Outline

• Introduction
• Data collection
• Methodology
• Data summary
• Statistical results
• Questions
Background

• The Utah Department of Transportation (UDOT) often provides enhancements at pedestrian crossings to minimize the risk of injury or death to pedestrians

• Some treatments are relatively new, so the safety benefits of these treatments are not well documented, especially at the local level

• These enhancements can be powerful tools to protect pedestrians from injury or even death
Literature Review

- Crosswalk enhancements tend to increase pedestrian safety:
  - Safety increase – Crash decrease
    - Nationally (54.7% CRF) for HAWK
    - Texas (29% CRF) for HAWK
    - Oregon (7% CRF) for RRFB
  - Compliance Increase (Reported CO)
    - HAWK: 93-99% (Nationally)
    - OFB: 47-52% (Nationally)
    - RRFB: 95-99% (Nationally)
Purpose and Need

• The goal of enhanced crossings is to increase vehicle compliance with respect to yielding to pedestrians, thereby decreasing vehicle-pedestrian collisions.

• There is a *need* to understand how effective these crossings are so as to provide appropriate improvements at high-risk locations.

• The *purpose* of this research is to determine compliance rates at enhanced pedestrian crossings.
Technologies Studied

Base Crosswalk

High-intensity Activated crossWalk (HAWK)

Overhead Rectangular Rapid Flash Beacon (ORRFB)

Overhead Flashing Beacon (OFB)

RRFB
Locations Considered

• Control for:
  – Speed (35-45 mph)
  – Number of lanes (5 → 2 in each direction and TWLTL)
  – Daylight (daytime only)

• Avoid Central Business District

• Collect data on: AADT, land use, walk score, pavement markings, pedestrian volume, weather, additional treatments

• Goal: 400 data points for each treatment
Locations Considered
Camera Installation

- CountCam2
- RYOBI automatic drill
- Steel duct clamp, worm drive fastener
- CountCam2 aluminum poles
Camera Installation

Pole Attachment

Camera Focus
Camera Installation

Stability

Installed Camera
Methodology

• Calculate stopping sight distance (SSD) from AASHTO based on posted speed limit
• Set two cameras at each crosswalk to see each approach and the crosswalk
• Collect two-days of video
• Download video, recharge batteries
• Re-deploy cameras at new locations
Methodology

• Review video in “fast forward” mode until a pedestrian is observed
• Note compliant (CO) and/or non-compliant (NC) drivers
• Log pedestrian crossing and quantity of CO/NC drivers in spreadsheet including timestamp of crossing
What is Compliance?

- The operator of a vehicle shall yield the right-of-way by slowing down or stopping if necessary:
  - (i) to a pedestrian crossing the roadway within a crosswalk when the pedestrian is on the half of the roadway upon which the vehicle is traveling; or
  - (ii) when the pedestrian is approaching so closely from the opposite half of the roadway as to be in danger

Utah Code 41-6a-1002(1a)
What is Compliance?

• Yield the right-of-way to pedestrians that are still in the intersection (pg. 7-1)
• Yield to pedestrians entering or in a crosswalk, even if it is not marked (pg. 7-7)
Non-HAWK (Past SSD Decision Point)

- Vehicle has passed SSD decision point
  - Yields
    - Yields until pedestrian reaches the TWLTL Median
      - Compliant
    - Yields but goes before ped. reaches the TWLTL median
      - Non-Compliant
  - Doesn’t Yield
    - Dangerous Compliance Opportunity
      - Not Counted
Non-HAWK (has time to safely stop)

- Vehicle hasn’t reached SSD decision point
  - Yields
    - Yields until pedestrian reaches the TWLTL Median
      - Compliant
    - Yields but goes before ped. reaches the TWLTL median
      - Non-Compliant
  - Doesn’t Yield
    - Non-Compliant
HAWK (Solid Red)

Vehicle arrives on red

Yields

Stays until end of solid red and yields until pedestrian reaches the TWLTL Median

Compliant

Stays until end of solid red and yields but goes before ped. reaches the TWLTL median

Non-Compliant

Doesn’t Yield

Non-Compliant
HAWK (Flashing Red)

Vehicle arrives on flashing red

- Stops or slows down significantly: Yields until pedestrian reaches the TWLTL Median → Compliant
- Drives through without stopping or slowing down significantly: Yields but goes before ped. reaches the TWLTL median → Non-Compliant
- Non-Compliant
Driver Compliance According to Pedestrian Approach

Near Approach
Car needs to yield until pedestrian reaches the TWLTL

Far Approach
Car doesn’t need to yield until pedestrian enters TWLTL median
# Data Summary by Type of Enhancement

2241 observations

<table>
<thead>
<tr>
<th>Type</th>
<th>CO Rate</th>
<th>NC Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>35%</td>
<td>65%</td>
</tr>
<tr>
<td>HAWK</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>OFB</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>ORRFB</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>RRFB</td>
<td>91%</td>
<td>9%</td>
</tr>
</tbody>
</table>

- **Base**: 35% Compliant, 65% Non Compliant
- **HAWK**: 94% Compliant, 6% Non Compliant
- **OFB**: 86% Compliant, 14% Non Compliant
- **ORRFB**: 90% Compliant, 10% Non Compliant
- **RRFB**: 91% Compliant, 9% Non Compliant

2241 observations
Statistical Results
Background

• It was observed during data collection that the leading driver behavior has significant impact on driver compliance of the following vehicles

• It was also determined that pedestrian safety is more compromised by the leading vehicle than the following vehicles

• To minimize such effects, an event-based analysis was used in the statistical analysis:
  – Event: pedestrian(s) is crossing at the same time as vehicle(s) is passing
  – NC Event: one or more vehicles are not compliant according to Utah code
NC Event Rate per Treatment Type

Treatment & State
- NC/Tot Events
- Inner Lane NC/Tot Inner Lane Veh
- Outer Lane NC/Tot Outer Lane Veh
- Turn Lane NC/Tot Turn Lane Veh
- NC/Tot Vehicles

Size ~ # of Events
- 200
- 250
- 300
- 350
- 400
Chi-Square Analysis

• The Chi-square test is used to determine whether there is a significant difference between the expected frequencies and the observed frequencies of compliant events between each pair of treatment types.
• The null hypothesis is that the two treatment types in the test have the same impact on event compliance rate.
• The alternative hypothesis is that the two treatment types in the test have different impacts on event compliance rates.
• The difference between treatment types are more significant as the P-value of the Chi-square test becomes closer to 0.
Chi-Square Results

• RRFB and ORRFB have a similar impact on compliance rate (P-value = 0.711)

• In addition, the high (>0.10) P-values (i.e., 0.599 and 0.191) show that the HAWK has a similar impact as OFB and ORRFB on compliance rate

<table>
<thead>
<tr>
<th>Type</th>
<th>OFB</th>
<th>RRFB</th>
<th>BASE</th>
<th>ORRFB</th>
<th>HAWK</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFB</td>
<td>1.000</td>
<td>0.010</td>
<td>0.000</td>
<td>0.079</td>
<td>0.599</td>
</tr>
<tr>
<td>RRFB</td>
<td>0.010</td>
<td>1.000</td>
<td>0.000</td>
<td>0.711</td>
<td>0.034</td>
</tr>
<tr>
<td>BASE</td>
<td>0.000</td>
<td>0.000</td>
<td>1.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>ORRFB</td>
<td>0.079</td>
<td>0.711</td>
<td>0.000</td>
<td>1.000</td>
<td>0.191</td>
</tr>
<tr>
<td>HAWK</td>
<td>0.599</td>
<td>0.034</td>
<td>0.000</td>
<td>0.191</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Binomial Logit Regression Analysis

• The binomial-logit regression is used to estimate the impact of various factors, such as treatment type, on driver compliance rates

• Several models were estimated and any independent variables that showed statistically insignificant impacts on an event being non-compliant were removed
The results show that the HAWK (-3.629) has a higher impact on reducing the probability of an event being NC than OFB (-1.469). Similarly, OFB has higher impact on reducing the probability of an event being NC than RRFB and ORRFB (-0.856).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.013</td>
<td>1.104</td>
<td>***</td>
</tr>
<tr>
<td>HAWK</td>
<td>-3.629</td>
<td>0.328</td>
<td>***</td>
</tr>
<tr>
<td>OFB</td>
<td>-1.469</td>
<td>0.218</td>
<td>***</td>
</tr>
<tr>
<td>RRFB &amp; ORRFB</td>
<td>-0.856</td>
<td>0.187</td>
<td>***</td>
</tr>
<tr>
<td>Total # Drivers in an Event</td>
<td>0.977</td>
<td>0.065</td>
<td>***</td>
</tr>
<tr>
<td>Stopping Sight Distance (ft)</td>
<td>-0.018</td>
<td>0.003</td>
<td>***</td>
</tr>
<tr>
<td>Walk Score</td>
<td>-0.041</td>
<td>0.006</td>
<td>***</td>
</tr>
</tbody>
</table>
Binomial Logit Regression Odds Ratio Results

- The odds ratio shows the constant effect of a factor (e.g., HAWK) on the likelihood of an outcome (e.g., an event being compliant).
- For example, the odds of reducing the chance of an event being NC (increased compliance) for HAWK crosswalks compared to Base crosswalks is 97%.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reducing chance of event to be NC</th>
<th>2.5% Conf. Int.</th>
<th>Mean</th>
<th>95% Conf. Int.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAWK</td>
<td>98%</td>
<td>97%</td>
<td>96%</td>
<td></td>
</tr>
<tr>
<td>OFB</td>
<td>81%</td>
<td>77%</td>
<td>71%</td>
<td></td>
</tr>
<tr>
<td>RRFB &amp; ORRFB</td>
<td>65%</td>
<td>58%</td>
<td>49%</td>
<td></td>
</tr>
<tr>
<td>Total # Drivers in an Event</td>
<td>-149%</td>
<td>-166%</td>
<td>-183%</td>
<td></td>
</tr>
<tr>
<td>Stopping Sight Distance (ft)</td>
<td>2%</td>
<td>2%</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Walk Score</td>
<td>5%</td>
<td>4%</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>
Results

• The Binomial-Logit regression model estimates show that adding a pedestrian enhancement to a marked crosswalk at a location with 5 lanes and a speed limit between 35 mph to 45 mph, can increase compliance event rate by:
  – 97% for HAWK
  – 77% for OFB
  – 58% for RRFB and ORRFB

• The total number of vehicles in an event, SSD, and walkability score showed significant impacts on compliance rates
Questions?

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