Characterizing Interstate Crash Rates Based on Traffic Congestion Using Probe Vehicle Data

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Abstract

Crash reduction factors are widely used by engineers for prioritizing safety investments. Work zones are routinely analyzed by the length and duration of queues. Queue detection warning technology has been growing in availability and reliability in recent years. However, there is sparse literature on the impact of freeway queueing on crash rates. This paper analyzes three years of crash data and crowd-sourced probe vehicle data to classify crashes as being associated with queueing conditions or free flow conditions. In 2014, only 1.2% of the distanced-weighted hours of operation of Indiana interstates operated at or under 45 MPH. A three-year study on Indiana interstates indicates that commercial vehicles were involved in over 87% of back-of-queue fatal crashes compared to 39% of all fatal crashes during free flow conditions. A new measure of crash rate was developed to account for the presence and duration of queues: crashes per mile-hour of congestion. The congested crash rate on all Indiana interstates in 2014 was found to be 24 times greater than the uncongested crash rate. Queues are found to be present for five minutes or longer prior to approximately 90% of crash rate is 21 times the uncongested crash rate. Queues are found to be present for five minutes or longer prior to approximately 90% of congestion crashes in 2014. Longer term, this information shows the importance in the development of technology that can warn motorists of traffic queues.

Interstate Crash Rates in 2014

- Overall Crash Rate Ratios
  - Congested Crash Rate: 1.14
  - Overall Crash Rate: 5.98
  - Overall Crash Rate (Ratio): 24.1

Mile-Hours of Congestion as Exposure

- Miles-Hours of Congested Conditions (Speed ≤ 45 MPH) by Interstate in 2014
- Percentage of Total Mile-Hours in 2014
  - Total Congested Mile-Hours
  - Total Uncongested Mile-Hours
  - Total Congested Mile-Hours with No Data

Queue Duration Prior to Crash

- Duration of Queue Before Fatal Back-of-Queue Crash
- Pareto Sort of Congestion Duration for All Crashes in 2014
- Back-of-Queue Crash Visualizer Website

Data Example

- Number of Fatal Crashes on Indiana Interstates by Year
- Percent of Fatal Crashes that Involved Trucks, 2012-2014

Uncongested crash rate = \( \frac{\text{Number of crashes in uncongested traffic}}{\text{Segment length} \times \text{Number of uncongested hours}} \)

Congested crash rate = \( \frac{\text{Number of crashes in congested conditions}}{\text{Segment length} \times \text{Number of congested hours}} \)

Overall Crash Rate Ratios

- Overall Crash Rate: 5.98
- Overall Crash Rate (Ratio): 24.1

Queue Crash:

- Queue Crash: Visualizer Website
- Crash Rate Ratio: Congested Crash Rate: 1.14
- Uncongested Crash Rate: 5.98

> Crash Rate Ratio = \( \frac{\text{Congested Crash Rate}}{\text{Uncongested Crash Rate}} \)

> Overall Crash Rate Ratio: 24.1

Back-of-Queue Crash: Probe Data Example

- Time-Space Diagram with Probe Data
- Shockwave Diagram Created from Probe Data
- Pareto Sort of Congestion Duration for All Crashes in 2014

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