

# **Understanding how darkness affects crash risk: Direct comparisons between dark and light conditions**

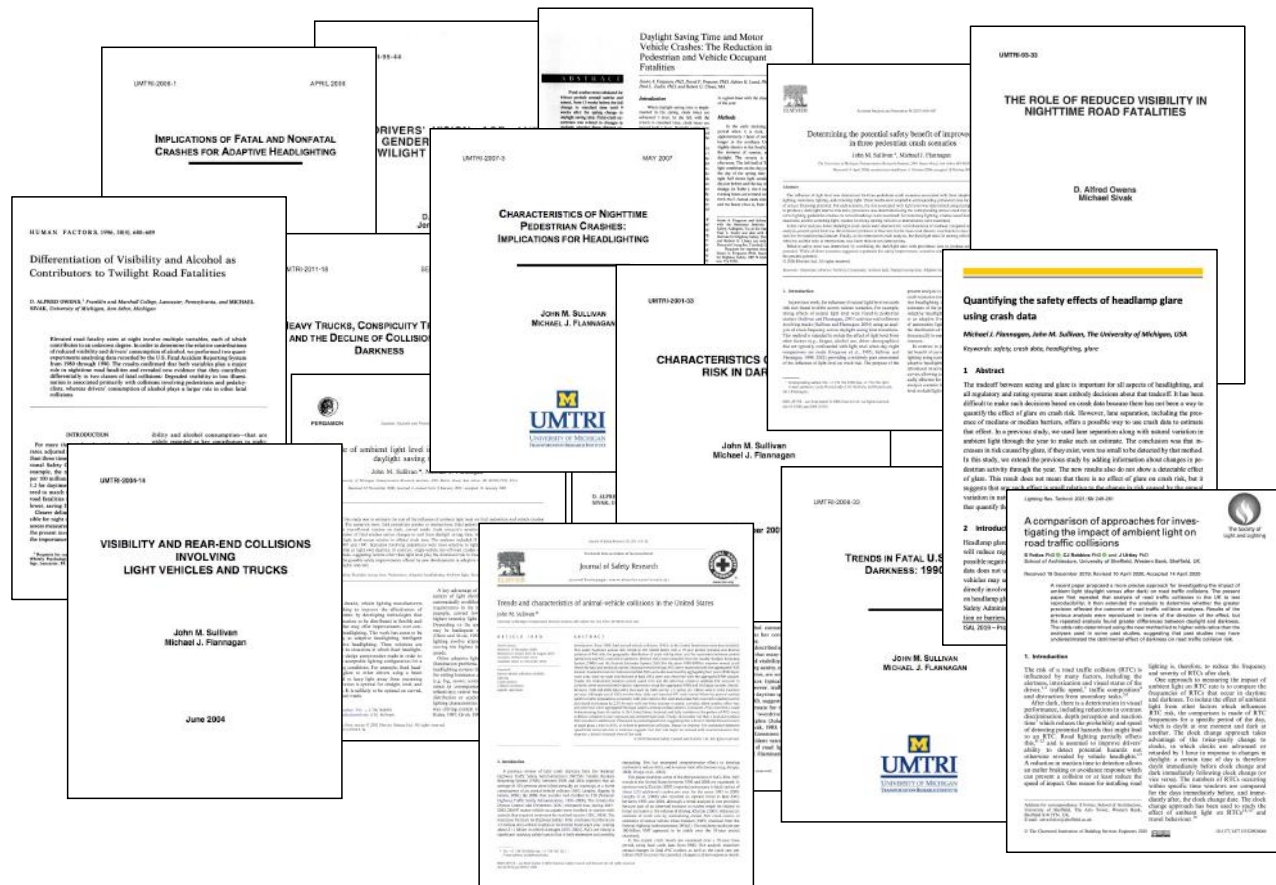
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The University of Michigan  
Transportation Research Institute  
(UMTRI)

September 21, 2021  
DVN  
Novi, MI

# Outline

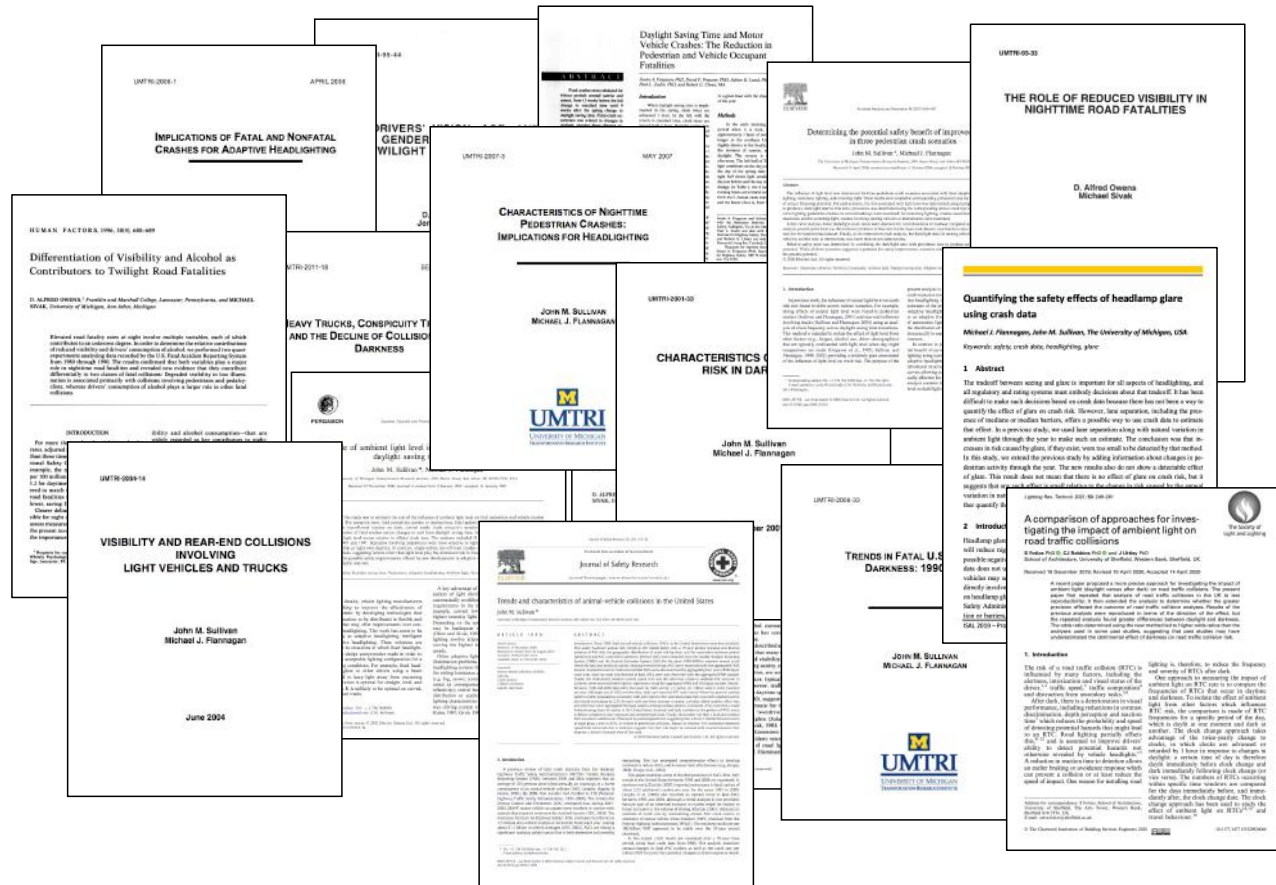
- Background and rationale
- Older findings on effects of darkness by crash type
- Newer results on headlamp glare
- Implications for advanced lighting

# Studies of natural light and crash risk, 1993-2021



## Rationale

**If (and only if?) darkness is the cause of increased risk, artificial lighting is a likely countermeasure.**

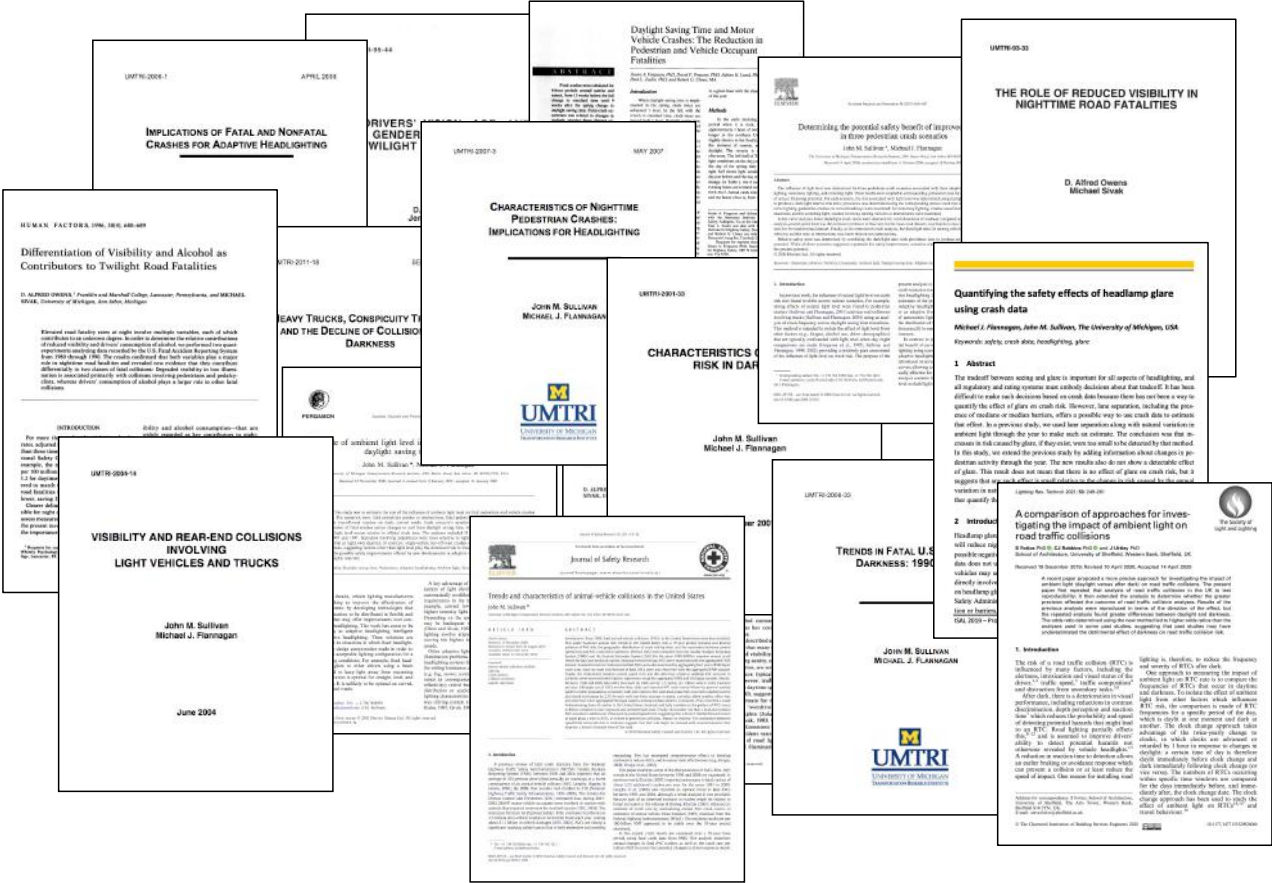


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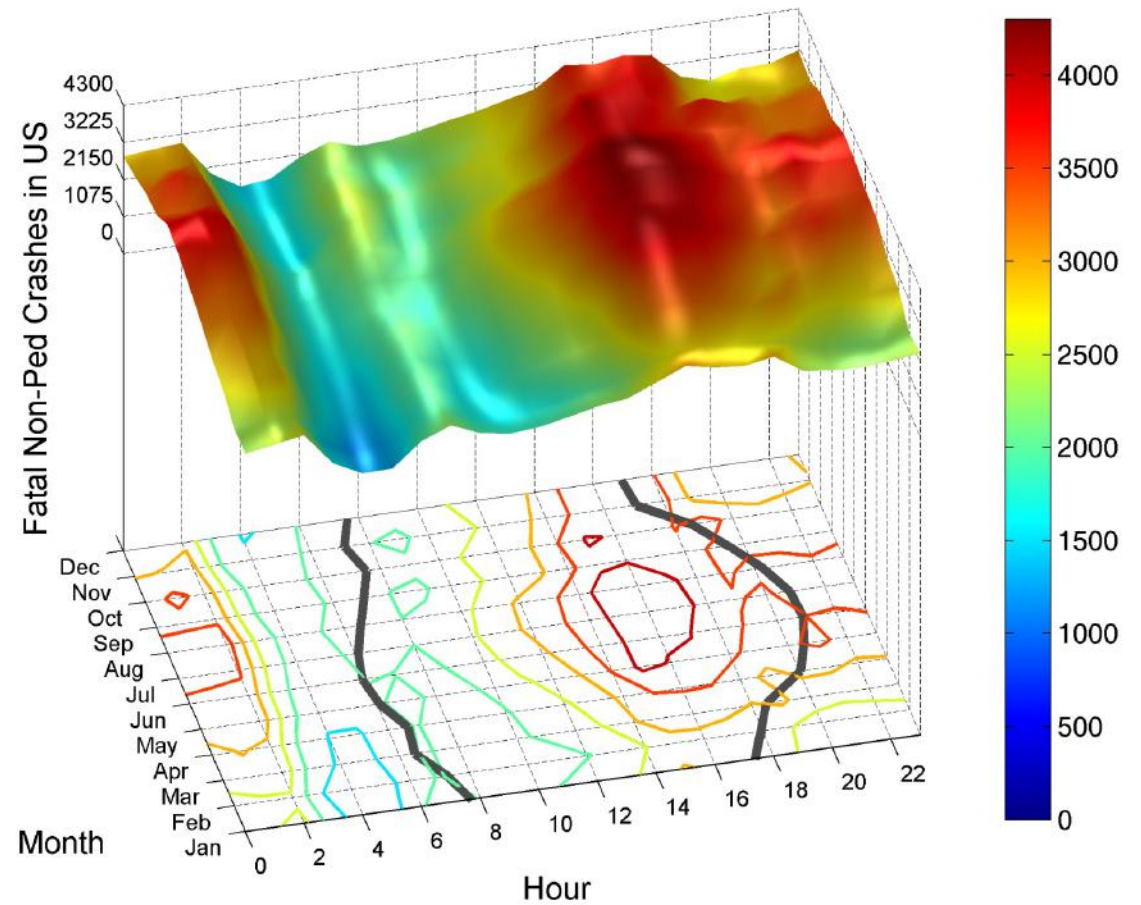
## General method

- **Separate risk & exposure**
- **How to treat exposure**
  - Assume travel is tied to time of day
  - Use travel survey data
- **Disassociate time of day and light**
  - Seasonal light cycle
  - Daylight saving time



## Crashes by hour and month (US, FARS, 1987-2003)

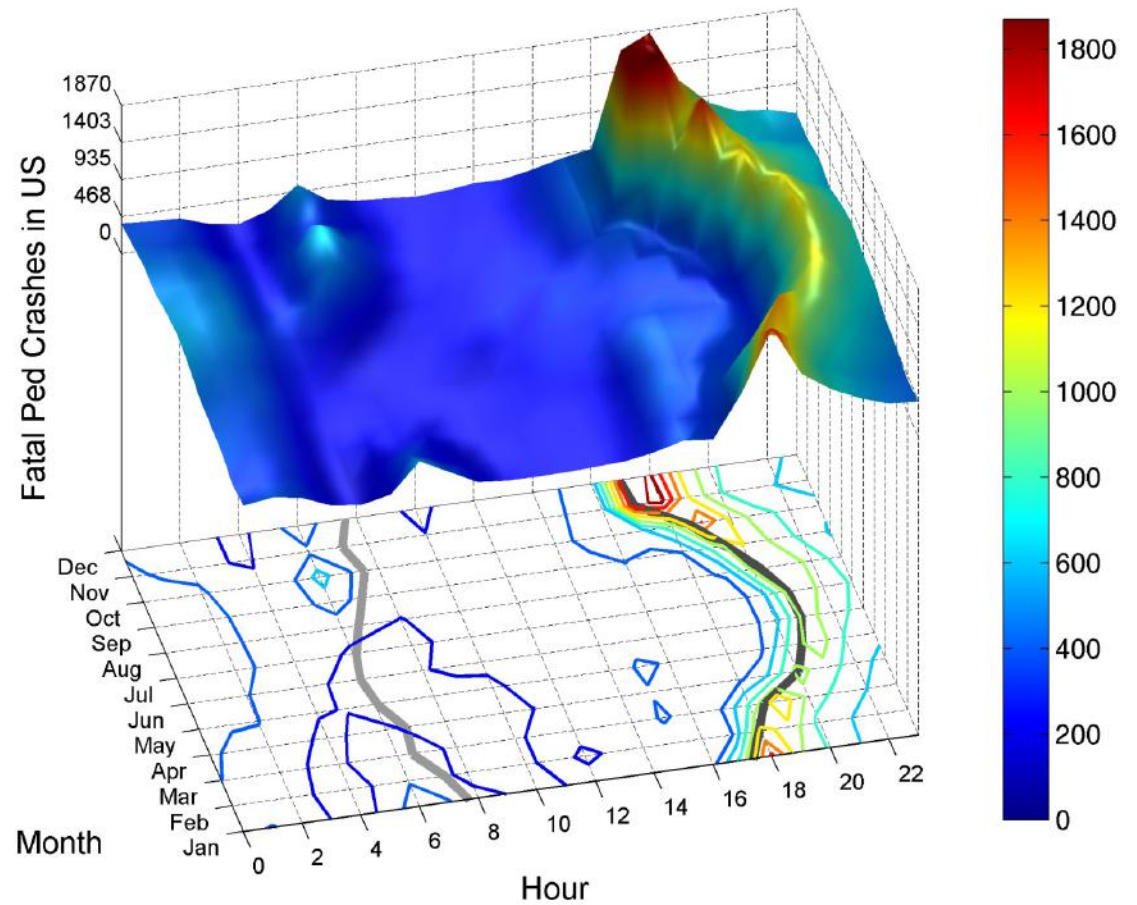
Crashes fatal to occupant





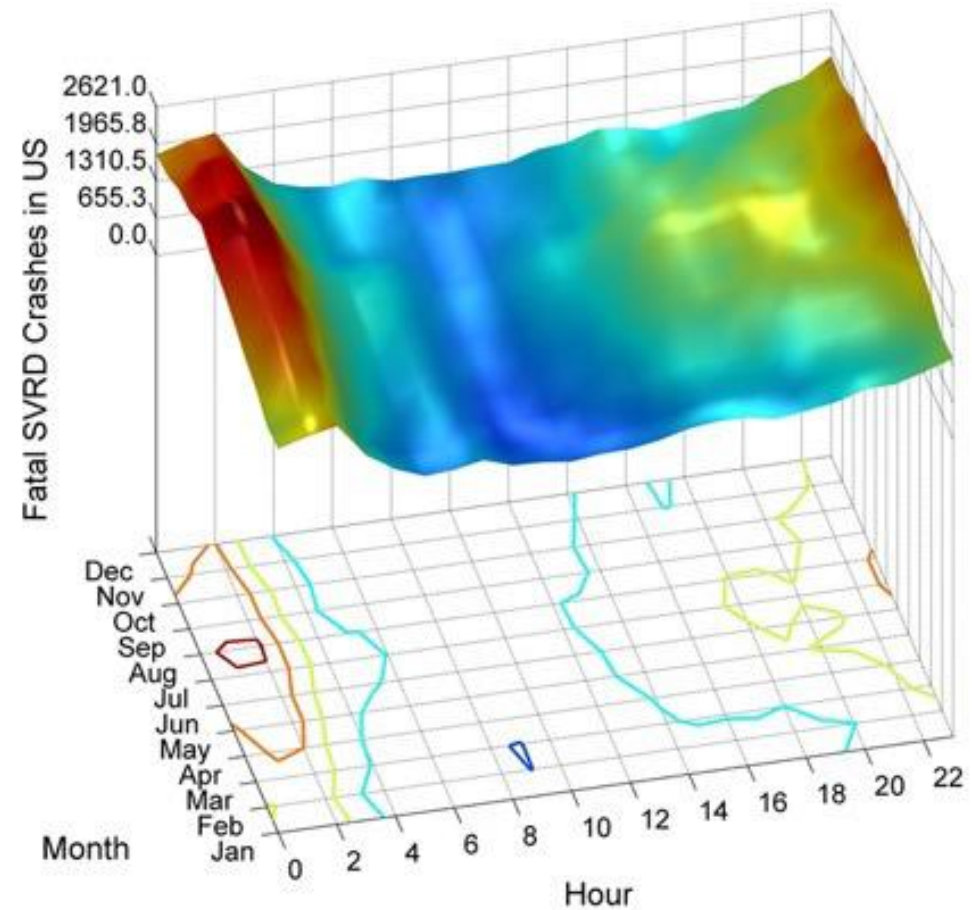
## Crashes by hour and month (US, FARS, 1987-2003)

### Crashes fatal to pedestrian



## Crashes by hour and month (US, FARS, 1987-2003)

### Road-departure crashes





# Examples of dark/light crash ratios

(Fatal crashes, FARS 1987-2004, Sullivan & Flannagan, 2007)

Dark/light risk ratio:

Crash rate in darkness/  
Crash rate in light

(derived from comparable  
conditions, in this case  
based on Daylight Saving  
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## ■ Multiple-vehicle crashes

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| Angle   | 1.22 |
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## ■ Single-vehicle crashes

|                         |      |
|-------------------------|------|
| Pedestrian – adult      | 6.73 |
| Animal                  | 5.55 |
| Fixed object - off road | 0.88 |

Can we use crash data to learn about the effects of headlamp glare on risk?

A possible opportunity:

Lateral lane separation is coded in U.S. FARS crash data.

And lateral separation has a substantial effect on glare light levels.

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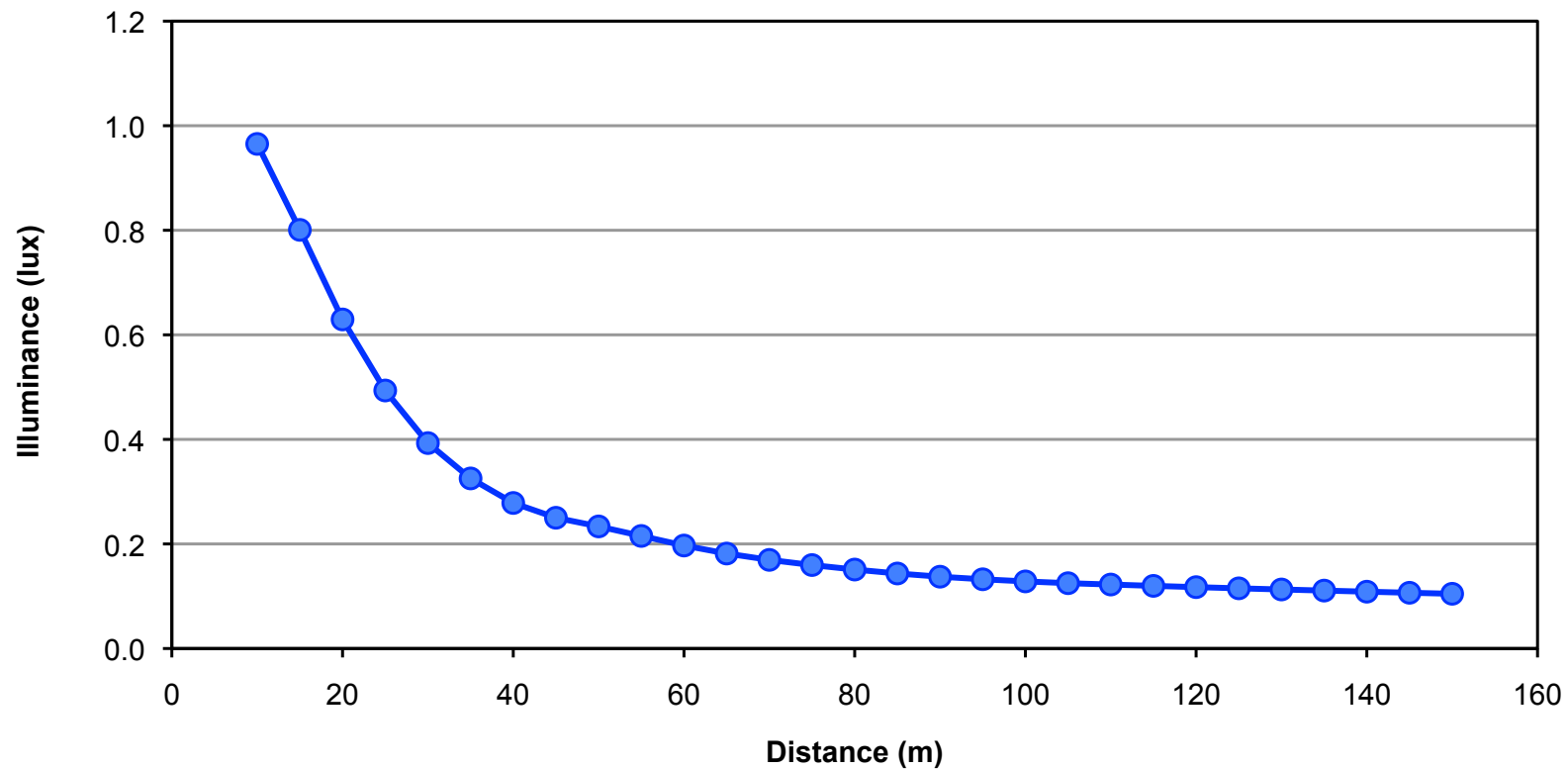
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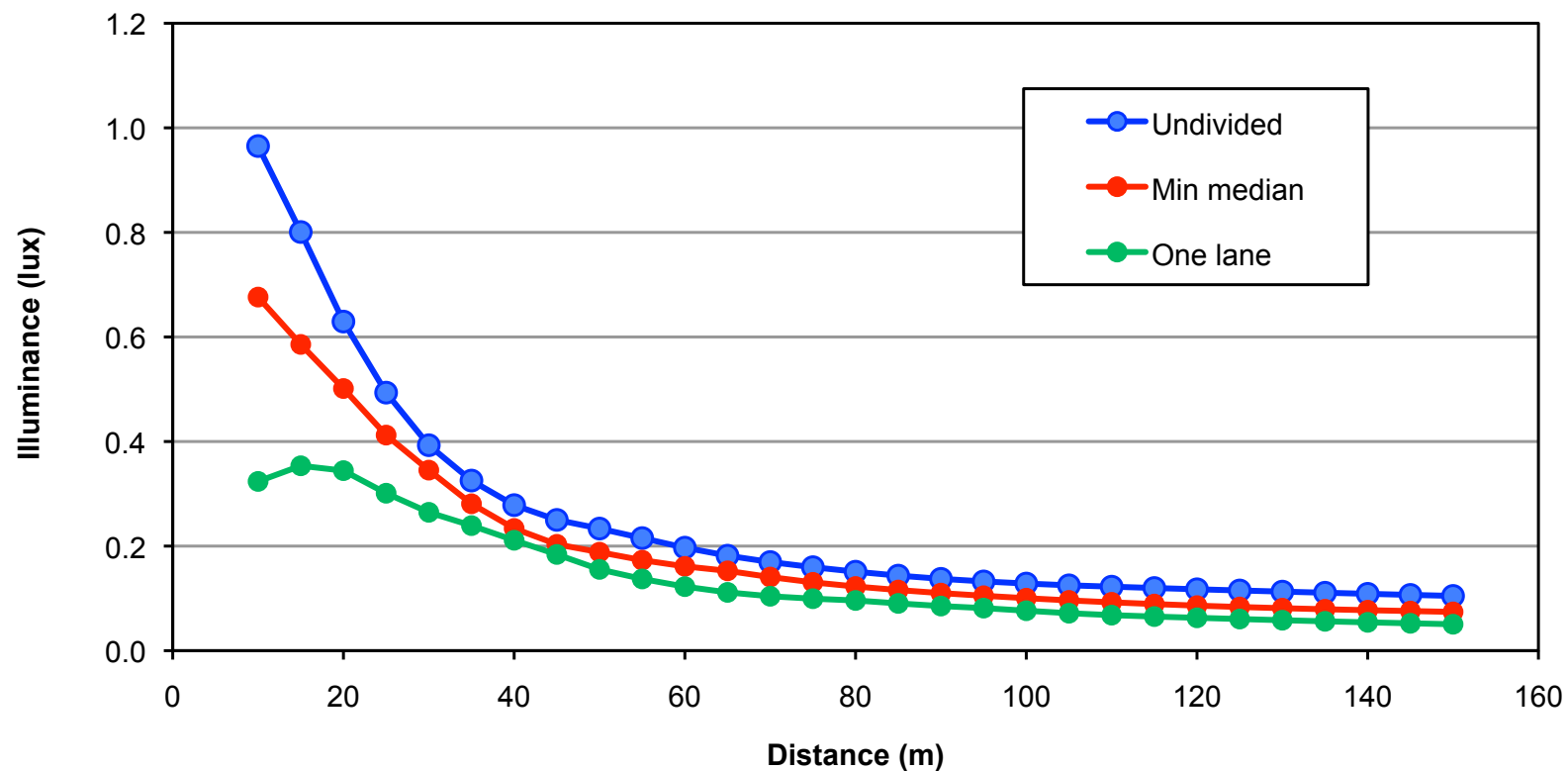


## Glare from lamps of approaching car, undivided two-lane road, median U.S. beam pattern



Flannagan & Sullivan, 2019

## Reduced glare from lamps of approaching car with minimum-width median (1.2 m) or one intervening lane



Flannagan & Sullivan, 2019



## Method:

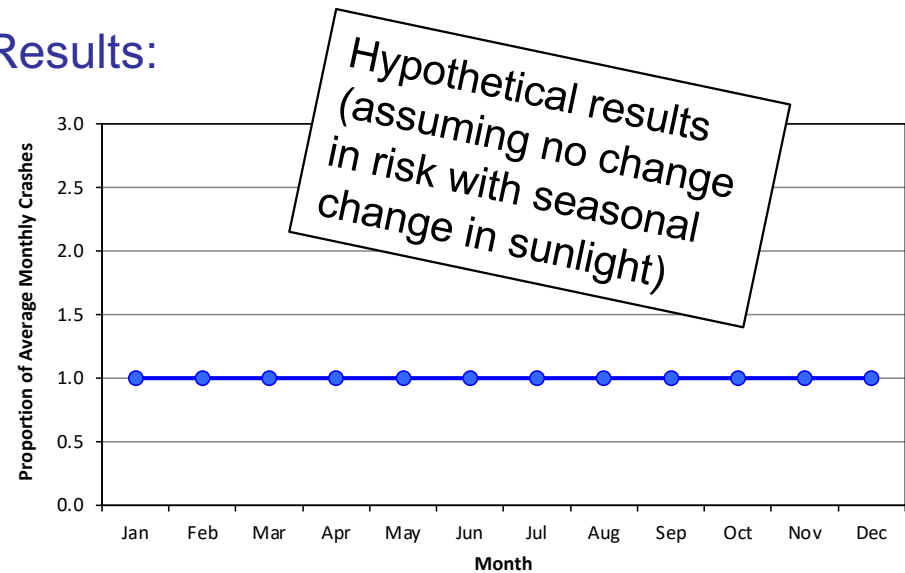
- U.S. pedestrian fatalities from 2015 to 2017 (FARS)
- In the evening twilight period (17:00 – 21:00) which is virtually all light in June and all dark in December
- The difference between the monthly minimum and maximum crash rates therefore provides an estimate of the overall effect of darkness on crash risk.
- The difference between undivided and divided roads provides an estimate of additional risk attributable to the difference in glare.

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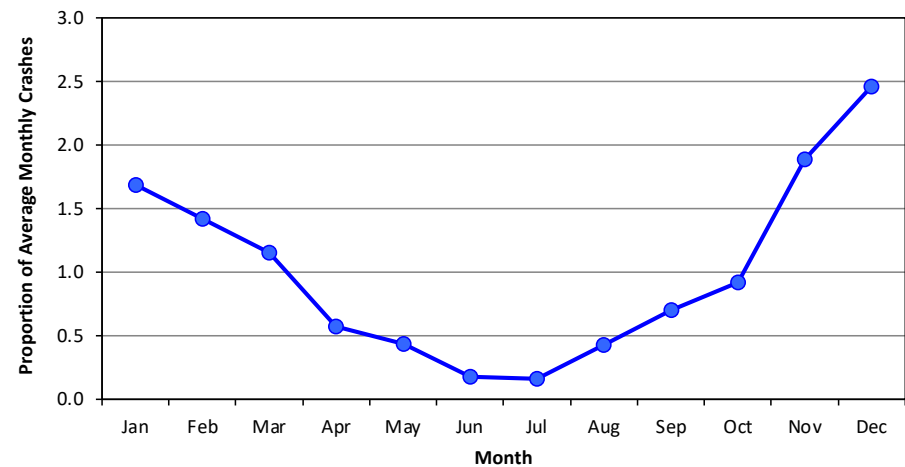
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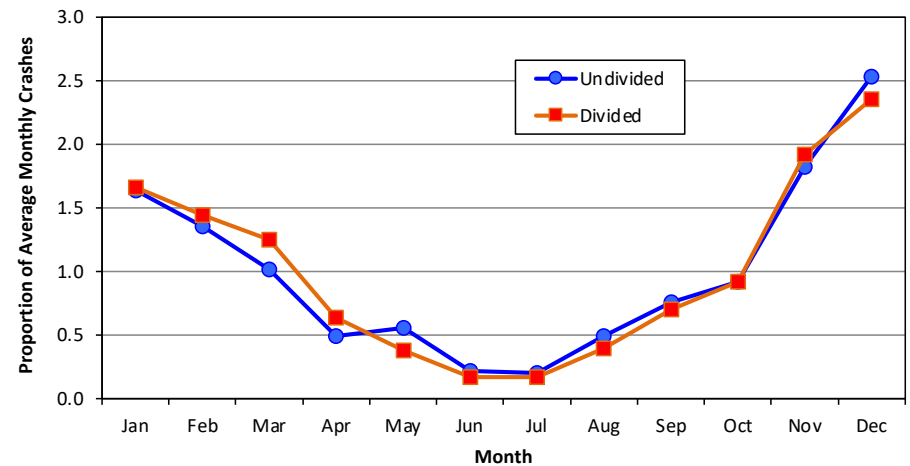
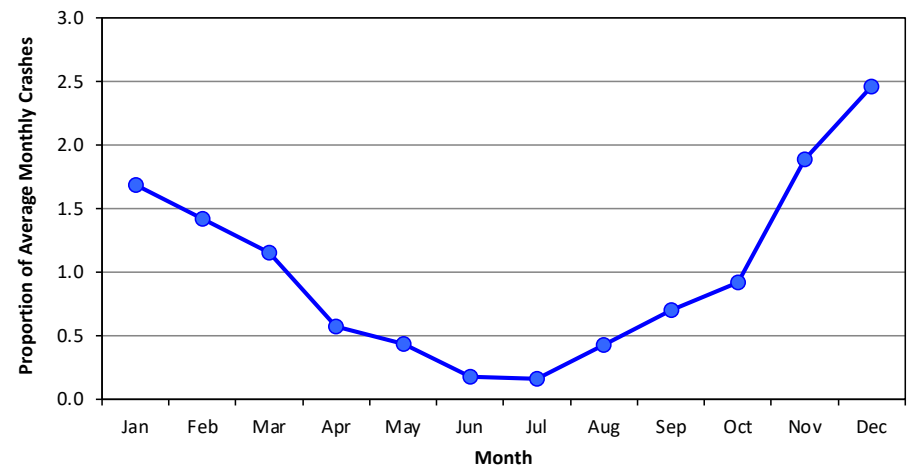
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## UMTRI/GM crash analyses

September 2019



### SAFETY SYSTEM FIELD EFFECTIVENESS

#### HIGH-INTENSITY DISCHARGE (HID) HEADLIGHTS

▼ **21%** NIGHTTIME ANIMAL/PEDESTRIAN/  
BICYCLIST CRASHES

#### FORWARD COLLISION ALERT

▼ **21%** REAR-END  
STRIKING CRASHES

#### LANE KEEP ASSIST W/ LANE DEPARTURE WARNING

▼ **20%** LANE DEPARTURE  
CRASHES

#### REAR VISION CAMERA

▼ **21%** BACKING  
CRASHES

#### REAR CROSS TRAFFIC ALERT W/ REAR VISION CAMERA & REAR PARK ASSIST

▼ **52%** BACKING  
CRASHES

#### INTELLIBEAM

▼ **35%** NIGHTTIME ANIMAL/PEDESTRIAN/  
BICYCLIST CRASHES

#### FORWARD AUTOMATIC BRAKING W/ FORWARD COLLISION ALERT

▼ **46%** REAR-END  
STRIKING CRASHES

#### LANE CHANGE ALERT W/ SIDE BLIND ZONE ALERT

▼ **26%** LANE CHANGE  
CRASHES

#### REAR PARK ASSIST

▼ **38%** BACKING  
CRASHES

#### REVERSE AUTOMATIC BRAKING W/ REAR CROSS TRAFFIC ALERT, REAR VISION CAMERA & REAR PARK ASSIST

▼ **81%** BACKING  
CRASHES

## ON THE ROAD TO ZERO CRASHES

#### HIGH-INTENSITY DISCHARGE (HID) HEADLIGHTS

provides you whiter, brighter low and high beam headlighting than conventional headlamps.

#### FORWARD AUTOMATIC BRAKING

can alert you when a front-end collision is detected to be imminent with a vehicle ahead you are following. It also can help reduce the collision's severity or avoid the collision by automatically applying hard, emergency braking if you have not already, or by enhancing driver hard braking.

#### LANE CHANGE ALERT W/ SIDE BLIND ZONE ALERT

can help you avoid lane change crashes by providing side-mirror alerts when a moving vehicle is detected rapidly approaching a side blind zone or in a side blind zone.

#### REVERSE AUTOMATIC BRAKING

can alert you in Reverse when it detects a collision with a detected object directly behind the vehicle is imminent, and if necessary automatically apply hard emergency braking if you have not already.

#### REAR VISION CAMERA

provides you a view of the scene directly behind the vehicle on the infotainment display (or inside rear-view mirror) to help you park and avoid crashing into nearby objects when in Reverse.

#### INTELLIBEAM

can automatically turn your high beam headlights on and off according to surrounding traffic conditions.

#### FORWARD COLLISION ALERT

can alert you when it detects a front-end collision is imminent with a vehicle ahead you are following. The system also can alert you if you are following a detected vehicle much too closely.

#### LANE KEEP ASSIST W/ LANE DEPARTURE WARNING

can help you avoid crashes due to unintentionally drifting out of your lane by providing gentle steering wheel turns when the system detects you are drifting out of your lane with no turn signal or steering activity. It can also provide Lane Departure Warning alerts when a lane marker is crossed.

#### REAR PARK ASSIST

can provide distance alerts to nearby detected objects behind the vehicle to help you park and avoid objects when in Reverse at low speeds.

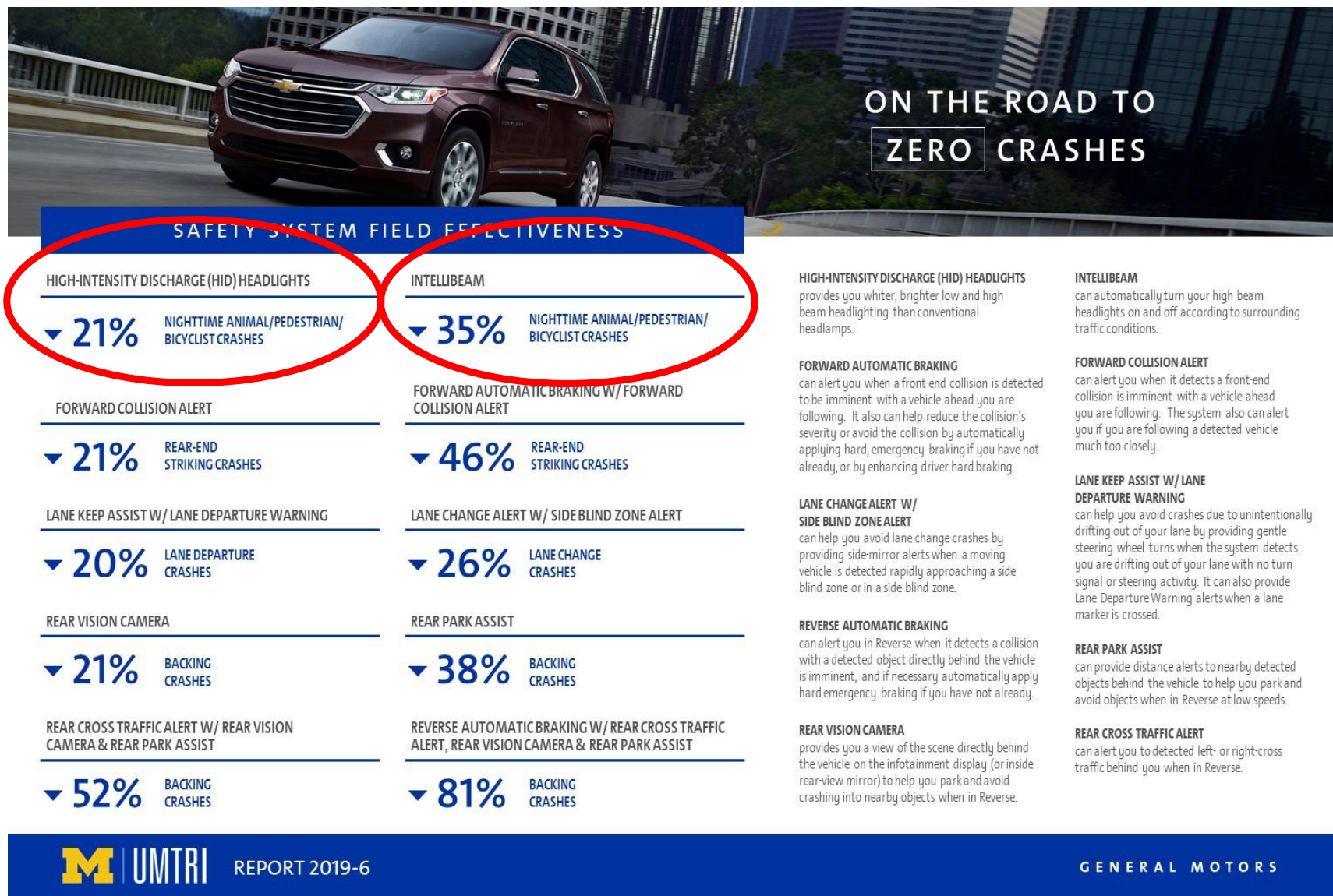
#### REAR CROSS TRAFFIC ALERT

can alert you to detected left- or right-cross traffic behind you when in Reverse.



## UMTRI/GM crash analyses

September 2019





## Summary

- The effects of darkness on risk are strong and specific: pedestrian (and animal) crashes are many times more prevalent in darkness.
- The visual mechanisms for this have long been well understood (e.g., Bhise et al., 1977).
- Improved headlighting has strong potential to reduce pedestrian crashes.
- The effectiveness of advanced headlighting should be straightforward to evaluate.

**Thank you**