Accident Analysis and Prevention xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Randomized trials and self-reported accidents as a method to study safety-enhancing measures for cyclists—two case studies

Harry Lahrmann*, Tanja Kidholm Osmann Madsen, Anne Vingaard Olesen

Department of Civil Engineering, Aalborg University, Thomas Manns Vej 23, DK-9220 Aalborg OE, Denmark

ARTICLE INFO

Keywords:
Cyclist traffic safety
Randomised controlled trial
Self-reported accident
Permanent running lights
Yellow bike jacket

ABSTRACT

A large number of studies show that high visibility in traffic is important in the struggle of getting the attention from other road users and thus an important safety factor. Cyclists have a much higher risk of being killed or injured in a traffic accident than car drivers so for them high visibility is particularly important. A number of studies have examined the effect of high visibility, such as reflective clothing, but most studies have been primitive, the data limited and the results very uncertain.

In this paper we describe the safety impact of increased visibility of cyclists through two randomised controlled trials: permanent running lights on bicycles and a yellow bicycle jacket, respectively.

The effect of running lights was studied through a trial where the lights were mounted to 1,845 bicycles and 2,000 others comprised a control group. The bicycle accidents were recorded every two month in a year through self-reporting on the Internet. Participants were asked to report all cycling accidents independently of severity to avoid differences between participants as regards to which accidents were reported. They reported a total of 255 accidents i.e. 7 accidents per 100 cyclists. The results showed that the incidence rate for multiparty bicycle accidents with personal injury was 47% lower for cyclists with permanent running light. The difference is statistically significant at the 5% level.

The effect of a yellow bicycle jacket was examined through a trial with 6,800 volunteer cyclists. The half of the group received a bicycle jacket and the other half comprised a control group. Both groups reported every month all their bicycle accidents independently of severity on the Internet. They reported a total of 694 accidents i.e. 10 accidents per 100 cyclists. The treatment group was asked each month if they carried the jacket on their last cycling trip. The results showed that on a random day the treatment group carried the jacket or other fluorescent cycling garment on 77% of their cycle trips. The incidence rate for multiparty accidents with personal injury was 38% lower than the control group. The difference is statistically significant at the 5% level.

The trials were not blind and it seems that the lack of blinding has influenced the level of the groups accident reporting. To address this bias we used a correction factor formed by the difference in the number of single accidents of the two groups.

The experiences with self-reporting of accidents via a web based questionnaire sent by e-mail with one respective two month intervals were very good; in both trials more than 80% answered all questionnaires whereas less than 2% did not answer, and the quality of the self-reported accident was considered high.

1. Introduction

Cycling is healthy, and a large Danish population study has shown that the mortality rate is 28% lower for cyclists compared to the part of the population using passive transport (Andersen et al., 2000). Furthermore, cycling provide a substantial contribution to reduce congestion in cities. Cycling is therefore a central instrument in many plans for a sustainable transport system in cities; see e.g. the EU white paper on transport (European Commission, 2011) and the Danish national bicycle strategy (Ministry of Transportation 2014). On the other hand, cyclists are also an exposed road user group. In 2010, nearly 2,000 cyclists were killed in traffic, corresponding to 7% of all traffic fatalities in the EU (Candappa et al., 2012). The risk of being killed or injured in a traffic accident is significantly higher for cyclists than for car drivers (Hansen and Jensen, 2012), and the risk is actually far greater than reflected by the official accident statistics. In 2014, 830 personal injuries involving cyclists were reported to the official Danish accident statistics, but if we also counts the numbers from the emergency rooms

* Corresponding author.
E-mail addresses: hsl@civil.aau.dk (H. Lahrmann), tkom@civil.aau.dk (T.K.O. Madsen), avo@civil.aau.dk (A.V. Olesen).

http://dx.doi.org/10.1016/j.aap.2017.07.019
Received 17 August 2016; Received in revised form 21 June 2017; Accepted 16 July 2017

and hospitals 16,481 cyclists were injured in Denmark in 2014. Of these numbers, 4,611 of the injured parties were attributed to multi-party accidents (Statistics Denmark, 2014). This means that the official accident statistics registers only 5% of bicycle accidents treated in Danish hospitals. However, not even the figure from emergency rooms and hospitals intercepts all bicycle accidents. Some injuries are treated by general practitioners only and finally there are also self-treated injuries. Several studies have tried to quantify the total volume of cycle accidents through self-reporting from a group of cyclists in a period of time. A Belgian study had a sample of 1,087 regular cyclists. Over a year, 62 of them were involved in 70 bicycle accidents. Police, hospital/emergency room or insurance companies were involved in only 7%, 10% and 30% of the cases, respectively (Geus et al., 2012). An Australian study examined self-reported accident data from 2,038 cyclists. During 25,971 days of cycling, 198 crashes were reported. Of those, 101 resulted in an injury which was either self-treated (85), was treated by a general practitioner (12) or in a hospital without an overnight stay (4). There were no crashes with a hospital overnight stay. Seven crashes were reported to the police. (Poulos et al., 2015). A British study collected data on cycling accident-related injury in the last five years from 4,961 cyclists using an online questionnaire. The cyclists were recruited from large British cycling organisation networks. 54% of the sample reported a cycling injury accident. (Hollingworth et al., 2015). Thus, it is important to investigate how the number of bicycle accidents can be reduced.

In the early 1990s it was made mandatory for car users to use daytime running lights in some countries. In 1996, Elvik (1996) conducted a *meta*-analysis estimating the mean effect of introducing daytime running lights to motorized vehicles. The mean effect was estimated to a 3–12% reduction in the occurrence of daytime multi-party accidents. In the “Handbook of traffic safety measures” (Elvik et al., 2009), the effect of making daytime running lights mandatory for motorized vehicles is estimated to 5–10% reduction in daytime multi-party accidents, and it is documented that the effect varies between different types of accidents. It is therefore reasonable to assume that permanent running lights on bicycles will also reduce the number of cycling accidents.

A 2004 *meta*-analysis did not find any studies directly measuring the safety effect of increased visibility, but it reports of 42 projects that studied the effect of visibility aids. The analysis concludes that visibility aids have the potential of making the motorists aware of the cyclists sooner (Kwan and Mapstone, 2004). In a New Zealand study, 2,500 cyclists were asked about their bicycle accidents for the past 12 months, and the study showed that the number of self-reported accidents was lower among cyclists who stated that they always wore garments in fluorescent colours (Thornley et al., 2008). In an Australian study, 185 cyclists involved in accidents were interviewed, and only two of them stated their own lack of visibility as a factor in the accident while 61% stated driver inattention as a factor (Lacherez et al., 2013). The study concluded that cyclists involved in accidents underestimate the importance of their own visibility. Another Australian study shows that cyclists overestimate their own visibility at night (Wood et al., 2013). A number of the vehicle-bicycle accidents are characterized as ”looked-but-failed-to-see” accidents where the motorist did not acknowledge the presence of the cyclist in time, even though the motorist explains that he actually did look to the side from where the cyclist came. The assumption is that the number of these situations can be reduced by increasing the cyclists’ visibility; a visibility that can be important to whether or not the situation results in an accident (Herslund and Jørgensen, 2003). This is supported by a Finnish in-depth study of vehicle-bicycle accidents concluding that motorists notice the cyclist too late in accidents (Räsänen and Summala, 1998).

The evidence on the use of visibility aids for cyclists is thus dominated by two directions. Firstly, a large *meta*-analysis that shows no effect. Secondly, several “into the substance” studies which suggest that cyclists could benefit from more visibility, for example in the form of running lights and fluorescent garments − and more awareness.

In this paper we will report the results from two Danish studies with the goal to improve cyclists' visibility in order to investigate the safety effect of different types of visibility measures. In one study it was tested whether permanent running lights on bicycles improve cyclist safety (Madsen et al., 2013). In the second study, the safety effect of a yellow bicycle jacket was studied (Lahrmann et al., 2015). Finally, we will discuss how the results can be used in the future work with cyclist safety.

2. Methodology

2.1. Randomised controlled trial

Many road safety evaluation studies are carried out as observational before–after studies. This is generally also the case for earlier studies of the safety effects of daytime running lights for motor vehicles. However, (Elvik, 1993, 1996) states that observational before–after studies may not provide sufficient control for confounding factors that may have affected the outcome of the evaluation. By comparison, randomised controlled trials (RCT) are deemed to provide a better control for confounding factors in studies of this type, see e.g. (Hauer, 1997). Consequently, such study design was adopted in both studies. The basic concept of a RCT is to create two groups; one group that receives treatment (i.e. the treatment group) and one group that does not receive treatment (i.e. the control group). Ideally, the two groups must be identical with respect to extraneous factors influencing the outcome of interest so that if none of the groups were treated, the outcome recorded in time T for both groups would be the same. Consequently, the effect of the treatment can be found by comparing the outcome of interest in time T for the treatment group with the control group. In order to obtain the desired control for confounding factors, the trial units must however be allocated to the treatment and the control group randomly; i.e. through randomization (Rothman et al., 2008).

2.2. Self-reporting of accidents

In the two studies the outcome of interest is cycling accidents for both the treatment and the control group. Ideally, the police should record all cycling accidents, but as described above the police only record few of the bicycle accidents and it would have required both a very large number of participants and a long trial period if police recorded accident should have been used. Therefore it was decided to use self-reporting of accidents in the studies. The question is however if we can trust on self-reported accident. Oblivion and/or memory loss may influence the correctness of recall (Lajunen and Öakan, 2011) as well as social desirability effects (Wåhlberg et al., 2010; Wåhlberg, 2010). Self-reports are also suspected to suffer from statistical bias due to under-reporting by those with many crashes and possible over-reporting by some subgroups (Tivesten and Wiberg, 2013; Wåhlberg 2009). The agreement between self-reported accident data and other data sources are sometimes low, which has been mentioned as a problem with the self-reported data (Wåhlberg, 2009). However, low agreement with other data sources does not in itself diminish the validity of self-reported data; it depends on the validity of the data source to which the self-reported data are compared. Other studies find high level of accuracy in drivers self-report and police recorded crashes (Boufous et al., 2010).

2.3. Trial setup

Both trials lasted for one year. In the *permanent running lights trial* (PRL), the light was mounted on the bicycles of the treatment group before start and the control group was promised to get the light after the trial had finished. In the *yellow bicycle jacket trial* (YBJ), the