PATTERNS OF INJURY SEVERITY AND ITS LIKELIHOOD IN TWO-VEHICLE CRASHES

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ABSTRACT

Understanding injury severity patterns in roadway crashes is important not only from the view point of treating crash victims, but also for directing the crash avoidance efforts of traffic safety agencies and motor vehicle manufacturers. The factor that is most discussed in this context is vehicle incompatibility. However, there are other vehicle-, occupant-, and roadway-related factors, too, that play roles in injury severity.

In order to investigate these factors in relation to the injury severity, this paper considers a two-vehicle crash as a 'system' with its elements: vehicles, drivers, and roadway. Some of the possible inputs (contributing factors) to this system are considered with a focus on injury severity of the driver as an outcome. The differences in weights, heights, and shapes, etc. of the crash-involved vehicles, vehicle speed, drivers' ages and genders are the factors in question. Data mining the crash databases compiled by the National Highway Traffic Safety Administration (NHTSA) makes many important revelations. The association between the subject variables and driver injury severity is studied through contingency analysis. Configuration frequency analysis helps to identify patterns of injury severity. The main objective of the study is achieved by building a logit model that can be used to predict the likelihood of injury severity from a given set of vehicle-, driver-, and roadway-related crash characteristics.

INTRODUCTION AND RATIONALE

Reducing crashes on the roadways is of paramount importance, as is the reduction in crash injury severity. Many studies have been conducted on injury severity [e.g., 5,9]. Most of them are based on controlled experimentation and look at the phenomenon purely from an engineering or medical point of view. One of the reflections of these studies is that vehicle incompatibility contributes to injury severity in a crash [6]. In other words, the larger differences in the sizes and weights of the crash-involved vehicles are likely to result in more serious injuries to occupants of the smaller vehicle.

Injury and its severity is the resultant effect of collision between two bodies (vehicles). Therefore, in order to study the magnitude of this effect, crash phenomenon must be looked at as an impact, i.e., the effect of transfer of energy from one vehicle to the other [7]. This results in change of relative velocity. As kinetic energy [$=\frac{1}{2}(\text{Mass}*\text{Speed}^2)$] increases with square of velocity, the energy of motion of the striking vehicle dissipated to the other vehicle increases not only with the increasing mass but also with the increasing velocity.

The vehicle occupants acquire the same velocity as the vehicles they are riding. Thus, while the colliding vehicles undergo changes due to conservation of momentum generated by the impact, their occupants, too. Also, the roadway conditions, to a large extent, govern the last moment changes, such as velocity change, etc. This makes it imperative in an injury severity related study to consider the vehicle, occupants, and roadway together. Following this rationale, a crash is considered as a system with interacting elements: Vehicles, Occupants, and Roadway.

An object with small inertial mass changes its motion more readily than an object with large inertial mass. This argument applies to both the vehicles in crash and their occupants. This shows that for injury severity, if vehicle mass is a contributing factor, so is the occupant body mass. In fact, each element of the crash system has certain associated characteristics that contribute to the outcome (injury severity) of this system. Using multivariate statistical methods, this paper explores factors that contribute to injury severity. Injury severity patterns are identified as well as a model is developed to predict the likelihood of injury severity.

The current analyses focus only on the injury severity of the drivers involved in two-vehicle frontal crashes. In the subsequent discussion, the term crash will refer to such crashes only. Also, the term 'occupant' and 'driver' will be used interchangeably, though always referring to driver and the term 'car' will be used for a 'passenger car.'

DATA SOURCE AND MANIPULATION

NHTSA compiles data on automated, comprehensive national traffic crashes and maintains: National Automotive Sampling System (NASS)-Crashworthiness Data System (CDS) database. The NASS-CDS database provides detailed information about vehicle-, driver-, and roadway-related variables. In the subsequent discussion, this database will be referred to as CDS. The results presented in the following sections are based on the CDS data for the years 1995 through 2003**.**

The data used in the subsequent analyses is extracted from the CDS database by including only the frontal crashes (manner of collision=head-on) and using other restrictions: the number of crash involved vehicles (=2) and the occupant role (=driver).

ANALYSIS VARIABLES

Once injury severity is considered as an outcome of the crash system, many variables become candidates for evaluation. From the earlier discussion, however, it follows that vehicle body type, speed and change in velocity are important vehicle factors. Similarly, in order to take into account the driver's response to changes that occur due to impact, occupant's body mass (weight and height), age, and sex need to be considered, too. Road surface condition is another possible contributing factor. Thus, the crash system can be considered as an input/output system as presented in Figure 1, with the above factors as inputs and injury severity as outcome.

As an aid to select appropriate CDS variables and for the sake of clarity in the subsequent discussion, some terms are explained below.

Vehicle Incompatibility: Vehicle incompatibility between two colliding vehicles is defined in terms of the difference between their weights, heights, and shapes, etc.
Using this definition in the context of impact, it may be inferred that the difference between masses of two colliding vehicles is one of the factors contributing to the extent of vehicle damage. For example, a sports utility vehicle or a light truck with large mass is likely to cause much more serious damage in a crash to a vehicle of smaller mass such as a sedan.

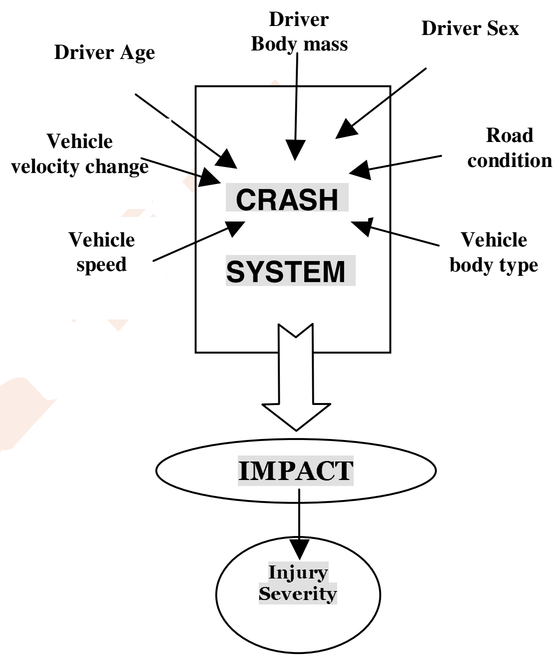

Figure 1. Crash as an Input-Output System

The variable in the CDS crash database that takes into account such vehicle parameters is the vehicle body type. Accordingly, the difference in the body types of crash vehicles is used to account for vehicle incompatibility. The two vehicle body types colliding in a crash will be referred to as 'crash configuration.' For example, a passenger car colliding with a light truck defines a crash configuration: car vs. light truck.

Body Mass Index: Body Mass Index (BMI) is a composite number assigned to a driver based on his/her weight and height and is given by [3]

$$\text{BMI} = \left(\frac{\text{Weight}}{\text{Height}^2}\right) \times 10{,}000 \ .$$

Based on these two driver characteristics, this number accounts for the response of the driver to forces that occur due to instant changes in an impact.

Injury Severity Score: Injury Severity Score (ISS) of an occupant is an anatomical scoring system that provides an overall score for patients with multiple injuries [2]. This scoring system depends on Abbreviated Injury Score (AIS). Of the six body regions, head, face, chest, abdomen, extremities, and external, AIS values for the three most severely injured body regions, say, B_1, B_2, B_3, are used in calculating ISS. Specifically, Injury Severity Score of a driver is given by

$$ISS_D = (AIS_{B_1})^2 + (AIS_{B_2})^2 + (AIS_{B_3})^2 .$$

<u>Driver Injury Severity</u>: Driver Injury Severity (DIS) in a two-vehicle crash is the larger of the two ISS values assigned to drivers, D_1, D_2 and is given by

$$DIS = Max\ (ISS_{D1}, ISS_{D2}) .$$

Based on these definitions, the following CDS variables associated with the three crash system-elements are considered in the analysis.

<u>Vehicle-related variables</u>: In order to take into account the impact-related vehicle characteristics, the CDS variables: *Body type*, *Travel speed*, and *Total Delta-V* are considered.

<u>Driver-related variables</u>: Since the response variable DIS is considered as the resultant effect of impact, the possible driver-related CDS variables: *Age, Sex, Height,* and *Weight* are used in the analysis.

<u>Roadway-related variables</u>: In this category, the CDS variable thought to have some bearing on the crash and hence on injury severity is the *Road Condition*.

To establish association of the selected variables with DIS and identify its patterns, these variables are categorized as shown in Table 1. This table presents the CDS variables, the categorization criteria and the resulting categories.

ANALYSIS AND RESULTS

Depending on the hypothesis of interest, mainly three methods are used in the analysis: Configuration Frequency Analysis (CFA), Contingency Analysis (CA), and Logistic Regression (LR). CFA is conducted to statistically assess the extent to which vehicle incompatibility (in terms of body type) can explain the differences in injury severity that are observed in the data [1]. LR provides estimates of the relative likelihood of injury severity [4]. For building an LR model, the predictor variables are initially screened by CA [8]. Statistical software SAS 8.2 and SUDAAN 8 are used for these analyses.

Table 1.
Categorization of Analysis Variables

VARIABLE	CRITERION	CATEGORIES
DRIVER INJURY SEVERITY	Injury Severity Score	**1**: 0-5, **2**: 6-10, **3**: 11-30, **4**: 31-50, **5**: 51 and above
SEX	Pregnancy (P)	Male, Un-pregnant Female, Pregnant Female
AGE	Driver age in years	14-25, 26-35, 36-45, 46-54, 55-64, 65 and above
HEIGHT WEIGHT	Body Mass Index (BMI)	0-18.5, 18.6-24.9, 25 and above
VEHICLE INCOMAPTIB-LITY	Body Types of vehicles	†C-C, C-UV, C-LT, UV-UV, UV-LT, LT-LT
TRAVEL SPEED	Vehicle Travel Speed	0-60, 61-75, 76-90, 91 and above
VELOCITY CHANGE	Total Delta-V	5-25, 26-35, 36-45, 46-55, 56-65, 66 and above
ROAD CONDITION	Road Surface Condition	Dry, Wet, Snow/Slush, Ice,

† C: Car, UV: Utility Vehicle and Van, LT: Light Truck

Configuration Frequency Analysis

CFA is a multivariate statistical technique that identifies those sectors of the data where the local associations are prominent. The method compares the observed to expected frequencies in a cross-tabulation. The goal of this comparison is to determine whether the difference between the observed and expected frequency for a given cell configuration is larger than some critical value and is statistically significant. Any significant difference between the observed and expected frequency for a configuration indicates that in that particular sector of the data space, the variables are (locally) associated with each other, thereby showing patterns in the data.

Table 7 (Appendix) shows the observed (weighted) and expected frequencies for each combination of crash configuration and DIS. Based on this joint frequency distribution, CFA results presented in Table 2 show that for driver injury severity of the lower order (DIS=1), the observed frequency of crashes involving two cars is much higher than the expected. This shows that on the average a driver of a car involved in a crash with another car: Car vs. Car would mostly sustain minor injuries. This pattern is also observed for the crash configuration: Utility Van vs. Light Truck, where the incompatibility is relatively low. In contrast, the difference between the observed and expected frequencies for crash configuration: Car vs. Utility Van or Car vs. Light Truck is higher for higher DIS. Thus, the results of CFA (Table 2) show that as body type of the vehicle colliding with a Car changes from a Car to UV and from UV to LT, more than expected crashes are observed to be resulting in higher DIS. The deviation from this pattern for some configurations as observed in the CFA results is indicative of the possible effects of other driver- and roadway-related factors. The selection of such factors for predictive modeling is done by CA in the following section.

Table 2.
Configuration Frequency Analysis:
Driver Injury Severity vs. Vehicle Incompatibility (Crash Configuration)

VEHICLE INCOMPA-TIBILITY	DRIVER INJURY SEVERITY				
	1	2	3	4	5
C† x C (1, 1)	**5014**	-1072	-2484	-859	-599
C x UV† (1, 2)	-3176	**2238**	**377**	-50	**611**
C x LT† (1, 3)	-1341	-1896	**2217**	**774**	**247**
UV x UV (2,2)	**103**	**132**	**-235**	**73**	**-73**
UV x LT (2, 3	**1122**	-387	-566	-63	-106
LT x LT (3, 3)	-1722	**985**	**691**	**126**	-80

†C: Car, UV: Utility Van, LT: Light Truck
Data Source: NASS-CDS (1995-2003)

Contingency Analysis

CA is conducted to test associations between the response variable, Injury Severity and other variables mentioned earlier. DIS as assessed by ISS is categorized in five categories, while for other variables the categories defined in Table 1 are used in the analysis. The results are presented in Table 3. These results provide strong statistical evidence, with significant χ^2 (95% confidence level), that DIS is closely associated with *Vehicle travel speed* and *velocity change*; *Driver age, sex,* and *body mass*; and *Road surface condition.*

Logistic Regression Model

Finally, a model is developed using LR modeling. This is a technique by which a functional relationship is established between a categorical response variable and the covariates.

Table 3
Contingency Analysis:
Significance of Association Between Injury Severity and Vehicle-, Driver-, and Roadway-Related Variables

VARIABLE	CHISQR (D. F.)*	ASSOCIATION WITH DIS
SEX	23.70 (7)	Highly significant (95% confidence)
AGE	1.09×10^4 (15)	Highly significant (95% confidence)
BMI	68.24 (8)	Highly significant (95% confidence)
TRAVEL SPEED	7.2×10^3 (11)	Highly significant (95% confidence)
VELOCITY CHANGE	1.55×10^4 (15)	Highly significant (95% confidence)
ROAD CONDITION	2.07×10^4 (12)	Highly significant (95% confidence)

*Degrees of Freedom
Data Source: NASS-CDS (1995-2003)

LR applies maximum likelihood estimation after transforming the dependent variable into a logit variable (the natural log of the odds of the dependent variable value occurring or not). In this way, LR model estimates the likelihood of a certain event occurring.

In the context of LR model, it is important to note that, based on ISS, the response variable DIS is polytomous, i.e., it assumes five values, depending on the range of ISS (Table 1), rather than two values as in the case of a dichotomous variable. Added to this is its ordinal (scale-based) nature. Therefore, an appropriate model for the current situation would be what is called Baseline Logit model [4]. Under this model, the logits are given by

$$g_k(x) = \ln\left[\frac{\pi_k(x)}{\pi_0(x)}\right] = \beta_{k0} + \beta_1 x_1 + \beta_2 x_2 + ...,+ \beta_K x_K$$

$$\beta_{121} x_1 x_2 + ...,+ \beta_K x_{K-1} x_K.$$

In this model, the coefficients provide log-odds comparing category Y=k to a baseline category, Y=0, where Y represents the response (DIS in the present study).

<u>Logit Model</u>
All predictor variables found to be significantly associated with DIS and all possible two-way interactions are considered for fitting the logit model.

The results of LR modeling are presented in Table 4, 5, and 6. All test statistics provide strong evidence of goodness of fit of the model (Table 4).

Table 4.
Logistic Regression Results

MODEL FIT STATISTICS			
CRITERION	INTERCEPT AND COVARIATES		
AIC	9.29×10^4		
SC	9.30×10^4		
-2 Log L	9.28×10^4		
TESTING GLOBAL NULL HYPOTHESIS: BETA=0			
TEST	CHISQR	DF	P-VALUE
LIKELIHOOD RATIO	4.9×10^4	22	0.000
SCORE	3.7×10^4	22	0.000
WALD	2.8×10^4	22	0.000

Table 5.
Logistic Regression:
Analysis of Effects and Interactions

VARIABLE/ INTERACTION	CHISQR (D. F.)†	SIGNIFICANCE IN THE MODEL
VELOCITY CHANGE * VEHICLE INCOMPATIBILITY	8.3×10^3 (5)	p-value << 0.05 Highly significant
AGE * SEX	6.5×10^3 (2)	p-value << 0.05 Highly significant
AGE * BMI	6.6×10^3 (1)	p-value << 0.05 Highly significant
VEHICLE INCOMPATIBILITY	8.0×10^3 (5)	p-value << 0.05 Highly significant
SEX	5.8×10^3 (2)	p-value << 0.05 Highly significant
AGE	120.4 (1)	p-value << 0.05 Highly significant
BMI	5.0×10^3 (1)	p-value << 0.05 Highly significant
TRAVEL SPEED	163.0 (1)	p-value << 0.05 Highly significant
VELOCITY CHANGE	7.7×10^3 (1)	p-value << 0.05 Highly significant
ROAD CONDITION	2.9×10^3 (3)	p-value << 0.05 Highly significant

†Degrees of Freedom
<< much less than
Data Source: NASS-CDS (1995-2003)

Results in Table 5 show that of all the variables considered in the model, the main effects: Vehicle Incompatibility (in terms of body type), Travel Speed, Total Delta V, Driver Age, Sex, and BMI are found to be highly significant predictors (with p-values much less than 0.05). However, among all possible interactions considered in the model, the only interactions that are found significant (95% confidence level) are: Age* BMI, Age*Sex, and Vehicle Incompatibility*Total Delta-V. Finally, the estimates of the model coefficients and their interpretation based on log odds are presented in Table 6. Along with these interpretations for significant main effects and interactions, this table also provides standard errors and p-values of the model coefficients.

CONCLUSIONS AND RECOMMENDATIONS

The baseline logit model with Injury Severity as the response variable and Body Type, Velocity Change, Body Mass Index, Age, Sex, and Road Condition as explanatory variables passed the adequacy test. The significance of all main effects in the model and some interactions provides strong evidence that driver injury severity can be explained by considering the vehicle-, driver-, and roadway-related variables together. In other words, the characteristics of these crash system elements are the contributing factors for the maximum injury severity of a driver in a two-vehicle frontal crash.

As regards patterns of injury severity, there are large sectors of the data space where driver injury severity is low for small or no body type difference, such as Car * Car, or UV * LT. Significantly large sectors of the two-vehicle frontal crash data are also identified where higher levels of DIS are observed for greater body type differences.

Restricting an injury severity study only to colliding vehicles, to their drivers, or to roadway can provide only partial information about crash injuries and their severity. The interactions between these crash elements, too, are significant. In order to fully understand the reason why in certain situations drivers sustain more severe injuries as compared to others, a study must consider all these elements together.

The results reported in this paper are relevant for driver injury severity in frontal two-vehicle crashes. More research is required, using the same system study approach, to investigate occupants' injury severity depending on their seating positions in the vehicle. Similarly, injury severity in multiple vehicle crashes and that resulting from other types of collisions such as rear-end, sideswipe, etc. can provide more insight into the phenomenon of crash injury. Due to incomplete information for some categories of vehicles and the sample size problem arising therefrom, the model built in this study is based on the crash level information (i.e., the driver with maximum ISS and the corresponding vehicle in a crash). However, it may be worthwhile to develop a model at the individual level using other information sources.

Table. 6
Analysis of Maximum Likelihood Estimates of Parameters in the Fitted LR Model

EFFECT/ INTERACTION	ESTIMATE (SE)	P-VALUE	INTERPRETATION
INTERCENPT 1	-0.1499 (0.5741)	0.7940	Log odds of getting injury (at DIS=1) versus DIS=2,3,4, or 5 for pregnant female driver in a crash with VEHICLE INCOMPATIBILITY (LT-LT) on icy road condition (=LO1)
INTERCENPT 2	0.9495 (0.5741)	0.0981	Log odds of getting injury (at DIS=2) versus DIS=1,3,4, or 5 for pregnant female driver in a crash with VEHICLE INCOMPATIBILITY (LT-LT)) on icy road condition (=LO2)
INTERCENPT 3	4.5836 (0.5748)	0.0000	Log odds of getting injury (at DIS=3) versus DIS=1,2,4, or 5 for pregnant female driver in a crash with VEHICLE INCOMPATIBILITY (LT-LT)) on icy road condition (=LO3)
INTERCENPT 4	6.4596 (0.5775)	0.0000	Log odds of getting injury (at DIS=4) versus DIS=1,2,3,or 5 for pregnant female driver in a crash with VEHICLE INCOMPATIBILITY (LT-LT)) on icy road condition (=LO4)
AGE * SEX (male)	0.0951 (0.0163)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) males of all ages
AGE * SEX (female)	-0.0131 (0.0163)	0.4216	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to females of all ages
AGE * BMI	-0.0103 (0.0001)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to AGE and BMI
VELOCITY CHANGE * VIC[†] (C-C)	-0.019 (0.0016)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VELOCITY CHANGE and VEHICLE INCOMPATIBILITY (C-C)
VELOCITY CHANGE * VIC (C-UV)	0.1142 (0.0015)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to VELOCITY CHANGE and VEHICLE INCOMPATIBILITY (C-UV)
VELOCITY CHANGE * VIC (C-LT)	0.0389 (0.0015)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to VELOCITY CHANGE and VEHICLE INCOMPATIBILITY (C-LT)
VELOCITY CHANGE * VIC (UV-UV)	-0.014 (0.0027)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VELOCITY CHANGE and VEHICLE INCOMPATIBILITY (UV-UV)
VELOCITY CHANGE * VIC (UV-LT)	-0.223 (0.0048)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VELOCITY CHANGE and VEHICLE INCOMPATIBILITY (UV-LT)
VELOCITY CHANGE	-0.1118 (0.0013)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VELOCITY CHANGE
TRAVEL SPEED	-0.00651 (0.0005)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to TRAVEL SPEED
AGE	0.1816 (0.0166)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to AGE
SEX (male)	-3.3883 (0.5581)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to male SEX
SEX (female)	1.1846 (0.5595)	0.0342	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to females
BMI	0.389 (0.0055)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to BMI
VIC (C-C)	-0.1956 (0.0788)	0.0130	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VEHICLE- INCOMPATIBILITY (C-C)
VIC (C-UV)	-5.2768 (0.0737)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VEHICLE- INCOMPATIBILITY (C-UV)
VIC (C-LT)	-3.3836 (0.0740)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to VEHICLE INCOMPATIBILITY (C-LT)
VIC (UV-UV)	0.9458 (0.1429)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to VEHICLE INCOMPATIBILITY (UV-UV)
VIC (UV-LT)	13.2949 (0.2741)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to VEHICLE INCOMPATIBILITY (UV-LT)
ROAD CONDITION (dry)	0.1339 (0.0267)	0.0000	Increment for all types of log odds (LO1, LO2, LO3, LO4) due to dry ROAD CONDITION
ROAD CONDITION (wet)	-1.1806 (0.0299)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to wet ROAD CONDITION
ROAD CONDITION (snow/slush)	-0.6407 (0.0503)	0.0000	Decrement for all types of log odds (LO1, LO2, LO3, LO4) due to snow/slush ROAD CONDITION

[†] VIC: Vehicle Incompatibility
Data Source: NASS-CDS (1995-2003)

REFERENCES

[1] Alexander von Eye. 2002. *Configuration Frequency Analysis*, Lawrence Erlbaum Associates, Publishers.

[2] Baker S. P. et al. 1974. "The Injury Severity Score: A Method for Describing Patients With Multiple Injuries and Evaluating Emergency Care," Journal of Trauma, 1974.

[3] Centers for Disease Control and Prevention, http://www.cdc.gov/nccdphp/dnpa/bmi/bmi-adult-formula.htm, April 2004.

[4] David W. Hosmer and Stanley Lemeshow. 2000. *Applied Logistic Regression*. John Wiley & Sons.

[5] Edwards, J., Happian-Smith, J., Byard, N., and Davis, C. 2000. "Compatibility–the Essential Requirements for Cars in Frontal Impact." IMechE, Conference Transactions, Vehicle Safety 2000.

[6] Evans, Leonard, 1991, *Traffic Safety and the Driver*, Van Nostrand Reinhold, New York.

[7] Haddon, W. Energy damage and the ten counter-measure strategies, Journal of Trauma 4:321-331, 1973.

[8] Kendall, M.G. and Stuart, A. 1967. The Advanced Theory of Statistics, Vol. 2, Hafner Publishing Company, New York.

[9] Summers, S., Prasad, A. 1999. Hollowell, W.T., NHTSA's Vehicle Compatibility Research Program.

APPENDIX

Table. 7
Joint Frequency Distribution of Driver Injury Severity and Vehicle Incompatibility (Crash Configuration) with the Corresponding Expected Frequencies

VEHICLE INCOMP-ATIBILITY	FREQ	DRIVER INJURY SEVERITY					Total
		1	2	3	4	5	
C† x C (1, 1)	Obsrvd.	83773	7686	10355	1030	838	103682
	Expctd.	78759	8758	12839	1890	1437	
C x UV† (1, 2)	Obsrvd.	48316	7964	8771	1186	1550	67787
	Expctd.	51492	5726	8394	1236	940	
C x LT† (1, 3)	Obsrvd.	47829	3571	10232	1953	1145	64731
	Expctd.	49171	5468	8015	1180	897	
UV x UV (2,2)	Obsrvd.	4100	577	417	169	0	5263
	Expctd.	3998	445	652	96	73	
UV x LT (2, 3	Obsrvd.	17096	1389	2037	320	186	21028
	Expctd.	15974	1776	2604	383	292	
LT x LT (3, 3)	Obsrvd.	4196	1643	1656	268	28	7791
	Expctd.	5918	658	965	142	108	
Total		205311	22830	33468	4926	3747	270281

†C: Car, UV: Utility Van, LT: Light Truck
Data Source: NASS-CDS (1995-2003)