

# **Factors Affecting Trucking Safety: A Hierarchical Bayes Model for Critical Events**

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# 1. Introduction

## Background:

- Transportation accidents **1<sup>st</sup>** cause of fatal occupational injury (**over 40%**), leading to over **2,000 deaths** in the US in 2016.
- Trucks → catastrophic accidents:
  1. Long routes,
  2. Huge weight
  3. Potentially hazardous cargo
- Critical events → crashes.
  1. Hard brakes
  2. Rolling stability
  3. Headways

## Hypotheses:

**H1:** The probability of at least a critical event increases as drivers get more cumulative driving time.

**H2:** The probability of at least a critical event differs from one driver to another.

**H3:** The probability of at least a critical event differs with different weather conditions.

## Nature of the problem:

To understand the risk factors associated with truck drivers' unsafety driving behavior.



## 2. Methods

- **Data:** 235 drivers, 22,633 short trips, 642 critical events by J.B.Hunt in May 2015
- **Statistical models:**

$$Y_i \sim \text{Bernoulli}(P_i)$$

$$g(P_i) = \beta_{0,d(i)} + \beta_{0,d(i)} \cdot CT_i + \xi \cdot W_i + \nu \cdot D_i + \log(t_i)$$

- $Y_i$ : Whether critical event occurred or not in a trip
- $CT_i$ : cumulative driving time
- $W_i$ : road visibility, precipitation probability, and precipitation intensity
- $D_i$ : driver's age and business unit
- $t_i$ : length of time for each trip
- **Priors:** flat priors  $\rightarrow$  Normal  $(0, 10^2)$  or Gamma  $(1, 1)$
- **Algorithm:** Hamiltonian Monte Carlo, No-U-Turn Sampler
- **Software package:** R and Stan



# 3. Roadmap

## Hypothesis 2

Driver random effects

Driver age

Driver business unit

Driver characteristics

$D_i$

Cumulative driving time

## Hypothesis 1 & 2

Fatigue

$CT_i$

$Y_i$   
Critical events

Traffic crashes

Precipitation probability

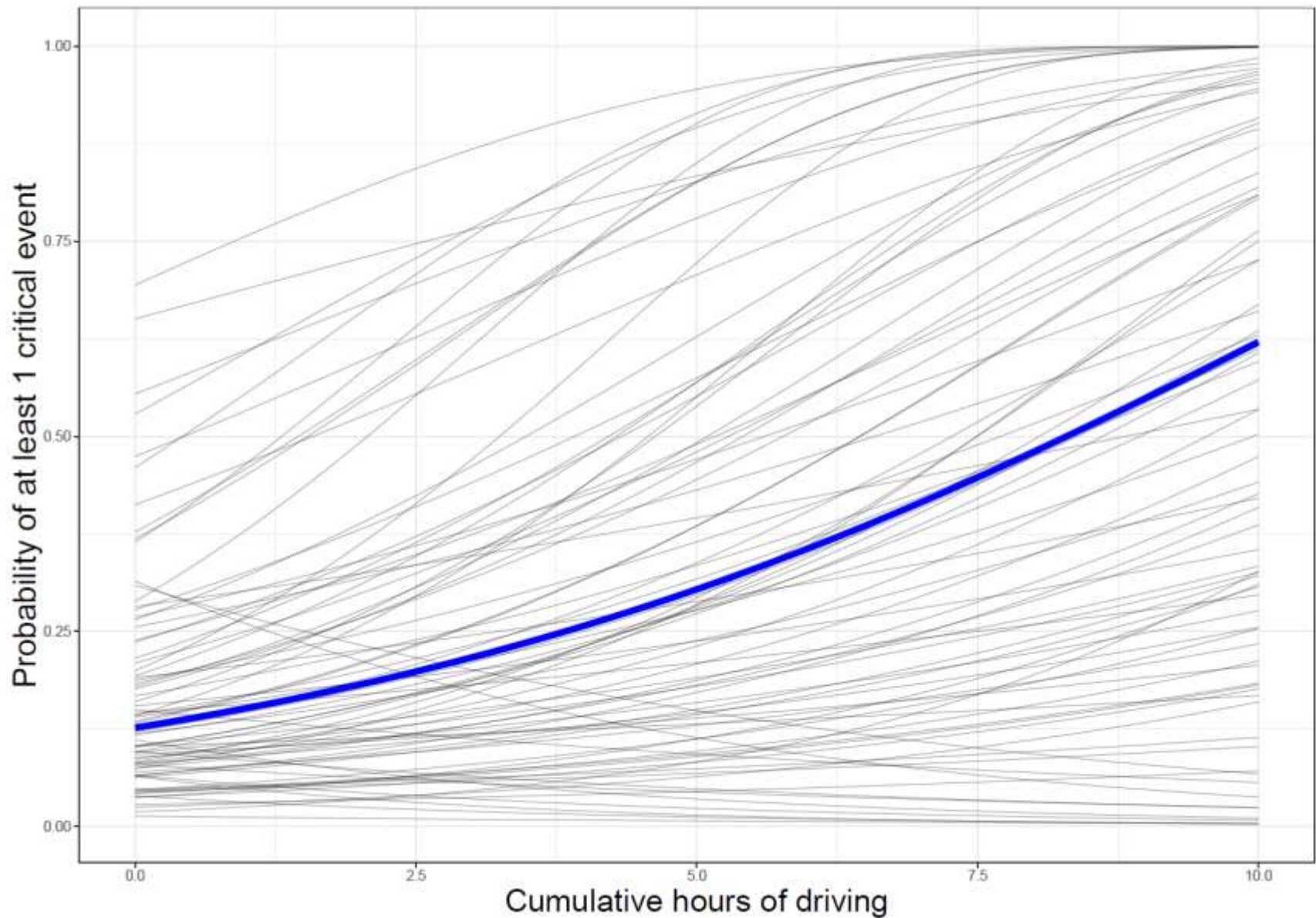
Precipitation intensity

Visibility

Environmental characteristics

## Hypothesis 3

$W_i$



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The mean of slope hyperparameter: **0.197**;  
95% credible interval: **[0.014, 0.281]**

**Hypothesis 1  $\checkmark$**

# 4. Results, conclusion, & implications

## Results:

- Truck driver's cumulative driving time was associated with higher probability of having critical events (posterior mean of slope hyperparameter: 0.197; 95% credible interval: [0.014, 0.281]). **Hypothesis 1** ✓
- These drivers demonstrated different patterns of fatigue,  $\sigma=0.073$ , 95% credible interval: [0.032, 0.114]. **Hypothesis 2** ✓
- The 95% credible intervals of these weather variables cover zero. **Hypothesis 3** ✗
- Driver's age was associated with **lower probability** of having critical events (posterior mean: -0.229, 95% credible interval: [-0.374, -0.084]).

**Conclusion:** Truck drivers demonstrate significantly higher risk of having critical events when they have been working in a long shift. This fatigue pattern varies substantially by drivers.



# Q & A



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