Impacts of Countdown Timers on Pedestrian Behavior - Case Study in UAE

Mohsin Balwan[1], Janice Jaison[2], and Martin Fellendorf[1]
[1]Technical University of Graz, Graz, Austria
[2]Surface Mobility Consultants, Dubai, UAE
Email: Balwan@student.tugraz.at, janice.jaison@surfacemobility.com, Martin.Fellendorf@tugraz.at

***Abstract*—The purpose of the research is to investigate the impact of pedestrian countdown timers on pedestrian behavior and examine if it enhances their compliance and safety. A treatment and control methodology was conducted at a total of seven intersections in Sharjah and Abu Dhabi. The pedestrian perception was gauged using a user preference survey that was distributed at the study intersections and online. Pedestrians are seen to have an overall positive perception of countdown timers. Pedestrian behavior was assessed via video recording. Video data was collected for a fixed duration in the morning and mid-day during a weekday. Various parameters were studied to measure pedestrian compliance and safety namely- proportion of violations, pedestrian-vehicle conflicts, successful crossings and pedestrians who ran out of time. Statistical analysis was carried out to analyze if the pedestrian proportion in a particular performance measure varied in a statistically significant manner between the two cases (with countdown timers and without countdown timers). A significant reduction in pedestrian non-compliance and a significant increase in the number of successful pedestrian crossings were observed. Overall, results show that pedestrian countdown timers are efficient in enhancing pedestrian safety and in aiding them to make better-informed decisions while crossing. However, to fully benefit from countdown timers, factors such as time allotted for the green and red phase as well as its location need to be considered.**

***Index Terms*—pedestrians, crossing behavior, countdown timer, walking speed, safety, successful crossing**

I. Introduction

Conventional pedestrian signals are the most commonly used type of signals worldwide. These systems in general show three messages: first, is a 'Steady Walk' sign (SW) or an animated green man walking- this indicates that pedestrians can cross the road; second, is the 'Flashing Don't Walk' sign (FDW) or a hand flashing- this indicates that pedestrians must not begin to cross the road, however pedestrians that have already commenced are ensured sufficient time; third, is a 'Steady Don't Walk' sign (SDW) or a steady hand- this indicates that pedestrians must not be on the streets at all [1].

Tidwell and Doyle found that only fifty percent of pedestrians understood what the FDW display indicated [2]. Another study found it to be even less than fifty percent [3]. Besides, Some pedestrians enter the intersection at the last few seconds of the FDW sign at the conventional signals [4]. The chances of pedestrian accidents are eight times higher while crossing immediately before the release of traffic (nearing the end of the SDW) than while crossing the road when it should be [5].

One way to resolve this concerns is to use Pedestrian Countdown Timer (PCT) as they give additional information to pedestrians by displaying the amount of time at intersections and improve their comprehension of the FDW signal. PCTs are advanced applications of Intelligent Transportation Systems used in conjunction with traditional traffic signals to develop pedestrian behavior and safety. A study in Korea [6] found the PCT to be easier to understand as compared to the conventional FDW signal. This resulted in pedestrians taking more informed decisions regarding their crossing- either to start or stop and wait until the pedestrian Green Interval.

A key governing parameter to validate the efficiency of the PCT is pedestrian safety. Without PCT, pedestrians are unaware of the waiting duration causing some of them to take the risk to cross. PCTs can hence result in reducing the percentage of violations thereby increasing pedestrian safety and also improving traffic flow [7]. A study undertaken at the University of Texas [8] highlighted the efficiency of PCTs where they were installed to enhance safety among pedestrians, particularly university students. Also, many other studies with similar findings were carried out at Toronto [9], Dublin [10], Croatia [11], California [12] and Korea [6]. Similarly, a study done by [13] showed an increased pedestrian safety in urban areas.

In some studies, a significant decrease in the proportion of violators (pedestrians who cross during the SDW or FDW sign) were found irrespective of location and traffic flow [4], [7], [10], [14], [15]

While this is true, many other authors seem to disagree. They found little evidence of safety enhancement and found it sometimes even lead to possible pedestrian safety issues [16], [17]. The reason for reduced safety however, in those study can be attributed to the fact that the pedestrian green phase was short causing increased

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number of violations. Likewise, a study in Lower Hutt, New Zealand found that pedestrian safety has reduced, as it appeared to be encouraging riskier behavior [14]. It was observed that the proportion of pedestrians that ran out of time and still remained on the streets while the SDW sign was displayed rose significantly. In addition, the proportion of pedestrians that began walking when the FDW sign displayed rose. Nonetheless, this does not imply decreased pedestrian safety as results of this study may be possible due to factors such as allotted phase time and type of intersection. Also, pedestrians who are aware of the buffer duration that spans between the release of traffic and SDW display may be tempted to cross during the FDW.

Some studies concluded that they had the negative outcome of increasing violators. Huang and Zegeer [18] found compliance reduced from 59% to 47% in Lake Buena Vista, Florida. However, it must be noted that since a ‘treatment’ and ‘control’ site approach was used, both sites are unlikely to be the same. Obtained findings may have the possibility of being affected by external factors such as the type of intersection and user population characteristics. Nevertheless, this reduction in pedestrian compliance does not necessarily affect pedestrian safety as pedestrians learn to adjust their speed according to the time displayed [17], [18].

As in the case of pedestrian-vehicle conflicts, a study done in San Francisco resulted in a 52% decrease in pedestrian crashes due to PCTs [19]. However, this may not be a significant decrease if one was to consider the change in the number of crashes at the control intersections. Similar results also found in [20]-[23], [15]. Furthermore, in some studies, there were no pedestrian-vehicle conflicts with the countdown display i.e. zero crashes in the after period [3].

Another parameter to evaluate the PCT is the change in pedestrian behavior. In some studies, authors have concluded that there is a positive impact on pedestrian behaviour [1], [7], [10], [13], [15], [24]. Other studies however, found little evidence of the influence of countdown signals and suggested conducting further researches [18], [19], [25], [26].

The reason for the difference in the findings may be due to the fact that PCT can encourage positive behaviour by helping pedestrians organize their crossing and making better-informed decisions like stopping and waiting or adjusting their speed. At the same time, pedestrians are also likely to adopt more risky behaviour like crossing at the last few seconds of the FDW. A study from Auckland, New Zealand found that the impact of PCT on pedestrian crossing behavior changes according to where it is located [27].

Research conducted by The Minnesota Department of Transportation (MnDOT) found a significant increase of in successful pedestrian crossings due to the installation of PCTs [19]. Similarly, [28]–[30]. This implies that more number of pedestrians are able to finish crossing in time indicating how the additional information of time being displayed is useful to pedestrians who now can make better-informed crossing decisions.

The behavior in response to installation of PCTs is statistically different between genders and age intervals. Sex differentiation is found in compliant behavior where men violating the red signal is more often [1], [7], [29], [31]. This violation is also statistical different among age intervals, with younger people committing majority of the offenses [1], [32], [33]. Another study in the city of Jinan, China analyzed the influence of PCT on children at school intersections. They found that using PCT during the Red Interval led to more violations and increased tendencies to run among children [34].

The literature review shows professional circles having different views on the efficiency of PCTs and its effect on pedestrians; making its installation debatable. These mixed views may be due to external factors such as site and/or pedestrian characteristics, type of countdown signal installed. This only emphasizes the fact that it is still crucial to conduct further studies to determine their efficiency. Improved knowledge of the impact of countdown signals will lead to their increased usage.

This research aims to explore all facets relating to the efficiency of countdown timers. Its main objective is to determine the influence it may have on pedestrian behavior with regard to safety, compliance, number of illegal crossings and many other aspects using a before and after study methodology. This will be done by analyzing pedestrian perception and preferences towards PCT via user preference survey and by analyzing pedestrian behavior, conducts and habits via video analysis.

II. Methodology

In this study, a treatment and control study methodology has been used. Such a type of study is usually carried out when there is no existing data prior a change (in this case, installation of a PCT). Instead, two sites with similar characteristics are chosen and compared. The drawback however, is that the control site and the treatment site can never be exactly the same and pedestrian behavior has possible chances of being affected by numerous external factors.

A series of surveys were conducted at five intersections with PCTs (the ‘treatment’ sites) which were compared with two intersections which had conventional pedestrian signals (‘control’ sites).

Two types of surveys were carried out at each site:

1. User preference surveys examining pedestrian perception
2. Video surveys examining pedestrian behavior

To analyse the significance of the obtained values, an assessment for the difference in proportion of the categories being examined is performed. Chi-square test is carried out to analyse if the pedestrian proportion of a particular performance measure (say, non-compliance) varies in a statistically significant manner between the two categories (with PCTs and without PCTs). The hypothesis testing is based on the chi-square statistic at 95% confidence level. The null hypothesis being there is no difference between the two categories, with the alternate hypothesis being that there is a statistically significant difference.

A. User Preference Surveys

The user preference surveys were carried out onsite as well as online using Computer-Assisted Personal Interviewing (CAPI) and Computer-Assisted Self-Interviewing (CASI) respectively. It included a total of 14 questions having multiple options as shown in **Error! Reference source not found.** The Google form distributed online is shown in **Error! Reference source not found.**. The survey took approximately 2-3 minutes to complete. Study group under consideration was such that it provided an equal distribution of social characteristics (age, gender, educational level etc.). The questionnaire was designed based on similar opinion surveys reviewed in the literature. It aimed to have an overall idea of pedestrian's opinion of PCT in terms of personal preference, safety, compliance, comfort level, speed, and crossing behavior.

For CAPI surveys, as soon as people finished crossing, some were requested to take part in the user preference survey. For CASI survey, an online version of the surveys was distributed. Two separate CAPI were conducted, one at the 'treatment' site and one at the 'control' site. Both questionnaires had the same set of questions except that the treatment site questionnaire had an added question (Question 14) to understand pedestrians change in behavior with the installment of the PCT. The questionnaire survey was conducted in a time-span of two months. A total of 500 surveys were collected. Around 50% were on-site.

Data of each survey was manually logged from which graphs and charts were generated.

B. Video Surveys

The video surveys were used to record the pedestrian's practices and their interactions with the PCTs as well as drivers. The video surveys were used to obtain information on:

1. Total number of pedestrians
2. Total number of violators
3. Total number of pedestrian-vehicle conflicts (run, stop, abort, collide)
4. Total number of pedestrians who ran out of time.
5. Total number of successful crossings.

At the five treatment sites, roadside digital video camera provided by the Abu Dhabi Department of Transport (DOT) was used. At the two control sites, a portable camera was used. The time periods were preferred such that there was a representative sample of pedestrian volumes at the intersections. A total number of 323 and 334 pedestrians has been observed at treatment and control sites.

III. Results and Discussion

This study used both video recording and user preference survey to evaluate how pedestrian perception and behavior were influenced by the presence of the PCT. A summary of the main results is discussed below.

TABLE I. Questionnaire Questions and Possible Answers

Emirates of Residence: ……………………….					
Area of Residence: ……………………………					
Resident status:	*Local*	*Resident*	*Tourist*		
Gender:	*Male*				*Female*
Age group:	*18-24*	*25-34*	*35-44*	*45-54*	*>55*
Are you familiar with pedestrian countdown timers as shown here?			*Yes*	*No*	
How many times you use the pedestrian crossing in a day:		*<1*	*1-3*	*4-6*	*>6*
Will you prefer a pedestrian signal countdown device?					
Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Don't Know*
Will you prefer a pedestrian signal countdown device?					
Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Don't Know*
Do you think that pedestrian crossing with signal countdown device is safer?					
Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Don't Know*
Do you think that you will not cross the red light if you know the remaining time?					
Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Don't Know*
Relieve frustration from stopping for long and uncertain amount of time during the red phase.					
Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Don't Know*
Assist better judgment to move faster or slower depending on the time remaining.					
Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Don't Know*
How did the countdown timers at pedestrian signals influence your crossing behavior?					
Didn't change	*Stopped and waited*	*Made me cross when I would've waited*			
Went quicker	*Went slower*				

A. User Preference Survey Results

Table II and **Error! Reference source not found.** show the results of the surveys. The main conclusion that can be drawn from the user preference surveys is that the majority of the pedestrians have a positive perception of the PCT with 87% of participants in the final 'After' study preferring PCT over the conventional signals. Pedestrians felt safer crossing in the presence of a PCT with 88% stating the same.

Majority of the pedestrians (88%) stated that the PCT helped them make better judgement to adjust their speed according to the remaining time displayed. This is not the case for conventional signals where pedestrians are unaware of the time they have left to cross the street.

A great proportion of respondents, 82% stated that displaying the time left until one can start crossing the road prevented them from illegally crossing which highlights the effect PCT can have on pedestrian compliance and safety.

83% of respondents agreed to timers relieving frustration of waiting for long and uncertain amount of time which in fact reduces the probability of pedestrian's non-compliance as they are willing to stop and wait. This reduces uncertainty among pedestrians, in turn, helps them make better crossing decisions. In fact, when asked how the PCTs changed their crossing behavior; more than 50% indicated change of behavior by stopping and waiting. Moreover, 18% indicated their change in behavior by crossing slower or quicker demonstrating how time displayed allows for pedestrians to adjust their speed accordingly.

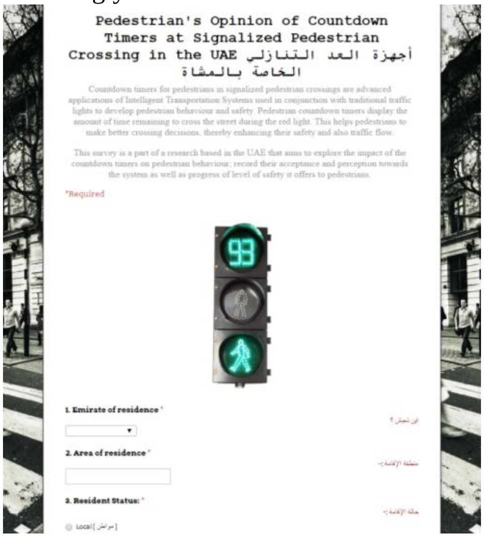


Figure 1. Survey questionnaire Google form

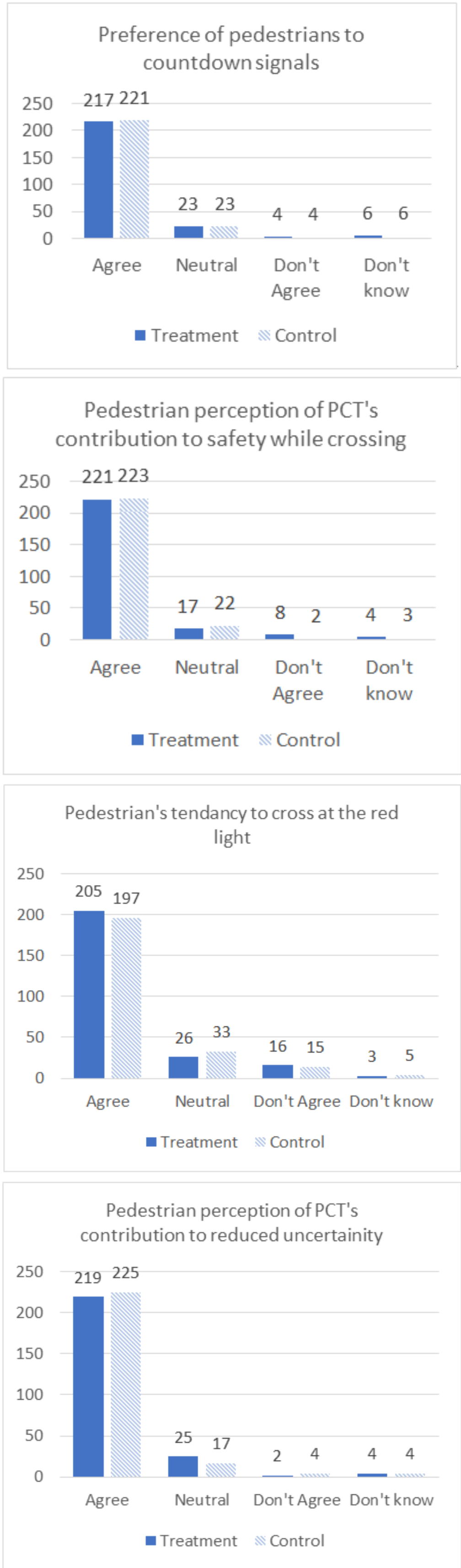
In addition, many of the respondents displayed their great support for the PCTs by adding further comments. Some stated that they felt more secure and could cross with more confidence. Others stated it helped them organize their crossing and make better decisions. A great majority requested for it to be installed in all signals, including remote areas. It was suggested that an 'outreach and education' be done to get the maximum benefit from the countdown signals.

However, there were also a handful of unfavourable comments. Few respondents stated that the time provided during green phase seem to be insufficient, causing problems for the elderly in particular. Also, few stated that PCT can prove harmful if one misjudged or underestimated the time required to cross the street.

TABLE II. DEMOGRAPHIC AND GENERAL QUESTIONS SURVEY RESULTS, 500 VALID RESPONDENTS FROM TREATMENT AND CONTROL SITES

<table>
<tr><th colspan="2">Nationality</th><th colspan="4">Gender</th></tr>
<tr><td>Local (Emirati)</td><td>27</td><td>Male</td><td colspan="3">200</td></tr>
<tr><td>Resident (expatriate)</td><td>468</td><td>Female</td><td colspan="3">300</td></tr>
<tr><td rowspan="3">Tourist</td><td rowspan="3">5</td><td colspan="4">Are you familiar with pedestrian countdown timers as shown here?</td></tr>
<tr><td>Yes</td><td colspan="3">487</td></tr>
<tr><td>No</td><td colspan="3">13</td></tr>
<tr><td colspan="2">Educational Level</td><td colspan="2">Age Group</td><td colspan="2">Crossing Trips/Day</td></tr>
<tr><td>Secondary/High School</td><td>51</td><td>18-24</td><td>185</td><td><1</td><td>100</td></tr>
<tr><td>Undergraduate/Bachelor Degree</td><td>342</td><td>25-34</td><td>141</td><td>1-2</td><td>167</td></tr>
<tr><td>Postgraduate/Master Degree</td><td>104</td><td>35-44</td><td>94</td><td>3-4</td><td>103</td></tr>
<tr><td rowspan="2">Doctoral Degree</td><td rowspan="2">3</td><td>45-54</td><td>56</td><td rowspan="2">>5</td><td rowspan="2">130</td></tr>
<tr><td>55></td><td>24</td></tr>
</table>

There was no significant difference in the responses between the treatment site and control sites as shown in Fig. 2.



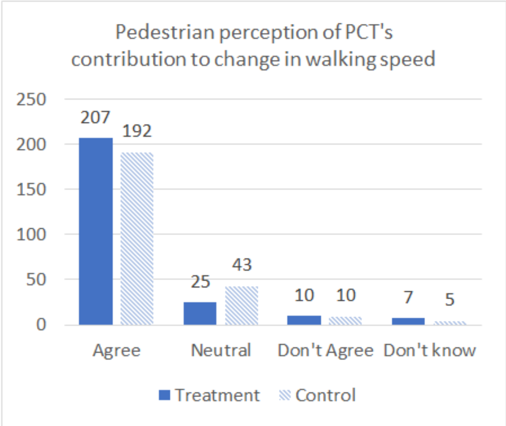


Figure 2. Comparison between treatment and control site results

TABLE III. PCT Related Questions Survey Results, 500 Valid Respondents from Treatment and Control Sites

Scale	Prefer Countd. Timer	Increase Safety	Preventing from Red Light Crossing	Releasing Frust.	Changing Walking Speed
Strongly agree	256	249	197	189	219
Agree	182	195	205	210	225
Neutral	46	39	59	68	42
Disagree	4	7	20	16	4
Strongly disagree	4	3	11	5	2
Don't know	8	7	8	12	8

B. *Video Survey Results*

A thorough analysis of the video recording was carried out to study how pedestrian behavior changed in the presence of a PCT as per the various parameters observed. **Error! Reference source not found.** shows the comparison results between the treatment and control site.

1) *Pedestrian compliance with PCT*

A pedestrian is said to have complied if he or she began to cross during the SW signal while pedestrians who crossed in the course of the FDW or SDW signal were not in compliance.

While comparing the treatment and control sites, 25% of pedestrians showed a non-compliant behavior in the control sites which reduced to 13% in the treatment sites. This reduction is statistically significant and clearly exhibits the effect of PCT on pedestrian crossing behavior; making it safer than conventional signals. This result is concurrent with many other studies [4], [7], [10], [14], [15]. This decreased rate of non-compliance may be due to reduced uncertainty among pedestrians as the additional display indicating amount of time left until one can cross, makes waiting more acceptable.

13% of pedestrians that showed non-compliance can be a result of the tendency of certain pedestrians to take the risk to cross the road during red light if they seem to think that there is enough time to cross during a gap in the traffic. Although not as much in the case of PCT, this occurs irrespective of the type of signal present.

It must be noted that most of the violations were recorded at a site where the time allotted for the pedestrian green phase was very less causing pedestrians to have no choice but to cross illegally. Although not observed during this trial, the alternate case of having a long waiting period can also cause a similar consequence of increased violations. Hence the allotted phase timings are an important aspect to consider while installing these systems.

Likewise, the second highest number of recorded violations were at the site where it had comparatively lesser traffic flow during the morning hours which resulted in longer gaps in traffic during which pedestrians tend to take the risk to cross.

Violators also include pedestrians that happen to reach at the curb during the end phase of FDW and still decide to go ahead and cross even if time left is insufficient, taking advantage of the buffer time. This has the undesirable effect of increasing non-compliance.

2) *Pedestrian-vehicle conflicts*

Pedestrian behavior and their interaction with vehicles were examined. The various scenarios studied are:

- Pedestrian ran to avoid on-coming vehicles
- Aborted crossing- pedestrian start to cross but walked back to curb to avoid on-coming vehicles
- Pedestrian stopped to avoid on-coming vehicles
- Pedestrian and vehicle collided.

No significant change in number of pedestrians-vehicle conflicts during the study period was observed. The conflicts observed primarily took place when pedestrians crossed during the DW signal benefiting from the gap in traffic.

3) *Pedestrians who ran out of time*

This comprises of pedestrians who still remain in the crosswalk when the SDW signal is displayed.

No significant differences were observed in pedestrians who ran out of time during the study period. However, the risk of pedestrians remaining in the roadway at the release of traffic in the case of PCT is comparatively lesser as there is a buffer time between the display of the SDW and the release of traffic. This gives ample amount of time for the pedestrians remaining in the crosswalk to finish crossing in time thereby increasing safety. Pedestrians who run out of time also include those pedestrians that happen to reach at the curb during the end phase of FDW and still decide to go ahead and cross even if the time left is insufficient. Again, this does not necessarily decrease their safety as, in addition to the fact that there is a buffer time, they tend to adjust their walking speed accordingly.

This is not, however, the case for conventional signals where as soon as the FDW signals end, within less than 5 seconds, the conflicting traffic is released. This does not ensure pedestrians remaining in the crosswalk will finish crossing the road in time and hence reduce safety.

4) *Successful pedestrian crossing*

A pedestrian is said to successfully cross a street if he/she begins to cross at the SW signal and manages to finish crossing before the end of SW or FDW signal.

A significant change (12% increase) in the amount of pedestrian successfully crossing the street is observed in the treatment sites with PCT. This can be mainly accounted to decreased violations in the treatment sites and implies that more number of pedestrians are able to finish crossing in time. This indicates how the additional information of available time can be useful to pedestrians who now make better-informed crossing decisions. Again, this only emphasizes the fact that PCT is safer for pedestrians. Similar findings were made by authors such as [29] and [35].

5) Further observations

Another observation made is that towards the last few seconds of the green phase or FDW, PCTs help pedestrians adjust their speed according to the time displayed which increases the rate of successful crossings among pedestrians and therefore safety. Similar findings of increased walking speeds were also found in other studies by [15], [18], [29], [36] and [37]. This is not the case however, for conventional signals where pedestrians are unaware of the time they have and sometimes may fail to complete their crossing in time.

Results from user preference surveys regarding pedestrian's willingness to wait at the red signal concur with the video recordings. A majority of the pedestrians were willing to stop and wait since they knew how long they had to. This is not the case however, for conventional signals where uncertainty among pedestrians increases the probability to commit a violation.

It must be noted that PCTs that display longer waiting time may nullify this effect of reduced uncertainty and may lead to pedestrians crossing illegally as also observed by [4] who found that Pedestrians maximum accepted waiting time before becoming impatient lied between 60-120 seconds.

TABLE IV. VIDEO SURVEY RESULTS IN COMPARISON BETWEEN TREATMENT AND CONTROL SITES

		Treatment	Control	Chi Square
Pedestrian compliance with countdown signal	Complied	252 (75.4%)	280 (86.7%)	Significant
	Did not comply	82 (24.6%)	43 (13.3%)	
Pedestrian ran to avoid on-coming vehicles	Run	2 (0.62%)	4 (1.2%)	Insignificant
	Didn't run	321 (99.4%)	330 (98.8)	
Aborted crossing	Aborted	4 (1.24%)	2 (0.6%)	Insignificant
	Didn't abort	320 (98.76%)	332 (99.4%)	
Pedestrians who ran out of time	Run out of time	2 (0.62%)	3 (0.9%)	Insignificant
	Didn't run out of time	321 (99.38%)	331 (99.1%)	
Successful crossing	Successful	280 (86.7%)	249 (74.5%)	Significant
	Not successful	43 (13.3%)	85 (25.5%)	

While observing pedestrian behavior, it was observed that pedestrians tend to cross illegally if alone as opposed to if they were in a group waiting for the display of the next SW. Similar to findings by [10] and & [10] Contrarily. It was also observed that a group of pedestrians tend to violate if one person violates.

IV. CONCLUSION

The purpose of the research is to investigate the impact of PCT on pedestrian behavior and examine if it enhances their compliance and safety. A treatment and control methodology was conducted at a total of seven intersections in Sharjah and Abu Dhabi. Data on pedestrian behavior and perception were collected via video recording and CAPI/CASI user preference survey conducted at the study intersections during the months October 2015 and February 2016. A total of 500 surveys were collected in which 50% were on-site. Pedestrians are seen to have an overall positive perception of PCTs in the user preference surveys. Video data was collected for a fixed duration in the morning and mid-day during a weekday. A total number of 323 and 334 pedestrians has been observed at treatment and control sites. Various parameters were studied to measure pedestrian compliance and safety namely- proportion of violations, pedestrian-vehicle conflicts, successful crossings and pedestrians who ran out of time. Statistical analysis was carried out to analyses if the pedestrian proportion in a particular performance measure varies in a statistically significant manner between the two cases (with PCT and without PCT). A significant reduction in pedestrian non-compliance and a significant increase in successful pedestrian crossings were observed. No significant changes in the other parameters studied were found. However, it was seen that the safety of pedestrians who ran out of time at the treatment sites did not necessarily decrease their safety as there is a certain buffer time allotted between release of conflicting traffic and display of SDW sign. Also, showing the available time allows for pedestrians to adjust their speed accordingly. The results of this trial are in conjugation with many other studies that were previously carried out in this field and demonstrate how pedestrian's safety and compliance was enhanced due to the installation of PCTs. Positive influence was also seen in pedestrian behavior as they organized their crossing and made better decisions. Road and Traffic Authorities consider pedestrian safety as an important factor and is always exploring approaches to enhance safety at traffic signals. In addition to demonstrating how pedestrian behavior may be changed; this trial highlights the efficiency of a system that equips pedestrian with extra information and can lead to decreased pedestrian fatalities in the UAE. Further steps may be taken to widespread the use of PCTs all over the UAE which is currently only used in the Emirate of Abu Dhabi.

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