Pergamon

Journal of Safety Research 36 (2005) 289 – 296

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Road safety effects of roundabouts in Flanders

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Received 4 March 2005; accepted 10 May 2005

Abstract

Introduction: This paper analyzes the effect on road safety of 95 roundabouts that were built in Flanders between 1994 and 1999. *Results:* The study shows that the effect on the number and severity of road accidents adjusted for the trend and regression to the mean is significant, but varies considerably in accordance with the speed limit regime on the intersection. Roundabouts are most effective on intersections of a main road with a high speed limit (90 km/h) and an adjacent road with a lower speed limit (50 or 70 km/h). The empirical analysis reveals a reduction of 34% (varying between 15% and 59%) for the total number of injury accidents, 30% (7%–45%) for light injury accidents, and 38% (27%–72%) for serious injury accidents. This study also takes a closer look at the impact of different post-implementation periods using accident data of 1-, 3-, or 6-years after the construction of a roundabout on the calculated effectiveness results and warns for a severe underestimation when a one-year period is used. *Impact on industry:* An effective traffic safety policy based on scientific results thus requires some patience from the policy-makers.

Keywords: Road safety; Roundabouts; Before-after study; Flanders; Belgium

1. Introduction

Effectiveness studies are helpful for designing and improving road safety policy. No such in-depth studies have ever been carried out for Belgium, which has some of the worst traffic safety records in Europe.[1] Policy measures are allegedly taken by rules of thumb. When figures indicated, for example, that twice as many accidents occurred at crossroads than on other road segments in Flanders (highways excluded), and that the accidents at the former locations gave rise to 1.5 casualties per accident compared to 1.3 on the latter, the Flemish government decided in 1993 to invest heavily in the construction of roundabouts. Arguably, roundabouts were and are reported to have various positive effects. Compared to signalized junctions, Hydén and Várhelyi (2000) observe a reduction of time consumption by 11 seconds per vehicle, noise level by 4dB, and accidents by 46%, yet a small increase of CO_2 and NO_X emissions by 4% and 6%, respectively. In their report, Robinson et al. (2000) found varying reductions in the number of injury accidents in Australia (between 45% and 87%), France (between 57% and 78%), United Kingdom (between 25% and 39%) and the United States (51%). Ogden (1996) demonstrated that the construction of roundabouts may reduce accidents by 60% to 80% at high speed intersections and 50% to 80% at low speed intersections. A naive before-after study by Robinson et al. (2000) shows a reduction of 73% in the number of injury accidents on single-lane roundabouts. At multilane roundabouts, injury accidents are reported to decrease by 31%. A study of 24 roundabouts by the Insurance Institute for Highway Safety reports a decrease of 76% in the number of injury accidents (IIHS, 2000). Although most studies suggest that roundabouts have a positive effect on road safety, there is a huge variance of results. Hence, the effectiveness of the Flemish roundabout program cannot directly be inferred from previous studies.

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[1] In 2001, Belgium ranked 12th of 15 countries with 14.5 fatalities per 100,000 residents compared to an average of 10.5 in the rest of the European Union (B.I.V.V.-N.I.S., 2001, p.50).

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doi:10.1016/j.jsr.2005.05.001

This paper is the first to analyse the safety effects of road safety measures in Flanders, more specifically, the impact of roundabouts on the number of accidents and injury severity. In 2003, a report from the Walloon government adopted a naive before-after approach in which the effect of 122 roundabouts was defined as the difference in the number of accidents and casualties before and after implementation at a particular location (M.E.T., 2003). Their analysis shows a reduction of 42% in the number of injury accidents and a reduction of 48% in the number of serious injury accidents. Since other measures or developments may also explain (part of) the improved accident results, it is imperative to compare the number and severity of accidents after implementation with the results that would have occurred if the safety measure analyzed had not been taken. In other words, since accident figures at a specific location not only measure the effect of the newly built roundabout, but also of new developments in car technology, law enforcement, and health care, among others, simple before-after studies will measure the impact of all these variables simultaneously. Furthermore, a significant part of road accidents happen randomly. Therefore, a comparison has to be made between locations with and without roundabouts that had similar safety characteristics beforehand. Neglecting these two aspects is likely to yield an overestimation of the safety effect associated with a particular safety measure that might be due to other causes. This distortion poses a serious policy management problem especially when, after a while, safety records start worsening again and the safety effect is questioned publicly.

The article is structured as follows. The next section describes the data set. In the third section, the model is specified. After checking the reliability of the comparison group, the number of accidents is estimated that would have occurred if the roundabouts had not been built taking into account the trend and the regression to the mean effect. These results are used in the fourth section to calculate the safety effects of roundabouts in terms of the number and injury severity of accidents. Specific attention is paid to the impact of the length of the post-implementation period of analysis. The final section concludes with some policy implications.

2. Data set

This study analyses the impact on road safety of 95 roundabouts that were built in Flanders between 1994 and 1999. Our database includes all registered injury accidents that occurred between 1991 and 2000 at these locations in the Flemish region. This way, calculations can be made going back at least 3 years before and at least 1 year after the construction of any particular roundabout. Furthermore, the dataset includes a comparison group of 119 road intersections without roundabouts.

Table 1
Number of roundabouts, intersections and accidents at both types of locations

Speed limit (km/h) Main road × adjacent road	Number of roundabouts	Number of accidents	Number of intersections	Number of accidents
50 × 50	33	682	16	299
70 × 50	23	547	39	578
70 × 70	15	289	37	681
90 × 50	8	104	11	530
90 × 70	9	200	10	512
90 × 90	7	123	6	256
Total	95	1945	119	2856

Table 1 gives an overview of the number of roundabouts, crossroads (intersections of the comparison group), and accidents at both types of locations that will be examined. The roundabouts are clustered in six groups in accordance with the legal speed limit (50, 70, and 90 km/h) as currently observed on the main road and the adjacent road. Each group of roundabouts has its own comparison group. As explained before, the intersections that are included in the comparison group should be similar to the locations where roundabouts were implemented. According to Hauer (1991), a comparison group should cover at least 150, preferably 300, accidents. For most locations in Table 1 the number of accidents in our data set is sufficiently high.

3. Model specification

The calculation of the overall reduction in injury accidents first requires an evaluation of each roundabout before a meta analysis of the clusters can be made. The first step, however, is to make sure that the intersections selected for the comparison group that hold the same exogenous characteristics (speed limits) are also similar in terms of accidents. Following Hauer (1997), an odds-ratio matching both groups is computed as follows:

Define

R_t: the number of accidents in year t at the roundabout locations before implementation,

C_t: the number of accidents in year t at all intersections of the comparison group.

The odds-ratio is then defined as the ratio of the change in the number of accidents at the roundabout locations before implementation and the change in the number of accidents in the comparison group. The odds-ratio for 1 year compared to a previous year can thus be written as:

$$\frac{R_t/R_{t-1}}{C_t/C_{t-1}} \tag{1}$$