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# Under-Reporting bicycle Accidents to Police in the COST TU1101 International Survey: Cross-Country Comparisons and Associated Factors

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## ABSTRACT

Police crash reports are often the main source for official data in many countries. However, police sampling and data are known to be subject to bias, making the countermeasures adopted according to them possibly inefficient. In the case of bicycle crashes, this bias is most acute and it probably varies across countries, with some of them being more prone to reporting accidents to police than others. Assessing if this bias occurs and the size of it can be of great importance for evaluating the risks associated with bicycling.

This study utilized data collected in the COST TU1101 action “Towards safer bicycling through optimization of bicycle helmets and usage”. The data came from an online survey that included questions related to bicyclists' attitudes, behaviour, cycling habits, accidents, and patterns of use of helmets. The survey was filled by 8,655 bicyclists from 30 different countries. After applying various exclusion factors, we remained with 7,015 questionnaires filled by adult cyclists from 17 countries, each with at least 100 valid responses.

The results showed that across all countries, an average of only 10% of all crashes were reported to the police, with a wide range among countries: from a minimum of 0.0% (Israel) and 2.6% (Croatia) to a maximum of a 35.0% (Germany). Some factors associated with the reporting levels were type of crash, type of vehicle involved, and injury severity. No relation was found between the likelihood of reporting and the cyclist's gender, age, marital status, being a parent, use of helmet, and type of bicycle.

The significant under-reporting – including injury crashes that do not lead to hospitalization - justifies the use of self-report survey data for assessment of bicycling crash patterns as they relate to (1) crash risk issues such as location, infrastructure, cyclists' characteristics, and use of helmet and (2) strategic approaches to bicycle crash prevention and injury reduction.

**Keywords:** bicycles, under-reporting, international survey of cycling, cycling behaviour, cycling attitudes, bicycle helmets, bicycle crashes.

## 1 INTRODUCTION

"Vulnerable road users" is the collective term used to refer to pedestrians, motorcyclists, and bicyclists. But other than their commonality in terms of their unprotected exposure to motorized traffic the three types of road users differ significantly from each other. Bicyclists often share the road with drivers (like motorcyclists), but they do not move at the traffic speed, they do not have a license (and are therefore less controlled), and they do not adhere as much to the rules of the road (like pedestrians). Consequently, they do have some unique risk factors that should be considered. A significant known obstacle to identifying their risk level is under-reporting of crashes to police.

Crash statistics on bicycles suffer from significant under-reporting compared to other types of road users, as they are often not documented by the police. This omission is most common when a motor-vehicle is not involved, such as when a cyclist hits a fixed object or falls, on or off the road (Schepers, 2008; 2010). This was borne out by Elvik and Mysen (1999) in a meta-analysis of the level of under-reporting of bicycle crashes in official state records, based primarily on police reports, of 19 countries. They concluded that while there is a great variability among countries, of all the crash types, consistently the least reported are bicycle crashes, and in particular single-vehicle bicycle injury crashes that "are very rarely reported in official road accident statistics" (0-8 percent in the various countries). This is a worldwide phenomenon that still exists (OECD/ITF, 2013), and that greatly compromises our comprehension of the scope, nature, causes, and characteristics of these crashes– and ultimately countermeasures to prevent such crashes. Even in the Netherlands, where cycling safety is a high national priority, based on hospital admissions records, approximately 75 percent of the serious injury bicycle crashes are single-vehicle crashes, not involving a motor-vehicle (Schepers *et al*., 2014b). In Israel based on hospital admissions in 2001-2007 only 30 percent of the bicycle crash victims were involved in a bicycle-motor-vehicle collision or conflict (Siman-Tov *et al*., 2012) and therefore were eligible to be included in the official police reports.

Police reports may not include single-vehicle bicycle crashes, because they may not be covered by the definition of an accident, which in some countries must involve a motor-vehicle. In Turkey, where this is the case, based on hospital admissions 20 percent of the severe injuries are from single-vehicle crashes; i.e., not involving a collision with a motor-vehicle (Kocak *et al.*, 2010). This is important because to understand the causes and characteristics of bicycle crashes, it is important to detect the characteristics of single-vehicle bicycle crashes relative to various factors such as road geometry data, ambient conditions, bicycle type, and rider characteristics.

Even when a motor-vehicle is involved, many of the collisions are not documented in police records. In a prospective study that tracked the cycling behavior and crashes of 1,087 adult commuter riders in Brussels, Belgium over a period of one year, the police documented only 7 percent of the crashes, even though 19 percent involved a collision with a car (de Geus *et al*., 2012). And even in a city where bicycling is more common than driving (Munster, Germany), hospital admission records contain twice as many injury bicycle crashes as the police records (Juhra *et al*., 2012).

In the U.K and the Netherlands just slightly over 30 percent of the crashes with severely injured cyclists are documented by the police. The situation is much worse in reporting slight injuries: only 21 percent in the U.K, and almost none (4%) in the Netherlands (Wegman *et al.*, 2012). Exceptions to the under-reporting are fatal crashes. This is in part, at least, because the more severe the injury, the more likely that it is due to a collision with a motor-vehicle, and hence the more likely it is to be documented by the police (Schepers *et al*., 2014b). With respect to fatal crashes the reporting level can be as high as 100 percent (U.K., Israel), but also lower (86 percent in the Netherlands).

Thus, the under-reporting of bicycle crashes is not only numerically significant, but also biased against the less severe, against those not involving a moving motor-vehicle, and against those occurring off the road. The problem can be so biased as to even project different trends from hospital and police records. For example, in the Netherlands in the decade of 2000 - 2009 bicycling fatalities decreased according to both police and hospital records. But while serious injuries in that period also decreased by 36%

according to the police records, they actually *increased* by 35% according to the hospital records (OECD/ITF, 2013).

With respect to rates, in addition to the under-reporting of the numerator (number of crashes), the under-reporting also suffers from a less reliable denominator (e.g., number of cyclists, trips, or kilometers of cycling in the relevant group) compared to the denominator for the motorized traffic. Consequently, the estimated rates of injuries, and crashes, are both under-estimates of the magnitude of the problem, and less reliable than the estimates for drivers and car occupants.

Despite the fact that the significant under-reporting of bicycle crashes is well known, it is "not very well researched" (Wegman *et al*., 2012). The findings noted above all assume that the hospital records are a reliable indicator of injuries. But what about injury crashes that are not documented in hospital records, or not systematically collected by national hospital registries? With rare exceptions (e.g., de Geus *et al*., 2012) the level of under-reporting is defined relative to hospital records. Thus, as de Geus *et al*. discovered, self-reports reveal an even greater disparity between the police reports and the actual events. For example, in Israel, a national survey of adult cyclists revealed that only 12 percent of the severe crashes that ended up in hospitalization were reported to the police (Megamot, 2016). Obviously the rate of reporting is undoubtedly much lower for less severe crashes.

One of the purposes of the present study, and the focus of the analyses reported here, was to obtain current crash involvement estimates from bicyclists' self-reports in different countries as a function of their self-reported exposure and individual differences. This information can be very useful in determination of the true extent of bicycling crashes at a time when bicycling is on rise in most countries.

## 2 METHOD

Information on cycling habits, attitudes, and crashes was collected via an internet-based questionnaire in 30 countries represented by members of the EU COST Action 1101 "Towards safer bicycling through optimization of bicycle helmets and usage". The questionnaire was developed in English, and then presented in each country in its own language, after being validated with back-and-forth translations. Following a pilot survey in Israel, data collection was initiated in 18 June 2014 and finalized in 04 July 2015.

## 2.1 Questionnaire development

The questionnaire consists of 30 core items that were common to all countries. These items were represented by a total of 123 specific questions. Participants were allowed to append to the core survey a few country-specific items (e.g., riding in ice and snow in northern countries).

The questionnaire commences with a screening question whether or not the participant has ridden a bicycle in the last month. This is followed by seven demographic items with response options taken from international surveys such as SARTRE to enable an evaluation of the representativeness of the survey sample. This is followed by five items regarding driving licences, travel and access to cars and bicycles. There are then nine items that measure the frequency of cycling and amount of cycling for different purposes (e.g., commuting, health, recreation) and in different environments (e.g., bicycle trails, bike lanes, on sidewalks, in traffic). The following section comprises five items concerning the circumstances for use and non-use of helmets. There are then two items related to the respondents attitudes towards bicycle use and towards helmet use. Theory of Planned Behaviour was used as a behavioural change model that guided the development of the items. The items were carefully worded to maximise the relevance and usefulness of information collected from both wearers and non-wearers of helmets. The final two items collected information about crash involvement (including helmet use) and whether the crash was reported to the police.

The questionnaire combined new scale items with items from previous bicycle safety surveys developed by the collaborating researchers including the Queensland Cycling Survey (Washington *et al*., 2012), and earlier Greek questionnaires (Papadakaki *et al*., 2013). In each country the questionnaire was presented in its official language. The software used to administer the online questionnaire varied among countries, with KeySurvey© being used in most. The Dutch Institute for Road Safety Research (SWOV) assisted in programming the survey in several languages, and in managing and maintaining the data bank.

Questionnaires were made available online, and their dissemination was promoted by different venues by the COST Action researchers in 17 countries (see Table 1). Prior to its general dissemination the questionnaire was pilot tested on 30 Israeli cyclists in face-to-face interviews.

## 2.2. Participant recruitment and sample size

Convenience sampling via social media, word-of-mouth, and bicycle organisations was the primary recruitment strategy. Participation was restricted to adults (18 years old or older) who had ridden a bicycle in the last month. The willingness to answer to the online survey was considered as consent to participate. A total of 9,248 responses to the survey were submitted, out of which 8,609 responses were received by the cut-off date of 4 July 2015. Subsequently, 639 responses from Argentina were added to this database. Some respondents completed questionnaires for their home country while they were responding from a different country (the largest group being 30 residents of Germany who completed the Swiss survey), and other respondents did not specify their country of residence (n=747), which led to subtracting them from the total sample of questionnaires. Exclusion of respondents occurred in a step-wise manner (see ). Firstly, countries with less than 100 participants were excluded, resulting in the 141 respondents being excluded (for example, 62 respondents from Belgium). Respondents who did not specify their country of residence were then excluded, followed by respondents who did not provide their age and gender, followed by those respondents who were under 18 years of age. Finally, respondents who provided no response, or reported “Never” to the question “During the last 12 months on average how often did you travel by cycling” were also excluded. The final sample size for analysis was 7,015.

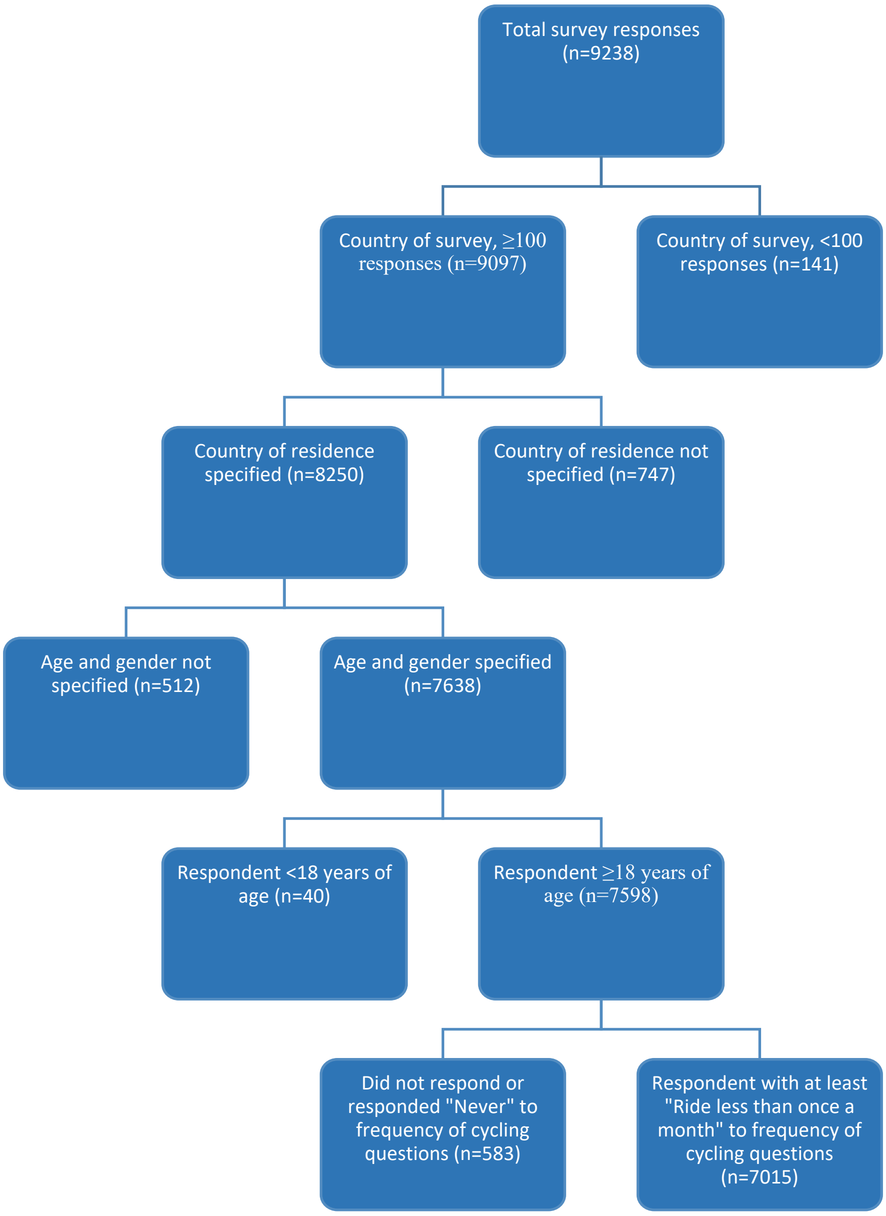



**Figure 1 Decision tree for cleaning the database**

2.3. Questionnaire items related to crash involvement and reporting.

The complete questionnaire is available on the web at the COST T1101 website as part of the Final Report of Working Group 2 (http://www.bicycle-helmets.eu/images/downloads/COST-Action-TU1101_WG2_2015.pdf.) The final questions of the questionnaire focused on the cyclist's crash and crash-reporting experience as stated in responses to the following questions:

Q28. In the last year, how many accidents have you been involved in as a cyclist in which you ... (please put the number zero [0] in each box, if you have not had a crash that matches the description):

(a) Had cuts or scrapes that did not require medical attention,

(b) Were treated by a nurse or doctor without being admitted to hospital,

(c) Were admitted to hospital.

Q28(a). For the most serious crash, which term below describes it best:

(a) Bicycle-motor vehicle crash,

(b) Bicycle into fixed object,

(c) Fall off bicycle,

(d) Bicycle-bicycle crash,

(e) Bicycle-pedestrian crash,

(f) Other/Unknown

Q28(b). Was the crash reported to police? (a)Yes, (b) No

Q28(c). Were you wearing a bicycle helmet at the time of the crash? (a) Yes, (b) No

Q28(d). Was the helmet fastened at the time of the crash? (a) Yes, (b) No

Q28(e). Do you think that wearing a helmet reduced the severity of any head injuries in that crash? (a) Yes, (b) No

Q28(e). Do you think that wearing a helmet would have reduced the severity of any head injuries in that crash? (a) Yes, (b) No

## 3 RESULTS

In this paper we present only results related to the under-reporting of crashes, focusing first on the variables that were significantly associated with the level of reporting: country, type of crash, crash severity, and marital status of the rider.

### 3.1. Differences between countries in bicycle crashes reported to the police

Table 1 shows the number of questionnaires filled out for each country, the number of crashes recalled in the past year in each country, the number of cyclists reporting one or more crashes in the past year, and the number and percent of crashes reported to the police by country. A total of 1783 riders responded that they had at least one accident in the past year, and further specified whether or not they reported the most severe crash to the police. A total of 30 respondents claimed to have had at least one accident but did not indicate if they reported to the police or not, so they were excluded from the analysis below.

**Table 1.** Number of responses from each country, number of crashes, number of cyclists reporting having one or more crashes, number of cyclists reporting the most severe crash to the police, and percent of these crashes reported to the police. The rows are sorted according to the last column. Lower-case italicized letters in the last column indicate the significance of the pairwise comparisons between countries in the percentages of reporting using z-tests when samples are larger than 10 or Fisher's exact test when the samples are smaller.

| *Country* | *Number of responses* | *Number of crashes* | *Number of cyclists reporting having one or more crashes* | *No. of cyclists reporting the most severe crash to police* | *Percent of these cyclists reporting it to police* |
|---|---|---|---|---|---|
| *Germany* | *104* | *32* | 20 | *7* | *b 35.0* |
| *Turkey* | *169* | *236* | 46 | *10* | *a, b 21.7* |
| *Switzerland* | *110* | *51* | 26 | *4* | *a, b 15.4* |
| *Netherlands* | *519* | *96* | 81 | *11* | *a, b 13.6* |
| *Portugal* | *310* | *535* | 114 | *15* | *a, b 13.2* |
| *Norway* | *1194* | [1] | 375 | *35* | *a, b 9.3* |
| *Spain* | *194* | *349* | 65 | *6* | *a, b 9.2* |
| *France* | *435* | *220* | 120 | *11* | *a, b 9.2* |
| *Estonia* | *130* | *42* | 22 | *2* | *a, b 9.1* |
| *Italy* | *2164* | *902* | 411 | *34* | *a 8.3* |
| *Australia* | *181* | *245* | 73 | *6* | *a, b 8.2* |
| *Sweden* | *360* | *238* | 125 | *9* | *a, b 7.2* |
| *Argentina* | *541* | *536* | 166 | *10* | *a 6.0* |
| *Romania* | *110* | *60* | 19 | *1* | *a, b 5.3* |
| *Greece* | *182* | *230* | 61 | *3* | *a, b 4.9* |
| *Croatia* | *130* | *169* | 38 | *1* | *a, b 2.6* |
| *Israel* | *182* | *40* | 21 | *0* | *a, b 0.0* |
| *Total* | *7015* | *3981* | *1783* | *165* | *9.3* |

[1] This question was not asked in Norway

When averaged across all respondents only 9.25% (CI = 7.9%, 10.6%) of all bicyclists reported their most severe crash to the police. When averaged across countries – thereby removing the effect of the different sample size in each country - the median reporting level is 9.1% and the mean is 10.5% (CI = 6.3%, 14.6%). If Germany is considered an outlier, then the distribution is closer to normal with a mean reporting level of 8.95% (6.2%, 11.7%). The data in Table 1 are sorted in descending order according to the percentage of cyclists who reported their most severe crash to the police. Lower-case italicized letters in the last column indicate the significance of the pairwise comparisons between countries in the percentages of reporting using z-tests when samples are larger than 10 or Fisher's exact test when the samples are smaller. The level of significance was adjusted using the Bonferroni correction to control for the number of comparisons. Percentage of the most severe crashes reported to the police for countries sharing the same letter were not statistically significant from each other. The examination of these differences show a very simple pattern, with Germany having a statistically significant higher rate than Argentina and Italy (35% of cyclists reporting in Germany, 6% in Argentina and 8,3% in Italy) and the rest of the countries situated in the middle, with no statistically significant differences among them. Note, however, that other countries, with reporting levels that are similar or below those of Argentina and Italy, did not differ significantly from Germany, and this is most likely due to the small numbers and large variance. Also, these rates are unadjusted for the injury severity, and, as discussed below, once the rates are adjusted for injury severity, the rank-order changes (see Table 6).

3.2. Type of crash: most frequently reported are with motor-vehicle, least reported are falling-off-bike,

The variable type of crash distinguishes among the following types: Bicycle-motor vehicle collision, Bicycle-bicycle collision, Bicycle-pedestrian collision, Bicycle-fixed object collision, Falling off bicycle, and Other/Unknown. The 181 respondents who claimed to have had one or more accidents but did not indicate the type of the most severe crash were excluded from the analysis. The Chi Square for the cross-tabulation of the type of crash and reporting to police was 159.29 (df=5, $p<0.001$) indicating a highly significant association between these two variables.

Table 2 shows the counts and percentages of the most severe crashes reported to the police by the type of crash sorted in descending order according to the percentage of positive reporting. Again, small italicized letters indicate significance of the differences, using either z-tests or Fisher exact tests when the frequency is smaller than 5. The results show that the most often reported crashes were collisions with motor vehicles. These crashes were reported at significantly higher rates than collisions with bicycles, fixed objects or simply falling off the bicycle. As these differences could be explained by the different severities associated with these types of crashes, we also examined the interaction between type of crash and severity for explaining reporting to police as part of a multivariate model later in this paper.

**Table 2.** Count and Percentage of bicyclists who reported one or more crashes to the police by type of crash

| | *Reporting to Police* | | |
|---|---|---|---|
| *Type of crash* | *Total* | *Yes* | *Yes (%)* |
| *Bicycle-motor vehicle crash* | *370* | *92* | *b 24.9* |
| *Other/Unknown* | *145* | *19* | *a, b 13.1* |
| *Bicycle-bicycle crash* | *98* | *10* | *a 10.2* |
| *Bicycle-pedestrian crash* | *23* | *1* | *a, b, c 4.3* |
| *Bicycle into fixed object* | *140* | *6* | *a, c 4.3* |
| *Fall off bicycle* | *835* | *22* | *c 2.6* |
| *Total* | *1611* | *150* | *9.3* |
| *Chi-Square=157.50, df=5, p<.001* | | | |

3.3. Injury severity: the higher it is the more likely to be reported

The questionnaire had one item consisting of three questions related to severity of the injuries. The item started as "In the last year, how many accidents have you been involved in as a cyclist that…" 1 - Had cuts or scrapes that did not require medical attention, 2 – Were treated by a nurse or doctor without being admitted to hospital, and 3 -Were admitted to hospital. Notice that we focused only on the most severe crash for each respondent, as we reckoned this would likely be the one reported to police.

Table 3 shows severity of the most severe crash the respondent had suffered, as a function of whether or not it was reported to the police. This table had Chi-square = 192.90 (df=2, p<0.001), indicating highly significant differences among the injury levels. Tests for the specific percentages showed that, as expected, the more severe the crash, the more likely it was to be reported to the police (with all differences being significant at p<.05 (using Bonferroni correction). It is indeed striking that on the average even the most severe crashes – those resulting in hospitalization - were reported to the police only slightly more than one third of the times.

**Table 3** Count and Percentage of bicyclists who reported one or more crashes to the police by severity of the injuries

| | *Reporting to Police* | | |
|---|---|---|---|
| *Injury Severity* | *Total* | *Yes* | *Yes (%)* |
| *Admitted to Hospital* | *157* | *59* | $_{a}$*37.6* |
| *Needed Medical attention* | *290* | *37* | $_{b}$*12.8* |
| *No medical attention* | *1055* | *41* | $_{c}$*3.9* |
| *Total* | *1502* | *137* | *9.1* |
| *Chi-Square=157.502, df=5, p<.001* | | | |

As expected, there was a strong interaction between injury severity and type of crash (Chi Square = 34.91, p<.001), which is depicted in Table 4. Of all collisions with motor-vehicles, 18.4 percent resulted in hospital admission, compared to 7.7 percent of all falling-off bike crashes, and these differences were statistically significant.

Table 4. Counts and percentages of crash severity for each type of bicycle crash. Each subscript letter denotes a subset within the same level of injury. Categories sharing the same letter indicate that their proportions do not differ significantly from each other at the ,05 level.

| | Level_Crash | | | | | |
|---|---|---|---|---|---|---|
| | No medical attention | | Need. Med. attention | | Admitted to Hospital | |
| | Count | %: | Count | % | Count | % |
| Bicycle-motor vehicle crash | 214$_{a}$ | 62,6 | 65$_{a}$ | 19,0 | 63$_{a}$ | 18,4 |
| Bicycle into fixed object | 79$_{a, b}$ | 65,8 | 29$_{a}$ | 24,2 | 12$_{a, b}$ | 10,0 |
| Fall off bicycle | 557$_{b}$ | 73,1 | 146$_{a}$ | 19,2 | 59$_{b}$ | 7,7 |
| Bicycle-bicycle crash | 62$_{a, b}$ | 72,9 | 16$_{a}$ | 18,8 | 7$_{a, b}$ | 8,2 |
| Bicycle-pedestrian crash | 18$_{a, b}$ | 85,7 | 3$_{a}$ | 14,3 | 0$_{a, b}$ | 0,0 |
| Other/Unknown | 80$_{a, b}$ | 70,2 | 21$_{a}$ | 18,4 | 13$_{a, b}$ | 11,4 |
| Total | 1010 | 69,9 | 280 | 19,4 | 154 | 10,7 |

3.4. Marital/partnership Status

Marital Status was split into three categories: a) Single/divorced/widowed, b) Married/de facto/partnered, and c) Other. Single people were 50 percent more likely to report the crash to the police than people living with someone (Chi square = 192.90 (df=2, p<0.001) (Table 5).

**Table 5.** Count and Percentage of bicyclists who reported one or more bicycle crashes to the police by marital status

| | *Reporting to Police* | | |
|---|---|---|---|
| *Marital Status* | *Total* | *Yes* | *Yes (%)* |
| *Single/divorced/widowed* | *648* | *76* | $_a$*11.7* |
| *Married/de facto/partnered* | *1027* | *80* | $_b$*7.8* |
| *Other* | *114* | *8* | $_{a,b}$ *7.0* |
| *Total* | *1789* | *164* | *9.2* |
| *Chi-Square=192.902, df=2, p<.001* | | | |

3.5. Logistic regression model of the predictors of police reporting

A logistic regression analysis was performed on the outcome variable "crashes reported to police" with four predictor variables, namely Country (with countries as categories), Severity (No medical attention, Needed medical attention, Admitted to the hospital), Type of Crash (Bicycle-motor vehicle crash, Bicycle into fixed object, Fall off bicycle, Bicycle-bicycle crash, Bicycle-pedestrian crash, Other/Unknown) and Marital Status (Single/divorced/widowed, Married/de facto/partnered, Other). A total of 1421 respondents in the database had had at least one accident and had completed all the information for the above variables. (Note: Israel was omitted from the analysis because of calculation problems due to its zero reporting to police).

A test of the full model using Country, Type of Crash, Severity and Marital Status against a constant-only model was statistically significant, Chi Square (28, N=1421)=295,88, p<.001. Classification correctly predicted 98.2% of non-reported crashes and 36.4% of reported crashes with an overall success rate of 92.5%.

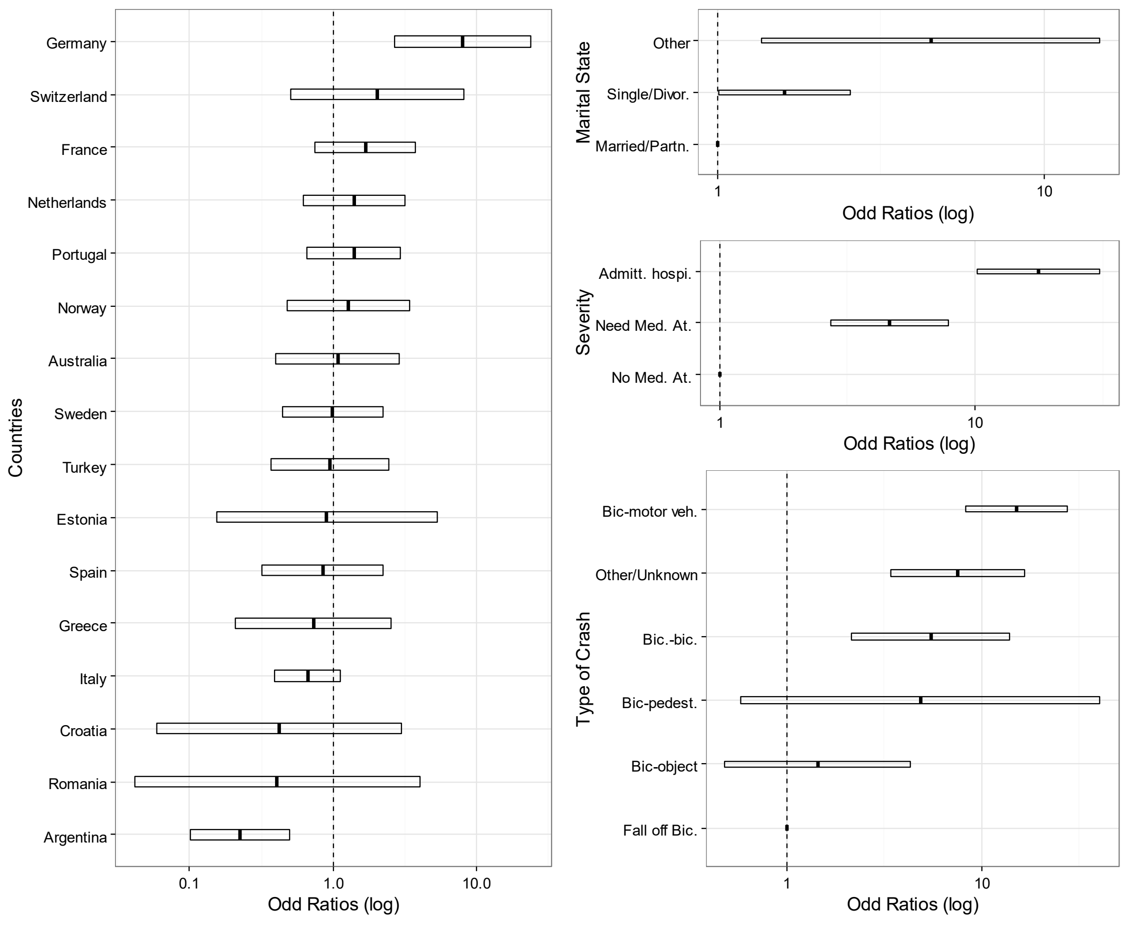
Table 6 shows the regression coefficients, standard errors, Wald statistics, degrees of freedom, significance, and odds ratios for the predictors and the categories of the predictors. Additionally, the intervals of confidence for the odds ratios are shown in Figure1. We discuss the results for the four predictors in the model in the paragraphs below.

**Table 6.** Regression coefficients, standard errors, Wald statistics, degrees of freedom, significance and odds ratios for logistic regression model for predicting reporting to police using Country, Severity of the crash and Type of crash as predictors.

| | *B* | *Std. error* | *Wald* | *Df* | *Sig.* | *Odds ratios* |
|---|---|---|---|---|---|---|
| *Country* | | | *35.773* | *15* | *0.002* | |
| *Argentina* | *-1.500* | *0.408* | *13.518* | *1* | *0.000* | *0.223* |
| *Australia* | *0.074* | *0.506* | *0.021* | *1* | *0.884* | *1.077* |
| *Croatia* | *-0.868* | *1.002* | *0.749* | *1* | *0.387* | *0.420* |
| *Estonia* | *-0.098* | *0.903* | *0.012* | *1* | *0.914* | *0.907* |
| *France* | *0.517* | *0.414* | *1.558* | *1* | *0.212* | *1.677* |
| *Germany* | *2.083* | *0.561* | *13.803* | *1* | *0.000* | *8.032* |
| *Greece* | *-0.317* | *0.642* | *0.244* | *1* | *0.621* | *0.728* |
| *Italy* | *-0.405* | *0.268* | *2.276* | *1* | *0.131* | *0.667* |
| *Netherlands* | *0.34* | *0.416* | *0.667* | *1* | *0.414* | *1.404* |
| *Norway* | *0.244* | *0.500* | *0.238* | *1* | *0.626* | *1.276* |
| *Portugal* | *0.333* | *0.386* | *0.744* | *1* | *0.388* | *1.395* |
| *Romania* | *-0.894* | *1.164* | *0.590* | *1* | *0.442* | *0.409* |
| *Spain* | *-0.17* | *0.494* | *0.118* | *1* | *0.731* | *0.844* |
| *Sweden* | *-0.004* | *0.414* | *0.000* | *1* | *0.991* | *0.996* |
| *Switzerland* | *0.711* | *0.712* | *0.997* | *1* | *0.318* | *2.037* |
| *Turkey* | *-.0470* | *0.479* | *.010* | *1* | *0.922* | *0.954* |
| *Severity* | | | *105.317* | *2* | *.000* | |
| *Needed Med. attent.* | *1.535* | *.271* | *32.119* | *1* | *.000* | *4.640* |
| *Admitted to hospital* | *2.875* | *.282* | *103.691* | *1* | *.000* | *17.730* |
| *Type* | | | *88.822* | *5* | *.000* | |
| *B.-motor vehicle* | *2.717* | *.304* | *80.057* | *1* | *.000* | *15.131* |
| *B. into fixed object* | *.365* | *.558* | *.426* | *1* | *.514* | *1.440* |
| *Bicycle-bicycle* | *1.700* | *.479* | *12.621* | *1* | *.000* | *5.476* |
| *Bicycle-pedestrian* | *1.579* | *1.082* | *2.129* | *1* | *.145* | *4.850* |
| *Other/Unknown* | *2.022* | *.402* | *25.365* | *1* | *.000* | *7.555* |
| *Marital_Status* | | | *8.171* | *2* | *.017* | |
| *Single/divorced/widowed* | *.473* | *.235* | *4.038* | *1* | *.044* | *1.605* |
| *Other* | *1.503* | *.607* | *6.128* | *1* | *.013* | *4.496* |
| *Constant* | *-4.936* | *.348* | *201.555* | *1* | *.000* | *.007* |

The variable Country has a Wald statistic (15, N=1421) = 35.773, p=.002, indicating that differences between the countries account for some of the differences in the level of reporting to police. In order to evaluate the contribution of the countries we used the average of the countries as reference. Thus, Germany stands out as a country with an odds ratio of 8.03 (p<.001), of reporting relative to the average of all the countries, whereas Argentina stands out for low reporting with an odds ratio of 0.22 (p<.001). The odds ratios of the rest of the countries are not significantly different from the average.

**Figure 1.** Plots odds ratios for the levels of predictors of reporting a crash to the police. Notice that the x axis is plotted in logarithmical scale in all the plots. The dotted line shows the reference criteria used in each case. Countries=average of all the countries, Marital Status= the Married/Partnered, Severity=No Medical Attention, Type of Crash=Fall off Bicycle.




The variable Severity has as Wald statistic (2, N=1421) = 105.32, p<.001 meaning that the injury severity is a significant predictor of the likelihood of reporting to the police. Using as reference crashes that did not require medical assistance, the odds ratio of those that needed medical attention was 4.64, p<.001. If the victim was admitted to hospital because of the crash, the odds ratio almost quadrupled to 17.73.

Therefore, severity of the crash is the most important factor in predicting if the crash will or will not be reported to the police.

The Type of Crash had a Wald statistic (5, N=1421) = 88.82, (p<.001). Using falling off the bicycle as the reference, we see that all the other types of crashes have odds ratios larger 1.0. Of those, however, the odds of reporting to the police after having a crash into a fixed object is not significantly different from that of falling off the bicycle (OR=1.44, p=.514) and colliding with a motor-vehicle has the largest odds ratio of all 15.13, p<.001.

Finally, the Marital Status had a Wald statistic (2, N=1421) = 8.171, (p<.001). Using having a partner as category of reference we see that other Marital Status had larger and significant odds ratios (Single/Divorced/Widowed=1.605, p<.05; Other = 4.496, p<0.05).

We also tested a model similar to the one in Table  but with the addition of the interaction between Severity and Type of Crash as it could be argued that certain combinations of Types of Crashes and Severity might lead to more/less reporting. However, this interaction had a non-significant Wald statistic [2.468 (9, N=1421), p=.714] and consequently this term was discarded.

3.6. Factors not associated with reporting of bicycle crashes to the police

All of the other factors that we evaluated in relation to the likelihood of reporting to the police were not statistically significant. We report below only the results of the ones that may seem relevant to safety but were not significantly associated with reporting. These included the cyclist's gender, having or not having children, type of bicycle, and use of helmet. Of course, there are many other factors – situational, behavioral, and attitudinal – that may or may not be related to the likelihood of reporting. The results are presented in Tables 7, 8, 9, and 10, respectively.

Table 7 shows that gender is not related to reporting to the police as the difference between males and females is non-significant.

**Table** 7. Count and Percentage of bicyclists who reported one or more crashes by gender

| | Reporting to Police | | |
|---|---|---|---|
| *Gender* | *Total* | *Yes* | *Yes (%)* |
| *Female* | *460* | *45* | *9.8* |
| *Male* | *1332* | *120* | *9.0* |
| *Total* | *1792* | *165* | *9.2* |
| *Chi-square=0.245, df=1, p-value=0.621* | | | |

Table 8 shows the type of bicycle of the respondents that reported having at least one accident. The Chi-square for this table was marginally significant (Chi-square=9.7, df=4, p-value=0.046) but the pairwise differences between the type of bicycles using the Bonferroni correction were not significant. Also, in an analysis that included this variable as an additional factor in the logistic regression the type of bicycle was not significant.

**Table 8.** Count and Percentage of bicyclists who reported one or more crashes by type of bicycle

| | *Reporting to Police* | | |
|---|---|---|---|
| *Type of bicycle* | *Total* | *Yes* | *Yes (%)* |
| *Electric* | *52* | *7* | *13.5* |
| *Other (Recumbent, Cargo, Folding, BMX)* | *113* | *14* | *12.4* |
| *Road* | *381* | *45* | *11.8* |
| *City or hybrid* | *704* | *63* | *8.9* |
| *Mountain* | *538* | *36* | *6.7* |
| *Total* | *1788* | *165* | *9.2* |
| *Chi-square=9.693, df=4, p-value=0.046* | | | |

Table 9 shows that having children aged 0-18 was not related to differences in reporting.

**Table 9.** Count and Percentage of bicyclists who reported one or more crashes by having or not having children

| | *Reporting to Police* | | |
|---|---|---|---|
| *Do you have children aged 0-18 children?* | *Total* | *Yes* | *Yes (%)* |
| *No* | *1153* | *114* | *9.9* |
| *Yes* | *620* | *50* | *8.1* |
| *Total* | *1773* | *164* | *9.2* |
| *Chi-square=1.596, df=1, p-value=0.207* | | | |

Use of helmet: Cyclists who are more concerned about safety may choose to wear a helmet more times than those less concerned about safety, and they may be more likely to wear a helmet at the time of the crash. This could in turn lower the severity of their crashes and reduce the likelihood of reporting them to the police. When we cross-tabulated use of helmet at the time of the crash with whether or not the crash was reported, we did not obtain a significant difference. Reporting level was 8.2% for those wearing a helmet at the time of the crash versus 10.9% for those not wearing a helmet (Chi Square = 3.03, p=/08). The results were similar when reporting was analyzed relative to 'typical use of helmet', as shown in Table 10. In both analyses not wearing a helmet was very slightly, and not quite significantly, associated with a greater likelihood of reporting the crash. Note that in this case injury severity is already adjusted for, as the reporting was for the 'most severe crash' only.

**Table 10.** Count and Percentage of bicyclists who reported one or more crashes by helmet's use

| | *Reporting to Police* | | |
|---|---|---|---|
| *Use of helmet* | *Total* | *Yes* | *Yes (%)* |
| *Always* | *894* | *85* | *9.5* |
| *Almost always* | *292* | *22* | *7.5* |
| *Sometimes* | *157* | *11* | *7.0* |
| *Almost never* | *140* | *18* | *12.9* |
| *Never* | *283* | *27* | *9.5* |
| *Total* | *1766* | *163* | *9.2* |
| *Chi-square=4.242, df=4, p-value=0.374* | | | |

## 4 DISCUSSION

There is a significant level of under-reporting of bicycle crashes in police crash reports, and this phenomenon is worldwide. The magnitude of this phenomenon is very large. In the samples of riders in the 17 participating countries, the rates of reporting the most severe crashes varied from zero (Israel) to 35% (Germany). The variability among the countries demands a deeper understanding of the cultures, the topography, and characteristics of the cyclists in each. Because the number of crashes reported was generally low, most of the differences among countries did not reach statistical significance, but whether they truly are or not deserves further study. This study focused on some of the reasons that could account for both the low level of reporting and the variance among the countries.

Perhaps the first factor to consider is the official definition of a traffic accident or crash. A survey of the definitions revealed that in all countries the involvement of a *motor*-vehicle – moving or stationary - was not a necessary condition. However, in all countries some vehicle had to be involved, and in nearly all countries – with the exception of France and Switzerland - it had to be moving at the time of the crash. Presumably, bicycles qualify as "vehicles" and therefore an accident involving a moving bicyclist should be included in the data base. Thus, in general, in nearly all countries a moving vehicle had to be involved, but not necessarily a motor-vehicle. The significant variations among the countries involved the crash location and level of severity. In 12 of the countries, the crash had to occur on a public road, but in five (Croatia, Estonia, Israel, Norway, Sweden) this was not a prerequisite. Finally, the largest variations were in crash severity. In about half the countries the crash had to involve a personal injury (with further variations in the severity of the injury), in three more countries the outcome had to be either personal injury or damage to a vehicle (Germany, Netherlands, Portugal, Switzerland), and in one country the definition did not address the crash severity at all (France). Interestingly, we were not able to relate the level of reporting to the definition. Thus, the reporting rates were not consistently higher in the countries with the least restrictive definitions than in the most restrictive definitions. For example, in Germany, with the highest reporting rates, to qualify as an accident the crash had to occur on a public road, while in Israel it did not. Still it is likely that individual officers may not adhere to the definitions, mistaking, for example a 'vehicle' as a 'motor-vehicle' and 'public road' as a 'public area'.

Type of crash was a significant factor in the determination of reporting. As might be expected, the most frequently reported were collisions with a motor-vehicle. This was probably due – at least in part - to the motor-vehicle driver's role in reporting the crash as well as to the fact that most of these crashes were on public roads. Interestingly, we did not find that these crashes were more severe. Perhaps more interesting were crashes due to 'falling off bike'. Although this was by far the most common crash type, representing slightly more than half of the cyclists' most severe crashes, they were reported in less than 3 percent of the times.

A third factor is the crash severity. The study demonstrated the close direct relationship between injury severity and the likelihood of reporting the crash to the police. To a lesser degree this is also the case for motor-vehicle crashes regardless of the involvement of a bicycle. There too, multiple studies have shown that the likelihood of a hospital-recorded crash to be included in the police data base is higher the more severe the injury. Yet we found that for bicycles, even in crashes resulting in hospital admissions, less than 40 percent were reported to the police. This means that crash data bases that merge police reports with hospital records, would still under-report serious injury crashes by as much as 60 percent, and less severe ones – requiring some or no medical attention, by approximately 90 percent or more! These findings provide strong support for relying on self-reports in addition to police and hospital data.

The fourth factor that figured significantly in the likelihood of reporting a bicycle crash was the marital status: married or partnered cyclists were less likely to report their crashes than single cyclists. A possible reason is that cyclists with partners had a recourse to report their crashes to – and get tended by - their partners, whereas single people had to resort more often to the official institutions – such as police - for aid or support.

Other factors that we examined, including gender, whether or not the rider had children, and whether or not the rider was wearing a helmet at the time of the crash, were not significantly related to the likelihood of reporting, yielding little variance among the levels. Interestingly, the type of bicycle was significantly related to the likelihood of reporting (albeit marginally at $p=.046$). The most commonly reported were crashes with electric bikes (14%) and the least likely to be reported were crashes with mountain bikes (7%). This may be due more to (1) the location of the crashes: electric bikes being used primarily in city traffic with motor-vehicles, whereas mountain bikes are typically used off-road without the presence of motorized traffic, and (2) by people who are better fit, accustomed to dealing with emergency situations by themselves, and often riding in the company of others who may assist them.

**4. Conclusions and Recommendations**

Our results clearly show that under- and biased reporting of bicycle crashes in police and medical records is a pervasive world-wide phenomenon. They point out that:

1. Greater harmonization among countries in crash definitions are necessary, especially for the inclusion of bicycle crashes. Similar efforts are now underway by the IRTAD countries for the evaluation and international comparisons of non-fatal serious injury crashes (e.g., ITF, 2016), and they should be expanded to harmonize the data by including all vehicles, on or off public roads.
2. The most commonly reported crash type *and also* the least likely to be reported to the police is "falling off the bike". Extending the crash data bases to self-reports would go a long way towards the inclusion of "falling off the bike" crashes – the most common bicycle crash type. Crashes involving two parties are more often reported than single-vehicle crashes (falling off bike, or colliding with a fixed object). This may be because in a single bicycle crash is no one to blame for it (other than the rider himself/herself) or there are no violations of the law, when we consider the definition of traffic accidents as mentioned before. The general exclusion of these crashes may hide problems with infrastructure that might be worth knowing for crash prevention. Social networks could provide a good way of gathering this missing information.
3. Severity of the crash is clearly related to the likelihood of reporting the crash to the police or being admitted to a hospital. To include all severities (at least MAIS 3+; ITF, 2016) there is need to resort to data sources such as self-reported data. This confirms the importance of alternative data sources, and reinforces the need to develop new ways for collecting information on bicycle's crashes. Here too, social networks for gathering this data seem to be a good option (as in www.bikemaps.org, for example). Simply repeating the same procedures already in place for motor-vehicle crashes is probably not appropriate and should be reconsidered (even if the monetary consequences of bicycle crashes are generally lower).

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