	1.078	1.377	1.760
Construction	1.118	1.294	1.498
Contributing factor: violated traffic control	1.159	1.288	1.431
Other roadway feature: intersection with public roadway	1.108	1.231	1.368
Other roadway feature: intersection with private roadway	1.097	1.176	1.262
Contributing factor: failed to grant right of way	1.060	1.156	1.259
At intersection	0.838	0.913	0.994
Injury type: possible injury	0.837	0.896	0.959
Female	0.794	0.827	0.862
Contributing factor: speed too fast	0.621	0.687	0.759
Contributing factor: following too closely	0.619	0.678	0.743
Light condition: dawn	0.359	0.594	0.981
Light condition: dark - lighted	0.394	0.578	0.847
MVC within past 1 year	0.303	0.487	0.783
Collision type: moving object	0.249	0.483	0.938
Collision type: overturn	0.224	0.430	0.989
Vehicle type: motorcycle	0.082	0.201	0.494

Based on multiple logistic regression with backward stepwise selection

Aside from vehicle type, the most significant predictor for a crash involving an elderly driver was driver illness (as identified by the investigating officer) as a contributing factor. Other significant predictors of involvement of elderly drivers in crashes were striking a deer, on a road under construction, while violating traffic control, at an intersection with public or private roadway, or while failing to grant right of way. Significant predictors of elderly drivers not being involved in crashes were drinking, high rate of speed, or following too closely, or where the vehicle overturned. This pattern of associated characteristics suggests that motor vehicle crashes in the elderly are more likely to be a result of confusing or changing stimuli than of drinking and/or aggressive driving. Elderly drivers were also significantly more likely to have been involved in a crash during day-time, and significantly less likely to be involved in a crash that occurred at night on a lit roadway, or at dawn. This may be the result of their being more likely to drive during daylight hours than after dark, relative to the rest of the population. Based on linked hospital records, elderly drivers were also significantly less likely to have had a motor vehicle crash within the past year; this implies that repeated involvement in motor vehicle crashes is not a problem in the elderly driver population.

Figure 9 and Figure 10 show the crash and injury rate of elderly drivers by town or city. The crash rate ranged from 0 to 28.6% and the injury rate ranged from 0% to 33.3%. It is clear that rural areas were associated with higher crash and injury rate for the elderly drivers. This is consistent with the result shown in Table 9 that the most frequent first object struck for elderly drivers was deer.

Figure 9. Percentage of Crashes Which Involve Elderly Drivers

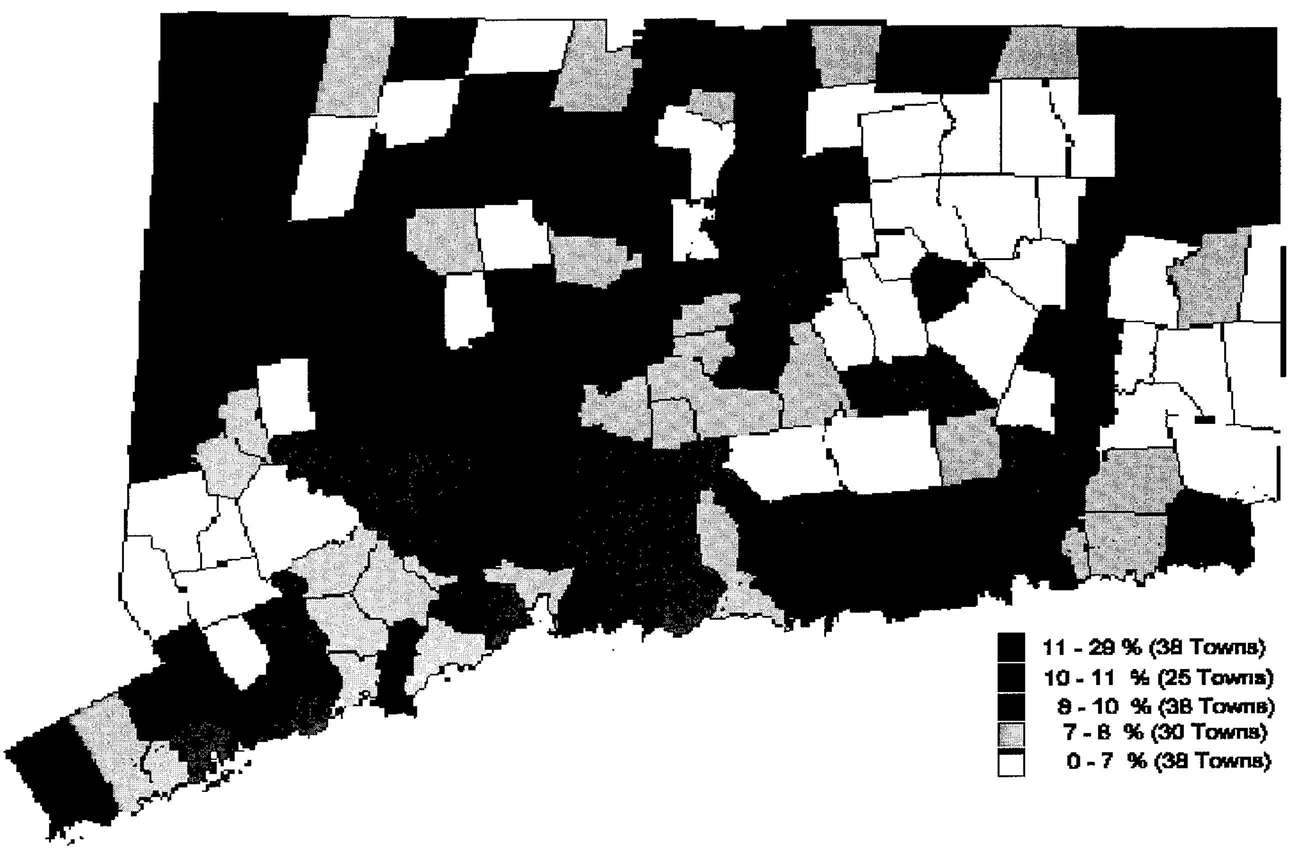
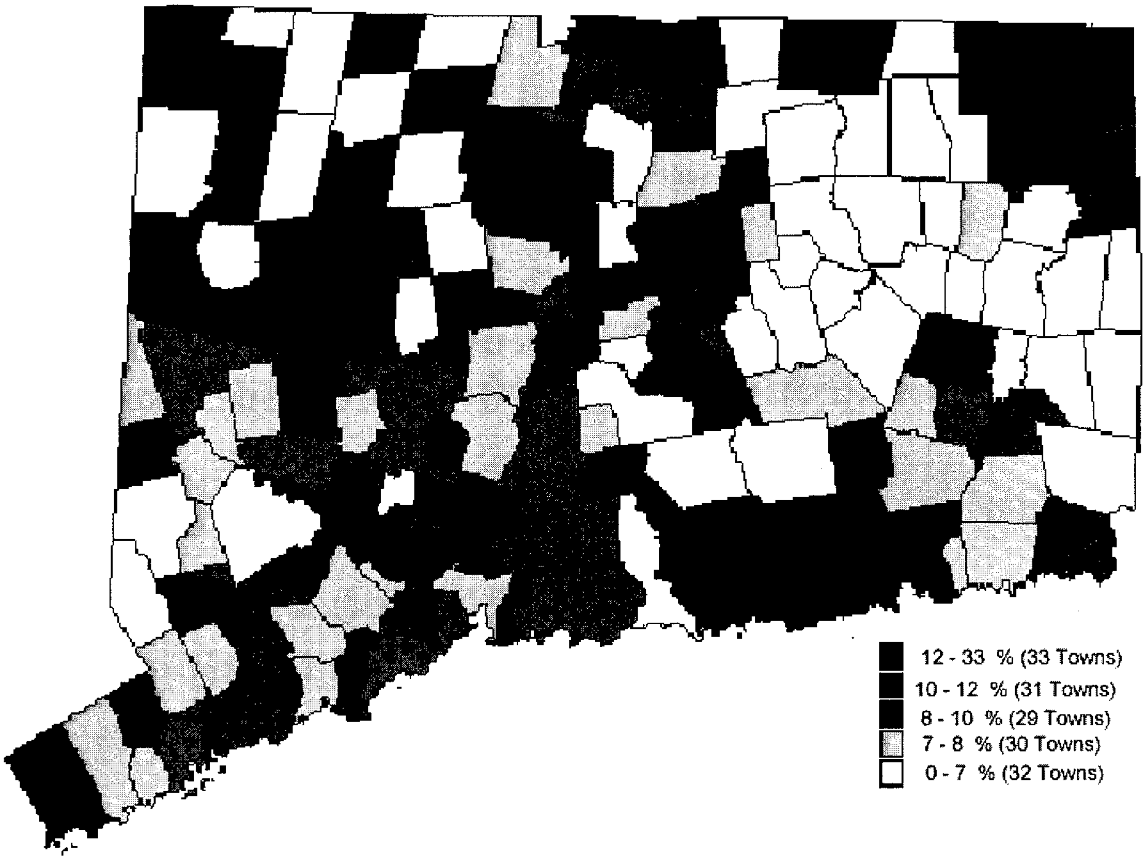


Figure 10. Percentage of Injured Drivers Identified as Elderly



PHASE TWO

Study Sample

Of 34,778 non-duplicate CHIME® records that linked to the DOT file (Table 6), 25,184 (72%) were drivers, included in this study (excluded were 1% who had unreliable key variables and 27% who were not drivers). Mean age was 32 years, with standard deviation of 15.8. Of these, 1,318 (5%) drivers were classified as elderly (age greater than 64 years), of whom 1,069 (81%) were treated in the ED and released (zero length of stay), and 249 (19%) were admitted as inpatients (LOS of at least one day). Females represented 49.4% of the elderly drivers, with males representing 50.6%. The median age of the elderly drivers was 72 years, for both females and males.

Results

Eighty one percent of the elderly drivers who were involved in crashes and had hospital care were treated and released from the ED. For the 249 elderly drivers admitted as inpatients, the median length of stay was 4 days. Of these, 220 (89%) persons had been classified at the time of the crash (in the DOT Type 4 records) as having an injury or possible injury, in addition to 6 (2%) classified with a fatal injury and 23 (9%) classified as no injury, indicating that 90% of the hospital admissions were identified as injured by the traffic safety officer at the scene of the crash.

Figure 11 and Table 10 display the number of those elderly drivers with inpatient admissions, by DOT injury classification. As might be expected, few drivers classified as fatalities by the traffic safety officer at the scene were admitted to hospital; however 9% of those classified as no injury were subsequently admitted.

Table 10. Elderly Drivers Admitted to Hospital, by DOT Injury Classification

DOT Injury Classification	Number	Percent of Total
K = Fatal Injury	6	2%
A = Incapacitating Injury	89	36%
B = Non-Incapacitating Injury	81	33%
C = Possible Injury	50	20%
N = No Injury	23	9%
Total	249	100%

Figure 11. Number of Elderly Drivers Admitted to Hospital, by DOT Injury Classification

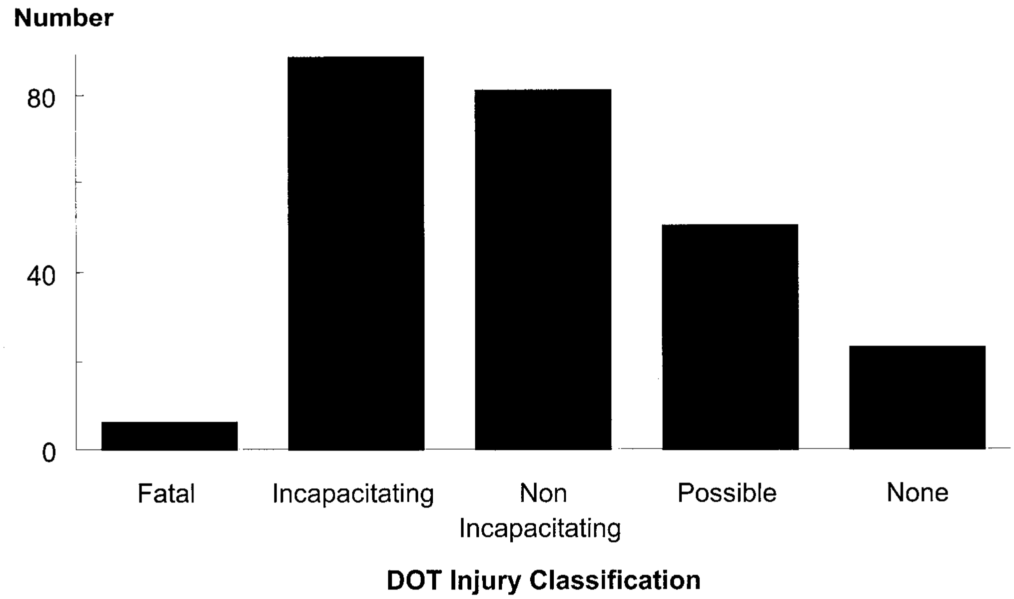


Figure 12 displays the mean age of those elderly drivers with inpatient admissions, by DOT injury classification. Drivers originally classified at the crash as having fatal injuries were the oldest of these groups, with mean age 77, although the numbers are too few to establish a reliable correlation between greater age and a higher probability of being classified as fatally injured.

Figure 12 Age Distribution of Elderly Drivers Admitted to Hospital, by DOT Injury Classification

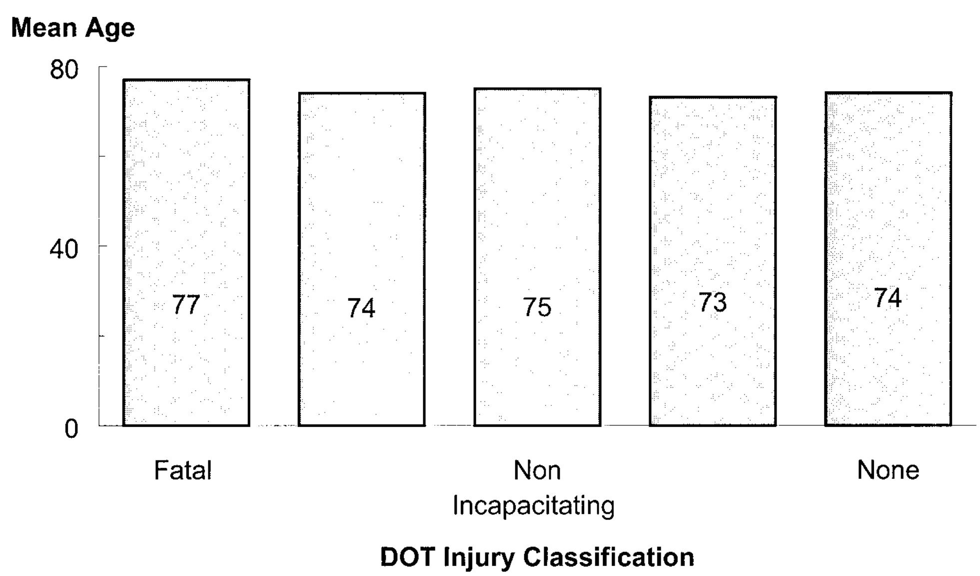


Figure 13. Age Distribution of Fatalities

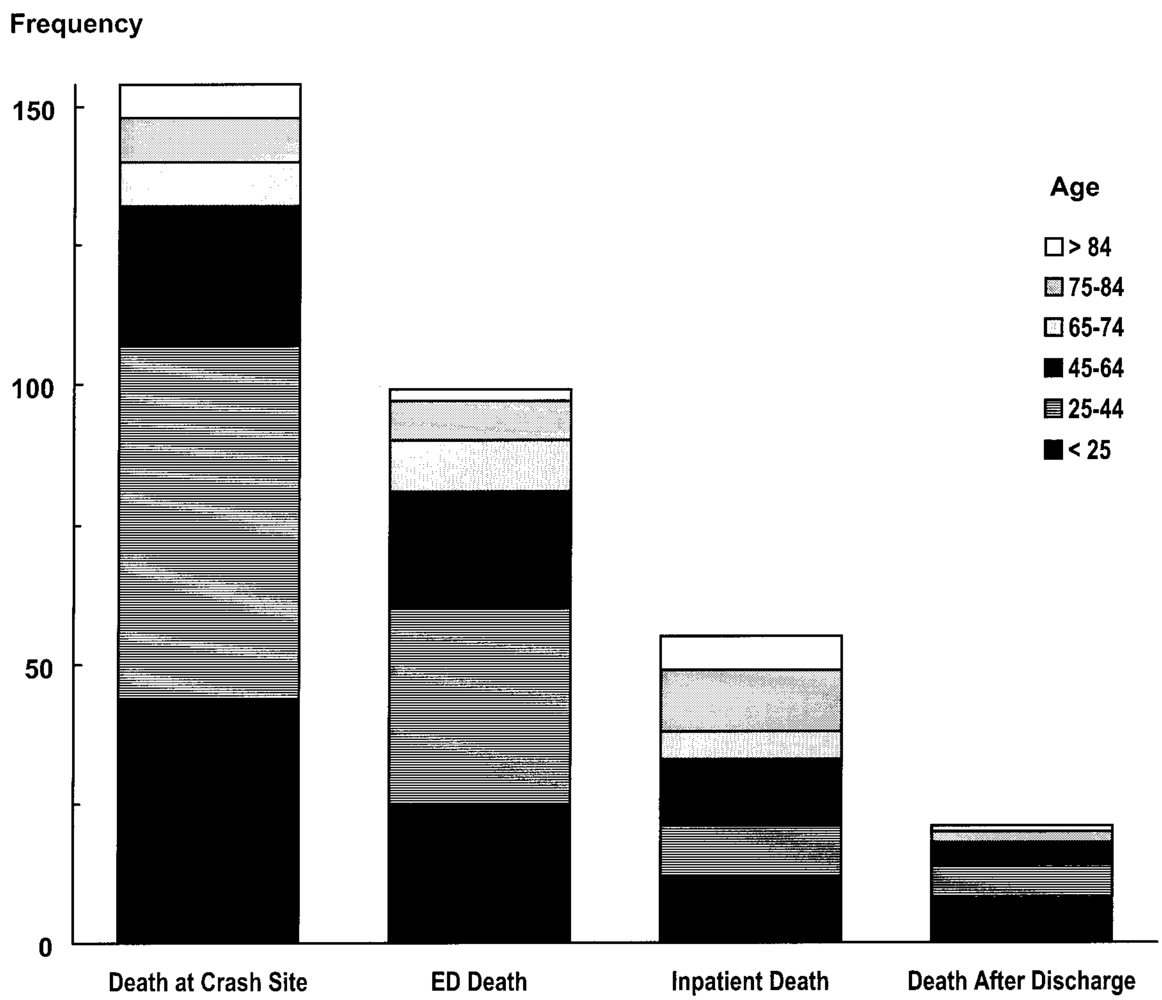


Figure 13 shows mortality by age distribution of the 329 persons killed in motor vehicle crashes. Of these deaths, 238 (72%) were drivers, of whom 42 (18%) were above 64 years in age. Among these elderly driver fatalities, 14 (33%) died at the crash site, 10 (24%) in the ED, 16 (38%) after inpatient admission, and 2 (5%) died after discharge. The median length of stay for those elderly drivers who died as inpatients was 3 days. Overall, mean total charges for elderly drivers were $4,317, with total individual charges for the elderly driver fatalities ranging from $638 to $212,711 with a mean of $37,801, and total charges for those who survived ranging from $45 to $270,992 with a mean of $3,590.

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.

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. 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.

One benefit of this linkage is that it allows study of how similar events occurring in a crash affect different population subgroups differently. It is now possible to examine the impact of environmental and physical forces on different groups of patients and determine the differences in cost and outcome, including how elderly patients with degenerating physiology and anatomy compare to younger healthier patients. Trauma has classically been thought of as a problem of the young, since it is the leading cause of death in the younger decades[5]; however, it has become a major problem for the elderly as well, as people live longer, are more independent, have more leisure time and more disposable income with which to enjoy their retirement[6]. The linked databases can 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.

Overall, there were 72,639 drivers involved in motor vehicle crashes in the state of Connecticut during 1995, 8.4% (10,615) of whom were more than 64 years old; this is significant both in number and as a percentage. As the population ages, the percentage of elderly will increase, particularly in the coming decades as the large cohort of baby boomers graduates into the over 65 age group. It is essential to begin to identify the factors that cause motor vehicle crashes associated with elderly drivers, as well as to determine how these factors differ from those affecting younger drivers. Understanding these factors will lead to appropriate recommendations for prevention and minimization of problems.

For elderly who have been involved in a crash, it is important to determine whether they are injured and visit the hospital at a higher frequency than younger victims, and whether they generate longer lengths of stay and higher costs. In general, the elderly have more brittle bones, a higher incidence of osteoporosis and osteoarthritis, and are more susceptible to musculoskeletal injuries and fractures[7,8]. Similarly, there is a higher incidence of heart disease[9], diabetes[10], and other pre-existing medical conditions, causing higher admission rates with longer lengths of stay, higher mortality, and significantly greater costs for the elderly. Of the elderly drivers in this study involved in crashes with linked hospital records, 81% were treated in the ED and released, while 19% were admitted as inpatients. In a companion study[11] of the same linked data files, 92% of the general population involved in a crash with linked hospital records were treated in the ED and released, while only 8% were admitted. Median length of stay for the elderly admissions was 4 days, and 3 days for the general population. Even more significantly, mean total charges for elderly drivers were $4,317, while for the general population mean total charges were only $1,779.

Driver illness was strongly associated with crashes involving the elderly, as well as with a higher severity of injury, and with striking an object[12], even adjusting for other factors. This finding may suggest that drivers, particularly the elderly, should be educated regarding the risks of driving while ill; on the other hand, this finding may just reflect a tendency by traffic safety officers to routinely code driver illness for any otherwise unexplained crash involving an elderly driver. The linked record allows for more detailed study of the medical condition and history of illness of drivers in crashes identified as caused by driver illness[13]. If driver illness is reliably identified as a cause of motor vehicle crashes, it may be necessary to advise medical professionals regarding what advice to give their aging patients *re* driving, as a routine part of administering medical care. A related factor affecting the ability to control a vehicle is medication usage[14,15]. As patients' pharmaceutical utilization records are incorporated into the CHIME® database, they can be merged with the rest of the linked dataset to allow identification of specific medications which, individually or in combination with other factors, are particularly problematic.

The data indicate that striking deer, construction zones, intersections with public and private roadways, violating traffic controls, and failure to grant right of way were associated with motor vehicle crashes in the elderly. These findings identify complex and confusing situations and stimuli as predictors of motor vehicle crashes involving elderly drivers, suggesting that the elderly might benefit from specific intervention regarding keeping control of the vehicle under emergency conditions. The ability to cope with multiple rapidly changing environmental stimuli can be a challenge for anyone, but this becomes more difficult with advancing age[16]. While a large animal, such as a deer, suddenly entering the roadway can present a challenge for any driver, this may represent a special risk for the elderly. Two factors may contribute to making crashes involving deer an especially important risk factor for elderly drivers; not only are the elderly less likely to maintain control of their vehicles under confusing conditions, they are also more likely to have crashes in rural areas. In the past few years, an expanding deer population has presented many new difficulties for rural and suburban Connecticut residents; increased involvement in motor vehicle crashes may be another such contemporary problem.

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. Using this data, educational programs can be developed for specific population subgroups in order to decrease the rate and severity of crashes.

By this analysis, motor vehicle crashes involving elderly drivers are largely the result of driver illness or perceptual stimulus overload.

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.

RECOMMENDATIONS

- Evaluate the responses of elderly drivers to sudden or confusing road stimuli, modify the highway environment to accommodate them, educate them regarding these risks, and train them in dealing with confusing stimuli.
- Educate people regarding the risk of being overcome by illness while driving.

APPENDIX A

THE BIVARIATE ASSOCIATION BETWEEN DRIVER'S AGE GROUP AND PREDICTORS

Table 11. Bivariate Analysis of Characteristics with Driver's Age Group

(N=126375, driver only and without age missing)

Characteristic	Total	Age					
		< 25	25 to 44	45 to 64	65 to 74	> 75	P value
	N	N=27317	N=61009	N=27434	N=6664	N=3951	
		%	%	%	%	%	
Mon.	17379	21.12	48.87	21.7	5.2	3.1	0.52
Tues.	17120	22.08	48.42	21.31	5.12	3.07	0.03
Thurs.	18431	20.94	47.91	22.59	5.49	3.08	<0.001
Fri.	19746	21.69	48.2	21.81	5.22	3.08	0.82
Wed	17507	21.81	48.11	21.53	5.42	3.12	0.76
Weekend	36192	21.84	48.23	21.48	5.23	3.22	0.27
No indication drinking	124338	21.71	48.02	21.77	5.33	3.17	<0.001
At-fault driver	66958	22.51	48.36	21.04	5.05	3.04	<0.001
Female	48915	21.7	48.31	21.42	5.27	3.3	0.71
At-fault traffic unit #1	74734	22.84	47.53	21.03	5.32	3.28	<0.001
At-fault traffic unit #2	45271	20.3	48.87	22.52	5.25	3.06	<0.001
At-fault traffic unit #3	5004	17.17	52.2	23.62	5.1	1.92	<0.001
Collision type: pedestrian	1122	20.23	44.21	25.4	6.33	3.83	<0.001
Involved more than 3 vehicles	15273	17.93	51.04	23.64	5.09	2.3	<0.001
Involved 1 vehicle	16257	29.05	48.05	17.3	3.68	1.91	<0.001
Involved 2 vehicles	94845	20.93	47.87	22.15	5.58	3.47	<0.001
Involved more than 1 pedestrians	1236	20.06	45.23	24.51	6.31	3.88	<0.001
Collision type: angle	8420	23.1	43.46	22.05	6.45	4.94	<0.001
Collision type: backing	2047	16.85	49.34	24.57	6.25	2.98	<0.001
Collision type: jackknife	108	8.33	56.48	28.7	4.63	1.85	0.02
Collision type: head-on	1272	21.86	50.08	23.11	3.14	1.81	0.08
Collision type: overturn	753	34	47.81	15.54	1.86	0.8	<0.001
Collision type: parking	758	12.93	50	26.25	6.07	4.75	<0.001
Collision type: rear-end	47718	19.88	50.65	22.4	4.89	2.19	0.09
Collision type: sideswipe-same direction	12157	17.69	50.79	23.57	4.89	3.05	<0.001
Collision type: turning-same direction	5322	21.44	48.21	22.27	5.15	2.93	0.8

Table 11 continued. Bivariate Analysis Of Characteristics With Driver's Age Group

Characteristic	Total	Age					
		< 25	25 to 44	45 to 64	65 to 74	> 75	P value
	N	N=27317	N=61009	N=27434	N=6664	N=3951	
		%	%	%	%	%	
Median barrier: no median barrier	116431	21.57	48.03	21.77	5.4	3.23	<0.001
Median barrier: no penetration	8886	21.7	51.2	21.46	3.7	1.94	<0.001
Collision type: fixed object	14630	30.09	48.05	16.34	3.66	1.87	<0.001
Construction	2464	17.45	49.88	24.51	5.32	2.84	<0.001
Contributing factor: driving/entered on wrong side of road	1700	24.53	48.06	19.41	5.35	2.65	<0.001
Contributing factor: driver illness	441	10.2	39.23	27.44	14.29	8.84	<0.001
Contributing factor: speed too fast	11732	28.2	48.88	18.25	3.44	1.23	<0.001
Contributing factor: violated traffic control	8328	21.64	43.48	22.2	7.14	5.54	<0.001
Contributing factor: failed to grant right of way	23814	22.56	43.39	21.77	6.87	5.42	<0.001
Contributing factor: following too closely	40404	20.1	50.39	22.49	4.83	2.19	0.39
Collision type: turning-intersecting paths	15688	22.64	44.22	21.41	6.74	4.99	<0.001
At intersection	62336	21.26	47.64	21.86	5.6	3.65	<0.001
Light condition: dark - lighted	23948	27.16	51.01	17.88	2.77	1.19	<0.001
Light condition: dark-not lighted	6600	28.88	49.62	17.56	2.88	1.06	<0.001
Light condition: dawn	999	17.42	52.55	26.33	3	0.7	0.41
Light condition: daylight	91474	19.59	47.44	23	6.16	3.81	<0.001
Light condition: dusk	2785	24.7	47	20.79	0	3.02	<0.001
Lig_Utd	569	21.97	51.67	19.86	3.51	2.99	0.13
Collision type: moving object	2189	13.16	54.41	27.18	3.97	1.28	<0.001
Non collision	109	31.19	50.46	16.51	1.83	0	<0.001
Object location: on shoulder	993	27.39	49.35	18.73	2.92	1.61	<0.001
Object location: off road and shoulder	12139	31.82	46.78	15.33	3.96	2.1	<0.001
Object location: in roadway	2673	14.55	53.54	25.89	4.23	1.8	<0.001
Object location: on median divider	2795	27.48	52.77	15.21	3.11	1.43	<0.001
Collision type: sideswipe-opposite direction	2700	20.59	49.89	22.11	5.26	2.15	0.96
Collision type: turning-opposite direction	11240	22.4	43.39	21.47	6.98	5.76	<0.001
OthFat_0	43657	21.9	50.49	21.26	4.3	2.05	<0.001
Other roadway feature: intersection with public roadway	52910	21.38	47.49	21.76	5.62	3.75	<0.001

Table 11 continued. Bivariate Analysis Of Characteristics With Driver's Age Group

Characteristic	Total	Age					P value
		< 25	25 to 44	45 to 64	65 to 74	> 75	
	N	N=27317	N=61009	N=27434	N=6664	N=3951	
		%	%	%	%	%	
Other roadway feature: intersection with private roadway	29808	21.62	46.43	22.27	6.08	3.6	<0.001
1st object struck: animal other than deer	1133	36.01	43.78	14.74	3.88	1.59	<0.001
1st object struck: curbing	1644	32.73	45.92	14.42	4.14	2.8	<0.001
1st object struck: deer	924	14.39	47.84	31.6	4.44	1.73	<0.001
1st object struck: highway	647	27.98	48.53	17.16	3.71	2.63	<0.001
1st object struck: Jersey barrier	1361	26.23	55.18	14.47	3.31	0.81	<0.001
1st object struck: metal beam guide rail	2930	28.5	50.85	15.7	3.48	1.47	<0.001
1st object struck: tree	1410	37.8	41.28	15.18	3.83	1.91	<0.001
1st object struck: utility pole	1615	31.52	46.44	15.48	4.46	2.11	<0.001
1st object struck: wire rope guide rail	2085	28.2	48.3	18.03	3.5	1.97	<0.001
2nd object struck	4435	32.97	45.95	14.7	3.92	2.46	<0.001
Road surface: other	197	24.37	44.67	24.87	4.06	2.03	0.59
Road surface: sand/mud/dirt or oil	1079	24.1	49.12	18.44	5.47	2.87	0.01
Road surface: snow/slush	6082	19.86	52.93	22.74	3.24	1.23	<0.001
SurfUtd	536	20.15	51.68	20.15	5.22	2.8	0.84
Road surface: dry	88782	21.37	47.61	21.89	5.63	3.5	<0.001
Road surface: ice	2796	20.99	51.93	22.35	3.51	1.22	<0.001
Road surface: wet	26903	22.8	48.97	20.96	4.73	2.54	<0.001
Weather: sleet/ hail	711	25.6	50.35	19.97	3.09	0.98	<0.001
Weather: blowing sand/soil/ dirt or snow	424	21.46	52.36	21.46	4.25	0.47	0.14
Weather: fog	909	25.41	46.97	21.56	4.4	1.65	<0.001
Weather: other	749	24.3	47.13	19.89	4.94	3.74	0.15
Weather: rain	19442	23.17	49.07	20.94	4.45	2.37	<0.001
Weather: snow	5203	19.53	53.32	22.66	3.4	1.1	0.01
WeatUtd	647	21.02	48.22	22.41	5.72	2.63	0.7
Weather: severe cross winds	139	26.62	50.36	17.27	2.88	2.88	0.04
Weather: no adverse condition	98151	21.33	47.84	21.84	5.57	3.42	<0.001
Vehicle type: automobile	104618	22.76	46.57	21.25	5.78	3.63	0.18
Vehicle type: motorcycle	938	27.51	57.89	14.07	0.43	0.11	<0.001
Vehicle type: truck	11578	16.18	57.26	22.43	3.16	0.97	0.97
Vehicle type: passenger van	3849	11.41	58.79	26.14	3.04	0.62	<0.001
Airbag deployed	3929	22.58	47.87	20.9	5.88	2.77	0.23

Table 11 continued. Bivariate Analysis Of Characteristics With Driver's Age Group

Characteristic	Total	Age					
		< 25	25 to 44	45 to 64	65 to 74	> 75	P value
	N	N=27317	N=61009	N=27434	N=6664	N=3951	
		%	%	%	%	%	
Injury type: incapacitating injury	3727	26.51	45.69	18.51	5.5	3.78	<0.001
Injury type: non-incapacitating injury	8555	29.53	44.99	17.51	4.48	3.5	<0.001
Injury type: possible injury	19943	21.1	48.92	22.13	5.22	2.63	0.8
Injury type: fatal injury	203	22.17	45.32	23.15	5.91	3.45	0.67
Property damage only	68180	20.35	49.07	22.25	5.22	3.11	<0.001
Past MVC with 1 year	1208	33.61	51.74	10.93	2.07	1.66	<0.001
Past MVC with 6 months	449	35.63	49.89	11.8	1.34	1.34	<0.001

APPENDIX B

Bivariate Analysis of Characteristics by DOT Injury Classification

Table 12. 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 12 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	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 direction	2918	5.59	11.86	17.72	0.48	64.36	<0.001

Table 12 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: 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
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

Table 12 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: 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

REFERENCES

[1] The Crash Outcome Data Evaluation System (CODES), U.S. Department of Transportation, National Highway Traffic Safety Administration, January 1996.

[2] State of Connecticut Department of Transportation Collision Analysis System Auxiliary Input File Documentation, State of Connecticut Department of Transportation, (1995).

[3] J. Landwehr, D. Pregibon, A. Shoemaker: Graphical methods for assessing logistic regression models. *JASA* 79: 61-63 (1984).

[4] J. Hanley, B. J. McNeil: The meaning and use of the area under the receiver operating characteristic (ROC) curve. *Radiology* 143: 29-36 (1992).

[5] G. K. Singh, T. J. Matthews, S. C. Clarke, T. Yannicos, B. L. Smith: Annual summary of births, marriages, divorces, and deaths: United States, 1994. US Department of Health and Human Services, National Center for Health Statistics, CDC Monthly Vital Statistics Report 43, #13 (1995).

[6] National Highway Traffic Safety Administration: *Conference on Research and Development Needed to Improve Safety and Mobility of Older Drivers.* US Department of Transportation Report DOT HS 807316 (1989).

[7] G. F. McCoy, R. A. Johnston, R. B. Duthie: Injury to the elderly in road traffic accidents. *J Trauma* 29: 494-497 (1989).

[8] L. Evans: Risk of fatality from physical trauma versus sex and age. *J Trauma* 28: 368-378 (1988).

[9] J. A. Waller: Cardiovascular disease, aging, and traffic accidents. *J Chronic Dis* 20: 615-620 (1967).

[10] P. Hansotia, S. K. Broste: The effect of epilepsy or diabetes mellitus on the risk of automobile accidents. *N Engl J Med* 324: 22-26 (1991).

[11] G. N. Zuckier, L. Jacobs MD, L. M. Thibeault: An evaluation of medical and financial outcomes of motor vehicle crash/injuries in Connecticut: U S Department of Transportation National Highway Traffic Safety Administration DTNH 22-96-R-07266 Final Report (1998).

[12] G. N. Zuckier, L. Jacobs MD, L. M. Thibeault: An evaluation of severity and outcome of injury by type of object struck (first object struck only) for motor vehicle crashes in Connecticut: U S Department of Transportation National Highway Traffic Safety Administration DTNH 22-96-R-07266 Final Report (1998).

[13] T. D. Koepsell, M. E. Wolf, L. McCloskey, *et al.*: Medical conditions and motor vehicle collision injuries in older adults. *J Am Geriatr Soc* 42: 695-700 (1994).

[14] W. A. Ray, R. L. Fought, M. D. Decker: Psychoactive drugs and the risk of injurious motor vehicle crashes in elderly drivers. *Am J Epidemiol* 136: 873-883 (1992).

[15] S. G. Leveille, D. M. Buchner, T. D. Koepsell, L. W. McCloskey, M. E. Wolf, E. H. Wagner: Psychoactive medications and injurious motor vehicle collisions involving older drivers. *Epidemiology* 5: 591-598 (1994).

[16] C. Owsley, K. Ball, G. McGwin, M. E. Sloane, D. L. Roenker, M. F. White, E. T. Overley: Visual processing impairment and risk of motor vehicle crash among older adults. *JAMA* 279: 1083-1088 (1998).