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Safety effects of an extensive black spot treatment programme in Flanders-Belgium

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ABSTRACT

Black spot management is a widely implemented measure to improve traffic safety. This study evaluates the safety effects of an extensive black spot programme that has been implemented in Flanders-Belgium. In total, around 800 black spots were selected, from which 134 locations, redesigned between 2004 and 2007, were included in this study. The adopted approach is an empirical Bayes before- and after study that accounts for effects of general trends and for the stochastic nature of crashes, including regression to the mean. Two different comparison groups were established. The analyses showed a decrease in the number of injury crashes of 24–27%, significant at the 1%-level. A separate analysis for crashes with serious or fatal injuries showed a decrease of 46–57%, also significant at the 1% level. The highest effects were found for the implementation of changes in the layout of priority controlled intersections and for the installation of traffic signals, which showed a decrease of respectively 42% and 35% in the number of injury crashes. Signalized intersections at which left-turn phasing was implemented resulted in a decrease of 22% in the number of injury crashes, changes in the layout leaded to a decrease of 11%. The conversion of intersections (both signalized and priority controlled) into roundabouts resulted in a decrease of 21% in injury crashes. The black spot programme generated a favourable effect on each of the road user categories (car occupants, moped riders, cyclists, motorcyclist, pedestrians and truck drivers).

1. Background

In an attempt to work to a better traffic safety, different countries introduced a black spot management (BITRE, 2012; Sørensen and Elvik, 2007). The term black spot refers to locations that have a higher expected number of crashes than other similar locations, as a result of local risk factors (Elvik, 2007). The purpose of a black spot programme is to reduce the number and severity of crashes, through infrastructural changes of these dangerous spots. In 2002 the Flemish Government decided to manage the most dangerous traffic spots as one of the main ways to reach the traffic safety goals. This programme included 809 black spots that were selected based on the number and the severity of the crashes. Ninety-nine percent were intersections, all located on highways. Every location at which at least three injury crashes occurred during the period 1997–1999 was selected, and a priority score was calculated. This score was based on the number of injured road users: every slightly injured person got a weight of 1, every severely injured person 3 and every fatally injured person 5. A total priority score of minimum 15 was necessary to be selected as a dangerous spot.

$$\text{Priority score} = 1 \times X + 3 \times Y + 5 \times Z$$

with X = number of slightly injured persons (any person who got injured, but cannot be defined as severely or fatally injured) Y = number of severely injured persons (any person who needed more than 24 h of hospitalization) Z = number of fatally injured persons (any person who died at the location of the crash or within 30 days after the crash).

The main research question in this paper is: what have been the effects of the Flemish black spot treatment programme on the number of crashes on the adapted sites?

2. Previous studies

Different previous studies examined the outcomes of black spot management in terms of the effect on crashes. Elvik et al. (2009) carried out a meta-analysis of studies that examined the traffic safety effect of black spot management trough a before- and after comparison of traffic crashes. They found that studies that did not controlled for regression to the mean (RTM) resulted in higher crash reductions than studies that did controlled for this confounding variable. As the selection of black spots is based on high crash

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counts, these locations are especially prone to RTM. For this reason Elvik et al. (2009) included only studies that controlled for this confounding variable. The authors found a decrease of 26% in the number of injury crashes as a result of black spot treatment. When only European studies were included, a decrease of 22% was found. A distinction between black spot treatment and black section treatment found a result that was somewhat greater for black spot treatment. The injury crashes on the latter decreased with 33%, whereas the crashes on black sections decreased with 28%. An extensive and recent Australian study (BITRE, 2012) examined 1599 black spot projects, which is 62% of the 2578 funded black spot projects approved and completed during the seven-year period from 1996–97 to 2002–03. This study showed a reduction of 30% in fatal and casualty crashes and 26% in property damage only crashes. Trend effects were controlled through inclusion of the total number of crashes in each state or territory. In order to control for RTM, pre-treatment crash data were selected during the interval of time between the date on which the funding application was submitted to the Australian Government and the date on which work on the project commenced.

3. Study design

The adopted approach is an empirical Bayes (EB) before- and after study. This is widely accepted as the best standard in the evaluation of traffic safety measures (Elvik, 2008; Elvik, 2012; Hauer, 1997; Persaud and Lyon, 2007). The method compares the observed number of crashes after the implementation of the treatment with the expected crash counts if there had been no treatment. This 'expected' number is based on the number of crashes before the treatment with correction for extraneous factors. Besides the effects of the treatment itself, a range of other factors has possibly had an effect on traffic safety and thus need to be corrected for. Those confounding factors are RTM, general crash trend, coincidence of the occurrence of crashes and general changes in traffic volumes (Elvik, 1997; Hauer, 1997). The chance effects were controlled through the use of point estimations and confidence intervals. According to Elvik (2002) traffic volumes do not need to be accounted for explicitly and it is sufficient to use a large comparison group, from which the total crash frequency encompasses several hundred. As the first comparison group comprised 211 locations, scattered around Flanders, and the second comparison group included all crashes in Flanders, this is sufficient to control for volume changes. Furthermore, it can be argued that the specific effect on traffic volumes due to the treatment of black spots most likely was very limited, because of the structure of the road system in Flanders. This structure does only give limited opportunity for drivers to choose alternative roads, as these mainly include local roads with lower speed limits. The treatment of black spots was mainly implemented at the upper category of roads, and therefore will probably have had a limited effect on the rerouting choices of the driver. To control for RTM and general trend effects the EB method was applied, as explained below.

4. Data

In order to make an analysis possible, a geographical localization of the crashes is necessary. At the time of the present study, localized crash data was available up to and including 2008. We considered it necessary to have available at least one year of crash data before and one year of data after the treatment of each black spot in order to make a before- and after evaluation possible. Subsequently, black spots treated and open for traffic up to and including 2007 could be evaluated, and a final research group of 134 black spots was selected. A graphical presentation of the selection process for the treated group and the comparison group is shown in Fig. 1.

The graph can be explained as follows: in total the Flemish government selected 809 black spots. On 160 of those 809 spots only small measures were planned, such as an alteration of the signal phasing or slightly changed markings. These locations were not selected, as no information was available about the date of those small changes, rendering it impossible to distinguish between the periods before and after the treatment. From the remaining 649 spots 201 were treated before 2008, which were selected as treated locations. After 2008, 294 locations remained to be treated, which as a result could be included in the comparison group. The latter locations are comparable with the locations in the treated group, but differ in that no treatment was applied yet. The other 154 locations could neither be included in the treated group, nor in the comparison group, as the infrastructural works had started before 2009 (and thus could not be selected for inclusion in the comparison group), but had not been finished yet until 2008 (and thus also could not be included in the treated group). This resulted in the inclusion of 201 locations in the treated group and 294 locations in the comparison group. For some locations traffic volume data was missing, which however was required to apply the EB approach. Subsequently, 69 locations from the treated group and 91 locations from the comparison group were excluded. Some black spots comprised two intersections, which were mainly intersections at the on- and off ramps of a highway. Since these locations were very close to each other, they were treated in the black spot programme as one location. However, in the present study each intersection was analyzed separately, and therefore the treated group had two locations extra and the comparison group eight locations. This eventually resulted in 134 treated locations; all being intersections. Depending on the location, different treatments were applied. Generally six sorts of treatments could be distinguished:

- signalized intersection → implementation of left-turn phasing: the majority of the treated locations (53) were signalized intersections on which protected left turns were implemented.
- Signalized intersection → changes in the layout: fifteen intersections that were signal controlled during the before period mainly got changes in the layout. Examples of alteration are: improved cycle facilities, separation of turning lanes and the installation of speed cameras.
- Signalized intersection → roundabout: five locations were changed from a signalized intersection into a roundabout.
- Priority controlled intersection → changes in the layout: of the locations that were priority controlled during the before period, 26 remained priorities controlled but changes were made in the layout. Examples of these changes are: provision of cycle facilities, improved delineation and construction of traffic islands or medians.
- Priority controlled intersection → signalized intersection: at nine locations that were previously priority controlled, traffic signals were installed, and six of them with protected left turns.
- Priority controlled intersection → roundabout: eight priority controlled locations were converted into a roundabout.

The final comparison group comprised 211 locations, all intersections. These locations can be expected to be comparable with the treated locations for certain characteristics (for example traffic volumes, maximum speed limit, . . .), whereas they differ in that there were no traffic safety measures implemented during the research period. As it is unclear whether or not a certain order in the treatment of black spots is present, and thus a certain distortion could be observed, a second comparison group was applied. This comprised all injury crashes in Flanders.