ROAD SAFETY EFFECTS OF SPEED ENFORCEMENT: A CASE-STUDY IN FLANDERS

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ABSTRACT

This paper analyzes the effects on road safety of speed enforcement on a main road in the province of Vlaams-Brabant (Flanders). After a descriptive accident analysis, carried out by the provincial government in the late nineties, the ‘N8’ was selected as one of the most unsafe roads, mainly with regard to speeding violations. By the end of 2002, a comprehensive speed enforcement programme was set up for the N8. The speed enforcement strategy consists of increased police control, installation of automated speed cameras, reduced speed limits and information campaigns. Taking into account accident data of a 12 year pre-period and 3 year after-period, this study shows that the effect of the programme on the number and severity of road accidents, adjusted for the trend and regression-to-the-mean, is significant. The empirical analysis reveals a reduction of 35% for the total number of accidents, 43% for the total number of accidents minus the collisions with parked vehicles, 25% for accidents with material damage only, and 19% for injury accidents. This study also takes a closer look at the impact of different post-implementation periods using accident data of 1 or 3 years after the implementation of the speed enforcement programme on the calculated effectiveness results and warns for severe overestimation when a one-year period is used.

INTRODUCTION

Flanders (Belgium) is confronted with a high level of road accidents and casualties. In 2004, the fatality risk was 109 fatalities per million inhabitants, a risk more than twice as high as the best performing European countries, such as Sweden, the United Kingdom and the Netherlands (OECD, 2006). Hundreds of speed and red light cameras have been recently implemented at intersections to reduce the number of accidents and casualties. It is generally agreed that driving at excess or inappropriate speed is an important risk factor, influencing both accident involvement and accident severity (WHO, 2004). The Belgian government introduced several compliance targets in their road safety strategies (MVG, 2001). The goal set for 2010 is to increase speed checks to 40 million vehicles per year, which would amount to 8 checks per vehicle per year. This study aims to provide additional insight on the safety effects of speed cameras. This is helpful for public policy since speed cameras are still considered to be implemented on an even larger number of intersections in Flanders.

This paper reports the analysis of the safety impact of a local speed enforcement programme in the province Vlaams-Brabant (Flanders). We assess the effect, not only of speed cameras, but also of speed limit reduction, mobile enforcement between the fixed speed cameras and information campaigns. More specifically, the effects on the number of accidents and levels of injury have been estimated by means of statistical analysis, which accounts for regression-to-the-mean and trend effects.
THE SPEED ENFORCEMENT PROGRAMME

In the late nineties, the working group ‘traffic safety’ of the provincial government Vlaams-Brabant investigated the possibilities to install fixed automated speed cameras on their roads, as part of an integral speed enforcement strategy. This research resulted in a list of the most unsafe roads of the province, based on several indicators such as: the 85% percentile speed, the number of accidents and injuries. The provincial road ‘N8’ was selected to serve as a pilot-project in order to elaborate an effective enforcement strategy. On the N8, the accident rate per kilometre road lies far above the provincial average. Furthermore, in 1998, respectively 1999, 36% and 46% of the accidents were caused by inappropriate or excess speed (BIVV, 2001).

In order to increase road safety, the project aims at improving compliance with existing speed limits. The underlying approach consists of a simultaneous increase of both the objective and subjective risk of detection by means of intensified speed enforcement and information (Scheers and Adriaensen, 2003).

The actual speed enforcement programme on the N8 started on 1 October 2002. An array of measures was taken. By the end of 2002, a speed limit reduction from 90 km to 70 km per hour was introduced. With regard to speed enforcement activity, automated manned and unmanned systems were implemented. On the basis of the accident analysis, 5 boxes for automatic speed cameras were installed along the N8 (8.14 km). To reduce possible halo effects, intensified police patrolling with automatic photo-radar cameras, with and without interception, were operating between the locations of the speed cameras since the start of the programme.

In addition to policing, road user information and media campaigns are set up to increase public support. The speed enforcement programme is called ‘met iN8-neming van de snelheidslimiet’ and refers to the ultimate goal of the project, i.e. compliance with speed limits. The project name and policy motives are made widely known by announcements on local TV, radio and websites, by distribution of information brochures and by project signs along the roadside. Likewise, the results of the enforcement actions are made public on a regular basis. Furthermore, individual feedback signs, which show the speed of the individual road user or display the message ‘your speed has been monitored’, are placed along the N8.

DATA

In order to establish the speed enforcement programme’s influence on safety, a before-and-after study with a comparison group is used. This approach allows us to control for the regression-to-the-mean effect and (long term) trends affecting the number and severity of accidents.

Police-reported collision data of 12 year before and 3 years after start of the speed enforcement programme are used in this study. Accidents related to speed violations, however, are not reported consistently. This does not allow a separate estimation of the effect on accidents caused by excess or inappropriate speed. In total, four analyses are carried out dependent on the type of accidents considered, i.e.: the total number of accidents, accidents with material damage only, injury accidents and the total number of accidents minus the accidents in which road users collide with a parked vehicle. We assume that the enforcement programme has no influence on this last type of accidents since conflict situations between parked vehicles and road users are not eliminated by the programme. Thus, it is expected that the estimate of the safety impact, concerning these accidents, is larger in comparison to the estimate of the total number of accidents. Furthermore, data from the year the enforcement programme has started, are left out of the analysis.
The comparison group should hold similar characteristics (speed limits, traffic intensity, ...) as the location under evaluation, in this case the N8 (Nuyts and Cuyvers, 2003). In our analysis, we opt for 2 roads, situated in the same police jurisdiction as the N8, namely the ‘Brusselstraat’ (6.16 km) and the ‘Stationsstraat’ (2.58 km).

Table 1 gives an overview of the accident data that will be used in the analysis.

Table 1: Number of accidents on the N8 and comparison group, in the before and after period

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Location</th>
<th>Before period (1990-2001)</th>
<th>After period (2003-2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total accidents</td>
<td>N8</td>
<td>1419</td>
<td>278</td>
</tr>
<tr>
<td></td>
<td>Comparison group</td>
<td>663</td>
<td>205</td>
</tr>
<tr>
<td>Total accidents - collisions with parked vehicles</td>
<td>N8</td>
<td>1337</td>
<td>278</td>
</tr>
<tr>
<td></td>
<td>Comparison group</td>
<td>499</td>
<td>186</td>
</tr>
<tr>
<td>Accidents with material damage only</td>
<td>N8</td>
<td>851</td>
<td>188</td>
</tr>
<tr>
<td></td>
<td>Comparison group</td>
<td>466</td>
<td>163</td>
</tr>
<tr>
<td>Injury accidents</td>
<td>N8</td>
<td>568</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Comparison group</td>
<td>197</td>
<td>42</td>
</tr>
</tbody>
</table>

**METHODOLOGY**

The first step in the analysis is to make sure that, in addition to the exogenous characteristics, the comparison group is also similar to the treatment location in terms of accident occurrence. To verify this, odds-ratio’s are computed for the years before the road safety programme is started. Following Hauer (1997), the odds-ratio is defined as the ratio of change in the number of accidents at the location (N8) and the change in the number of accidents in the comparison group.

The odds-ratio for 1 year compared to a previous year is thus calculated as:

\[
\frac{N_{8,t}}{N_{8,t-1}} \div \frac{C_t}{C_{t-1}}
\]

in which:
- \(N_{8,t}\): the number of accidents in year \(t\) on the N8
- \(C_t\): the number of accidents in year \(t\) in the comparison group

The comparison group is considered reliable if the mean of the odds-ratios is close to one (Hauer, 1997). In our case, the computed means, dependent on the type of accident considered, vary between 1.02 and 1.14. This indicates that the chosen comparison group is indeed sufficiently similar.

The number of accidents, that occur at a specific location, can be attributed partly to the specific characteristics of the location and partly to chance (Nuyts and Cuyvers, 2003). The latter effect states that there is some random variation in accident frequencies around the long-term average. Observed accident data are subject to regression-to-the-mean, i.e. high short-term accident frequencies are likely to decrease and low short-term accident frequencies are likely to increase, in the direction of the long-term mean (Elvik and Vaa, 2004). Road safety measures, however, are principally taken on locations with high accident rates. In the subsequent period, lower accidents might be expected, regardless of the effect of the measure. Therefore, to evaluate the effectiveness of a road safety measure, it is primordial to distinguish the regression-to-the-mean effect from the safety measure effect.

To control explicitly for the regression-to-the-mean effect, the expected number of accidents at the N8, as if the speed enforcement programme was not implemented, is computed as follows (Hauer et al., 2002):
\[ N_{8\text{ rem,T}}^T = w_1(N_{8,C}^T) + (1 - w_1)\sum_{t=1}^TN_{8, t} \]

where

- \( N_{8\text{ rem,T}} \): the expected number of accidents on the N8, after correction for regression to the mean (rtm);
- \( \mu_{N_{8,C}} \): the average number of accidents per year for the comparison group (C), including the accidents on the N8 (before the implementation of the speed enforcement project, the N8 is considered similar to the comparison group and could be included);
- \( T \): the number of years considered in the before-period;
- \( N_{8, t} \): the number of accidents in year \( t \) on the N8;
- \( w \): weight given to the mean number of accidents of the group;
- \( (1 - w) \): weight given to the number of accidents on the N8.

The weight \( (w) \), assigned to the number of accidents of the comparison group, is computed as (Hauer et al. 2002):

\[ w = (1 + k\mu_{N_{8+C}})^{-1} \]

in which \( k \) is the overdispersion parameter:

\[ k = \frac{\sigma^2_{(N_{8+C})} - \mu_{(N_{8+C})}}{\mu^2_{(N_{8+C})}} \]

This parameter relaxes the assumption that accident counts of several locations should all follow the same Poisson distribution. Its most important characteristic is that it should be positive. Otherwise, the estimate of the expected number accidents, corrected for regression-to-the-mean, will result in a correction away from the mean.

In addition to the regression-to-the-mean effect, we should also correct for the overall trend in accident frequencies. Changes in economic conditions, legislation, weather conditions, safety standards of vehicles or changes in public support towards traffic safety can all have an effect on the safety level of a location, that cannot be attributed to the road safety measure taken. The overall trend in traffic safety is derived from the evolution of accidents in the comparison group.

Define:

- \( N_{8\text{ after}} \): the number of accidents on the N8 after the speed enforcement programme was implemented;
- \( N_{8\text{ rem,T}} \): the number of accidents on the N8, before the speed enforcement programme was implemented, after correction for regression-to-the-mean;
- \( C_{\text{after}} \): the number of accidents in the comparison group after the speed enforcement programme was implemented;
- \( C_{\text{before}} \): the number of accidents in the comparison group before the speed enforcement programme was implemented.

The effectiveness ratio \( (\varepsilon) \) is then calculated as:

\[ \varepsilon = \frac{N_{8_{\text{after}}}/N_{8_{\text{rem,T}}}}{C_{\text{after}}/C_{\text{before}}} \]

with a 0.95 confidence interval:

\[ \exp \left[ \ln \left( \frac{N_{8_{\text{after}}}/N_{8_{\text{rem,T}}}}{C_{\text{after}}/C_{\text{before}}} \right) \pm 1.96* s \right] \]
in which

\[ s^2 = \frac{1}{N_{\text{after}}} + \frac{1}{N_{\text{ratio}}C_{\text{after}}} + \frac{1}{C_{\text{before}}} \]

since the effectiveness ratio follows a lognormal distribution (Fleiss, 1981; Elvik, 1995).

**RESULTS**

In table 2, the safety effects of the speed enforcement programme are presented. These estimations are based on a 12 year before and a 3 year after period. It can be concluded that the overall effect of the speed enforcement programme on accidents is a significant reduction of the number of accidents by 35%. As expected, the effect on the number of accidents with the exception of the collisions with parked vehicles is even more pronounced: a significant reduction of 43%. Concerning material-damage-only accidents, the analysis shows a significant 25% decrease. The speed enforcement programme is less effective regarding injury accidents. The estimated reduction of 19% is also not statistically significant.

Table 2: Reduction of accidents, 3 years after the implementation of the speed enforcement programme

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Reduction in the number of accidents</th>
<th>Confidence interval (.95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total accidents</td>
<td>35 %*</td>
<td>21 %</td>
</tr>
<tr>
<td>Total accidents - collisions with parked vehicles</td>
<td>43%*</td>
<td>30 %</td>
</tr>
<tr>
<td>Accidents with material damage only</td>
<td>25%*</td>
<td>4 %</td>
</tr>
<tr>
<td>Injury accidents</td>
<td>19%</td>
<td>- 21 %</td>
</tr>
</tbody>
</table>

* Statistically significant at 5% level.
A negative number means an increase in the number of accidents.

Table 3 summarizes the effects with regard to different post-implementation periods, i.e. 1 to 3 years after the implementation of the speed enforcement programme on the N8. In this analysis, we used 12 years of data in the before-period. We observe that a longer after-period in the analysis results in a lower safety effect of the enforcement programme. So, an assumed prolongation of the effect of the 1 year analysis in the subsequent years will probably be an overestimation of the impact. Our calculations show that the overestimation is in the range of 14 to 24%, depending on the level of accident severity that is considered.

Table 3: Reduction of accidents using different post-implementation periods and a 12 year before-period

<table>
<thead>
<tr>
<th>Number of years considered after the implementation of the project</th>
<th>Absolute difference 1 vs. 3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>2 years</td>
</tr>
<tr>
<td>Total accidents</td>
<td>49 %* (30% , 63%)</td>
</tr>
<tr>
<td>Total accidents - collisions with parked vehicles</td>
<td>60 %* (44% , 71%)</td>
</tr>
<tr>
<td>Accidents with material damage only</td>
<td>40 %* (12% , 60%)</td>
</tr>
<tr>
<td>Injury accidents</td>
<td>43 % (-2% , 69%)</td>
</tr>
</tbody>
</table>

* Statistically significant at 5% level.
95% confidence interval between parentheses.
A negative number means an increase in the number of accidents.
In addition, we examined the effect of using data from different lengths of before-periods. The analysis takes into account 12, 9 and 6 years of data before and 3 years after the implementation of the speed enforcement programme. The results are presented in table 4. Considering the total number of accidents, the number of accidents without the collisions with parked vehicles and material-damage-only accidents, it is found that the estimates do not differ significantly. In case of injury accidents, the confidence interval is narrower when the estimate is based on a longer before-period. However, these estimates are not statistically significant and no valuable inference can be drawn.

Table 4: Reduction of accidents using data from different lengths of pre-implementation periods and a 3 year after-period

<table>
<thead>
<tr>
<th>Number of years considered before the implementation of the project</th>
<th>12 year</th>
<th>9 years</th>
<th>6 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total accidents</td>
<td>35 %* (21% , 47%)</td>
<td>32 %* (36% , 45%)</td>
<td>34 %* (17% , 47%)</td>
</tr>
<tr>
<td>Total accidents - collisions with parked vehicles</td>
<td>43%* (30% , 54%)</td>
<td>45 %* (31% , 56%)</td>
<td>48%* (33% , 59%)</td>
</tr>
<tr>
<td>Accidents with material damage only</td>
<td>25%* (4% , 41%)</td>
<td>21% (-2% , 42%)</td>
<td>24%* (1% , 42%)</td>
</tr>
<tr>
<td>Injury accidents</td>
<td>19% (-21% , 46%)</td>
<td>16 % (-28% , 44%)</td>
<td>6% (-46% , 39%)</td>
</tr>
</tbody>
</table>

* Statistically significant at 5% level.
95% confidence interval between parentheses.
A negative number means an increase in the number of accidents.

DISCUSSION

This paper analyzes the road safety effects of the speed enforcement programme on the N8, a main road in the province of Vlaams-Brabant (Flanders). Starting in 2002, this programme consists of an array of measures, namely: installation of speed cameras, intensified police control, speed limit reduction from 90 km to 70 km per hour and information campaigns.

The analysis of the safety effects is based on a before-after study with a comparison group, which controlled for the regression-to-the-mean effect and the trend. Taking into account accident data of a 12 year before-period and a 3 year after-period, the estimates show a reduction of 35% in the total number of accidents, a reduction of 43% in the number of accident without collisions with a parked vehicle, a reduction of 25% in the number of property-damage-only accidents and a statistically non-significant reduction of 19% in the number of injury accidents. With regard to the effectiveness results, using accident data from different post-implementation periods, it is found that the initial safety effect of the speed enforcement programme wanes away. Considering a 1 year evaluation period only, the effect is overestimated in the range of 14 to 24%, compared to a 3 year after-period. Calculations, based on data from different lengths of before-periods, do not seem to vary significantly.

In comparison with other effectiveness studies of automated speed cameras in Flanders (Nuyts, 2006), our results, in terms of reduction in accidents, are relatively high. This could be expected since our estimations reflect the effectiveness of an integral speed enforcement programme and not of speed cameras alone. It is impossible, though, to attribute the effects to any specific enforcement method. In a meta-analysis (11 locations), Nuyts (2006) estimated the effect of speed cameras to be in the order of a 20% reduction in the total number of accidents and a non-significant reduction of 7% in the number of injury accidents. As opposed to international observations (Zaidel, 2002), the positive impact of speed cameras on Flemish roads is smaller with injury accidents, compared to the effectiveness results of the total number of accidents.
The evaluation of the speed enforcement programme on the N8 has a number of limitations though. First, it is not assessed whether it is necessary to control explicitly for changes in traffic volume. These changes can be accounted for with safety performance functions (Hauer, 1997). Due to data limitations, we were unable to statistically estimate these changes at the locations considered. In this case, it is assumed that the comparison group captures the effects on accidents of traffic growth. Second, since the speed enforcement programme’s main goal is to reduce speed-related accidents, more valuable conclusions could be drawn from the analysis of this type of accidents. However, these data are not consistently registered in the accident reports over the period of evaluation. Furthermore, the evaluation of the speed enforcement programme would be more complete if data on speeding behaviour and attitudes were also recorded. Finally, we neglect the possible bias in the results, due to the underreporting of accidents, especially in case of material-damage-only accidents.

REFERENCES


