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

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

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34 Abstract

35 The role of conspicuity in preventing bicycle–motorized vehicle collisions has been the subject
36 of investigation. To date, no study has evaluated the impact on bicycle safety of legislation
37 imposing bicycling visibility aids. The aim of the present study is to investigate whether a
38 legislation imposing high-visibility clothing for cyclist affects bicycle safety. Data on the
39 monthly number of vehicles (including bicycles) involved in road crashes during the period
40 2001–2015 were obtained from the Italian National Institute of Statistics. Data were analyzed
41 through an interrupted time-series analysis using a generalized least-squares method. Results
42 revealed that the implementation of legislation imposing high-visibility clothing for cyclist did
43 not influence the number of bicycles involved in road crashes as well as its proportion in the total
44 vehicles involved in road crashes. The introduction of the legislation did not produce immediate
45 effects, nor did it have any effects over time. Lack of knowledge on how the law was introduced,
46 the degree of enforcement by the police, and behavioral changes in response to the law makes it
47 difficult to attribute the lack of effect on bicycle crashes.

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

49

50 **Introduction**

51 The conspicuity of cyclists could be considered a contributory factor in some bicycle–
52 motorized vehicle collisions (Prati et al., 2017a). One systematic review analyzing 42 trials
53 assessing the effect of visibility aids on drivers’ responses revealed that while visibility aids may
54 have the potential to increase visibility and improve drivers’ responses in detection and
55 recognition, the effect of their use on cyclist safety remains to be determined (Kwan and
56 Mapstone, 2006). The findings of recent studies suggest that the safety effect of high-visibility
57 bicycle clothing is not consistent (Lahrman et al., 2017; Miller et al., 2017; Tin Tin et al.,
58 2014).

59 Although several studies focused on the impact of mandatory bicycle helmet laws (e.g.,
60 de Jong, 2012; Kett et al., 2016; Macpherson and Spinks, 2008; Markowitz and Chatterji, 2015;
61 Rodgers, 2002), to date, no study has sought to answer the question of whether the legislation
62 imposing high-visibility clothing for cyclist has an impact on bicycle safety¹.

63 **Theoretical Background**

64 In the design and implementation of enforcement measures in the area of road safety,
65 deterrence theory is the most common framework (Bates et al., 2012; Fleiter et al., 2013; Homel,
66 1988). According to classical deterrence theory, compliance with the law is likely to occur when
67 the expected costs from violations are higher than the gains. Those costs are assumed to arise
68 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.

69 addition to these costs, the costs associated with the perceived likelihood and severity of a road
70 crash should be taken into account. Indeed, one of the reasons cyclists are considered vulnerable
71 or minority road users (Prati et al., 2017b) is that the risks for cyclists are generally higher than
72 for motorists (e.g., motorized vehicles have greater mass and speed compared to bicycles, while
73 cyclists do not have physical protection, are less stable, less visible, and more affected by road
74 surface irregularities). Therefore, the costs of non-compliance with laws are not negligible for
75 cyclists. Nevertheless, there are also perceived costs associated with complying with the
76 legislation imposing high-visibility clothing for cyclist. Aldred and Woodcock (2015) revealed
77 that, despite perceived social pressure on cyclists to wear visibility aids, many cyclists were
78 reluctant and expressed complaints about inconvenience and personal appearance.

79 **The Present Study**

80 The aim of the present study was to investigate the influence of a mandatory visibility
81 aids law in Italy. In Italy, a nationwide mandatory visibility aids law (Law 29/7/2010 n. 120) for
82 cyclists of all ages was introduced in October 2010. Specifically, the law requires cyclists to
83 wear high-visibility clothing when riding after dusk and before dawn. Moreover, the law imposes
84 the use of high-visibility clothing in addition to (and not in replacement of) bicycle lights. In the
85 context of the international debate on whether traffic laws are actually effective in promoting
86 traffic safety, it is important to study whether this law has had the intended effect on cycling
87 safety. Comprehensive data on cycling crashes before and after the law was introduced are now
88 available, and this allows for an investigation of the effects of the law using time series
89 techniques. Specifically, it is possible to analyze the national trends in the number of bicycle
90 crashes and examine whether any changes in the trend happened in conjunction with the
91 legislation imposing high-visibility clothing for cyclist. While the present study investigated the

92 relationship between introduction of the law and bicycle crashes, it did not evaluate how the law
93 was introduced (i.e., process evaluation) and it did not assess intermediate outputs (e.g., the level
94 of enforcement and campaign activities) and other outcomes (e.g., behavioral changes such as
95 wearing visibility aids).

96 **Method**

97 **Data collection**

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

106 **Statistical Analysis**

107 A simple interrupted time-series analysis was conducted using Stata 15.0. Each series
108 was made stationary or prewhitened by differencing (i.e., replacing the original series with the
109 differences between adjacent values in the original series). Interrupted time-series analysis was
110 conducted using the *itsa* command (Linden, 2015), which relies on regression models designed
111 to adjust for autocorrelation. Specifically, the *itsa* command includes the Prais-Winsten
112 regression model, which uses the generalized least-squares method to estimate the parameters in
113 a linear regression model in which the errors are assumed to follow a first-order autoregressive
114 process. Because Poisson regression models may be more appropriate for count data such as

115 crash data, I have repeated the analysis using this approach (Bhaskaran et al., 2013). Results did
116 not change. However, using Poisson regression models, there was evidence of residual
117 autocorrelation. Therefore, I used the Prais-Winsten regression model as recommended by
118 Bernal et al. (2017).

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

123 **Results**

124 In the period between 2001 and 2015, 231,962 bicycles were involved in road crashes in
125 Italy, including 140,058 before the legislation (i.e., October 2010) and 91,904 after the
126 legislation. The monthly mean number of bicycles involved in road crashes was 1197.08 ($SD =$
127 372.76) before the legislation and 1458.79 ($SD = 435.25$) after the legislation. Results from the
128 time-series analysis (Figure 1) indicated that there was no evidence of an effect in the period
129 immediately following the introduction of the legislation (compared with the counterfactual) on
130 the number of bicycles involved in road crashes ($\beta = -8.51$, $p = 0.939$ [95% CI : -229.02, 212.01]).
131 No evidence of legislation effect over time was found since the difference between pre-
132 intervention and post-intervention slopes of the number of bicycles involved in road crashes was
133 not significant ($\beta = -0.25$, $p = 0.921$ [95% CI : -5.25, 4.75]). Since the Durbin-Watson d statistic
134 was 2.05 and lies outside the tabulated upper and lower bounds, it is possible to conclude that the
135 disturbances were not serially correlated.

136 A second time series analysis (Figure 2) revealed that the proportion of bicycles involved
137 in road crashes in the total vehicles involved in road crashes did not change in the period

138 immediately following the introduction of the legislation ($\beta = -0.00$, $p = 0.996$ [95% *CI*: -0.52,
139 0.52]). Also, the introduction of the legislation did not have an effect over time since the
140 difference between pre-intervention and post-intervention slopes of the number of bicycles
141 involved in road crashes was not significant ($\beta = -0.00$, $p = 0.780$ [95% *CI*: -0.15, 0.11]). The
142 Durbin–Watson *d* statistic was 2.06 and, since it lies outside the tabulated upper and lower
143 bounds, the null hypothesis of non-autocorrelated errors was not rejected.

144 **Discussion**

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

149 I suggest three main explanations for finding of no change in bicycles involved in road
150 crashes following the introduction of the bicycle visibility aids law. First, the use of high-
151 visibility clothing for cyclist had no effect on cyclists' safety. In the Introduction section, I
152 pointed out that it is unclear the effect of the use of high-visibility clothing on cyclist safety
153 (Kwan and Mapstone, 2006; Miller et al., 2017; Tin Tin et al., 2014). While the use high-
154 visibility clothing for cyclist has the potential to improve recognition and detection in laboratory-
155 based and road-based simulation trials (Kwan and Mapstone, 2006), according to Miller et al.
156 (2017), high-visibility clothing may not be effective in promoting cycling safety when used in
157 the absence of other bicycle crash prevention measures such as lower motor vehicle speeds.

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

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

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

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

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

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

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

216 **Conclusion**

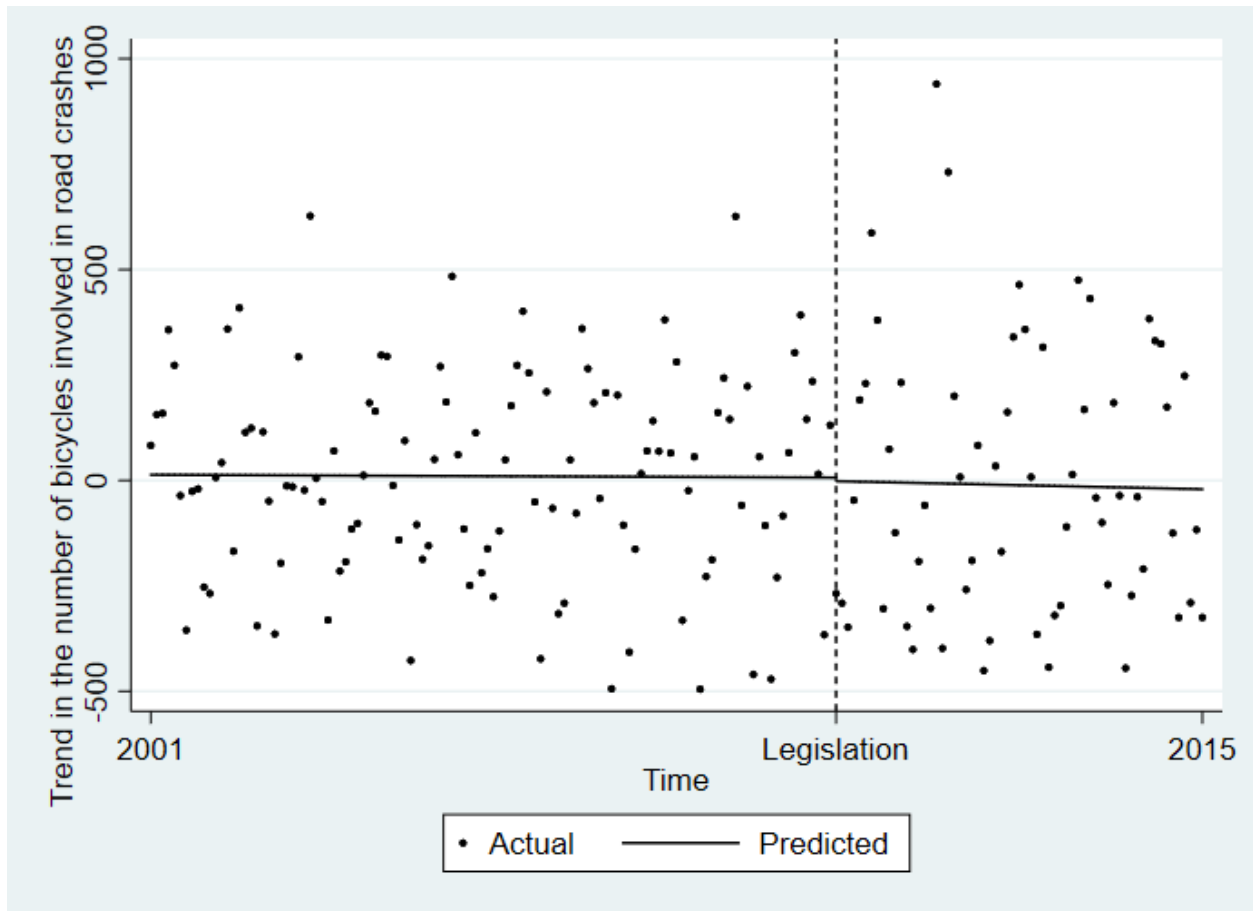
217 The data showed that the implementation of legislation imposing high-visibility clothing
218 for cyclist did not have either immediate or long-term effects on the number of bicycles involved
219 in road crashes as well as on its proportion in the total vehicles involved in road crashes.
220 Therefore, the findings of the present study provide reason for caution about mandating the use
221 of high-visibility clothing for cyclist per se (i.e., without considering how the law is
222 implemented). The mechanisms behind the lack of effect of legislation imposing high-visibility
223 clothing for cyclist may require further scientific inquiry. Findings from this study suggest that
224 future research should focus on the investigation of other important factors that may impact
225 cyclist compliance and public acceptability. Future studies should also investigate whether the
226 implementation of legislation imposing high-visibility clothing for cyclist followed by public
227 education and law enforcement campaigns could be effective in making bicycle riding safer.
228

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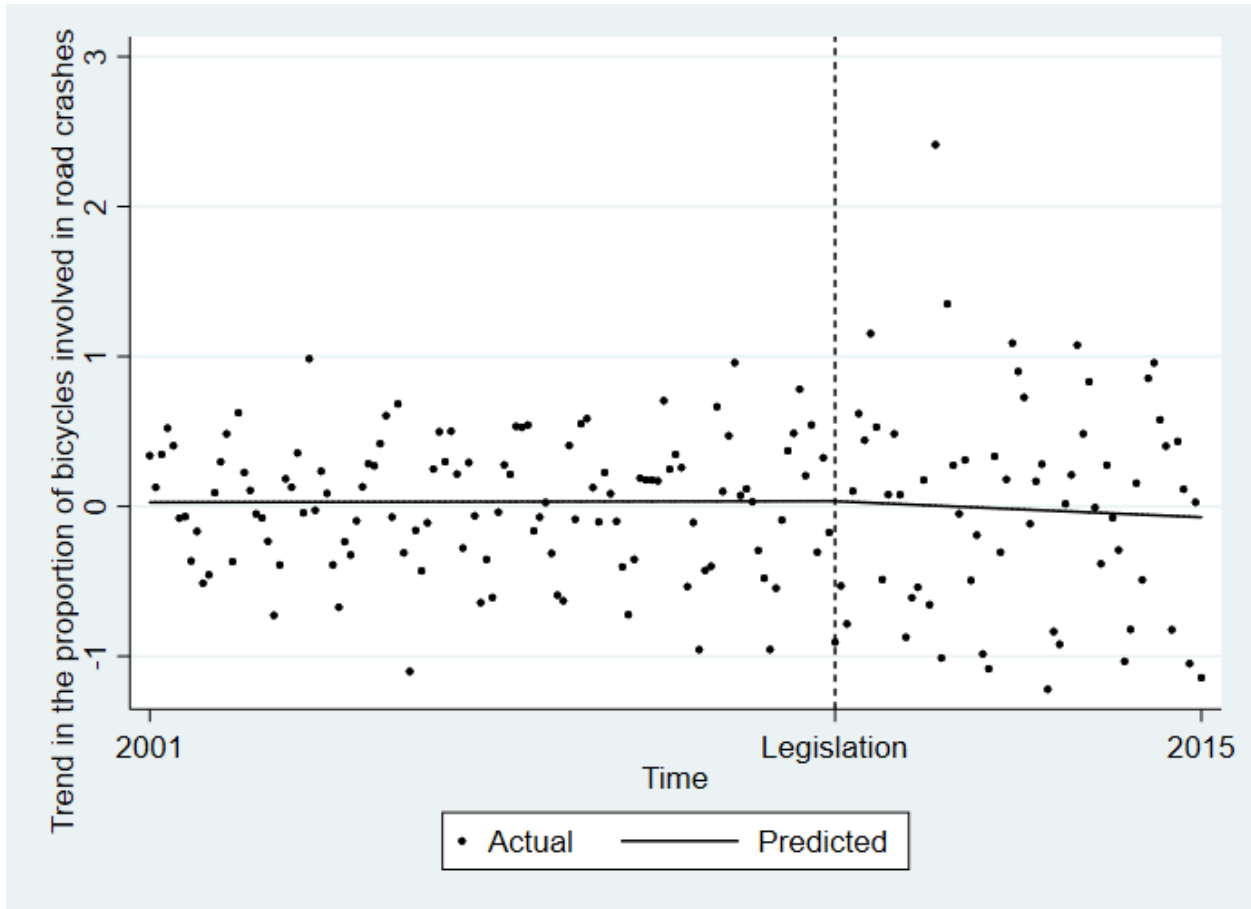


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299 *Figure 1.* Interrupted time series to assess the impact of legislation on the number of bicycles

300 involved in road crashes. Line: predicted trend based on the regression model.

301



302

303 *Figure 2.* Interrupted time series to assess the impact of legislation on the proportion of bicycles

304 involved in road crashes. Line: predicted trend based on the regression model.

305