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Infrastructural and Human Factors affecting Safety Outcomes of Cyclists

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Infrastructural and Human Factors affecting Safety Outcomes of Cyclists

Abstract The increasing on traffic crashes involving cyclists registered during the last decade, and the high proportion of accidents implying severe injuries and deaths among them constitute, nowadays, a global issue for community health, urban development and traffic safety. However, the incidence of many risk factors for road accidents of cyclists remains empirically unexplained, reason for that it is pertinent to study this matter, in order to strengthen the design of measures for preventing traffic crashes and injuries on cyclists. Objectives: This study aimed, first, to examine the relationship between key infrastructural and human factors present in cycling, bike-user features and their accident records. And second, to determine whether a set of key infrastructural and human factors may predict their traffic safety outcomes. Methods: For this cross-sectional study, a total of 1064 cyclists (38.8% women; 61.2% men; $\bar{x}$=32.8 years of age) from 20 different countries from Europe, Latin and North America, participated answering an online-survey composed by four sections: demographic data and cycling-related factors; human factors; perceptions on infrastructural factors; and traffic accidents suffered. Results: The results of this study shown significant associations between human factors, infrastructural conditions and accident rates. Also, through the modelling of a logistic regression model for predicting traffic accidents of cyclists, it was found that the last could be explained through many of the used study variables, being age, riding intensity, risky behaviors, and problematic user/infrastructure interactions significant predictors for traffic crashes involving this type of road users. Conclusions: The results of this study suggest that accident rates of cyclists are influenced by features related to the user, such as age, road behaviors and perceptions, and its interaction to infrastructural characteristics of the road. Moreover, the promotion of bike-using should be accompanied by

safety regulations and urban design parameters contributing to strengthen a friendly interaction with cyclists.

Keywords: Cyclists; Bike Users; Risky Behaviors; Human Factors; Infrastructure; Traffic Accidents; Road Safety.

1. Introduction Traffic crashes have been a permanent concerning for public health agencies (governments, public entities, healthcare systems), and even for the society by itself along the last half century. However, and even keeping in mind that the bicycle is older than every motorized vehicle as a transport mode, the problem of cyclists injured or dead as a result of road accidents has been rising as a public health problem just during the last few years. In consequence, the amount of evidence available for explaining, predicting and preventing traffic accidents involving cyclists is relatively scarce, especially in developing countries, in which the increase in the use of the bicycle can be described as "exponential" and little documented by scientific studies over the last few years [1]. On the other hand, although high-income countries have a broader and longer bike-using tradition [2,3], the mechanisms by which human and infrastructural factors act on accident causation remain practically unexplained, but the worrying elevated losses that road accidents imply for road users continue affecting the community health [4,5]. Considering that, especially in cities, cyclists' risk exposure has been constantly increasing in a simultaneous manner with the number of bicycle users, their average daily journeys and distances traveled, the need of analyzing the factors that affect the problem of cyclists' accident rates has emerged essentially in the last decade [6,7]. For instance, in the case of Spain, in the period 2008-2013 (6 years), 25.439 cyclists were implied in accidents involving injured or dead victims [8]. Further, only in 2013 bicycle users were involved in a total of 5.853 traffic accidents, from which 69 cyclists died (only 3 less than in 2012), 646 were seriously injured and 4.779 were slightly injured [9]. Further, for the year 2015, from the total of 59.148 traffic accidents involving death or injured victims, 3.85% (2.277) them involved cyclists, leaving as a result 49 dead cyclists -47 men, and 1 woman- [10]. Regarding accident characteristics, the weekdays presenting a higher percentage of accidents are Tuesday (15.2%), Wednesday and Thursday (15.4% each), and the lowest rate is observed at Sundays (12.2%). As for the zones in which accidents occur, urban centers have a higher percentage of accidents (70.7%) and victims (67.4%), compared to interurban roads, which report 29.3% of accidents, and 32.6% of victims. Moreover, 47.2% of severe injuries of cyclists occur in conventional urban roads [8]. In short, although the overall rates on traffic accidents (especially involving motorized vehicles) have been systematically decreasing along the last forty years, the constant rising in the number of bike users injured and death as a result of traffic accidents would not be disregarded [11]. In addition, the subsequent health and financial costs of traffic accidents involving cyclists are considerably elevated [12], especially considering two facts: first, compared to accidents suffered by motor vehicle-users, cyclists have a greater physical vulnerability, even when they were properly using passive-safety elements [13,14,15]; and second, that in most of the countries cyclists do not need to have an accident insurance policy to circulate, and often their attention is totally subsidized by healthcare systems [12,16]. Recent studies have stated the injury rates derived of traffic accidents involving cyclists may increase during the next decade [17,18], keeping in mind the massive increasing of biking as a cheap, efficient and alternative transport mode to

conventional motorized vehicles [19], what has implied, in many cases, a disproportionate, and sometimes disorganized, growth of the use of the bicycle, often devoid of infrastructure improvement strategies and road education for users [20-22]. In this regard, is clear that, at the same time that the using of the bicycle is promoted, the safety of its users gets more relevance for public health agents [13,23]. In accordance, cycling has been constantly put in a balance, considering that, on the one hand improves the healthy habits of the population, but on the other, the vulnerability of cyclists in case of accident is very high [4,24]. However, this problem has implied a significant increasing in the need of studies seeking to associate different road and infrastructural-related factors to the probability of traffic injuries suffered by cyclists [13,25]. In this sense, one of the factors with a greater attributed influence on the traffic injuries suffered by cyclists is the own risky behaviors performed by them during riding. It is estimated that 40% of the accidents suffered by bike users are preceded by one or more risky behaviors -especially traffic violations or distracted riding- of the cyclist [26]. Furthermore, the risk behavior on the road may be influenced by several various present on the road, such as problematic interactions with other users/vehicles, infrastructure problems and the lack of a cycling culture among the population [27-31].

Nevertheless, and even when considering its recent advances, the matter of studying cyclist's behaviors as a predictor of their accidents stills being very scarcely developed [32,33], compared to the number of empirical research already published for explaining traffic accidents suffered by motorized vehicle drivers, fact that contributes to the backwardness on the improvement of evidence-based prevention and safety-promotion programs for cyclists [34-36]. In this regard, it becomes worth to study factors associated to accident frequency and severity of this vulnerable population of road users, aiming to reducing road risk and actual consequences of traffic accidents on their safety, health and welfare [4,37,38], through a scientific approach to the human and structural factors influencing potentially positive and safer behavioral habits and interactions for road users [39] –and specifically for cyclists- [7,40,41], as a manner of strengthen the overall status of road safety [42-44].

1.1 Objectives The objectives of this study focus on the examination of, first, the relationship between key infrastructural and risk-related human factors present in cycling, characteristics of cyclists and their accident rates. And second, of whether infrastructural and human factors on the road are associated to traffic accident rates reported by cyclists, through the built of a predictive model for explaining traffic safety outcomes.

2. Methods and materials 2.1 Sample The full study sample was composed by n=1064 bike users of 20 different countries from Europe Latin and North America, being 413 (38.8%) of them women, and 651 (61.2%) men, with an average of $\bar{x}$=32.83 (SD=12.63) years of age. The mean time (intensity) along which participants use the bicycle per week was $\bar{x}$=6.71 (SD=6.34) hours, i.e., $\bar{x}$=0.96 hours or 57.6 minutes per day. Their average length for each normal bicycle journey was $\bar{x}$=47.60 (SD=42.68) minutes, or $\bar{x}$=0.80 hours.

2.2. Study Design and Procedure For this cross-sectional study, participants completed an electronic questionnaire. The survey was conducted guaranteeing the anonymity of the participants, and emphasizing on the fact that the data would only be used for research purposes. The importance of answering honestly to all questions was emphasized, as well as the non-existence of wrong or right answers. It was used an informed consent statement, checked and accepted by participants as a requirement for voluntary answering the questionnaire. Surveys were fully completed by n=1064 cyclists, discarding incomplete or partially completed questionnaires, and the response rate was approximately 42.6%, considering that approximately 2500 questionnaires were initially delivered.

2.3 Description of the questionnaire The questionnaire was administrated in Spanish language, and consisted of various sections: Its initial part addressed individual/demographic variables, such as age, gender, and city of residence, and cycling-related factors, such as the frequency, length and habits associated to bike-using. For the second part, it was assessed a relevant set of human factors of cyclists: first, it was measured the self-rated risky behaviors on the road using the Cyclist Behavior Questionnaire (CBQ) [34], a self-report measure on road behavior specifically designed for measuring high-risk riding behaviors (errors and violations) among bike users. This Likert scale is originally composed by 44 items, distributed in three factors: Violations (V), consisting of 16 items; Errors (E), composed by 16 items; and Positive Behaviors (PB), consisting of 12 items. A global score of “Risk Behaviors” was built through the summing of Errors and Violations reported by respondents. The entire questionnaire used a frequency-based response scale of 5 levels: 0=never; 1=hardly ever; 2=sometimes; 3=frequently; 4=almost always. The third part of the survey asked for perceptions and subjective assessments about the infrastructural conditions and perceptions of road users. Firstly, it was used a set of Likert-type items for measuring the following factors in a scale from 0 (none existing) to 4 (highly present in their habitual cycling experience): the avoidance of cycling under adverse weather conditions (scale 0-4); the perceived signalizing and infrastructure problems on habitual roads employed; the perceived density of traffic and complexity of urban roads; the perceived respect for priority at intersections; and the perceived overcrowding (or massification) of bike using in their residence cities/towns. Secondly, a set of dichotomous items (Yes/No) addressing potential negative interactions they may recently had in terms of: a) problematic interactions with other road users; b) problematic interactions with obstacles on the road; and c) the perception of environmental overstimulation through visual elements present on their circulation roads. Finally, the fourth part of the instrument consisted on a series of questions related to their accident rates (despite its severity) suffered along a period of time of five years (how many accidents have you suffered when cycling in the last 5 years?).

2.4 Ethics For realizing this study, Research Ethics Committee for Social Science in Health of the University Research Institute on Traffic and Road Safety at the University of Valencia was consulted, certifying that the research subject to analysis responds to the general ethical principles, currently relevant to research in Social Sciences, and its accordance with the Declaration of Helsinki, issuing a favorable opinion to carry out the study. Further, it was used an informed consent statement containing ethical principles and data treatment details, explaining the objective of the study, the mean duration of the survey, the personal data treatment and the voluntariness of their partaking, always presented before the participants answered the questionnaire. Personal and/or confidential data were not used and the participation was anonymous, implying not potential risks for the integrity of its participants.

2.5 Statistical Analysis (Data Processing) Basic descriptive analyzes were performed in order to obtain raw and standardized scores for study variables. Further, descriptive statistics (means, standard deviations) and Pearson' (bivariate) correlational analysis were performed to obtain, respectively, basic study factors and associations between study variables. The association between independent study variables and road accident rates of cyclists (dependent variable) was tested using Logit (logistic regression) modelling, using a significance parameter of p>0.05. All statistical analyses were performed using ©IBM SPSS (Statistical Package for Social Sciences), version 23.0.

3. Results Descriptive statistics and study variable scores The average mean of cycling accidents suffered in the last 5 years of the full sample was x̄=0.65 (SD=0.98), a relatively high value considering the high morbidity and mortality that severe cycling accidents use to present. Regarding behavioral issues, the mean value on self-rated risky behaviors when cycling (scale 0-4) was x̄=1.26 (SD=0.73), and avoidance of cycling under adverse weather conditions (scale 0-4) scored x̄=2.75 (SD=1.25). The average score obtained for perceived signalizing and infrastructure problems of used roads (scale 0-4) was x̄=3.44 (SD=0.80). Perceived density of traffic and complexity of urban roads (scale 0-4) had a mean value of x̄=3.38 (SD=0.91). The perceived respect for priority at intersections (scale 0-4) scored a mean of x̄=1.29 (SD=1.17). In addition, the perceived massification of bike using in residence city/town (scale 0-4) presented a mean value of x̄=2.27 (SD=1.14), as shown in Table 1. Regarding categorical (dichotomous) indicators, 83.6% of cyclists composing the sample report they had frequent problematic interactions with other road users. Further, 84% of them have had problematic interactions with obstacles on the road. On the other hand, only 34.7% of them have reported perceiving an environmental overstimulation through billboards or visual elements present on the road.

Correlation analysis The Bivariate (Pearson) correlation analysis (see Table 1), realized for the full study sample, allowed to identify significant associations between infrastructural and human demographic factors, and traffic safety outcomes. Specifically, age was negatively and significantly related to the intensity of bike-using (average hours riding per week), self-rated risky behaviors on the road and traffic accidents suffered along the last five years. On the other hand, age correlates positively with avoidance, perceived massification of bike using and environmental overstimulation. As for the case of risky behaviors, significant association measures were found for perceived complexity of urban roads [-], perceived respect for priority in crossings [-], avoidance [-], and for traffic accident rates [+]. Accident rates were also found associated to intensity [+], massification [+], avoidance [+], and for the perceived respect for priority in crossings by other road users [-]. Finally, no significant associations were found between categorical variables and accident rates registered along the last 5 years, as also reported in Table 1.

Table 1. Descriptive statistics and bivariate correlations between study variables. Continuous Variables Mean SD 2 3 4 5 6 7 8 9 10 11 12 13 1 Age of Users 32.83 12.630 -.177** -.274** -.040 .176** .102** -.222** .161** .024 .048 .171** -.197** -.190** 2 Hours Riding per Week 6.71 6.341 1 .206** .058 -.097** -.033 .107** -.199** -.024 -.040 -.090** .286** .228** 3 Own Risky Behaviors 1.26 0.734 1 .038 -.170** -.115** .049 -.247** .033 .018 .044 .341** .306** 4

Signalizing and Infrastructure Problems 3.44 0.801 1 .203** -.169** -.028 .053 .102** .115** .026 .035 .040 5 Traffic Density and Complexity of Urban Roads 3.38 .913 1 .042 -.050 .155** .026 .093** .087** -.012 -.023 6 Respect for Priority at Intersections 1.29 1.172 1 .182** .047 -.086** -.069* .053 -.066* -.087** 7 Massification of Bike Using in Residence City/Town 2.27 1.249 1 .008 .021 -.022 -.004 .133** .128** 8 Avoidance (Weather Conditions) 2.75 1.136 1 .000 .047 .103** -.211** -.170** Categorical Variables (0/1) Frequency Percent 9 Problematic Interactions with other Road Users 890 83.6% 1 .471** .135** .007 .054 10 Problematic Interactions with Obstacles in the Road 893 84.0% 1 .130** -.017 -.018 11 Environmental Overstimulation (Billboards) 695 34.7% 1 -.053 -.046 Accident Records Mean/Frequency SD/ Percent 12 Accidents (5 Years) 0.65 0.983 1 .794** 13 Accidents (Yes/No) 425 39.9% 1 **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Logit (Logistic Regression) Modelling The significant Logit model, conducted through stepwise regression (forward) technique, was built using variables contained in Table 2 showing its Beta coefficients, significance level and Confidence Intervals (CI) at 95%. The final model (contained at the fifth step) had an overall accuracy percentage of 66.7%, explained 19.5% of the variance between subjects (with a Nagelkerke's R-square coefficient of R2=0.195), and showed a -2 Log likelihood coefficient of 1282.77 after 3 iterations, with a level of significance of p>0.001. There was found that an increase in some of the variables contained in the model decreases the Odd Ratio (OR) of belonging to the Group 1 (i.e., to have suffered at least one traffic accident in the last five years during bike riding). These variables are: the age of cyclists, which increasing in one logarithmic unit (one year of age) represents a decreasing in 1.3% of the OR [Exp(B) =0.978; CIExp(B)=0.975:0.999]; the respect for the priority of cyclists at intersections, decreasing the OR in 12.9% [Exp(B)=0.879; CIExp(B)=0.778:0.993] when one logarithmic unit is increased, and the avoidance of riding under adverse weather conditions, for which one-logarithmic unit increasing explains a subsequent decreasing of 19.4% [Exp(B)=0.823; CIExp(B) =0.727:0.933] in the Odd Ratio.

On the other hand, there is a set of included variables increasing the Odd Ratio: the number of weekly riding hours, increasing OR in 5.5% [Exp(B)=1.056; CIExp(B)=1.031:1.083] for each additional hour; the massification or overcrowding of cycling in the residence zone, signifying an increasing of 21.1% [Exp(B)=1.235; CIExp(B)=1.098:1.389] in the OR; the level of traffic density and complexity, increasing in 16.2% [Exp(B)=1.176; CIExp(B)=1.007:1.375] the OR; and, finally, the self-rated risky behaviors when cycling, increasing OR in 71.3% [Exp(B)=2.041; CIExp(B)=1.647:2.529] per logarithmic unit. Figure 1 shows graphically the observed groups and probabilistic predictions based on the variables contained in the model.

Table 2.

Logistic Regression (Logit) Model. Dependent variable: Accidents suffered along the last 5 years (Dichotomous, with 1=probability of success). Step Variable B S.E. Wald df Sig. Exp(B) 95% C.I. for Exp(B)

Lower Upper Step 1a Age of Users -.018 .006 8.927 1 .003 .982 .971 .994

Hours Riding per Week .061 .013 23.905 1 .000 1.063 1.037 1.090

Own Risky Behaviors .733 .105 48.366 1 .000 2.082 1.693 2.560

Constant -1.165 .277 17.762 1 .000 .312 Step 2b Age of Users -.014 .006 5.544 1 .019 .986 .974 .998

Hours Riding per Week .059 .013 21.898 1 .000 1.061 1.035 1.087

Own Risky Behaviors .743 .106 49.064 1 .000 2.102 1.707 2.588

Massification of Bike Using in Residence City/Town .175 .058 9.082 1 .003 1.191 1.063 1.334

Constant -1.678 .327 26.299 1 .000 .187 Step 3c Age of Users -.013 .006 4.646 1 .031 .987 .975 .999

Hours Riding per Week .054 .013 18.375 1 .000 1.056 1.030 1.082

Own Risky Behaviors .695 .107 41.905 1 .000 2.003 1.623 2.472

Massification of Bike Using in Residence City/Town .185 .058 10.050 1 .002 1.203 1.073 1.349

Avoidance -.180 .063 8.148 1 .004 .835 .738 .945

Constant -1.157 .373 9.628 1 .002 .314 Step 4d Age of Users -.012 .006 3.734 1 .053 .988 .976 1.000

Hours Riding per Week .054 .013 18.102 1 .000 1.055 1.029 1.081

Own Risky Behaviors .683 .108 40.222 1 .000 1.981 1.603 2.446

Respect for Priority at Intersections -.126 .062 4.138 1 .042 .882 .781 .995

Massification of Bike Using in Residence City/Town .209 .060 12.203 1 .000 1.232 1.096 1.385

Avoidance -.183 .063 8.323 1 .004 .833 .736 .943

Constant -1.071 .376 8.123 1 .004 .343 Step 5e Age of Users -.013 .006 4.666 1 .031 .987 .975 .999

Hours Riding per Week .055 .013 18.791 1 .000 1.056 1.031 1.083

Own Risky Behaviors .713 .109 42.536 1 .000 2.041 1.647 2.529

Traffic Density and Complexity of Urban Roads .162 .079 4.182 1 .041 1.176 1.007 1.375

Respect for Priority at Intersections -.129 .062 4.314 1 .038 .879 .778 .993

Massification of Bike Using in Residence City/Town .211 .060 12.427 1 .000 1.235 1.098 1.389

Avoidance -.194 .064 9.289 1 .002 .823 .727 .933

Constant -1.589 .456 12.162 1 .000 .204 aVariable(s) entered on step 1: Own Risky Behaviors. bVariable(s) entered on step 2: Massification of Bike Using in Residence City/Town. cVariable(s) entered on step 3: Avoidance. dVariable(s) entered on step 4: Respect for Priority at Intersections. eVariable(s) entered on step 5: Traffic Density and Complexity of Urban Roads.

Figure 1. Observed groups (Logit) and probabilistic predictions, corresponding to 1's=Positive cases, and 0's=Negative cases.

4. Discussion and Conclusions The results of this empirical study support the existence of a relationship between infrastructural and human factors, including demographic features of cyclists, such as age and risky behaviors on the road, and the negative road safety outcomes reported by the international sample of cyclists participating in this research. Initially, and regarding our first study objective, it is worth mentioning that the observed directionality of association measures (Pearson correlations) between study variables related both to human factors, as to infrastructural issues, result consistent to other empirical studies previously performed with samples of cyclists [3,45], and diverse groups of road users, specially drivers with high exposure to diverse road risks [46,47]. Specifically, it is worth remarking the associations reported between age of cyclists and traffic accident rates in the last 5 years: in accordance with key empirical sources, we found that cyclists with less age tend to accumulate higher rates of (despite severity) crashes when riding than those with a higher age/experience [48,49]. Further, the problem of road user's age result also correlated to risk-related perceptions and risky behaviors on the road, being theoretically assumed that not only young drivers [50-52], but also young cyclists tend to present a lesser crash risk when riding [53,54]. In addition, intentions, attitudes and perceptions of users have also been correlated to the age, experience and other human factors of cyclists and, subsequently, may play a crucial role for the design of bicycle-related policies [55]. Finally, behavioral factors such as avoidance and problematic interaction with environmental elements of the road result correlated to user's age and intensity of cycling. As for the second study objective, this study allowed to identify the impact of human and infrastructure-related factors on accidents suffered by cyclists, i.e., the fact of have suffered (or not) traffic crashes when cycling in a period of five years. In this regard, not only demographic factors of cyclists shown to have a substantial influence on safety records, but also the perceived complexity of urban roads for cycling, traffic density, the respect given for the priority of certain road users and the overcrowding of cycling in their residence zones. In accordance, the existing literature has systematically shown how transportation infrastructure plays an important role on user's safety. For instance, Reynlods et al. [56] stated that improvements in this regard may enhance the prevention of crashes and injuries, and a successive promotion of a safety culture, inclusive for all road users, nowadays a matter still pending to be developed in many countries [2,56,57]. Later, and keeping in mind problematic interactions with other road users, most of the empirical evidence in this regard addresses the existence of structural incompatibilities and fails on urban design policy, that enhance the amount of latent risks for cyclists [53,58,59]. In brief, all significant variables related to infrastructure have shown to have in increasing effect on the OR (Odd Ratio) of being involved in a traffic crash while riding.

Moreover, human factors increasing the risk should be also discussed, making a special emphasis on risky behaviors, being this the variable with a greater incidence in the Odd Ratio, according to the obtained significant model. Even though that age and intensity of cycling are sufficient documented as variables linked to the road risk assumed by cyclists [7,19,27], the often-unspecific taxonomy and complexity of risky behaviors, of which cyclists sometimes are not even aware, have made it difficult to recognize the importance of intervening user behavior as a road safety measure by itself. In this sense, the lack of legislation and road formation strategies for cyclists may explain a substantially “problematic state of affairs” for promoting a road safety culture both from as towards cyclists [8,60]. Finally, it is worth mentioning that, summed to the cited generalized poor state of infrastructures, lack of legal protection and Road Safety Education enforcement, low empathy from other road users and a wide lack of risk perception from cyclists [22,42], empirical studies have described the dominance of motor transport [61], often as an urgent policing issue, above topics concerning to the safety in alternative means of transport, which represents not only a difficulty for the construction of an inclusive road safety culture, but also in terms of environmental, public health and sustainable development issues.

5. Limitations of the Study Although sample size was considerably large, and statistical parameters were overall accurately and positively tested, some potential biasing sources and facts related to the data collection and analysis should be mentioned. First, that being the present an international study, the specific conditions governing traffic dynamics of cyclists belonging to different countries may substantially vary [58,62], considering relevant factors such as the aforementioned status of Road Safety Education [22], absence of legislation and normative regulations for biking [60], the using of helmet and reflecting accessories [15], and infrastructure-related issues of every circulation environment [56], that at the same time could increase or decrease the occurrence of risky and protective behaviors among road users [25,32]. Further, and keeping in mind the greater explicative role identified in self-reported risky behaviors it could be need analyzing the influence of positive behaviors on the explanation of crashes involving cyclists. Later, and very close to the methods used for realizing this study, the used questionnaire offered a dependent variable founded on the self-reports of users, but not recorded crashes derived from external data sources, being this fact extensive for the measuring of risk behaviors [63]. This fact appears to be directly related to the often-observed methodological bias and weaknesses of tools used for empirical research [64], and specifically for accident-causation research [65], that, at the same time, could minimize or omit the impact of complimentary variables that many substantially explain large portions of the variability between accidents suffered by different types of road users [39,50]. In this sense, and depending on the attributed complexity of each study, bike-user’s road risk estimation methods may require addressing more data/variables than motor vehicles to explain the high variability that characterizes the task of riding this type of non-motorized vehicles [66].

Finally, it is worth addressing the worrying rate of underreported accidents, not only in institutional records, but also for the case of self-reporting based studies. Regarding the first, a substantial part of registered traffic crashes involving cyclists, especially those not implying major material losses or injuries, may not be reported [67]. As for the later, a potential large part of their accidents suffered may be not reported by cyclists [68], remarking the lack of a standardized and/or well-known definition of the concept among participants, fact that could be an issue to fulfill for future experiences of accident-related research.

6. Practical Applications This study, based on self-rated data of cyclists, provides a useful conceptualization of the impact of human and infrastructural issues that may modulate the road risk and road safety outcomes of cyclists. In this sense, policy makers and program designers could consider the reported data as a useful empirical framework for the building of applied interventions aimed at addressing risk factors explaining accidents, considering its proven relationship to the prevention of traffic injuries, especially when considering the evident insufficiency of empirical evidences in this regard, that have not been largely previously documented through applied studies. Also, the authors consider that this work represents a useful experience for the statistical approaching of the public health problem of traffic injuries among bike users, suggesting new questions about how to strengthen a sustainable and responsible promotion of alternative transport modes.

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