DOI: 10.7251/JTTTP1801022K
UDC: 656.142:711.4(497.6Banja Luka)
ORIGINAL SCIENTIFIC PAPER

# The Effect of Countdown Pedestrian Signals on Pedestrian Behavior in Various Weather Conditions - Case Study in Banja Luka

**Mirsad Kulović[1], Slavko Davidović[2]**
[1]*College of Traffic Engineering, Pan-European University "Apeiron", Banja Luka, mirsad.f.kulovic@apeiron-edu.eu*
[2]*College of Traffic Engineering, Pan-European University "Apeiron", Banja Luka, slavko.j.davidovic@apeiron-edu.eu*

*Received: January 10, 2018*
*Accepted: June 4, 2018*

**Abstract:** Pedestrians represent the most vulnerable category of participants in traffic. More and more complex traffic conditions in cities across Europe, and therefore BiH, threaten traffic to become a challenge for pedestrians, and pedestrians often experience traffic as a challenge. Studies of behavior of pedestrians at signalized pedestrian crossings conclude that there is a high level of insecurity and a high percentage of unsafe crossings by pedestrians. Timers that add pedestrian signals indicate the length of the red light, the remaining time to the beginning of the green light for the safe crossing of pedestrians across the street. This paper analyzes the effect of the countdown pedestrian signals- CPSs in different weather conditions, ie the comparison of pedestrian behavior (switching to red light) without CPSs and with CPSs in different weather conditions (sun, snow, rain, no precipitation with a temperature of 0 degrees) was performed. The paper analyzes a traffic light pedestrian crossing over the road that consists of four traffic lanes in Banja Luka, BiH.

**Key words:** pedestrians, countdown pedestrian signals- CPSs, pedestrian behavior, crossing the street to red light.

## INTRODUCTION

Walking is the basic and common mode of transport in all societies around the world. Each trip begins and ends on foot. Travelling on foot has proven environmental and health benefits, but unfortunately there is an increased risk of traffic accidents.

According to the World Health Organization (WHO, "Pedestrian Safety" 2012), around 270,000 pedestrians died in 2010, accounting for about 20% of the total number of dead people, and their 2013 report ("Global status report onroad safety "2013) shows that a lot of attention should be paid to the safety of pedestrians and cyclists, and it is necessary to work on establishing measures to promote non-motorized movements and for which they must be able to be safe.

Traffic accidents involving a motor vehicle and a pedestrian are19 times more likely to result in death, than accidents involving only vehicles, while the risk of mortality depends on age and gender (1) (DETR, 1999).

The International Transport Forum (ITF) in its report (2) shows that pedestrians experience traffic as something hostile and that many experience fear of complex traffic.

In order to increase the safety of pedestrians, local authorities create a combination of specific activities, called 3E (engineering, enforcement and education). Pedestrian injury can be the result of one or more factors, the behavior and habits of pedestrians, infrastructure design, and the environment.

## RESEARCH BACKGROUND

The irregular and unavoidable crossing of pedestrians across the road at pedestrian crossings with traffic lights, during the blazing red light, is a frequent occurrence and one of the most common ways of occurrence of traffic accidents with the involvement of pedestrians - (3) (Wang et al.2011).

Many studies emphasize the important role of infrastructure on the safety of pedestrians (4) (Elvik, 2009); (5) (Miranda-Moreno et al., 2011).

In order to improve the behavior of pedestrians at pedestrian crossings and improve their safety, countdown pedestrian signals CPSs are increasingly used as a supplement to traditional traffic lights. The main role of countdown pedestrian signals CPSs is to show pedestrians the information on the remaining duration of the red light, to show the time remaining until the start of the green light, ie the beginning of the stage for their safe crossing across the street. The main goal is to reduce the number of pedestrian crossings to red light, to increase the safety of pedestrians, and to provide better traffic flow.

Previous scientific studies on the effect of the pedestrian timer show a decrease in the percentage of red light transitions. Eccles et al. (2003) (6) investigated 20 pedestrian crossings and obtained results that generally reduce the number of street crossings to red light, with the percentage reduction not the same and it depends on the microlocation of pedestrian crossings.

Researchers (PHA Traffic Consultants) from Berkeley concluded in their research (7) that the percentage of crossing the street at a red light was reduced from 23% to 15%, following the installation of countdown pedestrian signals, and that the 5% reduced the number of pedestrians who have tried to switch to red flashing light.

The reduction of 27.3% to 23.9% crossing at a red light, was proved in a research by Lipovac K. 2013. (8)

A survey in Montreal, Canada, analyzed the type of injuries and came to the conclusion that a 15% reduction in injuries was achieved at timer crossings - (9) Brosseau, M., Zangenehpour, S., Saunier, N., Miranda-Moreno, L., 2013.

Minnesota Department of Transportation (Mn/DOT) conducted a before-and-after study of CPSs at five intersections in the Minneapolis and Saint Paul metropolitan area (10) (Cook Research and Consulting, Inc., 1999; Farraher, 2000). After replacing conventional pedestrian signals with CPSs, researchers observed an increase in crossing success from 67 percent to 75 percent. The greatest increase was observed for teenagers, whose rates of compliance and success increased by 20 percent.

The City of San Francisco, CA conducted a preliminary evaluation of pedestrian behavior before and after conventional signals were replaced by CPSs (11) (DKS Associates, 2001).The CPSs pilot program involved 14 intersections. Investigators found a significant increase in crossing success (from 86 percent to 91 percent) when conventional pedestrian signals were replaced by CPSs, though pedestrian behavior differed substantially between sites. There was also a small, statistically insignificant increase in compliance with the pedestrian change interval after the CPSs was installed.

Markowitz and colleagues (12) conducted a before-and-after study in San Francisco, California, to assess the effectiveness of countdown pedestrian signals at 14 intersections. This study found that the countdown signals reduced the numbers of pedestrian crashes and injuries, that countdown signals reduced the proportion of pedestrians who completed the crossing during the red signal, and that pedestrians viewed countdown signals favorably.

Eccles and colleagues (13) performed a study in Montgomery County, Maryland, to evaluate the effectiveness of countdown pedestrian signals at five intersections. In that study, the authors reported a statistically significant increase (based on the t-test), in the after period, in the percentage of pedestrians crossing during the "Walk" interval at six of the eight locations studied. The results of the before-and-after study indicated that countdown pedestrian signals had no effect on vehicle approach speeds during the pedestrian clearance interval, that countdown pedestrian signals generally increased the number of pedestrians who entered on the "Walk" indication, and that countdown pedestrian signals significantly decreased pedestrian–vehicle conflicts. Additionally, the authors found that the pedestrians interviewed were aware of and understood the countdown pedestrian signals correctly.

The goal of this paper is to determine the percentage, the number of pedestrians crossing the roadway to the red light before setting the countdown pedestrian signals CPSs, after the CPSs is set, in different weather conditions.

## METHOD

The research in this article was done in the central area of the City of Banja Luka, at a traffic light at a pedestrian crossing near the building of the City Administration. The traffic light works in such way that the green pedestrian light is 13 seconds, the protective time is 10 seconds, and the red light is 87 seconds (110 seconds in total). The street that pedestrians need to cross consists of 4 lanes (2 lanes for each direction), with a total width of 12m.

Research involves 5 phases:

- Phase I - before setting the CPSs,
- Phase II - CPSs set - sunny weather (temperature around $20^0$),
- Phase III - CPSs set - snowfall,
- Phase IV - CPSs set - rain and
- Phase V - CPSs set - clean weather, temperature $0^0$.

The research of each phase was conducted during 3 hours during the day. In the phase I of the study, the behavior of pedestrians was analyzed before setting the countdown pedestrian signals CPSs. The video camera was placed in a kiosk near the pedestrian crossing, and it can be said with certainty that it had no effect on the observed sample. The recorded video material was transferred to the computer, then it was statistically processed and analyzed the behavior characteristics of pedestrians for different phases of research.

## RESULTS

Before setting the CPSs (Phase I), it was found that 23.30% of pedestrians started crossing the street duringthe red light.

The results after setting the CPSs, in different weather conditions exhibit the following (Figure 1):

- Phase II - during sunny weather with a temperature of about 20 degrees: the number of crossings of the street during the red light was reduced to 16.3%,
- Phase III - during the snowfall: the CPSs did not have a significant impact,
- Phase IV - during the rains: the number of crossings of the street during the red light was reduced to 15.8% and
- Phase V - clean weather, with a temperature of about 0 degrees, the number of crossings of the street during the red light was reduced to 6.8%.

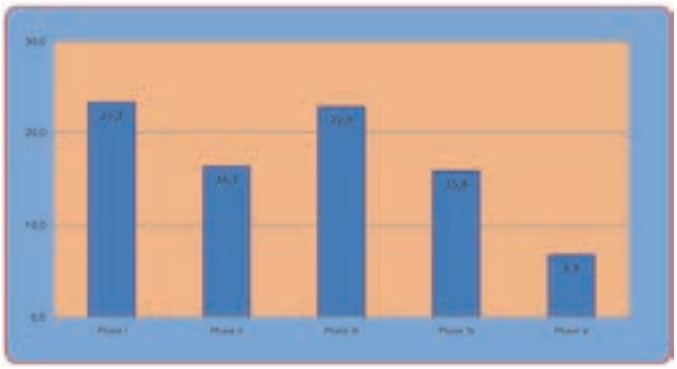

**Figure 1.** the number of crossings of the street during the red light (%)

If you analyze pedestrian crossings, without pedestrians who started crossing the road in the first 5 seconds of the red light and pedestrians that started their transition 5 seconds before the start of the green light (the last 5 seconds of the red light), the results are as follows (Figure 2):

- before setting the CPSs (Phase I): 10.9% of pedestrians started crossing the street during the red light;
- during sunny weather with a temperature of about 20 degrees (Phase II): the number of crossings of the street during the red light was reduced to 5.5%;
- during the snowfall (Phase III): the CPSs did not have a significant impact;
- during the rains (Phase IV): the number of crossings of the street during the red light was reduced to 6.0% and
- clean weather, with a temperature of about 0 degrees (Phase V): the number of crossings of the street during the red light was reduced to 3.2%.

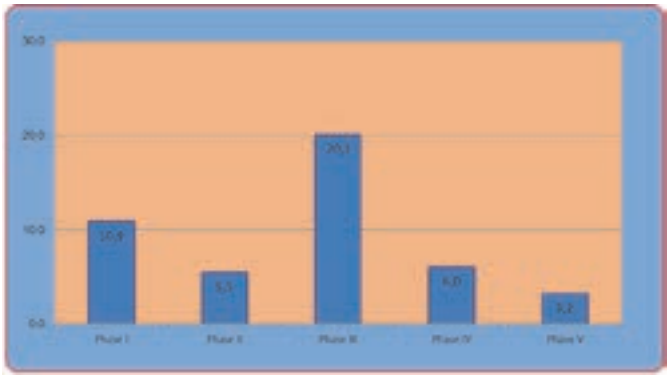

**Figure 2.** the number of crossings of the street during the red light (%) – without the first/last 5 seconds of the red light

Analyzing the moment of transition during a red light, it was found the same behavior of pedestrians, except in the phase when the snow falls (Figure 3).

After setting up a CPSs, pedestrians decided to cross the street in the first or last period of the red light in all phases. (Figure 4 - moment of transition during a red light without phase 5).

Analyzing the age structure of pedestrians crossing the street during the red light, the CPSs had no impact on the different age categories of pedestrians (Figure 5).

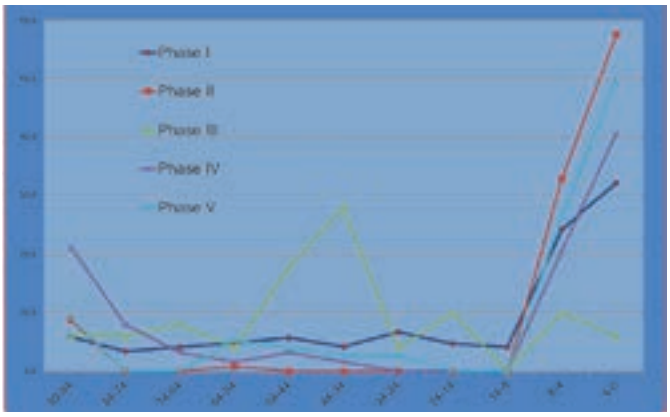


**Figure 3.** moment of transition during the red light

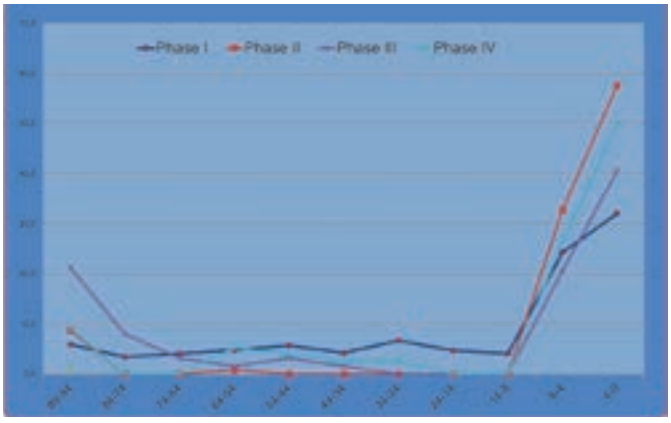


**Figure 4.** moment of transition during the red light without phase 5

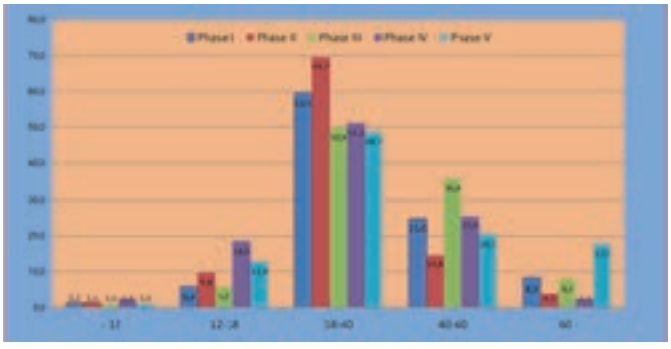

**Figure 5.** Age structure of pedestrians crossing the street during the red light

## DISCUSSION

The study found that the setting of the countdown pedestrian signals – CPSs had a positive effect. The total number of pedestrians crossing the red light decreased in all phases of the research (in all weather conditions), except during snow, (Phase V) when there is no impact.

An additional analysis was done for the phase when it was snowingand showed that about 90% of pedestrians lacked adequate clothing for weather conditions (there is no hood or umbrella), and that the speed of traffic flow is reduced, so pedestrians choose to cross the street during red light.

Also, if we do not analyze the initial 5 seconds of the red light and the last 5 seconds of the red light, the

use of the CPSs had a far greater impact on the pedestrians. Again, it is necessary to emphasize that in the phase of snowfall, the CPSs does not have a significant impact.

Analyzing the age structure of pedestrians before and after setting the timer in different weather conditions, pedestrians between 18 and 40 years of age conducted a number of improper behaviors, which is in line with previous scientific studies on the impact of timers on the behavior of different age structures when crossing the street (7) ( LIpovac, (2013); (14) King et al. (2009); (15) Ying and Keping, (2011)).

By analyzing the distribution of the street crossing during the red light, it was determined that the pedestrians decide on an irregular crossing during the first and last 5 seconds of the red light. The above can be explained in the way that, by setting the CPSs , the pedestrians have information about the duration of the red light, or the duration of time for which they will be able to cross during the green light.

If the pedestrians notice that the red light has just begun or that there is very little time left to start the green light (the end of the red light), pedestrians are more likely to decide to cross the street in an irregular, unsafe way.

After 5 seconds of the red light for up to 5 seconds until the end of the red light, the CPSs had a significant positive effect and it can be concluded that these seconds represent the limit values for deciding to cross the street during the red light from the pedestrian area. From the distribution analysis, the phase was dropped when the snow fell, for which it was again confirmed that the CPSs had no significant impact.

## CONCLUSION

The countdown pedestrian signals – CPSs have a positive effect on the behavior of pedestrians and their decision to cross the street, in the weather conditions when it is sunny (Phase II), when it rains (Phase III) and when there is no precipitation (clear time –) and the temperature is 0 degrees (Phase IV), and there is no significant impact during snowfall (Phase V).

The effect of the CPSs on the age structure of pedestrians does not exist and often those who are crossing the street during the red light at all phases of the study are pedestrians from 18 to 40 years.

The study found that CPSs influence the decision to cross the street, and the 5th second of the start and the 5th second before the end of the red light can be considered as the limit value for the decision of the pedestrian.

The research and results confirm previous experience of the effect countdown pedestrian signals on pedestrian behavior.

The research should expand and analyze the average number of pedestrians who crossthe street during the red light, the impact of pedestrians crossing the street during the red light on pedestrians waiting for the green light, the duration of the waiting time of pedestrians crossing the street during the red light, analyzing pedestrian crossings on different types and characteristics of roads, the percentage of crossing the street in relation to traffic flows of different parameters, in order to establish more accurate conclusions on the influence of the effect that the countdown pedestrian signals CPSs have in the areas of different cities in BiH.

## REFERENCES

[1] Department of the Environment, Transport and the Regions. Road Accidents Great Britain 1998: Annual Report. London: DETR

[2] ITF, 2012. Pedestrian Safety, Urban Space and Health. OECD Publishing. http://dx.doi.org/10.1787/9789282103654-en.

[3] Wang, S., Yang, J., Hu, C., and Chen, Y. *"Study on pedestrian safety evaluation and improvement at urban intersections."* Proc., ICTIS 2011, 1st Int. Conf. on Transportation Information and Safety: Multimodal Approach to Sustained Transportation System Development— Information, Technology, Implementation, ASCE, Reston, VA.

[4] Elvik, R. *The non-linearity of risk and the promotion of environmentally sustainable transport. Accident Analysis and Prevention*, 2009, 41(4), 849–855

[5] Miranda Moreno, L., Morency, P., & El Geneidy, A. *The link between built environment, pedestrian activity and pedestrian-vehicle collision occurrence at signalized intersections*. Accident Analysis and Prevention, 2011, 43(5), 1624–1634.

[6] Eccles, K. A., Tao, R., and Mangum, B. C. *Evaluation of pedestrian countdown signals in Montgomery County, Maryland.* Proc., 83rd Annual Meeting, Transportation Research Board, Washington, DC, 2003.

[7] PHA Consultants. *Pedestrian countdown signal evaluation—City of Berkeley*, Berkeley, 2005.

[8] Lipovac, K., Vujanić, M., Marić, B. i M. Nešić., (2013). *Pedestrian Behavior at Signalized Pedestrian Crossings*, Journal of Transportation and Engineering, American Society of Civil Engineers, 2005, 139(2), 165-172.

[9] Brosseau, M., Zangenehpour, S., Saunier, N., Miranda-Moreno, L., *The impact of waiting time and other factors on dangerous pedestrian crossings and violations at signalized intersections: a case study in Montreal*. Transp. Res. F: Traffic Psychol. Behav. 2013, 21, 159–172.

[10] Cook Research & Consulting, Inc. *Countdown Pedestrian Indication Market Research*. Minneapolis, MN: Mn/DOT's Metropolitan Division Traffic Engineering Section, 1999.

[11] DKS Associates. *San Francisco Pedestrian Countdown Signals: Preliminary Evaluation Summary.* San Francisco, CA: San Francisco Dept. of Parking and Traffic, 2001.

[12] Markowitz, F., S. Sciortino, J. L. Fleck, and M. Y. Bond. *Countdown Pedestrian Signals: Experience with an Extensive Pilot Installation*. ITE Journal, Vol. 76, No. 1, 2006, pp. 43–48.

[13] Eccles, K. A., R. Tao, and B. C. Mangum. *Evaluation of Countdown Pedestrian Signals in Montgomery County, Maryland. In Transportation Research Record*, Journal of the Transportation Research Board, No. 1878, Transportation Research Board of the National Academies, Washington, D.C., 2004, pp. 36–41.

[14] King, M. J., Soole, D. W. and Ghafourian, A. *Illegal pedestrian crossing at signalized intersections: Incidence and relative risk*, Accident Analysis and Prevention, 2009, 41(3), 485-490.

[15] Ying, N. and Keping, L. *Modelling Pedestrian Behavior at Signalized Intersections: A Case Study in Shanghai*, ICTIS 2011: Multimodal Approach to Sustained Transportation System Development - Information, Technology, Implementation, Proceedings of the 1st International Conference on Transportation Information and Safety.