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Accident Analysis and Prevention 40 (2008) 742–750

ACCIDENT ANALYSIS & PREVENTION

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Safety effects of blue cycle crossings: A before-after study

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Received 6 June 2007; received in revised form 15 August 2007; accepted 7 September 2007

Abstract

This paper presents a before-after accident study of marking blue cycle crossings in 65 signalised junctions. Corrections factors for changes in traffic volumes and accident/injury trends are included using a general comparison group in this non-experimental observational study. Analysis of long-term accident trends point towards no overall abnormal accident counts in the before period. The safety effect depends on the number of blue cycle crossings at the junction. One blue cycle crossing reduces the number of junction accidents by 10%, whereas marking of two and four blue cycle crossings increases the number of accidents by 23% and 60%, respectively. Larger reduction and increases are found for injuries. Safety gains at junctions with one blue cycle crossing arise because the number of accidents with cyclists and moped riders that may have used the blue cycle crossing in the after period and pedestrians in the pedestrian crossing parallel and just next to the blue marking was statistically significant reduced. Two or four blue cycle crossings especially increase the number of rear-end collisions only with motor vehicles involved and right-angle collisions with passenger cars driving on red traffic lights.

Keywords: Blue cycle crossing; Road safety; Pavement marking; Before-after study; Meta-analysis; Denmark

1. Introduction

Blue cycle crossings was invented by the Municipality of Copenhagen and marked in 1981 for the first time. The basic idea is to mark the area of conflict between motor vehicles and cyclists blue so road users pay more attention to this conflict and cyclists have a lane marking through the junction area. Today, blue cycle crossings are often used in Denmark. A few other countries also mark cycle crossings in blue, and several countries mark crossings in other colours e.g. red, yellow and green.

Nettelblad (1990) made a before-after study of blue cycle crossings marked in 37 junctions in 1985, both signalised and non-signalised, in Malmö, Sweden. These cycle crossings were located in relation to dual-way cycle paths, meaning that cyclists were travelling in both directions on these blue cycle crossings. Nettelblad found that police recorded bicycle injury accidents fell from 126 to 119, and the rate of bicycle injury accidents per entering cyclist to the junctions were unchanged. Nettelblad did not use a comparison group in order to take accident trends into account.

Linderholm (1992) studied two of the signalised junctions marked in Malmö in 1985 using the Swedish conflict technique (see e.g. Hydén, 1987). In this technique near-accidents are studied. A near-accident is a situation, where road users are less than 1.5 s from a collision but avoid this by evasive manoeuvres. Hydén (1987) describes a relationship between the number of near-accidents and real accidents. Linderholm could neither document any safety effect of these dual-way blue cycle crossings, even though there was a tendency to a fall in rate of severe conflicts between left-turning cars and cyclists going in the opposite direction of the cars in the drive lane next to them.

Jensen and Nielsen (1996) made a before-after study of cycle crossings marked in 47 signalised junctions in the period 1989–1994 in Danish urban areas. They took accident trends into account using a general comparison group, and found that blue cycle crossings reduced the number of accidents involving cyclists/moped riders by 31% from expected 47 to observed 32 in the after period. The number of injuries in these accidents fell by 34%, from 33 to 22. Both results were statistical significant on a 10% level. Other accidents not involving cyclists or moped riders and injuries in these accidents did not change

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0001-4575/$ – see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.aap.2007.09.016

significantly. They did not try to relate results to the number of blue cycle crossings marked in the individual junctions. Cycle crossings were with one-way bicycle traffic in 44 of 47 junctions. Jensen and Nielsen also investigated single accidents at junctions among two-wheelers, in order to find out if the change in friction from asphalt to thermoplastic marking could result in single accidents. They only found evidence that two of 734 single accidents may have been caused by slippery markings both cases were zebra stripes in pedestrian crossings.

Hunter et al. (2000) studied road user behaviour before and after the marking of one blue cycle crossings at 10 conflict areas in Portland, USA. They found that significantly fewer cyclists turned their head to look for motor vehicles and fewer cyclists used hand signals after the blue cycle crossing was marked. More cyclists travelled on the "correct path" through the junction after the blue pavement had been marked. Motorists also changed behaviour. Significantly fewer motorists used turn signal, but more slowed or stopped on approach after marking the blue cycle crossings. Overall, the yielding behaviour was markedly changed from 72% yielding motorists before to 92% after. The number of cyclist–motorist conflicts also got lower from 0.95 per 100 entering cyclists before to 0.59 after. A conflict was defined as an interaction where at least one of the parties had to make a sudden change in speed or direction to avoid the other, a rather stringent definition.

Seventy six percent of the cyclists felt the locations in Portland with blue pavement were safer, and only 1% less safe (Hunter et al., 2000). Forty nine percent of motorists thought the junctions were safer with blue cycle crossings, whereas 12 percent thought less safe. In Copenhagen, cyclists feel a lower perceived risk, are more comfortable and more satisfied when blue cycle crossings are present (Jensen, 2006a).

The before-after study of accidents and injuries, which will be presented in the following, include marking of between one to four blue cycle crossings per junction in 65 signalised junctions in Copenhagen, Denmark. The blue thermoplastic pavement was marked during the years 1981–2003. The width of the blue cycle crossing is typically 2 m. The volume of incoming motor vehicles per day to the junction varies from 7000 to 66 000 and volumes of incoming cyclists span from 2500 to 27 500. A report describes the study and results in detail in Danish (Jensen, 2006b). Fig. 1 shows a junction with four blue cycle crossings.

Fig. 1. Photo of signalised junction in Copenhagen with four blue cycle crossings.

2. "Second-best" methodology

Randomized experiments (see e.g. Hutchinson, 2007), where the experimental units like junctions are randomized to treatment like blue cycle crossings, are often viewed as the best way to study effects of safety measures. In our case, a randomized experiment is actually practicable due to the low costs of the blue pavement, but such experiment has not been undertaken.

The safety effects of blue cycle crossings are therefore studied using a "second-best" observational study methodology. The Empirical Bayes method (see e.g. Hauer, 1997) is viewed by many as the best of the non-experimental observational methods. The Empirical Bayes method accounts for three major possible biases in before-after accident studies; regression-to-the-mean effects, accident trends and traffic volumes.

However, the Empirical Bayes method has not been used in this study. The prime reason for this is that the signalised junctions, where blue cycle crossings have been marked, include the most trafficked junctions in Copenhagen in terms of motor vehicles, cyclists and pedestrians, and constitute one sixth of all signalised junctions in the city. The accident models that need to be developed if the Empirical Bayes method were to be used could be of the kind shown in general in Formula 2 later in this paper. Such accident models are relatively reliable to use in order to predict the number of accidents, if the incoming traffic volumes to the junction, where you wish to predict accident figures, are pretty normal compared to the traffic volumes in the junctions that the accident model is based upon. In the Copenhagen case, many of the studied junctions are in the far end of the traffic volume axis, i.e. much trafficked, and we are therefore close to or outside the boundaries of the possible accident models' valid area. The prediction of accident figures for these much trafficked junctions are unreliable, because the beta figures of the accident models becomes crucial for the prediction, and these beta figures change from model to model primarily due to uncertainty, because the models are based on a relatively low number of junctions. The prediction results for regression-to-the-mean effects and figures for expected accidents and consequently safety effects will therefore be relatively