#### Examining the Role of Driving Volatility on Intensity of Crashes: Insights from Naturalistic Driving Study Data

Ramin Arvin PhD Candidate



The paper is published in the journal of Accident Analysis and Preventation

# Introduction

- Each year, near \$1 Trillion crash cost in the U.S.
- Tennessee (2018):
  - 24,612 distracted driving crashes
  - 996 fatalities
- Note: Certain types of crashes are **under-reported** in such databases.
  - Specifically, a National Highway Traffic Safety Administration report: 50% of no-injury crashes and 25% of minor injury crashes are unreported.
- Availability of high-resolution naturalistic driving study → In depth analysis of crash contributing factors
- Information on driver behavior and vehicle kinematics help us to investigates their contribution on crash severity



# Main objectives:

- 1. Instead of analyzing conventional police-reported crashes that do not contain microscopic vehicle kinematic information, this study analyzes pre-crash kinematic data and extracts a different set of contributing factors.
- 2. Study the association of driver behavior, roadway/environmental factors on driving stability
- 3. Analyze correlations of crash severity with speed and stability



# **Conceptual framework**

Safety features

#### Associated factors, XDriver Behavior: Distracted driving • Driving instability, $Y_1$ Aggressive driving Seatbelt use ٠ $\beta_1$ Speed volatility Both hands on wheel Acceleration volatility Deceleration volatility Roadway and environmental factors: Location of crash • Relation to junction ٠ γ Intersection influence ٠ Traffic density ٠ Road alignment ٠ Crash intensity, $Y_2$ Traffic flow ٠ Light condition ٠ $\beta_2$ Low-risk Tire Strike $\beta_3$ ٠ Weather condition • Driving speed Minor crash ٠ Surface condition (V)Police-reportable crash ٠ Most severe Vehicle-specific factors Vehicle type Vehicle age



# Path analysis

 Model 1 (*f*volatility): Estimates the impact of driving behavior and surrounding environment factors on the driving volatility prior to crash:

 $Y_1 = f_{volatility}(\alpha_1 + \beta_1 X_1)$ 

• Model 2 (*f*<sub>severity</sub>): Estimates the severity outcome of the crash using the direct association of driving volatility, speed, driver behavior, and roadway factors to the crash severity

$$Y_2 = f_{severity}(\alpha_2 + \beta_2 X_2 + \gamma Y_1 + \beta_3 V)$$



## Data

- Second Strategic Highway Research Program (SHRP 2) is used
- Biggest naturalistic driving study High-quality data on more than 3500 drivers
- 617 crashes containing the information on 30 seconds of vehicle kinematic data
- 20 seconds of data is used for each crash

*Level 1 Severe Crash*: includes any injury, airbag deployment, vehicle rollover, or highdelta V.

*Level 2 Crash Moderate Severity:* Not a level 1 crash. Crashes that are minimum \$1500 damage worth. Also, the crashes that acceleration reaches  $\pm 1.3$  g.

*Level 3 Crash Minor Severity:* Not a level 1 or 2 crash. The crashes that the vehicle contacts other objects, or crashes that vehicle depart from the road and sustain minimal damage.

*Level 4 Crash Tire Strike:* Not a level 1, 2 or 3 crash. Crashes that the tire is struck with little risk element.



# Instability in driving

Driving volatility: Quantifies variations in instantaneous driving behavior

Measures of volatility	Formulation		
Time-varying stochastic volatility	$V_{f} = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (r_{i} - \bar{r})}$		
Standard Deviation	$S_{dev} = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}$		
Coefficient of Variation	$C_{v} = \frac{SD}{\bar{x}} * 100$		
Quartile Coefficient of Variation	$Q_{cv} = \frac{Q_3 - Q_1}{Q_3 + Q_1} * 100$		



## **Exclusion of evasive maneuver**





8



## **Descriptive Statistics**

Description	Mean/	S.D./	Min	Max
Description	Percent	frequency		
Low-risk Tire Strike	40.19%	248	0	1
Minor Crash	36.79%	227	0	1
Moderate Crash	13.61%	84	0	1
Severe Crash	9.4%	58	0	1
Two hands on wheel	46.52%	287	0	1
Other	53.48%	330	0	1
Aggressive driving	9.72%	60	0	1
None	90.28%	557	0	1
Distracted driving	64.67%	399	0	1
None	35.33%	218	0	1
Seatbelt used	90.6%	559	0	1
No	9.4%	58	0	1
	Description Low-risk Tire Strike Minor Crash Moderate Crash Severe Crash Two hands on wheel Other Aggressive driving None Distracted driving None Seatbelt used No	DescriptionMean/ PercentLow-risk Tire Strike40.19%Minor Crash36.79%Moderate Crash13.61%Severe Crash9.4%Two hands on wheel46.52%Other53.48%Aggressive driving9.72%None90.28%Distracted driving64.67%None35.33%Seatbelt used90.6%No9.4%	Description Mean/ Percent S.D./ frequency   Low-risk Tire Strike 40.19% 248   Minor Crash 36.79% 227   Moderate Crash 13.61% 84   Severe Crash 9.4% 58   Two hands on wheel 46.52% 287   Other 53.48% 330   Aggressive driving 9.72% 60   None 90.28% 557   Distracted driving 64.67% 399   None 35.33% 218   Seatbelt used 90.6% 559   No 9.4% 58	Description Mean/ Percent S.D./ frequency Min   Low-risk Tire Strike 40.19% 248 0   Minor Crash 36.79% 227 0   Moderate Crash 13.61% 84 0   Severe Crash 9.4% 58 0   Two hands on wheel 46.52% 287 0   Other 53.48% 330 0   Aggressive driving 9.72% 60 0   None 90.28% 557 0   Distracted driving 64.67% 399 0   None 35.33% 218 0   Seatbelt used 90.6% 559 0



# Pathway diagram



## Results

 Driving stability in terms of speed and deceleration volatility are highly correlated with the crash severity

Distracted driving directly and indirectly increase the probability of severe crash

• Higher driving speed increases the likelihood of severe crash





### Thank you!

