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Modeling and comparing injury severity of at-fault and not at-fault drivers in crashes

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ABSTRACT

This paper examines and compares the effect of selected variables on driver injury severity of, both, at-fault and not at-fault drivers. Data from the Highway Safety Information System (HSIS) for the state of North Carolina was used for analysis and modeling. A partial proportional odds model was developed to examine the effect of each variable on injury severity of at-fault driver and not at-fault driver, and, to examine how each variable affects these two drivers' injury severity differently. Road characteristics, weather condition, and geometric characteristics were observed to have a similar effect on injury severity in a crash to at-fault and not at-fault drivers. Age of the driver, physical condition, gender, vehicle type, and, the number and type of traffic rule violations were observed to play a significant role in the injury severity of not at-fault drivers when compared to at-fault drivers in the crash. Moreover, motorcyclists and drivers 70 years or older are observed to be the most vulnerable road users.

1. Introduction

Road crashes affect the society in numerous ways; they impede development, pose threat to public health, and result in economic losses. Each year, approximately 1.24 million people are killed, and 50 million people are injured in traffic crashes worldwide (World Health Organization (WHO), 2009). Over the last two decades, researchers have used several methods to analyze and understand the causes of crashes. Undoubtedly, the results have provided valuable insights about the contributing factors related to road geometry, driver characteristics, weather and environment, vehicle features, etc. associated with crash frequency and severity. These insights are useful in selecting and implementing countermeasures that help transportation officials reach the "zero deaths on roads" vision. Since the year 1966, with a 7.2% increase, year 2015 had the largest increase in traffic fatalities compared to year 2014 (Brown, 2016). The early trends of fatalities predicted a similar increase for year 2016. Therefore, there is a need to better understand the causes and factors associated with road crashes.

Human factors play a predominant role among various factors associated with crashes (Blanco, 2013). Aberrant driving behavior is a vital human factor that contributes to road crashes; they can be either intended deviations or unforced errors. Deviations of drivers from safe practices are not recommended since they increase the chances of getting involved in crashes. Safe practices are put forward as traffic rules by transportation system managers. For example, drivers are required to come to a complete stop at a stop light. Similarly, drivers should be traveling at or below the posted speed limit under ideal conditions. Such kind of traffic rules ensure a smooth traffic flow while ensuring safety on roads. However, drivers deviate from these safe practices and get involved in crashes. For instance, speeding and driving under the influence of alcohol accounted for 58% of the road deaths in the United States in year 2014 (National Center for Statistics and Analysis, 2016). More than 50% of the drivers involved in crashes committed some type of violation (Penmetsa and Pulugurtha, 2017a).

To reduce, both, crash frequency and crash severity, a thorough understanding of factors that contribute to crashes and severity of crashes is necessary. Discrete choice models are widely used in traffic safety area to identify the effect of independent variables on dependent variable such as driver injury severity, crash severity, or occupant severity. Wang and Kockelman (2005), Savolainen and Mannering (2007), and Chen and Chen (2011) identified the need for developing separate injury severity models for single-vehicle and multi-vehicle crashes. Further, a study by Abdelwahab and Abdel-Aty (2001) concluded that at-fault drivers are less likely to succumb a severe injury when compared to not at-fault drivers, showing the need for examining these two drivers separately. Penmetsa and Pulugurtha (2017b)

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Table 1
Frequency of Variables and Categories.

Variable	Categories	Not At-Fault (%)	At-fault (%)
Driver Injury Severity (Dependent Variable)	PDO	270,249 (77.33)	303,576 (86.87)
	Moderate Injury	77,781 (22.26)	44,286 (12.67)
	Severe Injury	1424 (0.41)	1592 (0.42)
Location	Rural	130,068 (37.22)	
	Urban	219,386 (62.78)	
Road Surface Condition	Dry	289,401 (82.82)	
	Wet	54,740 (15.66)	
	Water Standing/Moving (WSM)	1560 (0.45)	
	Ice	1601 (0.46)	
	Snow	1565 (0.45)	
	Slush	452 (0.13)	
	Sand, Mud, Dirt, Gravel (SMDG)	68 (0.02)	
	Fuel, Oil	8 (< 0.01)	
	Other	59 (0.02)	
Weather Condition	Clear	252,372 (71.82)	
	Cloudy	60,652 (17.36)	
	Rain	32,286 (9.64)	
	Snow	1908 (0.55)	
	Fog, Smog, Smoke (FSS)	1091 (0.31)	
	Sleet, Hall, Freezing Rain/Drizzle (SHFR)	890 (0.25)	
	Severe Crosswinds (SC)	30 (0.01)	
	Blowing Sand, Dirt, Snow (BSDS)	15 (< 0.01)	
	Other	210 (0.06)	
Light Condition	Daylight	283,238 (81.05)	
	Dusk	8060 (2.31)	
	Dawn	4097 (1.17)	
	Dark – Lighted Road (DLR)	29,679 (8.49)	
	Dark – Road Not Lighted (DRL)	23,931 (6.85)	
	Dark – Unknown Lighting (DUL)	364 (0.10)	
	Other	85 (0.02)	
Road Characteristics	Straight – Level	268,266 (76.77)	
	Straight – Hillcrest (SH)	10,597 (3.03)	
	Straight – Grade (SG)	46,655 (13.35)	
	Straight – Bottom (SB)	2485 (0.71)	
	Curve – Level (CL)	11,368 (3.25)	
	Curve – Hillcrest (CH)	1560 (0.45)	
	Curve – Grade (CG)	8060 (2.31)	
	Curve – Bottom (CB)	407 (0.12)	
	Other	56 (0.02)	
Road Classification	Interstate (IN)	33,144 (9.48)	
	US Route (USR)	62,984 (18.02)	
	NC Route (NCR)	59,108 (16.91)	
	State Secondary Route (SSR)	57,854 (16.56)	
	Local Street (LS)	133,301 (38.15)	
	Public Vehicular Area (PVA)	2588 (0.74)	
	Private Road, Driveway (PRD)	76 1(0.02)	
	Other	399 (0.11)	
Road Configuration	One-Way, Not Divided	14,490 (4.15)	
	Two-Way, Not Divided (TWND)	201,622 (57.70)	
	Two-Way, Divided, Unprotected Median (TWDUM)	81,499 (23.32)	
	Two-Way, Divided, Positive Median Barrier (TWDPM)	51,660 (14.78)	
	Unknown	183 (0.05)	
Access	No Access Control	246,193 (70.45)	
	Partial Control (PC)	62,615 (17.92)	
	Full Control (FC)	40,646 (11.63)	
Number of Violations Committed by Fault Driver	One	–	249,555 (71.41)
	Two	–	88,239 (25.25)
Drivers' Gender	Male	180,861 (51.76)	191,893 (54.91)
	Female	168,593 (48.24)	157,561 (45.09)
Drivers' Age	< = 18 years	15,568 (4.45)	35,308 (10.10)
	19–25 years	54,902 (15.71)	82,604 (23.64)
	26–40 years	108,858 (31.15)	93,577 (26.78)
	41–55 years	99,583 (28.50)	69,591 (19.91)
	56–70 years	55,744 (15.95)	44,503 (12.74)
	> 70 years	14,799 (4.23)	23,871 (6.83)
Vehicle Type	Passenger Car (PC)	191,833 (54.90)	200,982 (57.51)
	Pickup/Light Truck/Van (PLTV)	73,967 (21.17)	73,730 (21.10)
	Sports Utility Vehicle (SUV)	67,842 (19.41)	60,040 (17.18)
	Bus	1784 (0.51)	979 (0.28)
	Truck/Tractor or Truck/Tractor Trailer (TT)	9848 (2.82)	10,785 (3.09)
	Farm Vehicle (FV)	0 (0.00)	4 (< 0.01)
	Two-wheeler (TW)	3016 (0.86)	2071 (0.59)
	Other	1164 (0.33)	863 (0.25)

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