BEFORE-AFTER STUDY OF SIGNALIZED INTERSECTIONS WITH VISUAL CYCLE IN THE CITY OF SÃO CARLOS, BRAZIL

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ABSTRACT

The main purpose of this paper is to compare the common traffic lights (CTL) versus traffic lights with visual cycle (TLVC) to green and red phase, and assess their effects on road safety. The comparison among CTL and TLVC is justified by the fact that there are no studies on the effect of TLVC with respect to its performance in terms of traffic safety. An observational before-after study was conducted to evaluate the safety in a period of one year before and one year after the implementation of the TLVC. This study used a comparison group of two intersections without the treatment. The results indicate that no conclusions can be built about the safety effect of the TLVC on safety with the data available.
Keywords: before-after study, traffic lights with countdown time*, and traffic safety.*

1. INTRODUCTION

Traffic safety research is a complex task in the sense it depends on variables which are difficult to measure and to control. The comparison between the number of accidents before a treatment and the number of accidents after this treatment is called “before-after” study, and it has been performed to evaluate the effect of countermeasures that are supposed to increase safety. More specifically the estimation of the safety effect of a treatment requires

the prediction of what would have happened in the after period in the absent of the treatment (Hauer, 1997).

Included on the "before-after" studies field is the use of comparison group. The central idea of using a comparison group is simple: indentifying a group of entities (streets, intersections, and etc.) that remained untreated, which are similar to the treated ones, and compare the safety in both. The treated entities form the "treatment group". The untreated entities form the "comparison group".

Nowadays, many features are incorporated to the traffic system without proper prior research of their possible effects on safety. An example of this situation is the implementation of traffic signals that allow the driver to see the remaining time of each phase. This kind of signal has been adopted by some cities in Brazil, including São Carlos. Figure 1 shows the signal with the phase remaining time information and the common signal.

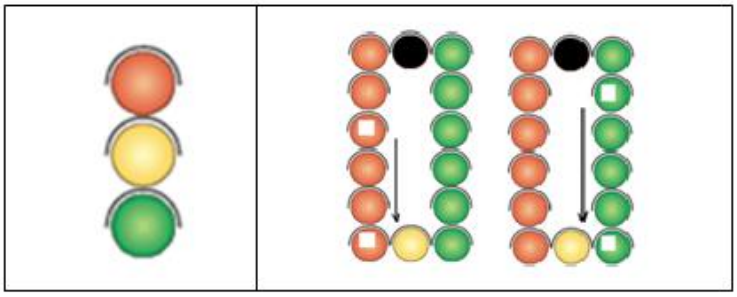

Figure 1: Common signal (left) and signal with visual cycle time informer (right)

The objective of this signal is the lost time decrease. Nevertheless, it may have an effect on safety that is still unknown. Drivers who are approaching the intersection may increase their speed to clear the intersection in the remaining green time. On the other hand, drivers who are stopped waiting on the second approach may start to move prior than they should do.

Based on that, the objective of this study is to analyze the safety effects of the signal with the phase remaining time informer in comparison to the common signals used nationwide, using the "before-after" method. This study became necessary because of the increase in the implementation of this kind of signal in median and big cities in Brazil.

This study was conducted in the city of São Carlos, located at São Paulo State in Brazil (Figure 2). According to IBGE (Brazilian Institute of Geography and Statistics) the city has an estimate for 2009 of 220,463 inhabitants, and a territorial area of 1141km². São Carlos has a fleet of almost 120,000 vehicles: 76% automobiles, 20% motorcycles, and 4% trucks and buses (DENATRAN – National Traffic Department, 2009).

Figure 2: Location of São Carlos

2. METHOD

The purpose of this topic is to provide a unified framework for the statistical interpretation of all variants of observational "before-after" studies. This framework will guide all subsequent discussions, and consists of four basic steps. The method is based in Chapter 9 of the book "Observational before-after studies in road safety", by Ezra Hauer (1997).

Some notation is required to the better understanding of this method, which is provided in the following items.

π : prediction of the expected number of target accidents of a specific entity in an "after" period would have been had it not been treated.

λ : estimation of the expected number of target accidents f the entity in the "after" period.

$\delta = \pi - \lambda$: reduction in the "after" period of the expected number of target accident.

$\theta = \lambda/\pi$: ratio of what safety was with the treatment to what it would have been without the treatment (index of effectiveness).

κ : number of before accidents on the treatment group.

μ : number of before accidents on the comparison group.

ν : number of after accidents on the comparison group.

$r_c = {}^{\nu}/_{\mu}$: ratio of the expected accident counts for the comparison group.

$r_c = {}^{\pi}/_{\kappa}$: ratio of the expected accident counts for the treatment group.

$\omega = {}^{r_c}/_{r_t}$: odds ratio

In this paper, prediction (π) is based on the trend of the number of accidents from the before to the after year. Prediction (λ) is based on the reports of the police. Table 1 contains the (λ) values for the before-after periods of the treated and non treated entities.

Table 1. Accidents expected on the studied intersections

Period	Treatment group	Comparison group
Before	(κ)	(μ)
After	(λ)	(ν)

For a comparison group to considered legitimate, it must fulfill the requirement that the average of ω values is equal to one (ω=1). Satisfied this requirement, the estimate of the parameters and of the variances can be done based on Tables 2 (steps 1 and 2) and 3 (steps 3 and 4).

Table 2. Estimates of the steps 1 and 2

Estimates of parameters (step 1)	Estimates of variances (step 2)
$\hat{\lambda}$ =λ	VÂR{ $\hat{\lambda}$ }=λ
$\hat{r}_T = \hat{r}_C = (v/\mu)/(1+1/\mu) \approx v/\mu$	VÂR{ $\hat{r}_T$ }/$r_T^2 \approx 1/\mu+1/v+$VÂR{ω}*
$\hat{\pi} = \hat{r}_T \kappa$	VÂR{ $\hat{\pi}$ }≈ $\hat{\pi}^2$[1/κ+VÂR{ $\hat{r}_T$ }/r_T^2]

* VÂR{ω} is estimated to be zero because of data for the calculus was not available.

Table 3. Estimatives of the steps 3 and 4

$\delta = \pi - \lambda$

$\hat{VAR}\{\hat{\delta}\} = VAR\{\hat{\pi}\} + VAR\{\hat{\lambda}\}$

$\theta^* = (\lambda/\pi)/[1+VAR\{\hat{\pi}\}/\pi^2]$

$VAR\{\hat{\theta}\} \approx \theta^2[(VAR\{\hat{\lambda}\}/\lambda^2)+(VAR\{\hat{\pi}\}/\pi^2)]/[1+(VAR\{\hat{\pi}\}/\pi^2]^2$

Method application

In some intersections, as stated in the introduction, signals containing a remaining time informer were implemented in São Carlos as a treatment to improve safety. This study compares two untreated intersections with a treated one, according to the following data.

Treated intersection:
São Carlos Av. X Carlos Botelho St.
Accidents 1 year before (κ) : 13
Accidents 1 year after (λ) : 9

Treated intersections
- Episcopal St. X Quinze de Novembro St.
Accidents 1 year before (μ) : 10
Accidents 1 year after (ν): 12
- Episcopal St. X Carlos Botelho St.
Accidents 1 year before (μ) : 10
Accidents 1 year after (ν) : 12

The use of these intersections as the comparison group is based on the similarities concerning geometry, grade and flow between the three intersections. In addition, they are located close (Figure 3). This set of conformable characteristics were necessary to validate the premise that the factors influencing the safety in all the intersections are the same and vary in an identical way.

Figure 3: Location of the three studied intersections

Because the two comparison intersections presented the same number of before and after accidents, the considerations made along this paper are related to both entities.

3. RESULTS

The results of Table 2 and 3 estimates are presented on Table 4.

Table 4. Results

Step 1	$\hat{\lambda}$	9
	$\hat{r}_T = \hat{r}_C$	1,091
	$\hat{\pi}$	14,182
Step 2	$\hat{\mathrm{VAR}}\{\hat{\lambda}\}$	9
	$\hat{\mathrm{VAR}}\{\hat{\pi}\}$	52,344
Step 3	$\hat{\delta}$	5,182
	$\hat{\theta}$	0,504
Step 4	$\mathrm{sd}\{\hat{\delta}\}$	7,832
	$\mathrm{sd}\{\hat{\theta}\}$	0,307

According to these results, it is not possible to declare that signals with remaining time informer reduced or increased the number of accidents on the studied intersections. The expected reduction found was 5,2 accidents. However, the square deviation (sd) is 7,83 accidents; in other words, the treatment may has increased or decreased the safety the entities.

4. FINAL CONSIDERATIONS

Further studies must be made, since the results, in this small study, are not conclusive about the impact on safety in the use of TLVC against TLC. For improve this study the authors in a future work will: included more intersections and years; observe type and number of conflicts in each type of traffic light; the number of vehicles running red light in each type (because empirical evidences shows that drivers tend to run red light more in TLVC than TLC, but until now this is only pure speculation).

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