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The effect of an italian nationwide mandatory visibility aids law for cyclists

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ARTICLE INFO	A B S T R A C T
Keywords: Legislation Bicycling Deterrence theory Visibility aids Road safety	The role of conspicuity in preventing bicycle-motorized vehicle collisions has been the subject of investigation. To date, no study has evaluated the impact on bicycle safety of legislation imposing bicycling visibility aids. The aim of the present study is to investigate whether a legislation imposing high-visibility clothing for cyclist affects bicycle safety. Data on the monthly number of vehicles (including bicycles) involved in road crashes during the period 2001–2015 were obtained from the Italian National Institute of Statistics. Data were analyzed through an interrupted time-series analysis using a generalized least-squares method. Results revealed that the implementation of legislation imposing high-visibility clothing for cyclist did not influence the number of bicycles involved in road crashes as well as its proportion in the total vehicles involved in road crashes. The introduction of the legislation did not produce immediate effects, nor did it have any effects over time. Lack of knowledge on how the law was introduced, the degree of enforcement by the police, and behavioral changes in response to the law makes it difficult to attribute the lack of effect on bicycle crashes.

1. Introduction

The conspicuity of cyclists could be considered a contributory factor in some bicycle–motorized vehicle collisions (Prati et al., 2017a). One systematic review analyzing 42 trials assessing the effect of visibility aids on drivers' responses revealed that while visibility aids may have the potential to increase visibility and improve drivers' responses in detection and recognition, the effect of their use on cyclist safety remains to be determined (Kwan and Mapstone, 2006). The findings of recent studies suggest that the safety effect of high-visibility bicycle clothing is not consistent (Lahrmann et al., 2017; Miller et al., 2017; Tin Tin et al., 2014).

Although several studies focused on the impact of mandatory bicycle helmet laws (e.g., de Jong, 2012; Kett et al., 2016; Macpherson and Spinks, 2008; Markowitz and Chatterji, 2015; Rodgers, 2002), to date, no study has sought to answer the question of whether the legislation imposing high-visibility clothing for cyclist has an impact on bicycle safety.¹

1.1. Theoretical background

In the design and implementation of enforcement measures in the area of road safety, deterrence theory is the most common framework (Bates et al., 2012; Fleiter et al., 2013; Homel, 1988). According to classical deterrence theory, compliance with the law is

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¹ Concerning the grey literature, Schepers et al. (2017) refer to evaluations by SWOV Institute for Road Safety Research about rear, pedal, and side reflectors that became obligatory in the Netherlands in the 1970s and 1980s. Schepers et al. (2017, p. 270) summarize the outcomes as follow: "Small positive effects have been found for some of these visibility measures SWOV." However, no other information was provided in the article of Schepers et al. and the research reports are in Dutch language and, therefore, it is not possible to get more information about the process and outcome evaluation.

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likely to occur when the expected costs from violations are higher than the gains. Those costs are assumed to arise from penalties (i.e., fines) that are perceived by the public as being certain, severe, and swift. In addition to these costs, the costs associated with the perceived likelihood and severity of a road crash should be taken into account. Indeed, one of the reasons cyclists are considered vulnerable or minority road users (Prati et al., 2017b) is that the risks for cyclists are generally higher than for motorists (e.g., motorized vehicles have greater mass and speed compared to bicycles, while cyclists do not have physical protection, are less stable, less visible, and more affected by road surface irregularities). Therefore, the costs of non-compliance with laws are not negligible for cyclists. Nevertheless, there are also perceived costs associated with complying with the legislation imposing high-visibility clothing for cyclist. Aldred and Woodcock (2015) revealed that, despite perceived social pressure on cyclists to wear visibility aids, many cyclists were reluctant and expressed complaints about inconvenience and personal appearance.

1.2. The present study

The aim of the present study was to investigate the influence of a mandatory visibility aids law in Italy. In Italy, a nationwide mandatory visibility aids law (Law 29/7/2010 n. 120) for cyclists of all ages was introduced in October 2010. Specifically, the law requires cyclists to wear high-visibility clothing when riding after dusk and before dawn. Moreover, the law imposes the use of high-visibility clothing in addition to (and not in replacement of) bicycle lights. In the context of the international debate on whether traffic laws are actually effective in promoting traffic safety, it is important to study whether this law has had the intended effect on cycling safety. Comprehensive data on cycling crashes before and after the law was introduced are now available, and this allows for an investigation of the effects of the law using time series techniques. Specifically, it is possible to analyze the national trends in the number of bicycle crashes and examine whether any changes in the trend happened in conjunction with the legislation imposing high-visibility clothing for cyclist. While the present study investigated the relationship between introduction of the law and bicycle crashes, it did not evaluate how the law was introduced (i.e., process evaluation) and it did not assess intermediate outputs (e.g., the level of enforcement and campaign activities) and other outcomes (e.g., behavioral changes such as wearing visibility aids).

2. Method

2.1. Data collection

Data on the monthly number of vehicles (including bicycles) involved in road crashes during the period 2001–2015 were obtained from the Italian National Institute of Statistics (ISTAT). ISTAT collects all road crashes documented by a Police authority or military corps on the national road net. Specifically, the exhaustive and monthly based data collection is carried out by ISTAT, with the cooperation of Automobile Club of Italy (ACI) and other public national institutions. In the present study, the monthly number of bicycles involved in bicycle crashes as well as the proportion of the monthly number of bicycles in the total number of vehicles (involved in road crashes) were used.

2.2. Statistical analysis

A simple interrupted time-series analysis was conducted using Stata 15.0. Each series was made stationary or prewhitened by differencing (i.e., replacing the original series with the differences between adjacent values in the original series). Interrupted time-series analysis was conducted using the *itsa* command (Linden, 2015), which relies on regression models designed to adjust for autocorrelation. Specifically, the *itsa* command includes the Prais-Winsten regression model, which uses the generalized least-squares method to estimate the parameters in a linear regression model in which the errors are assumed to follow a first-order autoregressive process. Because Poisson regression models may be more appropriate for count data such as crash data, I have repeated the analysis using this approach (Bhaskaran et al., 2013). Results did not change. However, using Poisson regression models, there was evidence of residual autocorrelation. Therefore, I used the Prais-Winsten regression model as recommended by Bernal et al. (2017).

Autocorrelation was assessed by examining the Durbin-Watson *d* statistic. The null hypothesis of non-autocorrelated errors is not rejected at the 5% level of significance if the Durbin–Watson *d* statistic is close to 2 and is outside the upper and lower bounds for the *d* statistic reported in conventional Durbin-Watson tables (e.g., Savin and White, 1977).

3. Results

In the period between 2001 and 2015, 231,962 bicycles were involved in road crashes in Italy, including 140,058 before the legislation (i.e., October 2010) and 91,904 after the legislation. The monthly mean number of bicycles involved in road crashes was 1197.08 (SD = 372.76) before the legislation and 1458.79 (SD = 435.25) after the legislation. Results from the time-series analysis (Fig. 1) indicated that there was no evidence of an effect in the period immediately following the introduction of the legislation (compared with the counterfactual) on the number of bicycles involved in road crashes ($\beta = -8.51$, p = 0.939 [95% *CI*: -229.02, 212.01]). No evidence of legislation effect over time was found since the difference between pre-intervention and post-intervention slopes of the number of bicycles involved in road crashes was not significant ($\beta = -0.25$, p = 0.921 [95% *CI*: -5.25, 4.75]). Since the Durbin–Watson *d* statistic was 2.05 and lies outside the tabulated upper and lower bounds, it is possible to conclude that the disturbances were not serially correlated.

A second time series analysis (Fig. 2) revealed that the proportion of bicycles involved in road crashes in the total vehicles

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