Pedestrian Crashes in Michigan: Daylight, Darkness, and Forward Vehicle Lighting

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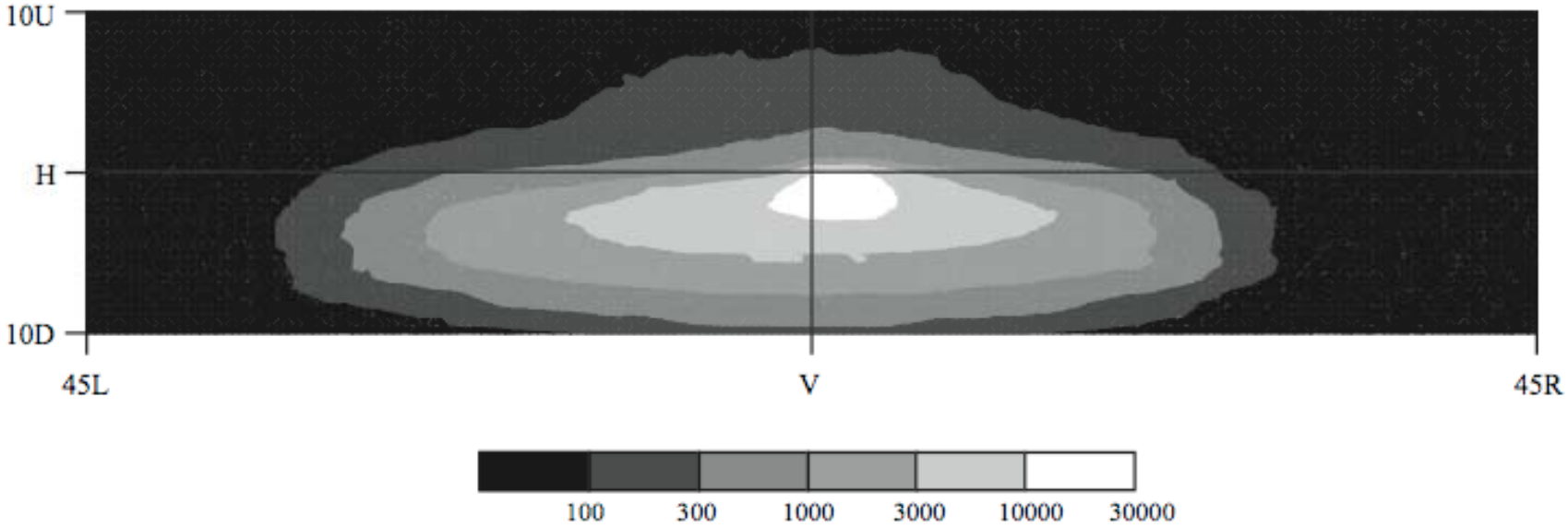
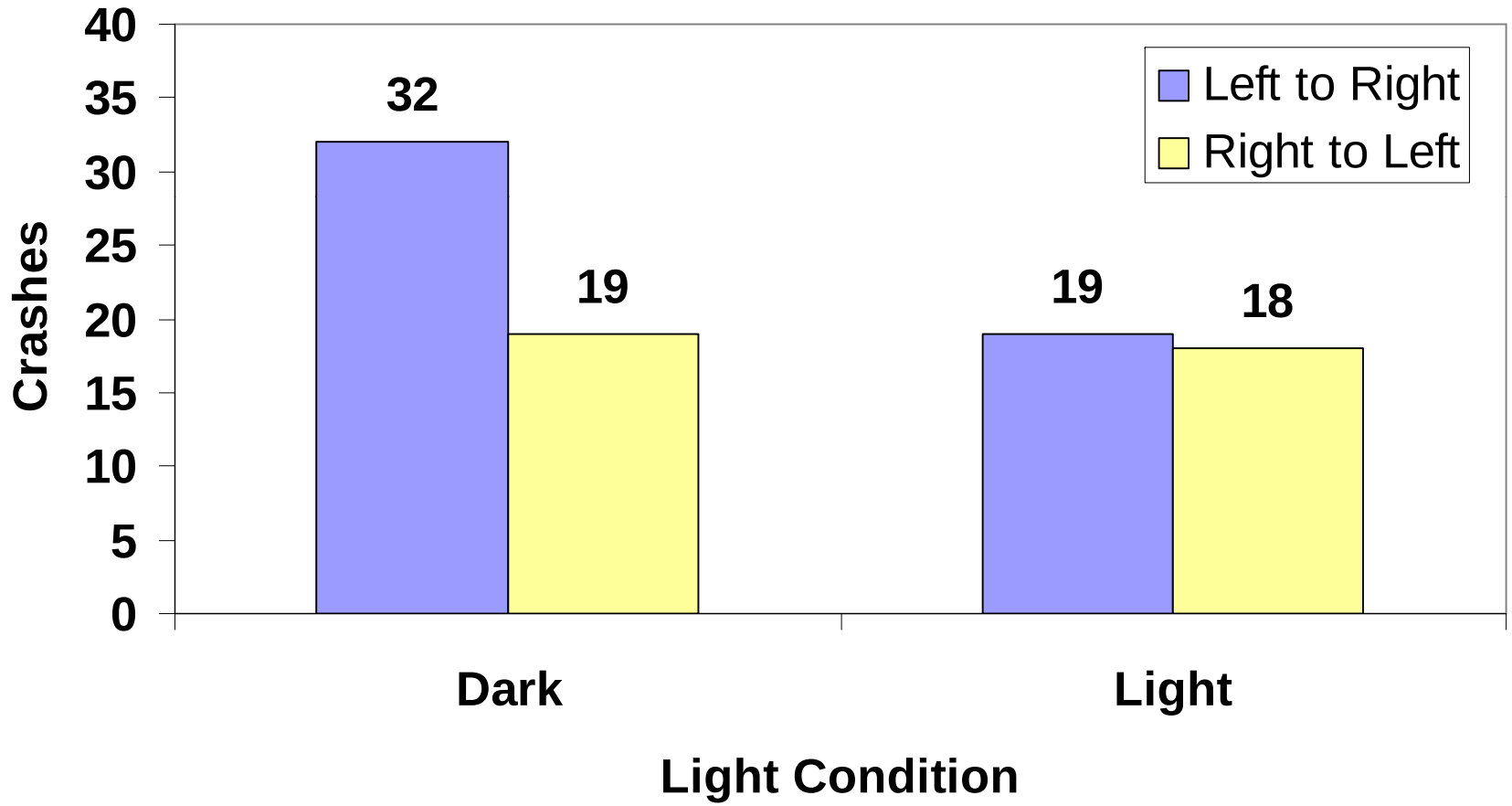
Typical U.S. low-beam photometry



More light is distributed on right, less on left

UMTRI-2004-23

Crash risk of pedestrian crossing direction appears to be asymmetric in the dark



Presentation Overview

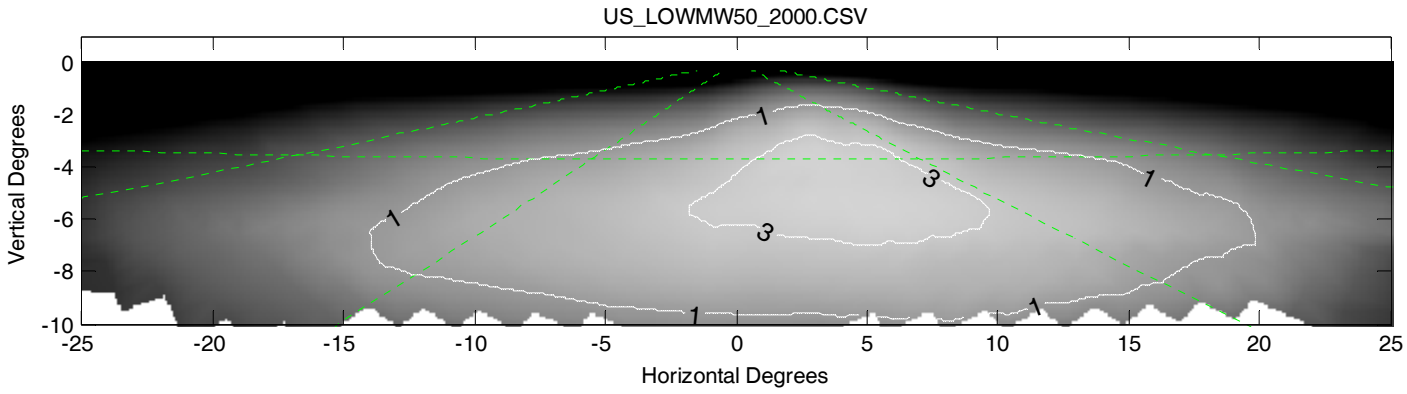
- Background:
  - Pedestrian crashes
  - Low-beam light distribution and use
  - Crash datasets
- Supplementing datasets with police reports
  - Recovering geometric information from crash diagrams
  - Recasting reports using vehicle-centric geometry
- Analysis of pedestrian crashes in Michigan
- Conclusions

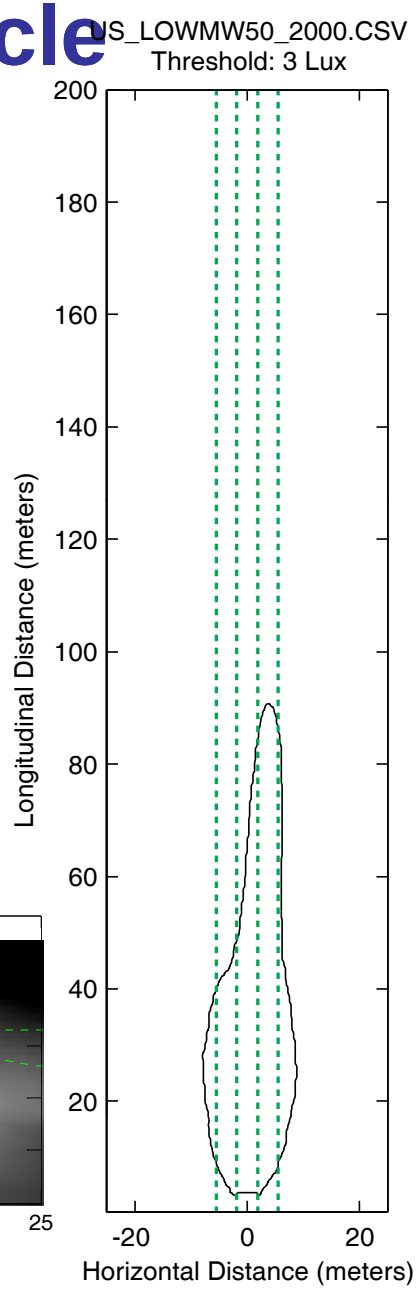
Background

- Pedestrians are the most important visibility concern associated with darkness.
  - Risk of a fatal pedestrian crash in darkness is 7 times that in daylight (UMTRI-2006-1)
- Developments in forward headlighting have made it possible to dynamically distribute light along the roadway where it is most needed.
- This raises a few questions:
  - Where should the light be directed?
  - What evidence exists that forward vehicle light distribution can affect pedestrian crash risk?

Facts About Forward Vehicle Lighting

- Distribution of low beam light is biased to the right:
  - Avoids glare to oncoming drivers
  - Visibility / glare compromise
- High beams are seldom used by drivers even when no threat of glare is present (UMTRI-2003-03)





Is this bias apparent in the crash record?

- Should mean that:
  - In darkness, pedestrians approaching from the left (driver side) of a vehicle may be less visible than those from approaching from the right
    - Compared to daylight risk
    - Assumes: pedestrian approach direction is independent of time-of-day, alcohol involvement, fatigue, demographics…
- Important because:
  - Allows more precise estimate of the influence of headlighting on crash risk
    - Relevant to adaptive forward lighting
  - More completely characterizes pedestrian-vehicle crash geometry
    - Relevant to other mitigation approaches

What is known?

- Kosmatka (2003) quantifies visibility in terms of approach direction and driver expectancy:
  - Left-to-right: 37 m
  - Right-to-left: 66 m
- In a sample of 76 nighttime pedestrian crash litigation cases,
  - 33% report approach from left
  - 17% report approach from right
- Not much else is known.

What is in the crash record?

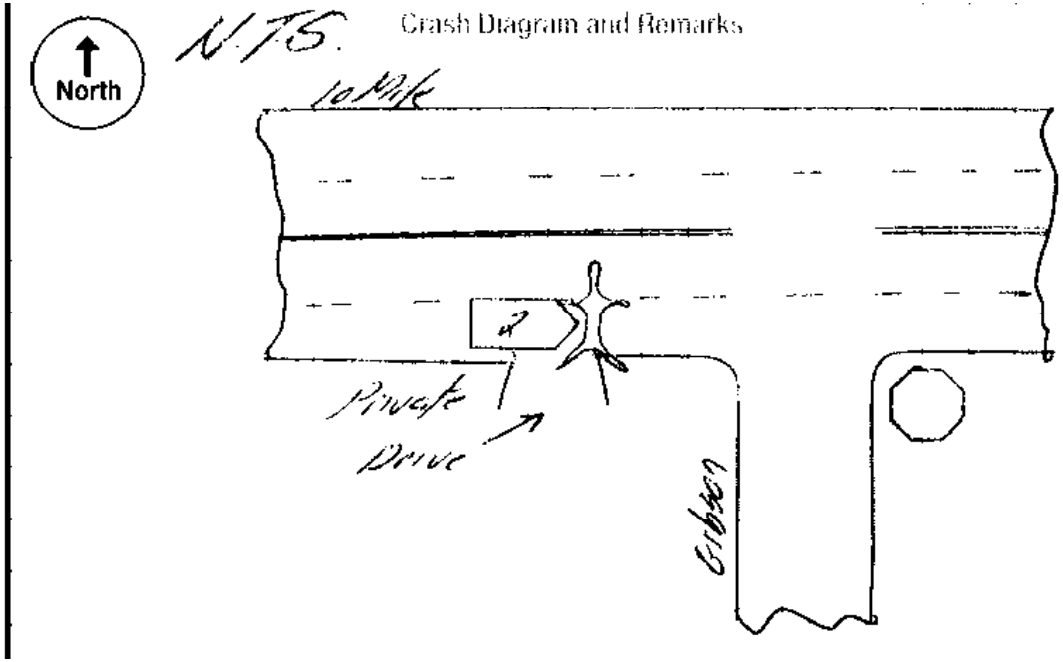
- Examined Michigan 2004 pedestrian crashes:
  - 75% of cases listed the pedestrian direction of travel as ‘Unknown’;
  - When known, movement direction is given by compass direction:
    - But, vehicle-centric coordinates are more desired:

Vehicle Direction	Pedestrian Direction	Vehicle-Centric
North	East	Driver Side
South	West	
East	South	
West	North	
North	West	Pedestrian Side
South	East	
East	North	
West	South	

What is in the crash record?

- Coding of vehicle direction is sometimes ambiguous:
  - E.g., A collision that occurs after a driver completes a turn may be identified as “turning” or “going straight”
- More information may be recovered from the crash diagrams and narratives in the crash report:
  - Diagrams often include arrows indicating travel direction of both vehicle and pedestrian
  - More complete description of crash event sequence

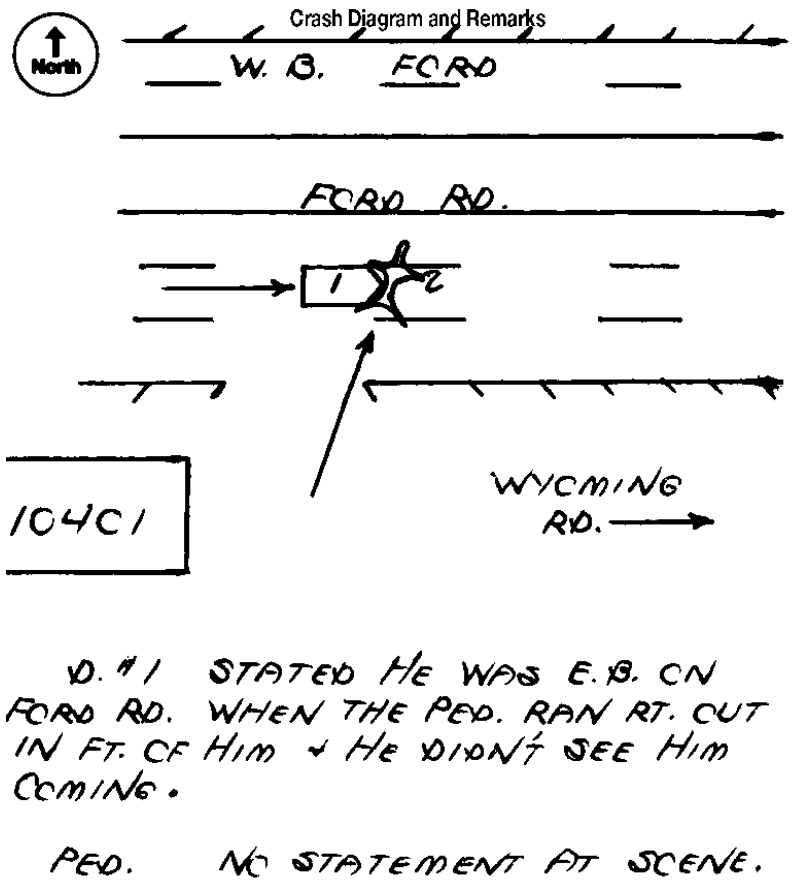
Example diagram:



- Text accompanying diagram:
  - Vehicle: Travelling eastbound on 10 mile. Driver stated pedestrian stepped out in front of vehicle, almost on purpose. Could not avoid collision. Stopped within 10 feet of impact.
  - Pedestrian: Refused verbal and written statement. Probably crossing to go home at [address].

Pedestrian travel direction reported as *UNKNOWN* in dataset.

Example diagram



D. #1 STATED HE WAS E.B. ON FORD RD. WHEN THE PED. RAN RT. OUT IN FT. OF HIM & HE DIDN'T SEE HIM COMING.

PED. NO STATEMENT AT SCENE.

- Pedestrian travel direction is reported as *unknown* in the dataset, although the arrow indicates the direction of travel.

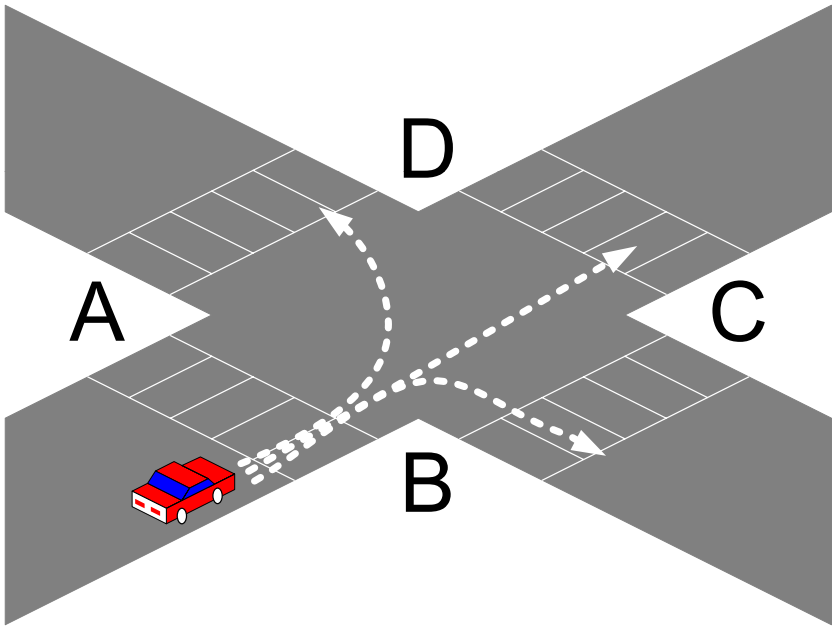
Method

- Base set of pedestrian crashes selected from Michigan 2004 dataset (1,240 crashes):
  - One vehicle, one pedestrian
  - Prior vehicle maneuver likely causally connected to crash:
    - Excluded: backing, driverless crashes, stopped vehicle, pedestrian striking vehicle—driver vision unlikely related to crash
  - Exclude pedestrians under 18 years:
    - Exposure differences between dark/light and other factors could complicate analysis

Supplemental Crash Coding

- Supplemental crash description developed for subset of base:
  - 200 crashes in darkness
  - 200 crashes in daylight
- Intended vehicle maneuver:
  - Left turn, Right turn, Straight
- Vehicle-centric pedestrian crossing :
  - Non-Intersection: Left-to-Right, Right-to-Left
  - Intersection: 8 directions:

Pedestrian Crossing Intersections



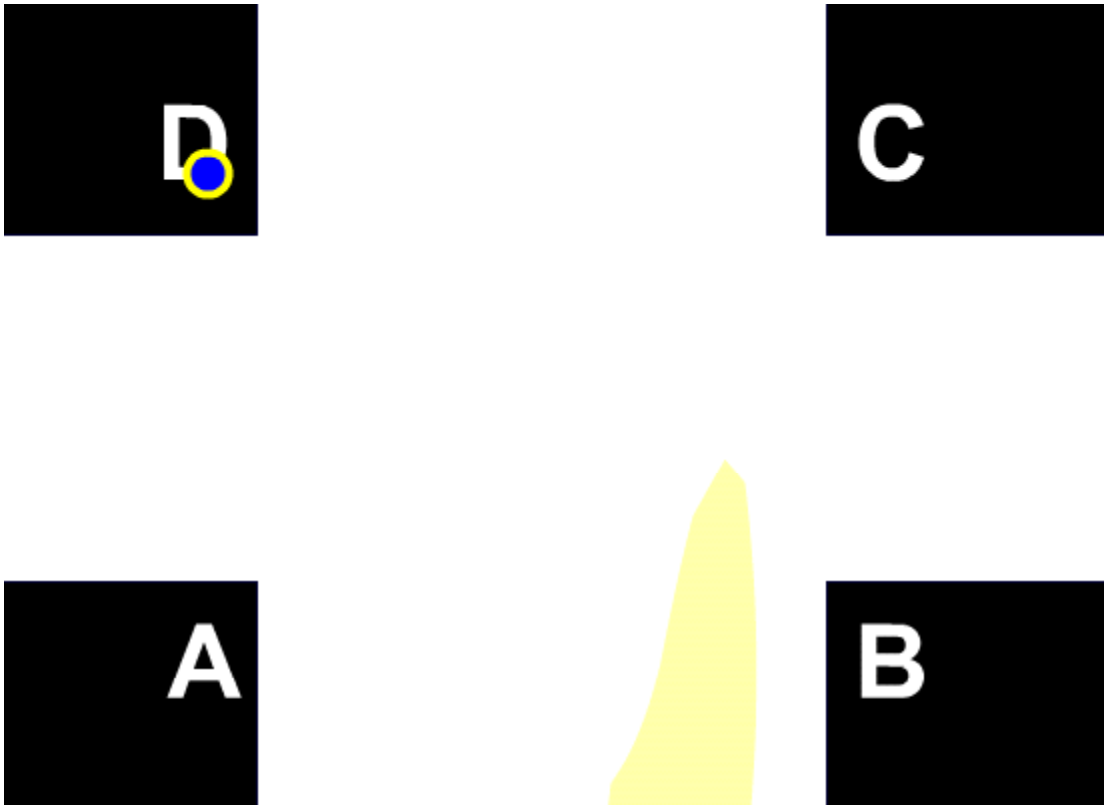
- Parallel with vehicle:
  - A-D
  - D-A
  - B-C
  - C-B
- Perpendicular to vehicle:
  - D-C
  - C-D
  - A-B
  - B-A

Analysis

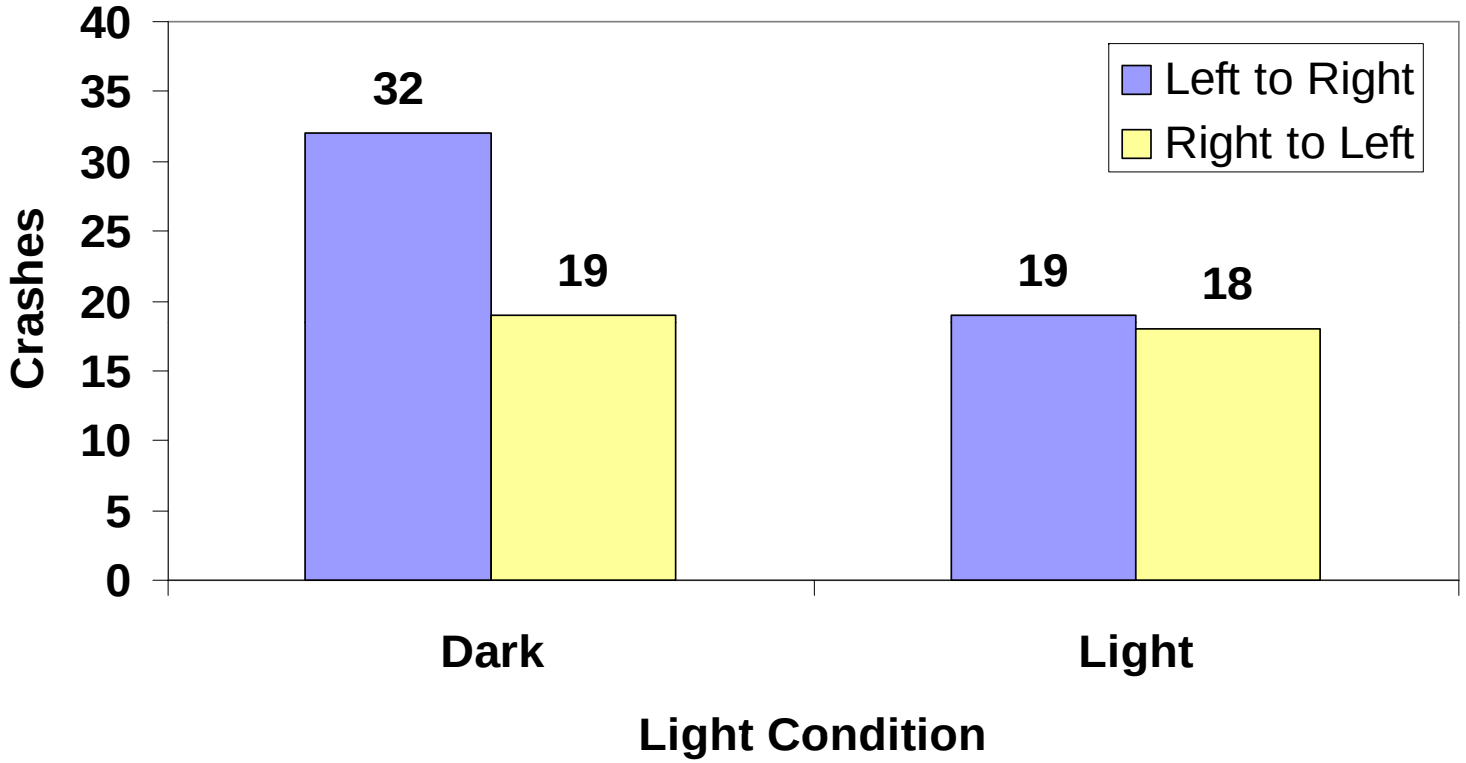
- Compared relative distributions of crashes in darkness to daylight for pedestrian travel directions and vehicle maneuvers:
  - Interactions between light condition and travel direction would suggest a geometric bias associated with light condition.
  - Vehicle maneuvers:
    - Straight
    - Left turn
    - Right turn

Results—Left to Right, Right to Left

- Pedestrian crossing direction when vehicles are going straight…



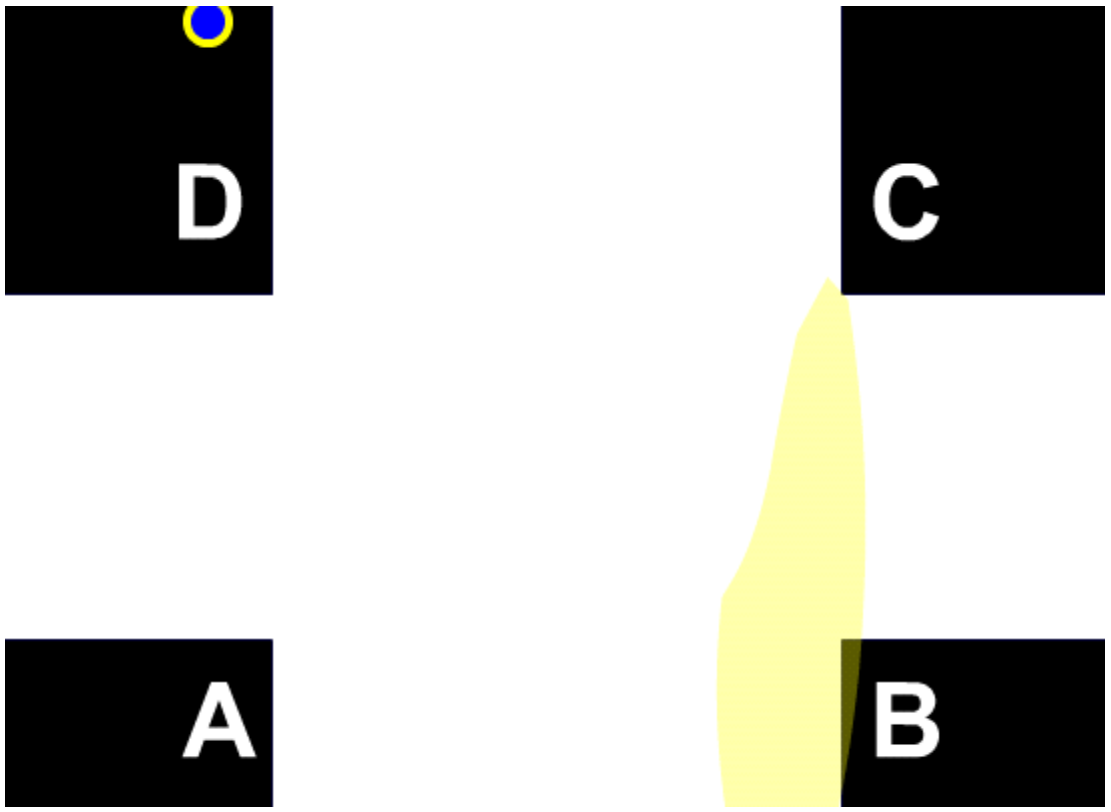
Results—Straight



- There are more LtoR than RtoL crashes in the dark
- There are an *even* number of RtoL and LtoR crashes in the light
- $\chi^2 = 1.14$ ($p = 0.29$);

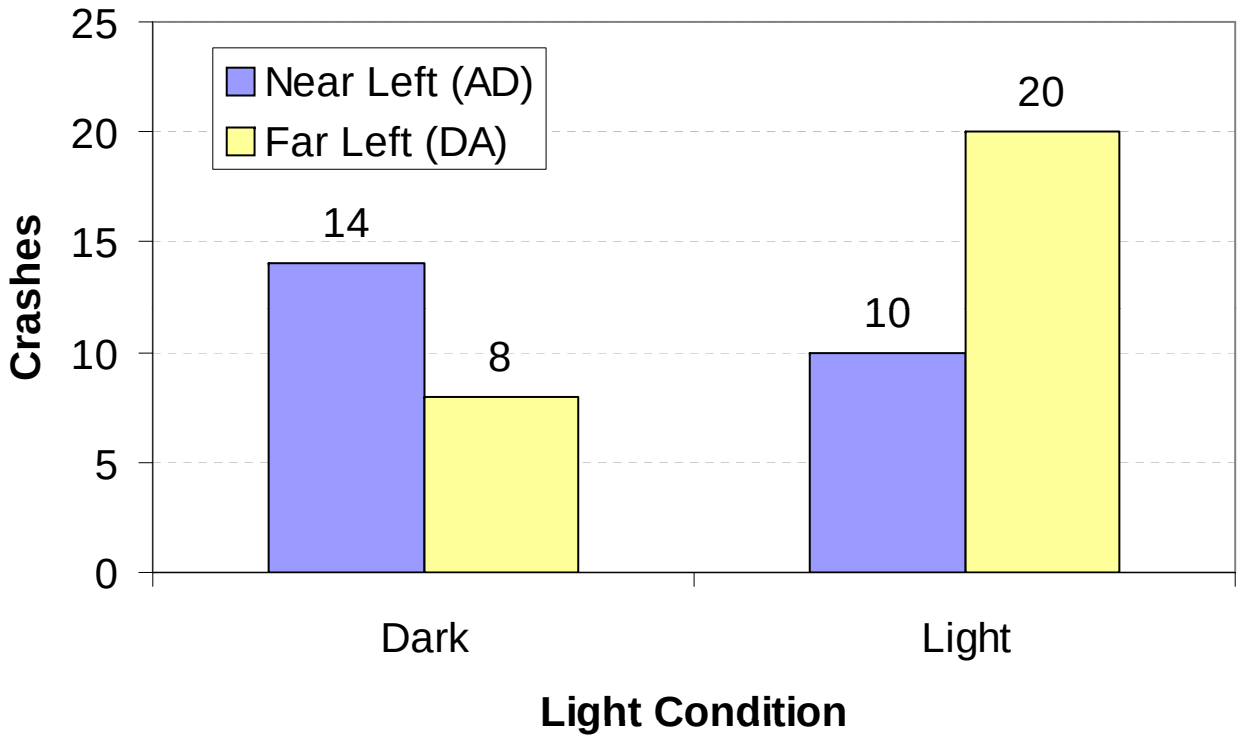
Results—Left Turns

- Pedestrian crossing direction when vehicles are turning left



(Only 4 collisions were A-B, B-A types.)

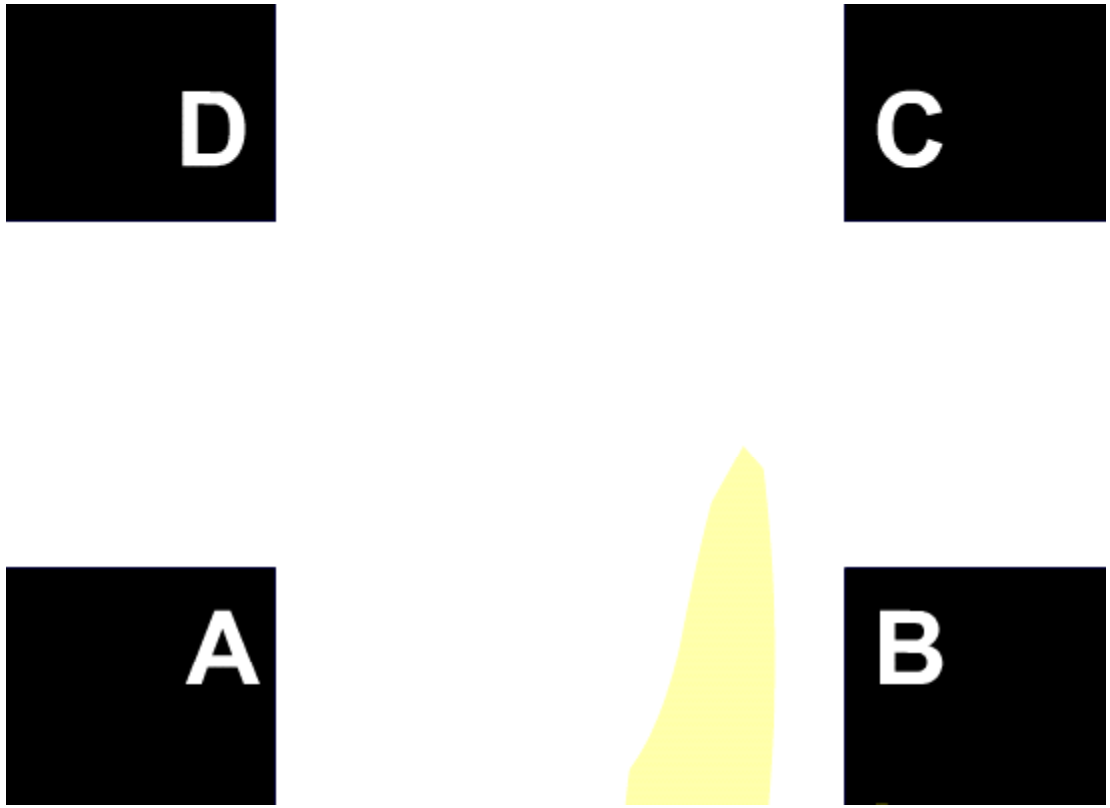
Results



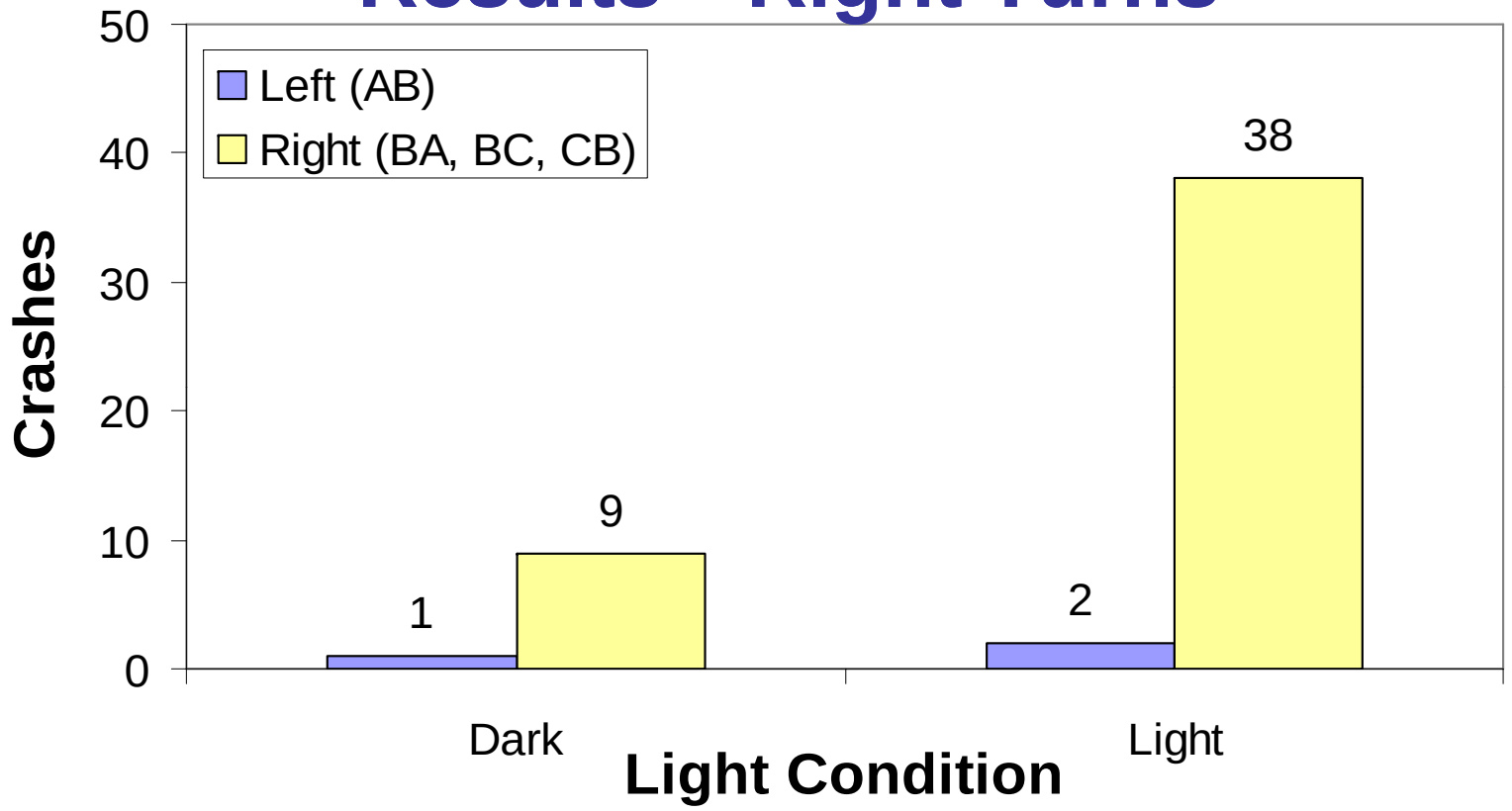
- More near-left than far-left in dark
- More far-left than near-left in light

Results—Right Turns

- Pedestrian crossing direction when vehicles are turning right:



Results—Right Turns



- More right turn crashes in light
- No obvious direction bias associated with light condition
- Probably a traffic density/driver attention issue

Conclusions

- There is useful information in the diagrams and narratives contained in police reports
  - Recovery is difficult and depends on the specific research question (e.g., crash geometry)
- Nighttime pedestrian crash risk affected by pedestrian and vehicle movement dynamics.
  - Asymmetric light distribution in low beam results in crash asymmetries at night.
  - Dynamic distribution of light in a turning maneuver at night also affects risk pattern.

Thank you