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The Effect of an Italian Nationwide Mandatory Visibility Aids Law for Cyclists

Abstract

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.

Keywords: legislation, bicycling, deterrence theory, visibility aids, road safety

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].

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 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

[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.

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.

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).

Method

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.

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).

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 (Figure 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 (β= -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 (β = -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 (Figure 2) revealed that the proportion of bicycles involved in road crashes in the total vehicles involved in road crashes did not change in the period

immediately following the introduction of the legislation (β = -0.00, p = 0.996 [95% *CI*: -0.52, 0.52]). Also, the introduction of the legislation did not have an effect over time since the difference between pre-intervention and post-intervention slopes of the number of bicycles involved in road crashes was not significant (β = -0.00, p = 0.780 [95% *CI*: -0.15, 0.11]). The Durbin–Watson *d* statistic was 2.06 and, since it lies outside the tabulated upper and lower bounds, the null hypothesis of non-autocorrelated errors was not rejected.

Discussion

The results from the present study showed that the implementation of legislation imposing high-visibility clothing for cyclist did not affect the number nor the proportion of bicycles involved in road crashes. The legislation did not result in significant immediate and prolonged effects in bicycle safety.

I suggest three main explanations for finding of no change in bicycles involved in road crashes following the introduction of the bicycle visibility aids law. First, the use of high-visibility clothing for cyclist had no effect on cyclists' safety. In the Introduction section, I pointed out that it is unclear the effect of the use of high-visibility clothing on cyclist safety (Kwan and Mapstone, 2006; Miller et al., 2017; Tin Tin et al., 2014). While the use high-visibility clothing for cyclist has the potential to improve recognition and detection in laboratory-based and road-based simulation trials (Kwan and Mapstone, 2006), according to Miller et al. (2017), high-visibility clothing may not be effective in promoting cycling safety when used in the absence of other bicycle crash prevention measures such as lower motor vehicle speeds.

Second, cyclists did not comply with the legislation. Although there is evidence that a proportion of Italian cyclists do not follow some basic traffic rules such as traffic lights (Fraboni et al., 2016), the number of cyclists that ignored the visibility aids law, and hence the size of the

behavior change, is unknown. Drawing from classical deterrence theory (Bates et al., 2012; Fleiter et al., 2013; Homel, 1988), I argue that cyclists may have not complied with the law because the expected costs from violations (e.g., certain, swift, and severe fine sanctions) are perceived lower than the costs of adhering (i.e., having to wear high-vis clothing, which may be considered cumbersome or unfashionable or embarrassing or inconvenient or not having it with you) as well as their gains (e.g., safety). In terms of the gains from using high-visibility clothing, cyclists may be reassured that the sole use of a bicycle light is safe and conforms to the law. There is evidence that some cyclists believe that a bicycle light provides enough visibility, thereby feeling that the use of high-visibility clothing is unnecessary (King et al., 2012; Wood et al., 2012). In addition, cyclists tend to underestimate the usefulness of high-visibility clothing and underutilize them during cycling (Hagel et al., 2007; Lacherez et al., 2013). Observational studies of London cyclists revealed that only a minority of cyclists wear some form of high-visibility clothing (Aldred and Dales, 2017; Goodman et al., 2014). Finally, perceptions of safety discourage the use of high-visibility clothing among cyclists (Aldred and Woodcock, 2015). Specifically, Aldred and Woodcock (2015) revealed that perceived threat from motor vehicles is strongly associated with use of high-visibility clothing among cyclists.

Third, there have been compensatory behavior changes by cyclists and/or motorists in response to the implementation of the legislation imposing high-visibility clothing for cyclist. Concerning this explanation, an important question to be answered in these cases is whether the visibility aids law had an effect on motorists and cyclists' behavior. As predicted by behavioral adaptation and risk compensation theory (e.g., Adams, 1988; Wilde, 1982), motorists and cyclists may have adjusted their behavior in response to a lower perceived level of risk. Specifically, after the nationwide law imposing high-visibility clothing for cyclist was introduced

in October 2010, motorists may have expected cyclists to wear bright clothing and may have taken even less care than previously. Also, cyclists may have reacted to the law imposing high-visibility clothing by acting less safely. In other words, the benefits of the legislation can be outweighed as motorists and/or cyclists increased their risk-taking behavior (Miller et al., 2017).

I also acknowledge that other alternative explanations may account for cyclists' non-compliance as well. First, non-compliance may be due to cyclists not experiencing existing laws as fostering their safety and convenience. Second, some cyclists are making a political statement, i.e., they refuse to accept responsibility for making themselves visible when road authorities are not taking responsibility for creating a safe road environment.

There is clear evidence that efforts such as legislation are most effective in combination with enforcement and campaigns (Phillips et al., 2011). Therefore, the main limitation of the present study is that data on behavior change among cyclists and on the degree to which the Italian state has enacted and enforced mandatory high-visibility clothing for cyclist are not available. It follows that it is impossible to determine why the implementation of legislation imposing high-visibility clothing for cyclist did not have any effect on the number of bicycles involved in road crashes. Another limitation is that the results may not be generalizable to other countries. Research could explore whether the effect of the implementation of legislation imposing high-visibility clothing for cyclist differs between countries with a limited cycling culture such as Italy and high cycling culture countries such as the Netherlands. It is also important to note that research examined the effectiveness of conspicuity, but a more critical examination of the other factors (e.g., road conditions, bicycle use) that may affect cyclists' safety is needed. I acknowledge that I did not take into account whether safe bike routes that bypass direct contact with traffic might have been created during the time the legislation went

into effect and might have contributed to cyclists using other routes of commuting. However, this explanation seems unlikely since there is no evidence that Italy had a long-range plan for developing and building bicycle infrastructure for the years after the implementation of legislation imposing high-visibility clothing for cyclist. Specifically, a search of Italian Ministry of Infrastructure and Transport's websites did not identify any relevant information. I also acknowledge that underreporting of bicycle crashes may affect the present results. However, the second measure (the proportion of bicycle crashes) accounted for changes in underreporting and that the new law was aimed at relatively well reported crash types (bicycle-motor vehicle crashes).

Conclusion

The data showed that the implementation of legislation imposing high-visibility clothing for cyclist did not have either immediate or long-term effects on the number of bicycles involved in road crashes as well as on its proportion in the total vehicles involved in road crashes. Therefore, the findings of the present study provide reason for caution about mandating the use of high-visibility clothing for cyclist per se (i.e., without considering how the law is implemented). The mechanisms behind the lack of effect of legislation imposing high-visibility clothing for cyclist may require further scientific inquiry. Findings from this study suggest that future research should focus on the investigation of other important factors that may impact cyclist compliance and public acceptability. Future studies should also investigate whether the implementation of legislation imposing high-visibility clothing for cyclist followed by public education and law enforcement campaigns could be effective in making bicycle riding safer.

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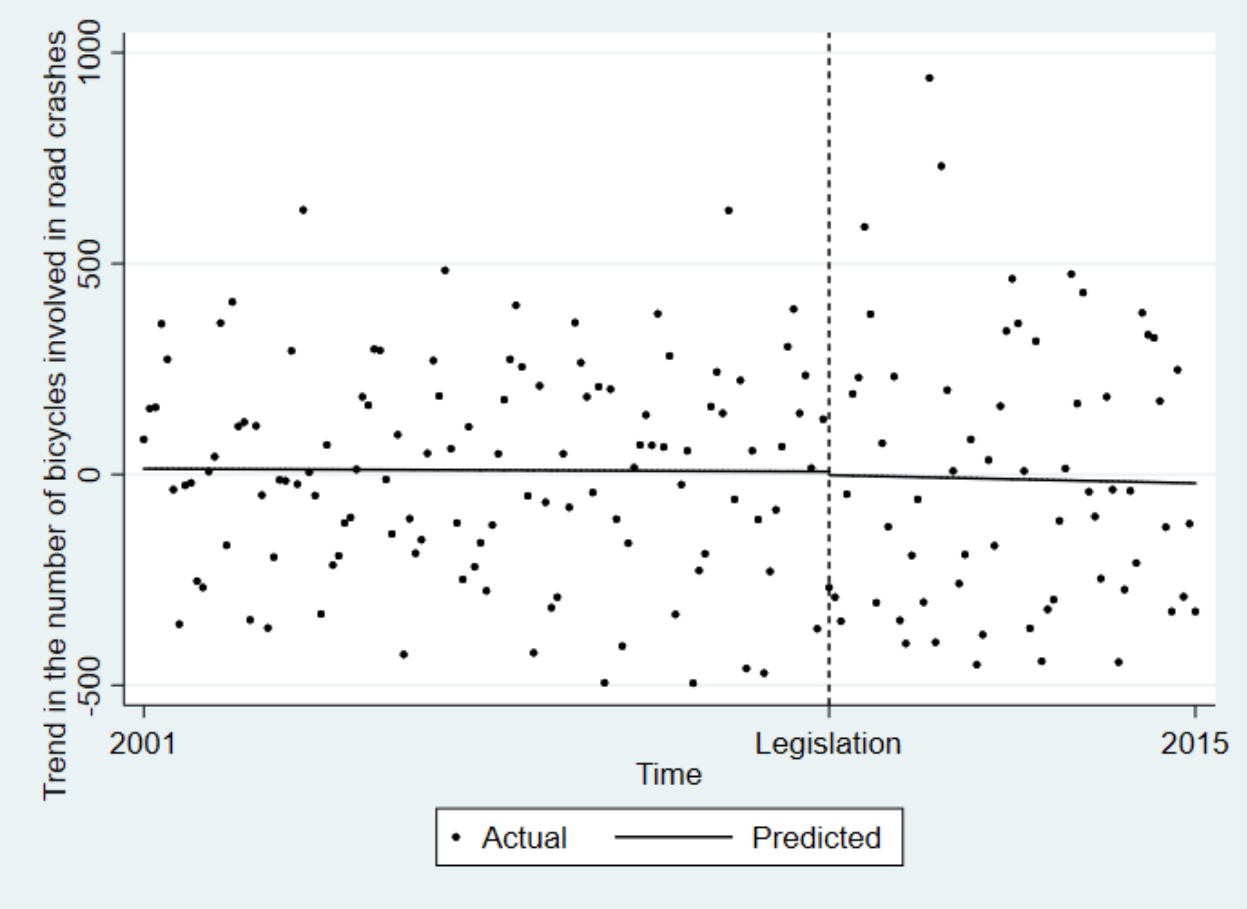

Figure 1. Interrupted time series to assess the impact of legislation on the number of bicycles involved in road crashes. Line: predicted trend based on the regression model.

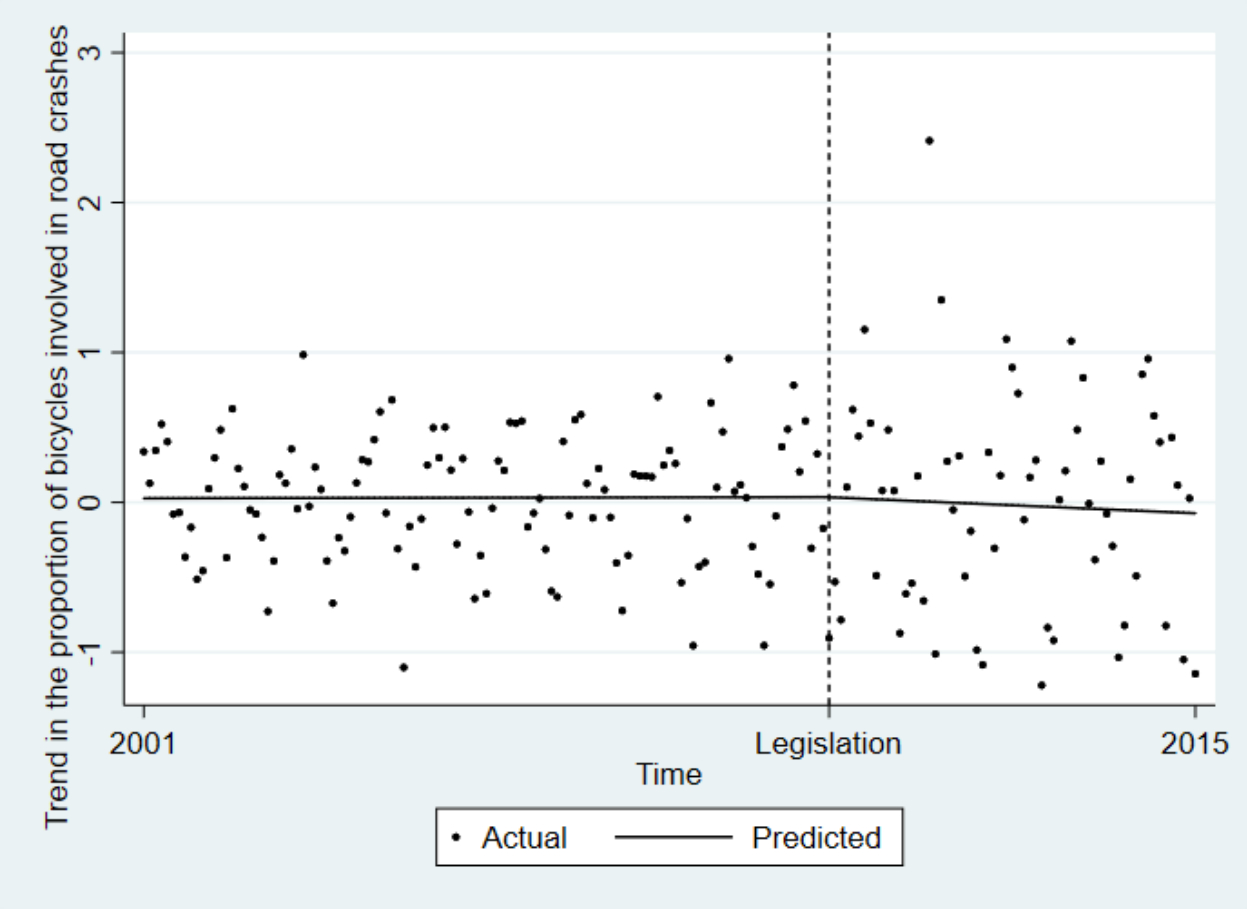

Figure 2. Interrupted time series to assess the impact of legislation on the proportion of bicycles involved in road crashes. Line: predicted trend based on the regression model.