Evaluation of the First Fixed Speed Photo Enforcement on an Urban Freeway in the US: The Scottsdale AZ Experience

Presentation by:
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• My research team members:
  – Prof Simon Washington
  – Kangwon Shin.

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  – Arizona State Department of Transportation
PRESENTATION OUTLINE

• Program summary

• Summary of findings
  – Impact of the speed enforcement camera demonstration program (SEP) on **speeding** behavior
  – Impact of the SEP on **mean speeds**
  – Impact of the SEP on **traffic safety**

• Conclusions
PROGRAM SUMMARY
BACKGROUND

• Speeding is recognized as a major contributing factor in traffic crashes
• Photo radar technologies are used in 75 counties throughout the world to enforce speeding
• Until 2006, the US had not seen a permanent installation of photo enforcement on limited access freeways
BACKGROUND

• In order to reduce speed-related crashes, city of Scottsdale implemented **the first fixed photo speed enforcement camera demonstration program (SEP)** in the US
  – January 22, 2006 – October 23, 2006 (9 months)
  – 6.5 mi stretch of Arizona SR 101 in Scottsdale
Enforcement zone: MP 34.51– MP 41.06 (Approximately 6.5 miles)
Location of 6 Enforcement Stations

<table>
<thead>
<tr>
<th>Station ID</th>
<th>Station</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scottsdale Rd. and Hayden Rd.</td>
<td>East Bound</td>
</tr>
<tr>
<td>2</td>
<td>Hayden Rd. and Bell Rd.</td>
<td>West Bound</td>
</tr>
<tr>
<td>3</td>
<td>Frank Lloyd Wright Blvd. and Raintree Dr.</td>
<td>South Bound</td>
</tr>
<tr>
<td>4</td>
<td>Raintree Dr. and Cactus Rd.</td>
<td>North Bound</td>
</tr>
<tr>
<td>5</td>
<td>Shea Blvd. and Mountain View Rd.</td>
<td>South Bound</td>
</tr>
<tr>
<td>6</td>
<td>Shea Blvd. and Mountain View Rd.</td>
<td>North Bound</td>
</tr>
</tbody>
</table>

- Three cameras per direction
- Posted speed limit: 65 mph
- Infraction speed \( \geq 76 \) mph
- Criminal speeding \( > 85 \) mph
Typical Equipment Set-up

**Front Camera and Flash Unit**

**Rear Camera and Flash Unit**
# OBSERVATION PERIODS

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>START &amp; END</th>
<th>LENGTH (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>2001 to 2005</td>
<td>5 years</td>
</tr>
<tr>
<td>Warning</td>
<td>1/22/2006 – 2/21/2006</td>
<td>31 days</td>
</tr>
<tr>
<td>Program</td>
<td>2/22/2006 – 10/23/2006</td>
<td>244 days</td>
</tr>
<tr>
<td>After</td>
<td>10/24/2006 – 12/31/2006</td>
<td>69 days</td>
</tr>
</tbody>
</table>
EVALUATION OF THE SEP PROGRAM

- Speeding
  - Detection frequencies
  - Average speeds

- Safety
  - Crash reduction
  - Socio-economic savings

- Travel Time
DAILY DETECTION FREQUENCY (per camera)

Weekend/Holiday Effects
## DAILY DETECTION FREQUENCY (per camera)

<table>
<thead>
<tr>
<th>Day of Week</th>
<th>Period Pair</th>
<th>Difference in Daily Speeding Detection</th>
<th>95% C.I.s</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekdays</td>
<td>Warning–Program</td>
<td>27.33 (&lt;0.001)</td>
<td></td>
<td>15.17</td>
<td>39.49</td>
</tr>
<tr>
<td></td>
<td>After– Program</td>
<td>1096.04 (&lt;0.001)</td>
<td></td>
<td>998.01</td>
<td>1194.06</td>
</tr>
<tr>
<td></td>
<td>Reactivation– Program</td>
<td>5.81 (0.072)</td>
<td></td>
<td>-0.53</td>
<td>12.16</td>
</tr>
<tr>
<td>Weekends and Holidays</td>
<td>Warning–Program</td>
<td>50.98 (&lt;0.001)</td>
<td></td>
<td>19.86</td>
<td>82.11</td>
</tr>
<tr>
<td></td>
<td>After– Program</td>
<td>1860.66 (&lt;0.001)</td>
<td></td>
<td>1689.91</td>
<td>2031.42</td>
</tr>
<tr>
<td></td>
<td>Reactivation– Program</td>
<td>9.13 (0.241)</td>
<td></td>
<td>-6.14</td>
<td>24.41</td>
</tr>
</tbody>
</table>
Typical relationship b/w speed and traffic volume during non-congested periods

- Reduction in mean speeds: 73.1 mph to 64.4 mph
- Reduction in speed dispersion: 3.5 mph to 1.2 mph
EFFECT ON SPEED

Distribution of speed by period (Normal distribution fitting)

- Before period
- Program period

Mean speed (mph)
ESTIMATED IMPACTS ON MEAN SPEEDS

- Speed reduction increase as volume decrease
- The mean speed decreased by
  - 9.97 mph when traffic volume was 206 vplph
  - 9.04 mph when traffic volume was 800 vplph
  - 8.47 mph when traffic volume was 1,169 vplph
START: Defining Target Crashes

- Which crashes materially affected?
  - rear-end
  - side-swipe
  - single vehicle
  - other

Effect of time of day?

OFF-PEAK CRASHES
(time of day as surrogate)
&
WEEKEND, HOLIDAYS

18 hrs on weekdays
24 hrs on weekends & holidays

- rear-end
- side-swipe
- single vehicle
- other
EVALUATION METHODS

Before-and-after (BA) studies

1. BA study with traffic flow correction  
   *(assumes only change B to A is traffic flow)*

2. BA study with comparison zone  
   *(assumes changes in safety reflected at comparison site)*

3. Empirical Bayes BA study  
   *(corrects for possible regression-to-the-mean)*
**BA STUDY DESIGN**

$k_i$: The observed target crash frequency during the before period

$l_j$: The observed target crash frequency during the project period

$\pi_j$: The expected number of target crash frequency during the project period if the treatment had not been installed
CHANGE IN EXPOSURE

- On average, 42% increase in AADT from 2001 to 2006
  - 66.2% increase from 2001 to 2006
  - 60.1% increase from 2003 to 2006
  - 16.7% increase from 2005 to 2006

Observed crashes (K) is not suitable for prediction
EMPIRICAL BAYES BA RESULTS

Similar results from other methods
ECONOMIC ANALYSIS

• Crash costs obtained from extensive national research (NHTSA, 2000; Economic Impact of Motor Vehicle Crashes)

• Reflect AZ-specific costs: hospital charges by injury severity category (from AZ high-speed freeways)

• Utilize inflation adjusted costs from
  – National Hospital Discharge Survey
  – National Health Interview Survey
  – AZ hospital cost/charge information
  – CHAMPUS data on physician costs
  – National Medical Expenditure Survey
  – National Council on Compensation Insurance
  – Crashworthiness Data System.
The AZ CODES Project

AZ-Specific Costs:
Urban Freeways (Phoenix Area)
AND
Crash Cost by Crash Type & Severity Level
The AZ CODES Project

- Crash cost estimations applied to linked and unlinked cases obtained from extensive national research (NHTSA ‘00; Economic Impact of Motor Vehicle Crashes)
- Utilize inflation adjusted costs from
  - National Hospital Discharge Survey
  - National Health Interview Survey
  - AZ hospital cost/charge information
  - CHAMPUS data on physician costs
  - National Medical Expenditure Survey
  - National Council on Compensation Insurance
  - Crashworthiness Data System
<table>
<thead>
<tr>
<th>Collision type</th>
<th>Crash severity</th>
<th>Final Medical Cost</th>
<th>Total Other Cost</th>
<th>Quality of Life Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single-vehicle</strong></td>
<td>K</td>
<td>$162,870</td>
<td>$1,340,063</td>
<td>$2,111,828</td>
<td>$3,614,761</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>$122,790</td>
<td>$200,291</td>
<td>$361,020</td>
<td>$684,101</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>$24,104</td>
<td>$61,295</td>
<td>$88,104</td>
<td>$173,503</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>$13,545</td>
<td>$34,771</td>
<td>$45,343</td>
<td>$93,659</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>$15,527</td>
<td>$41,402</td>
<td>$50,277</td>
<td>$107,206</td>
</tr>
<tr>
<td><strong>Side-swipe</strong> (same direction)</td>
<td>K</td>
<td>$119,065</td>
<td>$1,651,039</td>
<td>$2,496,842</td>
<td>$4,266,946</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>$133,636</td>
<td>$301,959</td>
<td>$442,205</td>
<td>$877,801</td>
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<tr>
<td></td>
<td>B</td>
<td>$27,504</td>
<td>$80,482</td>
<td>$86,291</td>
<td>$194,277</td>
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<tr>
<td></td>
<td>C</td>
<td>$16,354</td>
<td>$65,398</td>
<td>$64,673</td>
<td>$146,425</td>
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<tr>
<td></td>
<td>O</td>
<td>$15,826</td>
<td>$62,247</td>
<td>$50,530</td>
<td>$128,604</td>
</tr>
<tr>
<td><strong>Rear-end</strong></td>
<td>K</td>
<td>$71,037</td>
<td>$1,608,206</td>
<td>$2,441,687</td>
<td>$4,120,929</td>
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<tr>
<td></td>
<td>A</td>
<td>$70,820</td>
<td>$162,469</td>
<td>$239,725</td>
<td>$473,013</td>
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<tr>
<td></td>
<td>B</td>
<td>$39,899</td>
<td>$100,244</td>
<td>$152,827</td>
<td>$292,971</td>
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<tr>
<td></td>
<td>C</td>
<td>$28,785</td>
<td>$77,037</td>
<td>$113,695</td>
<td>$219,517</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>$30,643</td>
<td>$77,278</td>
<td>$117,022</td>
<td>$224,942</td>
</tr>
<tr>
<td><strong>Other Crashes</strong></td>
<td>K</td>
<td>$77,949</td>
<td>$1,200,900</td>
<td>$1,784,243</td>
<td>$3,063,092</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>$97,374</td>
<td>$236,524</td>
<td>$310,713</td>
<td>$644,611</td>
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<tr>
<td></td>
<td>B</td>
<td>$15,431</td>
<td>$62,216</td>
<td>$60,957</td>
<td>$138,604</td>
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<tr>
<td></td>
<td>C</td>
<td>$8,557</td>
<td>$42,965</td>
<td>$43,917</td>
<td>$95,439</td>
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<tr>
<td></td>
<td>O</td>
<td>$3,421</td>
<td>$34,919</td>
<td>$11,019</td>
<td>$49,359</td>
</tr>
</tbody>
</table>

**KABCO Scale**
K = Killed
A = disabling injury
B = evident injury
C = possible injury
O = property damage only (no apparent injury)
## Annualized Estimated Crash Benefits

<table>
<thead>
<tr>
<th>Analysis method</th>
<th>Collision type</th>
<th>Crash severity</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fatal Crashes (K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BA study with traffic flow correction</td>
<td>Single Vehicle</td>
<td>$1,503</td>
<td>$134</td>
<td>$1,370</td>
<td>-$184</td>
<td>$4,266</td>
<td>$7,088</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Side-swipe (same)</td>
<td>$1,651</td>
<td>$0</td>
<td>$476</td>
<td>$204</td>
<td>$1,312</td>
<td>$3,643</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rear-end</td>
<td>$0</td>
<td>-$859</td>
<td>$1,018</td>
<td>$63</td>
<td>$2,021</td>
<td>$2,243</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>$1,748</td>
<td>$368</td>
<td>$369</td>
<td>$438</td>
<td>$605</td>
<td>$3,529</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$4,902</td>
<td>-$358</td>
<td>$3,234</td>
<td>$521</td>
<td>$8,204</td>
<td>$16,503</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EB BA study with time-varying $\kappa$</td>
<td>Single Vehicle</td>
<td>$1,471</td>
<td>$87</td>
<td>$1,341</td>
<td>-$192</td>
<td>$4,273</td>
<td>$6,980</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Side-swipe (same)</td>
<td>$1,803</td>
<td>$0</td>
<td>$520</td>
<td>$263</td>
<td>$1,373</td>
<td>$3,960</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rear-end</td>
<td>$0</td>
<td>-$822</td>
<td>$1,145</td>
<td>$155</td>
<td>$2,064</td>
<td>$2,543</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>$1,762</td>
<td>$371</td>
<td>$372</td>
<td>$443</td>
<td>$618</td>
<td>$3,565</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$5,036</td>
<td>-$364</td>
<td>$3,379</td>
<td>$669</td>
<td>$8,328</td>
<td>$17,048</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KABCO Scale**
- K = Killed
- A = disabling injury
- B = evident injury
- C = possible injury
- O = property damage only (no apparent injury)
CONCLUSIONS
• Speeding detection
  – Speeding detection frequency (speeds ≥ 76 mph) increased by a factor of 10.5 after temporarily termination of SEP
    • During termination the cameras were “bagged” and advertising and news media advertised the end of the program.
    – The Scottsdale 101 SEP appears to be effective deterrent to speeding in excess of 75 mph
• No evidence of “spillover effects”
• Drivers appear to respond to “certainty” of enforcement
• Average Speeds
  – Reduced the average speed at the enforcement camera sites by about 9 mph
  – Contributed to reducing the speed dispersion at the enforcement camera sites.
  – Both the prerequisites for crash reduction (safety improvement) are met with the SEP
  – Traffic flow affects reduction in the mean and variance of speed resulting from the SEP
• Changes in target crashes
  – Total frequency of target crashes reduced by about 54%
  – Total number of injury crashes by about 48%, and
  – Total number of PDO crashes decreased by about 56%.
  – All but rear-end crashes types appear to have been reduced.
• Although the changes in safety for rear-end crashes were inconsistent among evaluation methods
  – the increase in rear-end crashes (other BA methods) was not significant.
• Swapping of crash types & reduction in severity distribution
  – Common for safety countermeasures (e.g. left-turn channelization, red-light cameras, conversion of stop signs to signals, etc.).

• Total estimated SEP benefits range from an estimated $16.5 M to $17.1 M per year.

• The fixed photo speed enforcement camera is a promising countermeasure to reduce crashes in AZ (consistent with findings in other countries).
• No significant difference in total free-flow travel time with and without the SEP
  – Suggests drivers can travel in the enforcement zone in the same acceptable amount of travel time regardless of the existence of the SEP.

• The insignificant difference in total free-flow travel time with and without the SEP conditions
  – Total travel time savings from reduction in crash frequency.
  – Reduction >‘569 vehicle-hrs/yr’ when assuming the 1-lane block crash state
  – Reduction >‘37,981 vehicle-hrs/yr’ when assuming the 2-lane block crash state
• Raises serious doubts: validity of arguments against photo speed enforcement on the grounds of reduced mobility
  – Findings suggest photo speed enforcement not only improves safety but also improves mobility through
    • travel time savings,
    • improved travel time reliability, and
    • reduced travel time (consistent with findings in other countries).