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

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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

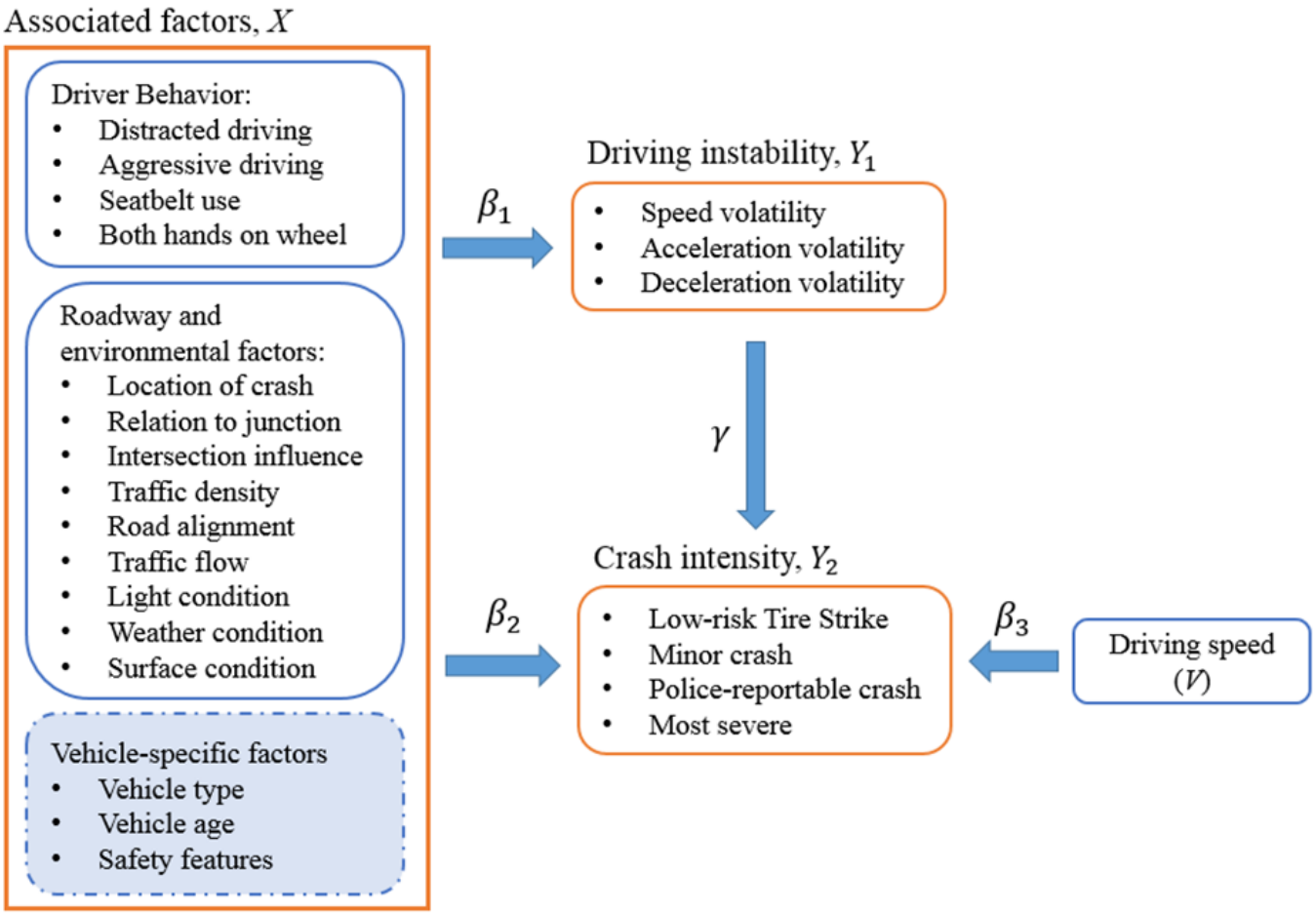
Main objectives:

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



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 ($f_{severity}$): 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 high-delta V.

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

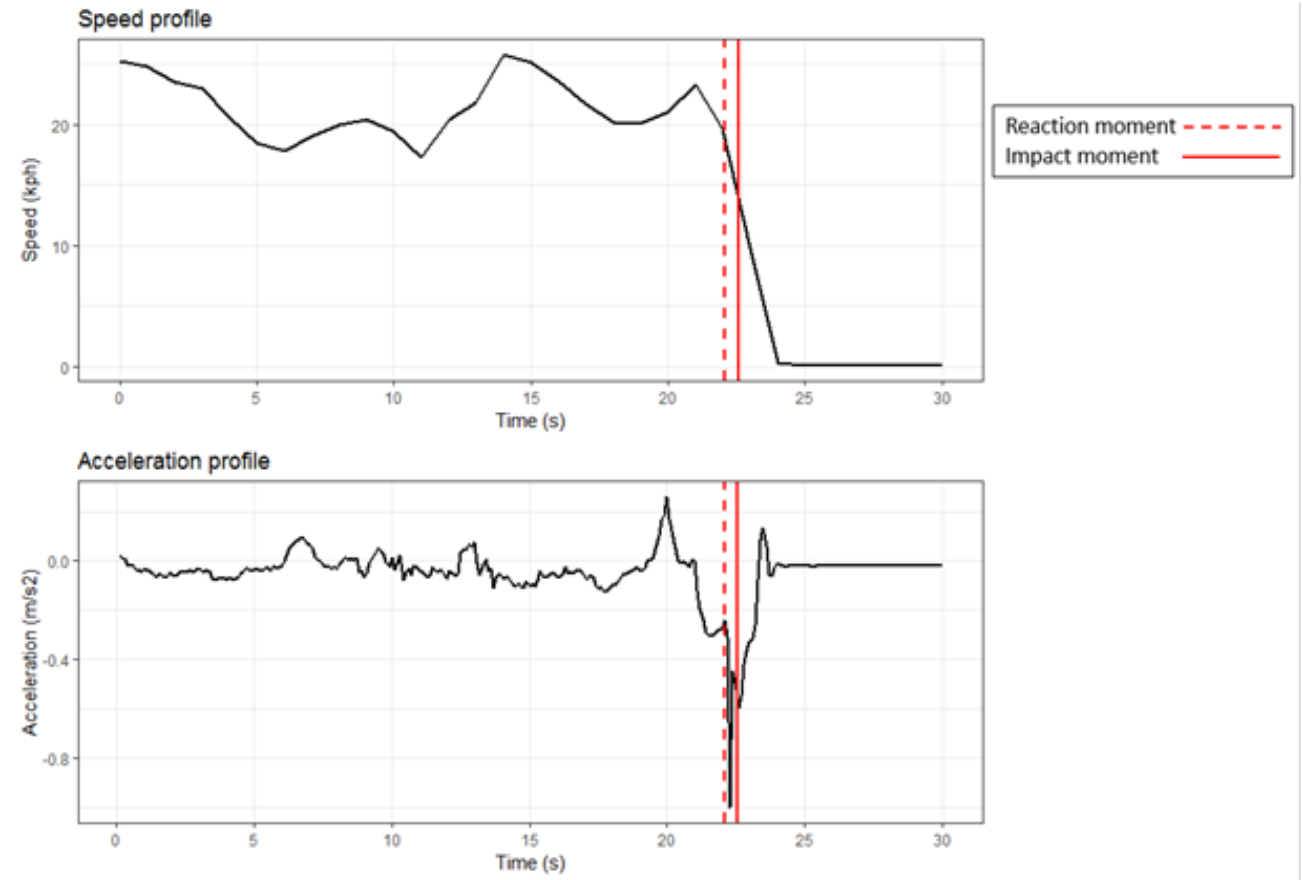
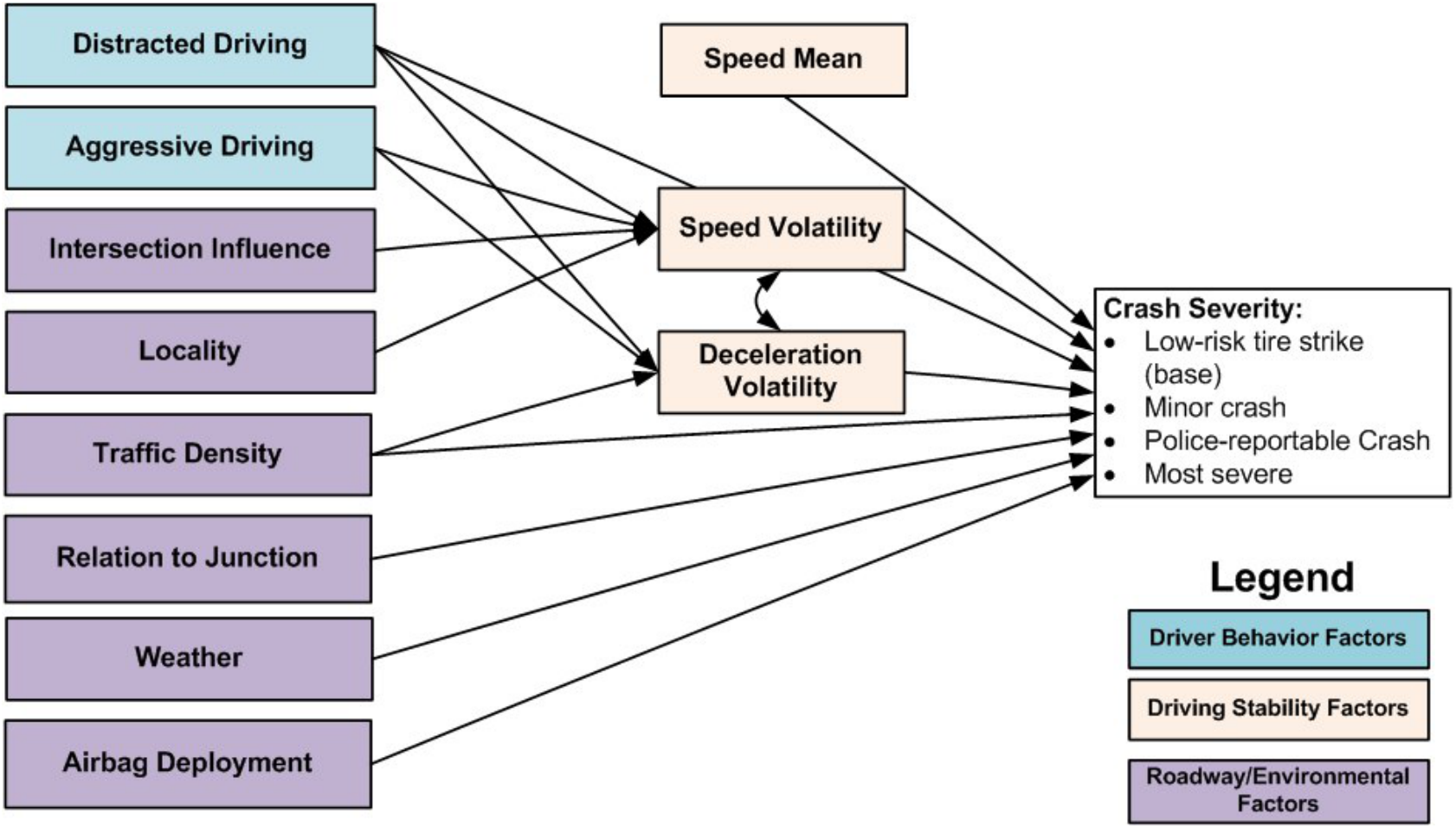


Figure 2 – Speed and acceleration profile of a randomly chosen crash

Descriptive Statistics

Variable	Description	Mean/ Percent	S.D./ frequency	Min	Max
Crash intensity					
	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
Driving behavior					
Hand on wheel	*Two hands on wheel*	46.52%	287	0	1
	Other	53.48%	330	0	1
Aggressive	*Aggressive driving*	9.72%	60	0	1
	None	90.28%	557	0	1
Distracted	*Distracted driving*	64.67%	399	0	1
	None	35.33%	218	0	1
Seatbelt	*Seatbelt used*	90.6%	559	0	1
	No	9.4%	58	0	1

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!

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