EVALUATING THE EFFECTIVENESS OF PEDESTRIAN COUNTDOWN SIGNALS ON THE SAFETY OF PEDESTRIANS IN MICHIGAN

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ABSTRACT

This study evaluated the safety effectiveness as well as economic benefits of pedestrian countdown signals (PCSs) for all pedestrians and pedestrians 65 years and above. The first part of this study deals with a perception survey of drivers and pedestrians in Michigan while the second and third parts deal with crash and economic analyses, respectively. A before and after study with a comparison group methodology was used to evaluate the effectiveness of PCSs. Geometric, land use characteristics as well as traffic data for each of the treated sites were used as the basis for selecting the comparison group. The perception survey results, as expected, indicated that there is a very strong preference of PCS for deciding when to start crossing, adjusting walking speed (if already started crossing), and feeling of safety. The crash analysis results indicated a nearly 32 percent reduction for all pedestrian crashes (all ages and all severities) and a reduction of 65 percent in total (all severities) crashes for pedestrian 65 years and above. An economic analysis conducted also showed a tremendous benefit-cost ratio of 122 to 1 for PCS. The findings in this study are consistent with previous studies documented in the literature review section.

Key words: Pedestrian, countdown, signal, safety, older drivers.
INTRODUCTION AND LITERATURE REVIEW

Michigan crash records for 2009-2013 show that the number of pedestrians involved in all crashes increased by more than 8 percent over the 5 year period, while fatal pedestrian crashes during the same years increased by approximately 23 percent. In the case of fatal crashes involving older pedestrians (age 65 and above), there was an increase of approximately 21 percent during the same period (1). Figure 1 shows the trend of pedestrian crashes in Michigan for years 2009-2013.

![Figure 1: Pedestrian Crash Record in Michigan (2009-2013)](image)

Consistent with MUTCD 2009 requirements and in an attempt to avert these fatalities, the Michigan Department of Transportation (MDOT) proposed and implemented pedestrian countdown signals (PCSs) as a safety measure to improve safety of pedestrians especially the older pedestrians. PCS is a timer that displays the counting down of seconds left to cross a street during the flashing UPRAISED HAND while the non-countdown pedestrian signal displays a flashing UPRAISED HAND only (MUTCD, 2009). PCSs are designed to provide safety benefit to all pedestrians, especially older pedestrians (age 65 years and above). A previous study conducted by Stollof et al (2) found that older pedestrians are more likely to move out of the cross walk at the onset of steady DON’T WALK at crossings with PCS compared with the MDOT’s standard pedestrian signals. Figure 2 shows a PCS and a MDOT’s standard pedestrian signal.
A study by Zegeer et al (3) evaluated the effectiveness of the PCSs based on: (a) pedestrian compliance with the “Walk” signal (b) pedestrians who run out of time and (c) pedestrians who began running when the flashing “Don’t Walk” signal appeared. Their study revealed that PCSs had a positive effect of reducing the number of pedestrians who would have ran upon the appearance of flashing “Don’t Walk” interval. Their study further revealed that, young pedestrians may try to cross the roadway whilst having some few seconds remaining and this resulted in pedestrian becoming stranded on the roadway. Hence, they recommended that, PCSs may not be useful at some intersections because their effectiveness could be based on age differences. However, they recommended that PCSs may be promising at intersections that have higher older population by virtue of its added information about the time available for crossing.

Eccles et al (4) conducted a study aimed at evaluating the PCSs in Maryland using a before-after study. They observed the signal indication when pedestrian entered the intersection when the conflict traffic is released, pedestrian and vehicle conflicts and approach speed of vehicle to an intersection. Their study revealed positive results for the PCS on behavior of pedestrians and significant reduction in pedestrian-vehicle crashes. Pedestrian survey results also showed that, pedestrians were aware of PCSs and understood the indications well. Arhin et al (5) used a before and after study approach to compare the two types of displays by PCSs. The before scenario studies considered “Steady Walk (SW)” interval through to the “Flashing Don’t Walk (FDW)” displays while in the after period, the countdown coincided with the FDW. Their findings revealed that, there was no statistical significant differences in the pedestrian crossing behaviors (using 5 percent significance level) because of the display type of the countdown pedestrian signals at most of the intersection considered in during the study.
Pulugurtha et al (6, 9) carried out a study in the Las Vegas Metropolitan on pedestrians countdown signals. Pedestrian surveys or interviews were also carried out to ascertain pedestrian understanding of the countdown pedestrian signals. Their findings showed that PCSs are effective in improving pedestrian safety. They however recommended a pedestrian crash study in the before and after installation of PCS to investigate its statistical significance. A before and after study analysis conducted at 95 percent confidence level revealed that, there was a statistically insignificant reduction in vehicle-pedestrian crashes but there was a statistically significant reduction in all crashes (pedestrian and vehicle involvement). Schattler et al (7, 8) conducted a study in the city of Peoria, Illinois. Their findings showed that PCSs encourage pedestrian compliance as compared to the traditional pedestrian signals. A study conducted by Markowitz et al (10) considered a 21-month before and after period at 14 signalized intersections. Their study results showed that, PCSs reduce pedestrian crashes and injuries. They again found out that, PCSs reduced the number of pedestrian who complete crossing on red signal. A report by Singer et al (11) on PCSs enumerated both types of studies that were carried out during the period (laboratory and observational). Their studies revealed enormous preference for PCSs by pedestrians. Their laboratory study again showed that, older pedestrians are likely to be the greatest beneficiaries of the PCSs.

In addition, a laboratory study was done by Mahach et al (12) to assess PCS preferences among a set of seven signals. Their findings showed that, about 60 percent of the participants preferred PCSs.

Although many studies have been done on evaluating pedestrian countdown signals, evaluation of these devices and their safety impacts on all pedestrians as well as older pedestrians have not been done. This paper seeks to bridge this gap by documenting a detailed evaluation of PCSs using a perception survey, crash and economic analysis with a comparatively larger sample size (93-treated and 97 - non-treatment sites).

OBJECTIVE OF THE RESEARCH

The objective of this study was to evaluate the safety effectiveness and quantify the associated economic benefits of PCSs on all pedestrians and pedestrians (age 65 years and above). A perception survey was carried out to determine pedestrian preferences for PCSs whilst crash analysis using a before-after study with comparison group methodology was used to carry out the evaluation and ascertain the safety impacts of these devices. Economic analysis was finally conducted to estimate the benefits of PCSs.

DATA COLLECTION

Survey of drivers and pedestrians

A two week perception survey of drivers and pedestrians was conducted in four cities in Michigan namely; Kalamazoo, Grand Rapids, Lansing and Detroit at grocery stores, restaurants, senior center and rest areas. These locations were randomly selected based on the application of the countermeasure, higher population of people 65 years and above and crash data for the same group of population. Questionnaires were administered to evaluate the perceived safety effects offered by the pedestrians countdown signals in Michigan based on drivers’ and pedestrians’ preferences. A rating system using a scale of 1 to 3 (1=low, 2= medium and 3= high) was used to
describe driver preferences between PCS and the standard pedestrian signal. The scenarios evaluated were (1) decision to start crossing, (2) adjustment of walking speed, and (3) increasing feeling of safety. Participant were allowed to choose either neutral or not applicable if they don’t have any preferences. A total of 1590 individuals participated in the survey. Since the main objective of the survey was to identify perspective and benefits of PCSs to older drivers and pedestrian in general, the survey targeted all drivers who at that moment were pedestrians. Preference of PCS over the MDOT’s standard pedestrian signal in a given scenario was measured.

Crash data

A total of 93 treated sites (locations with PCSs) were selected randomly from a list of intersections with PCSs in Michigan. Also, a total of 97 comparison sites (locations without PCSs) were selected randomly based on the AADT, geometric characteristic and land use characteristics of the treated sites. Summary of variables considered in site selection are shown in table 1. This larger sample size for both treatment and non-treatment were selected to mitigate the potential limitations of the before-after methodology. The sites were randomly selected to cover the state of Michigan. The study considered a period of six years with 3 years in the before period and 3 years in the after period. Geometric characteristics, traffic volume, land use characteristics were the main factors used in selecting the non-treatment group so as to minimize the regression to the mean bias which becomes an issue when sites are selected based on crash occurrences (14).

To ensure that, the comparison sites are similar to the treated sites, a graph of crashes in the before period were plotted for both treatment and comparison sites and they traced each other well. Again samples odds ratio were computed as described by Fayish et al (14). Installation dates of the PCSs for each intersection was also obtained. Crash data from 2004-2013 were collected for each of the treated and non-treated sites in the three years before and after period of installation of the PCSs using ArcGIS 10.0. Crashes were collected within 150 feet buffer radius as shown in Figure 3. Michigan crash record type 4 which deals with involved party (age, party type, etc....) was joined to record type 1 and 2 for the crash collection and analysis.
Table 1: Summary of variables considered in site selection

<table>
<thead>
<tr>
<th>No</th>
<th>Variables</th>
<th>Treated Sites</th>
<th>Non-Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Std. Dev</td>
</tr>
<tr>
<td>1</td>
<td>AADT_Maj_ave</td>
<td>14072</td>
<td>11459</td>
</tr>
<tr>
<td>2</td>
<td>AADT_Min_ave</td>
<td>7348</td>
<td>6600</td>
</tr>
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<td>3</td>
<td>Min_median_div_raised</td>
<td>0.02</td>
<td>0.15</td>
</tr>
<tr>
<td>4</td>
<td>Min_median_div_not_raised</td>
<td>0.72</td>
<td>0.45</td>
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<td>Min_median_not_div_not_raised</td>
<td>0.26</td>
<td>0.44</td>
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<td>6</td>
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<td>0.71</td>
<td>0.46</td>
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<td>8</td>
<td>Maj_median_not_div_not_raised</td>
<td>0.09</td>
<td>0.28</td>
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<tr>
<td>9</td>
<td>Commercial</td>
<td>0.53</td>
<td>0.50</td>
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<tr>
<td>10</td>
<td>Residential</td>
<td>0.08</td>
<td>0.27</td>
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<tr>
<td>11</td>
<td>Mixed</td>
<td>0.40</td>
<td>0.49</td>
</tr>
<tr>
<td>12</td>
<td>Total number of lanes_Major</td>
<td>5.68</td>
<td>2.00</td>
</tr>
<tr>
<td>13</td>
<td>Total number of lanes_Minor</td>
<td>3.85</td>
<td>1.77</td>
</tr>
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<td>14</td>
<td># of exclusive_left_turns Maj_NB</td>
<td>0.63</td>
<td>0.53</td>
</tr>
<tr>
<td>15</td>
<td># of exclusive_left_turns Maj_SB</td>
<td>0.51</td>
<td>0.52</td>
</tr>
</tbody>
</table>

A. Treated and Non-treatment.  
B. 150 ft. buffer for collection of crashes

FIGURE 3 Site Locations and Crash collections
METHODOLOGY

Survey of drivers and pedestrians
Descriptive statistics was used to classify the perception and the level of preferences of the participants during the perception survey analysis. A survey was administered across four cities in Michigan and a total of 1590 people participated. Enlarged pictures of PCS and MDOT’s standard pedestrian signals shown in Figure 2 were used to seek preference of the survey participants in three scenarios: (1) decision to start crossing, (2) decision to adjust walking speed, and (3) increasing feeling of safety.

Crash analysis
In order to evaluate the effectiveness of PCSs on all and older pedestrians (65 years and older), a comparison group methodology in the before-after study described by Fayish et al (14) and Hauer (15) was used. Geometric characteristics of the various intersections as well as other factors such as traffic data for both major and minor roads, type of intersection, median type, land use characteristics and number of lanes were some of the factors considered in choosing the comparison group as described by Fayish et al (14). In this method, crash data from comparison sites are used to estimate crashes that would have occurred at the treated sites if these sites had no PCSs installed. The strength of this method depends on the similarities of the comparison sites to the treated sites as described by Shen et al (16). Qualitative evaluation of suitability and comparability of the comparison sites was done by plotting the before years of crash occurrences to the total crashes before the installation of the PCSs as shown in Figure 4. It is evident from visual inspection that both graphs trace each other well as described by Gross et al (17) and Hauer (15).

FIGURE 4 Graph shows non-treated Sites tracing the treated sites in the before years
In terms of quantitative evaluation of the suitability and comparability of the non-treated sites, Gross et al (18) discussed the use of sequence of sample odd ratios. In this, the sample odd ratios for each before-after pair were computed using total crashes before the installation of the PCSs as follow:

\[
Sample \text{ Odds Ratio} = \frac{T_b \times C_a / T_a \times C_b}{(1 + 1/T_a + 1/C_b)} \tag{1}
\]

Where: \(T_b\) = total crashes for the treatment sites in the year a, \(T_a\) = total crashes for the treatment sites in the year b, \(C_b\) = total crashes for the comparison group in year a, \(C_a\) = total crashes for the comparison group in year b. A 95 percent confidence interval, computed as mean ±1.96 * Std. Deviation was found to be 0.885 - 1.090. The sample mean odd ratios computed was 0.99. Since the confidence interval includes 1 with relatively small variance, the comparison group samples are suitable and similar to the treated samples.

The before-after with comparison group method is based on the following two basic assumptions: (a) there is similar change in the factors that influenced safety in the before-after installation of countdown signals at both the treated and non-treated sites and (b) changes in these factors influenced safety at the treated and non-treated sites in the same way. This means that, the change in the number of crashes recorded before and after installation of the countdown signals at treated sites would be the same proportion as that of the non-treated sites if there were no PCSs installed (16).

The main steps in the use of comparison group method in the before-after treatment are as follows (17):

\[
N_{TB} = \text{number of crashes recorded in the before period at the treatment sites},
\]

\[
N_{TA} = \text{number of crashes recorded in the after period at the treatment sites},
\]

\[
N_{CB} = \text{number of crashes recorded in the before period at the comparison sites},
\]

\[
N_{CA} = \text{number of crashes recorded in the after period at the comparison sites}.
\]

The comparison ratio describes how the number of crashes is expected to change in the absence of the treatment.

\[
\text{Comparison ratio} = \frac{N_{CA}}{N_{CB}} \tag{2}
\]

The expected number of crashes for the treatment group that would have occurred in the after period without the installation of countdown signals (\(N_{expTA}\)) is estimated from equation 3.

\[
N_{expTA} = (N_{TB}) \left(\frac{N_{CA}}{N_{CB}}\right) \tag{3}
\]

The variance of expected number of crashes in after period without treatment \(N_{expTA}\) is estimated from equation 4 as shown below:

\[
\text{Var}(N_{expTA}) = (N_{expTA})^2 \left(\frac{1}{N_{TB}} + \frac{1}{N_{CB}} + \frac{1}{N_{CA}}\right) \tag{4}
\]
In order to compute the number of expected crashes after the installation of the countdown signals, a multiplicative factor called crash modification factor (CMF) as well as its variance \[ \text{var. (CMF)} \] were estimated by:

\[
\text{CMF} = \frac{N_{TA}}{N_{expTA}} \left[ 1 + \frac{\text{var}(N_{expTA})}{N_{expTA}^2} \right]
\]  \hspace{1cm} (5)

\[
\text{Var(CMF)} = CMF^2 \left\{ \frac{1}{N_{TA}} + \frac{\text{var}(N_{expTA})}{N_{expTA}^2} \right\} \left[ 1 + \frac{\text{var}(N_{expTA})}{N_{expTA}^2} \right]^2 \]  \hspace{1cm} (6)

Again, to measure the certainty or uncertainty in the crash modification factor, standard error and confidence interval were also computed by:

\[
\text{standard error} = \sqrt{\text{var}(CMF)}
\]  \hspace{1cm} (7)

\[
\text{confidence interval} = CMF \pm \text{cumulative Probability} \times \text{standard error}
\]  \hspace{1cm} (8)

After estimating the CMF, crash reductions (in percent) can be obtained as \(100 \times (1 - \text{CMF})\)

RESULTS AND DISCUSSIONS

Perception Survey Analysis and Discussions

Statistics of participants of the survey were based on whether they have noticed the difference between PCS and standard pedestrian signals prior to the survey. There were participants who have noticed the countermeasure prior to the participation of the survey and such people were taken into consideration during data disaggregation. The survey results are shown in Table 2.

TABLE 2: Distribution of survey participants by age and location

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Detroit</th>
<th>Grand Rapids</th>
<th>Kalamazoo</th>
<th>Lansing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-24_Years</td>
<td>38</td>
<td>51</td>
<td>54</td>
<td>48</td>
<td>191</td>
</tr>
<tr>
<td>25-34_Years</td>
<td>76</td>
<td>57</td>
<td>51</td>
<td>49</td>
<td>233</td>
</tr>
<tr>
<td>35-49_Years</td>
<td>70</td>
<td>109</td>
<td>77</td>
<td>92</td>
<td>348</td>
</tr>
<tr>
<td>50-64_Years</td>
<td>68</td>
<td>144</td>
<td>128</td>
<td>112</td>
<td>452</td>
</tr>
<tr>
<td>65-74_Years</td>
<td>49</td>
<td>50</td>
<td>50</td>
<td>102</td>
<td>251</td>
</tr>
<tr>
<td>75-84_Years</td>
<td>18</td>
<td>18</td>
<td>21</td>
<td>32</td>
<td>89</td>
</tr>
<tr>
<td>85+</td>
<td>8</td>
<td>2</td>
<td>5</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>327</td>
<td>431</td>
<td>386</td>
<td>446</td>
<td>1,590</td>
</tr>
</tbody>
</table>
Signal Preference When Deciding to Start Crossing

Figure 5 shows the results on the usefulness of PCS when deciding to start crossing or not. The study revealed that about 91 percent of all participants who noticed the difference between PCS and MDOT’s standard pedestrian signal stated that they preferred the PCS. This enormous preference was consistent with studies conducted in the previous (11, 12). In the case of participants who had not noticed the difference between PCS and MDOT’s standard pedestrian signal, about 86 percent believed that the PCS would be more helpful when deciding to start crossing or not. The participants who had not noticed the difference before stated their preference based on the pictures presented to them. The study also revealed that about 91 percent of pedestrians 65 years and above who noticed the difference between PCS and MDOT’s standard pedestrian signal stated that they preferred the PCS. For pedestrian 65 years and above who had not noticed the difference between PCS and MDOT’s standard pedestrian signal, about 85 percent believed that the PCS would be more helpful when deciding to start crossing or not.

FIGURE 5 Preference of pedestrian countdown signal in decision to start crossing

Signal Preference for Decision to Adjust Walking Speed

In the case of the second scenario where participants were asked to state and rate their preference when adjusting their walking speed while crossing, Figure 6 shows that about 92 percent of the participants who noticed the difference between PCS and MDOT’s standard pedestrian signal preferred the PCS to the MDOT’s standard pedestrian signal. Again, over 88 percent of the participants who admitted that they had not noticed the difference between PCS and MDOT’s standard pedestrian signal, however they believed that the PCS would be useful in adjusting ones walking speed while crossing.

The study again showed that, about 93 percent of pedestrians 65 years and above who noticed the difference between PCS and MDOT’s standard pedestrian signal stated that they preferred the PCS. For pedestrian 65 years and above who admitted that, they had not noticed the
difference between PCS and MDOT’s standard pedestrian signal, about 92 percent believed that
the PCS would be more helpful when deciding to start crossing or not.

![Bar charts showing preference of pedestrian countdown signal in adjustment of walking speed]

**FIGURE 6 Preference of pedestrian countdown signal in adjustment of walking speed**

*Signal Preference for Feeling of Safety*

The final scenario focused on people’s feeling of safety while crossing and the results in Figure 7
showed how the participants perceived PCS in increasing the feeling of safety when crossing the
street. About 92 percent of the participants who noticed the difference between PCS and MDOT’s
standard pedestrian signal preferred PCS to the MDOT’s standard pedestrian signal. In the case of
people who have not noticed the countermeasure before the survey, the study showed a
comparatively lower percentages (about 83 percent) in people believing that PCSs would be more
useful in increasing the feeling of safety than the MDOT’s standard pedestrian signal.

For pedestrians 65 years and above, the study showed that, about 93 percent of those who
noticed the difference between PCS and MDOT’s standard pedestrian signal stated that they
preferred the PCS. For those who admitted that, they had not noticed the difference between PCS
and MDOT’s standard pedestrian signal, about 89 percent believed that, the PCS would be more
helpful when deciding to start crossing or not.
Crash Analysis Results and Discussions

Assessment of effectiveness of PCSs was done using before-after comparison group methodology described above. The total crashes during the before and after the installations of the devices for all pedestrian crashes (all severities) and pedestrian 65 years and above (all severities) were used in the computations for the expected crashes at the treatment locations in the after period if the PCSs were not installed.

*Pedestrian Crashes (All Severities)*

Figure 8A presents the trend in total (all severities) crashes involving pedestrian at both treated and non-treated sites in the before and after periods of study. The comparison ratio computed using equation 2 was found to be 0.935 and the expected crashes in the after period at the treated site was estimated to be 89, compared to the observed number of crashes in the after period which was 64. A crash modification factor (CMF) of 0.683 with standard error of 0.173 were obtained for total pedestrian crashes. This reduction of 32 percent was in the predicted direction but not statistically significant at the 95 percent confidence level with an interval of 0.400 to 0.967.

*Pedestrians 65 years and above (All Severities)*

Figure 8B shows the trend in crashes (all severities) involving pedestrians 65 years and above at both treated and non-treated sites in the before and after periods. Even though there were very few crashes recorded for pedestrians 65 years and above, comparison ratio was found to be 1.0, and the expected crashes in the after period at the treated site was 5 whilst the observed number crashes in the after period was 3. A crash modification factor (CMF) of 0.353 with standard error of 0.211 were calculated (suggesting a reduction of 65 percent in crashes). This CMF was statistically significant at the 95 percent confidence level. Again, it should be noted that the CMF for pedestrians age 65 and above was derived from too few crashes to be reliable.
Economic Analysis and Discussions

The economic analysis involves a comparison between the benefits associated with PCSs expressed in dollar units to the installation and maintenance cost of the signals. The benefit to cost analysis for the PCSs was done by determining the estimated crash reductions due to the presence of PCS from the crash modifications factor (CMF) and crash savings. A report by Kostyniuk et al. (18) documented average cost of a traffic crash in the state of Michigan as $19,999 while fatal/injury (KABC) and property damaged only (PDO) crash costs were estimated at $106,860.93 and $3690.00, respectively. Their estimates were based on both monetary costs which relates to medical care, emergency responses, future earnings, public service and property damage and loss and non-monetary costs (quality-of-life) pertaining to the state of Michigan from traffic crashes and crimes.

MDOT provided data on the cost of installing a PCS and the cost of installing a standard pedestrian signal. The average differential installation cost for a typical four-leg intersection was estimated as $822.74 per intersection. It was assumed that the differences in maintenance costs are negligible. With CMFs for total crashes and fatal/injury crashes, it was possible to estimate the annual fatal/injury crash savings and PDO crash savings. This was important due to the significant difference between the cost of a fatal/injury crash and a PDO crash. The annual crash saving was computed as follows:

FIGURE 8 A graphical presentation of observed and expected total (all severities) crashes
AAS = (RFI × FIC) + (RPDO × PDOC) \hfill (9)

Where

AAS = average annual saving per intersection,
RFI = reductions in fatal/injury crashes,
FIC = fatal/injury crash cost,
RPDO = reductions in PDO crashes,
PDOC = PDO crash cost.

Benefit-cost ratio (BCR) calculations were based on present values of crash saving and costs associated with a given countermeasure. A discount rate of 3.4, associated with a 30 years of service life, was used for PCS installation. The discounted present value of benefits (crash saving) was determined from the estimated annual crash saving as follows:

\[
PV_{benefits} = (AAS) \times \left( \frac{(1 + R)^N - 1}{R \times (1 + R)^N} \right)
\]

Where:

PV = Present value of savings,
R = discount rate (in decimals),
N = Service life (years).

Finally, the benefit-cost ratio (BCR) was estimated as follows:

\[
BCR = \frac{PV_{benefits}}{PV_{costs}} = \frac{100,713.64}{822.74} = 122
\]

The present value of the safety benefit of PCSs is estimated as $100,713.64 per intersection whilst the present value cost per intersection is estimated as $822.74. The resulting benefit to cost ratio is 122 to 1. This shows that installation of PCSs savings in crash cost compared to the cost to convert the signal from standard to PCSs.

CONCLUSIONS AND RECOMMENDATION

The objective of this study was to evaluate the effectiveness of PCSs and their safety impacts on all pedestrians and pedestrians 65 years and above. A comparatively larger sample sites which included both state and local roads for both treatment and non-treatment were selected to account for the potential limitations of before and after with comparison group methodology.

The study generally revealed significant crash reductions for all pedestrians (all ages, all severities) and pedestrians 65 years and above after implementation of the PCSs. The study results showed a statistically significant (at the 90 percent confidence level) reduction of nearly 32 percent in all pedestrian crashes (all severities). The study further revealed a reduction of almost 65 percent in crashes involving pedestrian 65 years and above. Although this was statistically significant at the 95 percent confidence level, the number of crashes for pedestrians age 65 years and above was very small. These findings, however, are consistent with the other studies done before (9, 13), which showed improvements in pedestrian safety. It is also consistent with the
recommendation made by Zegeer et al (3) and Singer et al (11) that PCS may be more beneficial to older pedestrians. Results from the perception survey also showed overwhelming preference for the PCS by all participants (pedestrians) and pedestrians 65 years and above as against the MDOT’s standard pedestrian signal when deciding whether to start crossing or not, deciding to adjust walking speed and feeling of safety while crossing the road way. The perception survey results are also consistent with studies conducted previously (11, 12).

The benefit to cost (BCR) ratio for the countdown signals was determined to be 122 to 1, based on savings gained in pedestrian crashes when compared to the cost of PCSs. This BCR suggests that converting MDOT’s standard pedestrian signals to PCSs is indeed economically beneficial.

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