Relationship between motorcyclists' attitudes, behaviour and other attributes with declared accident involvement in Europe

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ABSTRACT

Objective: The objective of this study is to investigate patterns of road safety attitudes and behaviour of motorcyclists in Europe on the basis of the results of the pan-European questionnaire-based survey SARTRE-4, carried out in late 2010 in eighteen European countries and Israel. In addition, it is attempted to explore the link between attitudes, behaviour and other motorcyclist attributes with motorcyclist involvement in accidents in the past three years, in which someone, including the rider, was injured and received medical attention as stated in the motorcyclists' responses.

Methods: The various components of motorcyclist attitudes and behaviour such as reasons for driving a motorcycle, driving while impaired, perceived risk factors and risk-taking behaviour were determined by means of a principal component analysis (PCA) on thirty eight variables contained in the survey. A binary logistic regression model was then applied in order to link the attitudes and the stated behaviour with the declared involvement in past accidents.

Results: The results revealed eight components. Component 1 (Driving while impaired and speeding accident factors), component 2 (MC benefits), component 3 (Perceived risk of manoeuvres), component 4 (Sensation seeking), component 5 (Road, Vehicle and Environmental risk factors), component 7 (No modal options) and component 8 (Attitudes towards drinking and friends-drinking) are associated with stated-preferences and attitudes, while component 6 (Dangerous and angry behaviour) is associated with stated-behaviour. Moreover, it was found that motorcyclists who tend to have dangerous attitudes and behaviour as well as younger motorcyclists, are more likely to have been involved in an accident. It was also showed that driving exposure is positively associated with increased probability of a past accident.

Conclusions: The findings of the study provide some insight on the association between attitudes, behaviour and declared past accident involvement. Furthermore, the analysis of such large databases with the inclusion of many different countries constitutes a step for further research in the field of motorcyclist behaviour and safety.

Key words: Motorcyclists; Attitudes; Behaviour; Past history accidents; Principal Component Analysis; Logistic Regression

INTRODUCTION

Each year about 7000 moped and motorcycle riders get killed in the European Union (ERSO, 2011a). In spite of the efforts of European Union (EU) and authorities to reduce Power-two wheeler (moped and motorcyclists) fatalities, PTW fatalities as percentage of the total number of road accident fatalities in EU-19 from 2000 to 2009 are gradually rising (ERSO, 2011a). Table 1 illustrates the number of PTWs, fatalities and fatality rates across European and other countries. On the other hand, Figure 1 shows the trend in PTW rider fatalities and total traffic fatalities in EU from 2000 to 2010.

*** Please insert Table 1 here***

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Power-two wheelers constitute a vulnerable type of road users, mainly because of the low mass of their vehicle, the light protection and their interaction with other heavy motorized traffic. International literature shows that the Power-two wheeler risk of being severely injured is significantly higher than car occupants (Aare and von Holst, 2003; Zambon and Hasselberg, 2006; Yannis et al., 2007). Moreover, riders are notably vulnerable when involved in collisions with roadside objects. Utility poles, guardrails and trees are more harmful to riders than collision to the ground (Daniello and Gabler, 2011).

Furthermore, a survey conducted by Jamson and Chorlton (2009), argue that the nature of motorcycling is undergoing changes because older riders appear and motorcycling tends to become a leisure pursuit. That raises the need for further research in motorcycle safety.

Some studies highlight and investigate the interaction of riders with other road users (Preusser et al., 1995; Pai et al., 2009). However, interaction is not always the issue, because many accidents may occur due to errors or dangerous behaviour of riders themselves, such as violations and dangerous manoeuvres. Consequently, international literature includes many studies that have attempted to measure errors (Elliot et al., 2007; Woodcock, 2007) or risk-taking behaviours (Haque et al., 2010; Chorlton et al.,2012).

Regarding motorcycle accidents, a study by Steg and van Brussel, (2009), examined accidents, aberrant behaviours, and speeding of young moped riders. They found that aberrant behaviour of moped riders could fall into three categories: errors, lapses, and violations. However, accidents involvement was not affected by errors, lapses, and violations. Another important finding was the fact that riders were more likely to speed and to disobey speed limits when they had positive attitudes towards speeding.

Cheng and Ng, (2010), aimed to develop a self-report questionnaire to assess the driving violations of Chinese motorcycle riders and evaluate its screening accuracy between accident-involved and accident-free motorcycle riders. The results showed that respondents who had been involved in an accident during the previous three years performed significantly more risky driving behaviour.

Motorcyclists' behaviour could be captured indirectly through attitudes and perceptions. Besides, road safety is highly dependent on actual road users' behaviour, which is influenced by their attitudes, beliefs and perceptions. Indeed, motorcyclists' attitudes and perceptions have gained much attention so far and analyzed in a number of studies (Steg and van Brussel, 2009; Cheng et al., 2011; Liu et al., 2009). The main tool to capture attitudes and perceptions was the use of questionnaires, while the main statistical analysis method was the factor analysis. Furthermore, Ulleberg and Rundmo, (2003), attempted to measure risk perception and attitudes towards traffic safety and argued that '*the relation between the personality traits and risky driving behaviour was mediated through attitudes'.*

In general, the literature review showed that, in most studies, there were a clear limitation of the sample size which was either small or focused (e.g. on young, students or adolescents etc.) and the results were difficult to be generalized. One exception is the study by McCartt et al., (2011), where a national sample was examined and was attempted to investigate motorcyclists' travel patterns and

attitudes towards motorcycle helmets and other safety issues by means of a national telephone survey. Consequently, the lack of such studies indicates that there is a need for a broader and larger sample including country comparisons. In this study, the link between attitudes and behaviour towards speeding, alcohol, sensation seeking, overtaking and also some other attributes (e.g. age, gender, engine size etc.) with past history accidents of motorcyclists is investigated by using also a large representative riders' sample from European countries and Israel. In addition, the structure of the question which constitute the dependent variable (*"In the last 3 years, how many accidents have you been involved in, as the driver of a motorcycle, in which someone, including yourself, was injured and received medical attention?"*), implies that accidents who resulted in pedestrian and car driver injuries or even fatalities are considered. For example, pedestrians could be involved in serious accidents with motorcycles or a car driver could deviate from the road in order to avoid a collision with motorcycle and be involved in a run-off road collision. More specifically, the aim of the study is twofold:

- to explore the structural patterns of road safety attitudes and behaviour of motorcyclists in Europe and
- to link the attitudes and behaviour of motorcyclists as well as other motorcyclist attributes with their past history accidents and more specifically with the probability to have been involved in an accident in the past 3 years.

METHODS

Data

The SARTRE-4 project (SARTRE-4, 2011) is a pan-European survey examining road users' (car drivers, motorcyclists, pedestrians, cyclists and public transport users) declared behaviour, attitudes, perceptions towards road traffic risk in Europe. More specifically, the objective of the project is to survey and highlight by having a uniform methodology many important transport issues such as mobility experiences, perception of safety needs by different types of road users, opinions and experiences about speeding and impaired driving, attitudes towards motorcycle riders, pedestrians and other road users. This project follows up the previous three SARTRE projects (1991, 1996 & 2004), with the inclusion of additional groups (motorcyclists, other road users such as pedestrians, cyclists

and public transport users), and a more policy-focused questionnaire. The participants in the survey made a personal interview for filling an extensive questionnaire. In total, 21,280 questionnaires were collected, between November 2010 and February 2011, from eighteen European countries, namely Austria, Belgium, Cyprus, Czech Rep., Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Serbia, Slovenia, Spain and Sweden, with the addition of Israel. In the total sample of 21,280 respondents, 4,483 were motorcyclists (approximately 200 per country, more specifically, 200 in Austria, 200 in Belgium, 204 in Cyprus, 202 in Czech Rep., 346 in Estonia, 211 in Finland, 209 in France, 204 in Germany, 202 in Greece, 204 in Hungary, 200 in Ireland, 202 in Israel, 194 in Italy, 208 in Netherlands, 545 in Poland, 152 in Serbia, 205 in Slovenia, 396 in Spain and 199 in Sweden).

The SARTRE-4 database, developed from the coding of the questionnaire responses, involved various common questions that all road users had to fill in. This is the common part of the questionnaire (CO). It is followed by a separate section dedicated to each category of road user [car drivers (CD), motorcyclists (MC) and other road users (ORU) such as pedestrians, cyclists, etc.]. The questions that were examined within the present research were only those of the dedicated part of the questionnaire on motorcyclists (MC) which were considered to be relevant to the aim of the analysis. Those questions were associated with:

- drink-driving related questions e.g. risk and drink-driving, friends' drink driving, possibility of alcohol check etc.
- drink-driving above the legal limit
- attitudes towards legal limits
- number of declared past accidents
- behavioural questions, such as giving way to pedestrians, driving through amber in traffic light, following too closely the vehicle in front, overtaking and use of intelligent devices (helmet phone system, electronic tag for toll payment)
- attitudes towards weaving between vehicles and overtaking

- reasons for using a motorcycle, such as saving time, easier to find parking, low cost of use, enjoy, acceleration, no other options etc.
- perceived risk factors, such as fatigue driving, drink-driving, medicines and driving, traffic congestion, poorly maintained roads/motorcycles etc.
- exposure in months per year
- engine size in cc
- age, gender

It is noted that helmet related questions were not chosen for analysis not only because this field has been extensively explored in international literature but also because of its limited (indirect) role in accident involvement (though important in injury severity). For further details about the questionnaire design and selection of questions the reader is referred to the final SARTRE-4 report (SARTRE4, 2013).

In order to achieve the aims of the study, it was required to transform the dependent variable *"In the last 3 years, how many accidents have you been involved in, as the driver of a motorcycle, in which someone, including yourself, was injured and received medical attention?"*, into a categorical variable. More details are presented in the preliminary analysis section regarding the descriptive analysis of the data.

Principal Component Analysis for Grouping Variables/Data Reduction

Firstly, it was aimed to find meaningful groups of variables reflecting motorcyclists' attitudes, perceptions and behaviour. In order to achieve this objective a Principal Component Analysis (PCA) was performed. More specifically, PCA will help understand the structure of this large set of variables (38) and secondly, to reduce this dataset to a more easily managed one without losing much information. These variables were tested on how much variance they share and they were grouped into appropriately labelled components. All the variables are presented in Table A1 in the Appendix.

An adequate sample size is critical to perform PCA. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used, with values above 0.7 are considered to be very satisfactory. Moreover,

Variables' communalities are calculated, which show how much of each variable's variance is common between variables. More specifically, the communality h^2, is the squared multiple correlation for the variable as dependent using the components as predictors. Variables with low values of communality can be eliminated from the analysis, since they do not share important variance with other variables.

The optimal number of components retained can be defined through a combination of more than one criterion and more specifically the criteria of Kaiser, the Scree plot and the Variance explained. The Kaiser rule suggests dropping all components with eigenvalues under 1. The Cattell scree test plots the components on the X axis and the corresponding eigenvalues on the Y axis. As the number of components increases, the eigenvalues are reduced. Cattell's scree test suggests that all further components after the number for which the reduction becomes too small should be dropped out of the analysis. The Variance Explained criterion can be used in order to keep enough components in order to account for as much variance as possible. It is noted that component scores are saved in order to be used for further analysis after performing PCA.

It is noted that rotation and more specifically, orthogonal rotation (Varimax), was selected to improve interpretability of the components. The components scores were calculated according to the Anderson-Rubin method to ensure that component scores are uncorrelated and also to ensure orthogonality of the estimated components. They have a mean of 0 and a standard deviation of 1.

Finally, a reliability analysis was carried out to test the reliability of the components. More specifically, the Cronbach's Alpha is estimated for each component as an indicator of reliability. Values around 0.7-0.8 are considered satisfactory.

Binary Logistic Regression

Linear regression models that have been used in transport application have the assumption that the response variable is continuous. However, in cases where the response (dependent) variable is not continuous, discrete outcome models should be applied. When there are two discrete outcomes, logistic regression models can be applied. It is obvious that the goal is the same as in simple linear

regression. We search for the best fitting model which describes the linear relationship between a binary (dichotomous) dependent variable and a number of explanatory variables (predictors).

If the 'utility function' is $U = \beta_o+\beta_i*x_i$ (Eq. 1)

then the probability P is: $P = e^U/(e^U +1)$ (Eq. 2)

The goodness-of-fit of the model can be assessed with the likelihood ratio test. The likelihood-ratio test uses the ratio of the maximized value of the likelihood function for the full model (L_f) over the maximized value of the likelihood function for the simpler model (L_0). The likelihood-ratio test statistic equals: $-2\log (L_o/L_f) = -2 [\log(L_o)-\log(L_f)] = -2 (L_o-L_f)$ (Eq. 3)

In order to perform the logistic regression, the backward LR (log-likelihood ratio) method is a straightforward method, according to which the all the independent variables are put in the model and one by one is eliminated provided that the change in the -2Log-likelihood is not significant for 1 degree of freedom at 95%.

Other indicators of the goodness of fit of the model are the Hosmer-Lemeshow statistic test (Hosmer and Lemeshow, 1980) and the McFadden R^2. In Hosmer-Lemeshow test, a non-significant value in the chi square suggests a good fit.

It is noted that, before entering the model, the component scores as independent variables have to be tested for potential inter correlation by using the Pearson correlation since they are continuous variables. The exponential of the coefficients, exp(B), expresses the odds ratio. More specifically, concerning positive coefficients, for each additional unit increase in the factor score, the odds of having been involved in at least on accident is increased by $100\%*(\exp(B_i)-1)$. For negative coefficients, one unit increase, decreases the odds of a past accident by $100\%*(\exp(B_i)-1)$.

RESULTS

Preliminary Analysis

A preliminary descriptive analysis was carried out in order to acquire a first insight on the structure of the data. First of all, the continuous variable referred to question MC19 (number of accidents involved in past three years) which is the dependent variable, is recoded to a dummy dichotomous variable (involved or not involved in at least one accident in past three years - 0 for no, 1 for yes) due to the

fact that the great majority of respondents mentioned one accident or none. More specifically, out of 4,483 participants, those who reported zero accidents, one, and two were 3941, 349 and 64 respectively. Consequently, after the coding values of 1 imply at least one accident.

It was also attempted to acquire a first idea of the attitudes of motorcyclists in respect with alcohol, manoeuvres such as weaving between cars in dense urban areas and overtaking, since these factors could be related with accidents. The next table (Table 2) illustrates the responses of motorcyclists on these questions.

*** Please insert Table 2 here***

Firstly, the responses of motorcyclists in question MC12 "MC12-Over the last month, how often did you drive a motorcycle, when you may have been over the legal limit for drinking and driving?" are illustrated. It is clearly observed that only a minority in each participating country drive when they have been over the legal limit (often/very often/always). However, in Cyprus motorcyclists tend to drink over the legal limit more often having a relatively high percentage (12.25%).

In general, there is a high variation in very/fairly responses regarding drinking and driving if done carefully. In this case, some countries have very high percentage such as Italy (35.05%) and Cyprus (18.63%), while other have very low such as Germany (0.49%) and Greece (0.99%). Drinking and driving is associated with another question, which examines whether most the respondents' friends would drink and drive a motorcycle or not (question MC10d of the questionnaire). Significance variation in very/fairly responses is also observed, for example, a high percentage in Italy (58.76%), Cyprus (41.67%) and Serbia (34.87%), while a very low percentage in Sweden (1.01%) and Germany (1.96%).

This table also shows the responses in question MC21d "MC21d-When riding a motorcycle, how often do you overtake when you think you can just make it?". Although many of the respondents did not perform dangerous overtakes, a considerable variation is observed. The highest percentages in 'often/very often/always' can be found in Cyprus (67.65%), Greece (50.00%), Serbia (57.24%) and Czech Rep. (47.03%). The lowest percentage is found in Slovenia, (only 1.95%).

Lastly, it is observed that the majority of motorcyclists consider weaving in and out between cars a very or fairly dangerous activity. The 'not much/not at all' responses average value in the whole

sample is 20.28%. However, some countries such as Cyprus and Austria have relatively high percentage (44.12% and 30.50% respectively).

Principal Component Analysis

The principal component analysis revealed the optimum number of eight components that appropriately summarize the thirty eight variables of the database, based on the eigenvalue and the Scree plot diagnostics as described in the methodology section. The communalities' values of the variables constituting the 8 factors, were relatively high (values higher than 0.6), with only a few between 0.45-0.55. As a result the variance that these variables share is satisfactory and all can be retained. The KMO test which assesses the adequacy of the sample was successful as expected due to the large sample size. Moreover, the total variance explained by the eight components was satisfactory (62.12%).

Component 1 involves questions related with risk factors perceived by motorcyclists as contributory. More specifically, these questions were associated with driving under the influence of alcohol, medicines or drugs, with fatigue and with speeding. This component can be labelled "Driving while impaired and speeding accident factors". The same approach is followed in order to label the other components. The Cronbach's alpha which indicated the reliability of this component is considered high satisfactory (0.866).

Component 2 (MC benefits), is associated with the reasons for choosing a motorcycle instead of another means of transport. It includes saving time, easier to find a parking, low price of purchase, reduction of CO_2 emissions and avoidance of congestion. The value of Cronbach's alpha is 0.806.

Component 3 (Perceived risk of manoeuvres), includes the questions associated with weaving between cars and overtaking ($\alpha = 0.832$).

Component 4 (Sensation seeking), involves other reasons for buying a motorcycle, namely pleasure, acceleration, sense of freedom and the spirit of the biker ($\alpha=0.722$).

Component 5 (Road, Environmental and Vehicle risk factors), consists of perceived risk factors such as bad weather, poorly maintained roads, poorly maintained motorcycle and traffic congestion ($\alpha=0.779$).

Component 6 (Dangerous and angry behaviour), is associated with behaviour. More specifically, this component is characterized by dangerous or angry actions, such as following too closely the vehicle in front, drive through an amber traffic light, dangerous overtaking and use of flash lights or anger horn (α=0.704).

Component 7 (No modal options), expresses the last kind of reasons for buying a motorcycle, namely no car possession and no other options to get to work (α=0.754).

Component 8 (Attitudes towards drinking and friends-drinking), involves questions MC10a and MC10d of the questionnaire. These questions express the attitudes of motorcyclists towards drinking and driving if done carefully the drunk-driving of respondents' friends (α=0.622).

All eight components had high loadings (especially components 1, 2, 3 and 5). In addition, the values of alpha were highly satisfactory except for component 8 whose alpha value was relatively low compared to the other components. Component scores and alpha values are illustrated in the next table (Table 3).

*** Please insert Table 3 here***

Binary Logistic Regression

The binary logistic regression was based on the relation between the dependent dichotomous variable (MC19-involved or not involved in at least one accident in the last three years) and the eight components as well as some other variables such as gender, age, exposure (in months per year) and engine size.

No correlations were identified so the components could be further analyzed in a linear model. The possible correlation between the eight components and the other independent variables were as well tested, suggesting no correlation. The insignificant chi square value in the Hosmer and Lemeshow test suggest a good fit of the model. The value of the Mc Fadden R square is 0.289. According to Mc Fadden (1979), Mc Fadden R square values more between 0.20 and 0.40 suggest a very good fit. Summarizing the logistic regression diagnostic test suggest a reasonable fit of the model. The binary logistic regression results are illustrated in the next table (Table 4). As shown below, Table 4

summarizes the coefficient B, the standard error (S.E.), the significance and the exponential of the coefficient B which is the odds ratio.

*** Please insert Table 4 here***

Perceived risk of manoeuvres, Dangerous and angry behaviour and attitudes towards drinking and friends-drinking (that is components 3, 6 and 8) were found to be statistically significant as well as age and exposure. The negative coefficient of the variable expressing component 8 score (Attitudes towards drinking and friends-drinking), indicates that positive scores decrease the probability of an accident, while negative scores increase the probability of an accident. This component has positive loadings and the questions composing it are scaled from 1-very to 4-not at all). As a consequence, motorcyclists who stated that they cannot drink and drive even if done carefully and whose friends do not drink and drive are less likely to have been involved in at least one accident in the past. On the other hand, overconfident motorcyclists who think that they can drink and drive if they are careful and whose friends are likely to drink and drive are more likely to declare a past accident. The exponential of the coefficient B of this variable (0.822) expresses the odds ratio, one unit increase in the component 8 scores means 17.2% decrease in the odds to have been involved in an accident (holding all other explanatory variables at a fixed value).

The variable expressing component 3 score (Perceived risk of manoeuvres) has a positive coefficient. As a consequence, positive scores increase the probability of an accident, while negative scores decrease it. Questions of this component are scaled from 1-very to 4-not at all. As a result, motorcyclists who do not consider manoeuvring (weaving between cars, overtaking when they can just make it, overtaking on the right) as dangerous are more likely to declare that they have been involved in a at least one accident in the past. The value of the odds ratio (1.131) means that 1 unit increase in component 3 score leads to 13.1% increase in the odds of having been involved in an accident if all other variables are fixed.

Similarly, explanatory variable for component 6 score (Dangerous and angry behaviour) has a positive coefficient B. Its questions are scaled from 1-never to 6-always meaning that positive scores increase the probability of an accident. More specifically, respondents who declared more frequent dangerous behaviour (following too closely the vehicle in front, drive through an amber traffic light,

dangerous overtaking and use of flash lights or anger horn) are more probable (14.2% increase in the odds if they score one more unit in component 6) to have been involved in at least one accident in the past.

The age was also tested as a discrete variable but it was not statistically significant, so it was retained as a continuous variable. The negative size of the coefficient indicates a negative relationship with accident involvement suggesting that younger motorcyclists are more likely to have been involved in accidents in the past. More specifically, for one year increase in age of the rider, the odds of having declared a past accident is also decreased by 1%. As expected, the positive coefficient of exposure means that as exposure increases, the probability to have been involved in an accident increases as well (6.9% increase in the odds for one month increase). Lastly, the town size, the gender and the engine size were not found to affect past accident involvement.

DISCUSSION

The present study is based on the SARTRE-4 research project which was carried out in late 2010 in Europe. In this project a large and representative sample of motorcyclists from nineteen countries was interviewed by means of an extensive questionnaire on attitudes and behavioural characteristics and demographics. This study attempts to give some insight on motorcyclists' attitudes and perceptions towards some important issues such as drink-driving, reasons for using a motorcycle, and perceived risk factors). Furthermore, some stated behaviours such as manoeuvring and overtaking were considered. Finally, it was attempted to link attitudes and stated behaviour with the declared involvement in an accident in the past three years.

Firstly, a Principal Component Analysis (PCA) was carried out in order to identify meaningful groups of variables (components) reflecting specific attitudinal and behavioural aspects of motorcyclists. This method of analysis was found to be suitable for the aims of the study, since this method can reduce the data size and lead to more interpretable results. Indeed, the results showed that the 38 variables of the study can be optimally grouped together in 8 main components. More specifically, component 1 (Driving while impaired and speeding accident factors), component 2 (MC benefits), component 3 (Perceived risk of manoeuvres), component 4 (Sensation seeking), component

5 (Road, Vehicle and Environmental risk factors), component 7 (No modal options) and component 8 (Attitudes towards drinking and friends-drinking) are associated with stated-preferences and attitudes, while only component 6 (Dangerous and angry behaviour) is associated with stated-behaviour.

Principal component analysis was found suitable for the purposes of this study not only because allowed the efficient handling of the large number of parameters but also because the attitudinal, behavioral and other factors were possible to be grouped and separated from each other giving a clearer picture of the factors affecting incidence of past crashes. If principal component analysis was omitted - as is the case in other studies - then the direct application of regression would not easily lead to straightforward and properly structured results.

Based on this PCA analysis, a binary logistic regression model was applied, in order to calculate the probability of a past declared accident depending on the factor scores and some other important parameters such as age, gender, exposure and so on. The binary logistic model indicated three statistically significant components, whose scores affect the probability of declared past accidents, namely Perceived risk of manoeuvres (comp. 3), Dangerous and angry behaviour (comp. 6), Attitudes towards drinking and friends-drinking (comp. 8). Moreover, age and exposure were found significant.

Perceived risk of manoeuvres (comp. 3), is positively affecting the probability of being involved in an injury accident indicating that riders who do not consider weaving between cars and overtaking under extreme conditions as dangerous (and perhaps insinuating that they ride the same way are more probable to declare (at least) one past accident. It is demonstrated thus that risky attitude is linked to increased probability to get involved in a road accident.

Dangerous and angry stated behaviour (comp. 6), is perhaps the more interesting component as it may represent actual behaviour. Respondents who stated a more frequent dangerous behaviour (following too closely the vehicle in front, drive through an amber traffic light, dangerous overtaking and use of flash lights or anger horn) are more probable to have been involved in at least one accident in the past, directly linking risky stated-behaviour with past accidents and indirectly putting some blame on these riders. This hypothesis is strengthened by the fact that the overconfident motorcyclists who stated that they can drink and drive if they are careful and whose friends do drink and drive (comp. 8), are more likely to have been involved in at least one accident in the past.

The effect of age on accident involvement was expected and supported by some studies where younger adults seem to get more involved in road traffic crashes than older ones and also drink and drive more frequently (Elliot et al., 2009; Holubowycz & McLean, 1995). On the other hand, increased age leads to higher injury incidence because of lower tolerances of older occupants (Viano et al., 1990). The positive correlation between the component associated with drinking and riding and accident involvement is also supported by the fact that younger adults tend to drink and ride and thus be involved accidents more frequently. As a result, a policy towards limiting access of young people to alcohol or applying zero alcohol tolerance is expected to be effective as shown from other studies (Voas et al., 2003).

Overall, the hypothesis between the linkage of attitudes/behaviour and past accident is supported by the findings of this study. The model is strengthened by adding a few parameters associated with motorcyclist attributes. It seems that stated preference, attitudes and behaviour in this case, do explain the probability of a past accident. On the other hand, the results revealed several interesting and intuitive structures of attitudinal and behavioural characteristics illustrated by the components.

The methods and the results of this study can assist researchers and practitioners to further understand the risk of accident of motorcyclists based only upon their attitudes and perceptions, without the use of complicated statistical models even when a large number of parameters is available. Policy making in the EU regarding motorcycle safety can be benefited from these results since the sample used in this study is large and includes respondents from a large number of European countries. Moreover, specific country analyses and country comparisons of attitudes can lead to significant conclusions about accident risk in order to support decision making for the related countermeasures.

The findings of this study demonstrate the high usefulness of all measures aiming to make riders more aware of the riding risks and in particular of the risk of manoeuvring and of the risk of drinking and driving. Furthermore, awareness and enforcement campaigns targeting on one hand younger drivers and on the other hand riders with dangerous and angry behaviour score seem to be the most beneficial for the motorcyclist safety. Finally, as higher riding exposure is expected in the coming years in Europe (ERSO, 2011b), road traffic authorities should put emphasis on measures for more

motorcycle friendly traffic conditions and behaviour by all road users (especially the passenger car drivers).

The authors recognize the limitations of the study. Firstly, only declared accidents were analyzed. As a result, there was not possible to link the attitudes and the behaviour with fatal accidents but only with slight and serious injuries. Moreover, it is possible that motorcyclists did not mention various minor accidents that happened to them. However, the nature of the analysis is not critically affected by this fact, since it was aimed to investigate the probability to have been involved in an accident or not. On the other hand, although the followed methodological approach of this study improved the data handling through reduction and grouping and also led to an easier classification of risk factors (attitudinal, behavioural etc.), the individual statistical significance of each variable separately before the grouping into eight components is not entirely captured. Lastly, it would be interesting to further analyze these data in order to examine the differences between motorcyclists for every-day commuting and for recreation in Europe based on large databases such as SARTRE-4.

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REFERENCES

Aare M, Von Holst H. Injuries from motorcycle and moped crashes in Sweden from 1987-1999. Inj Control Saf Prom. 2003;10:131-138

Begg DJ, Langley JD, Reeder AI. Motorcycle crashes in New Zealand resulting in death and hospitalisation. I: Introduction methods and overview. Accid Anal Prev. 1994; 26(2):157-164

Chen C-F, Chen C-W. Speeding for fun? Exploring the speeding behaviour of riders of heavy motorcycles using the theory of planned behaviour and psychological flow theory. Accid Anal Prev. 2011;43:983–990

Cheng S-KA, Ng C-KT. Development of a Chinese Motorcycle Rider Driving Violation Questionnaire. Accid Anal Prev. 2010;42:1250–1256

Cheng S-KA, Ng C-KT, Lee HC. A comparison of the hazard perception ability of accident-involved and accident-free motorcycle riders. Accid Anal Prev. 2011;43:1464–1471

Chorlton K, Conner M, Jamson S. Identifying the psychological determinants of risky riding: An application of an extended Theory of Planned Behaviour. Acc. Anal. Prev. 2012; 49:142-153

Daniello A, Gabler H. Fatality risk in motorcycle collisions with roadside objects in the United States. Accid Anal Prev. 2011;43:1167-1170

Elliot S, Woolacott H, Braithwaite R. The prevalence of drugs and alcohol found in road traffic fatalities: A comparative study of victims. Sci Just. 2009;49:19-23

Elliott MA, Baughan CJ, Sexton BF. Errors and violations in relation to motorcyclists' crash risk. Accid Anal Prev. 2007;39:491–499

ERSO - The European Road Safety Observatory. Powered Two Wheelers 2011b. http://safetyknowsys.swov.nl/Safety_issues/Safetynet/Powered%20two%20wheelers.pdf. Retrieved August 1, 2008 from www.erso.eu

ERSO - The European Road Safety Observatory. Traffic Safety Basic Facts "Motorcycles and Mopeds" 2011a. http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2011-dacota-ntua-motomoped.pdf. Retrieved May 2011 from www.erso.eu

Haque MM, Chin HC, Lim BC. Effects of Impulsive Sensation Seeking, Aggression and Risk-Taking Behaviors on the Vulnerability of Motorcyclists. As Transp Stud. 2010;1(2):165-180

Holubowycz OT, McLean AJ. Demographic characteristics, drinking patterns and drink-driving behaviour of injured male drivers and motorcycle riders. J Stud Alc. 1995;56:513-521

Hosmer DW, Lemeshow S. A goodness-of-fit test for the multiple logistic regression model. Comm Stat. A 1980;10:1043–1069

IRTAD- International Traffic Safety Data and Analysis Group, 2011. 'Road Safety Annual Report 2011'. Retrieved from: http://internationaltransportforum.org/irtadpublic/pdf/11IrtadReport.pdf.

Jamson S, Chorlton K. The changing nature of motorcycling: Patterns of use and rider characteristics. Transp Res Part F 2009;12:335-346

Liu CC, Hosking SG, Lenné MG. Hazard perception abilities of experienced and novice motorcyclists: An interactive simulator experiment. Transp Res Part F 2009;12:325–334

McCartt AT, Blanar L, Teoh ER, Strouse LM. Overview of motorcycling in the United States: A national telephone survey. J Safety Res. 2011;42:177–184

McFadden D. Quantitative methods for analyzing travel behaviour of individuals: some recent developments. In: Henser, D.A. & Stopher, P.R.: (eds): Behavioural travel modelling. London: Croom Helm, 1979:279-318

Pai C-W, Hwang KP, Saleh W. A mixed logit analysis of motorists' right-of-way violation in motorcycle accidents at priority T-junctions. Accid Anal Prev. 2009;41:565–573

Preusser DF, Williams AF, Ulmer R. Analysis of fatal motorcycle crashes: crash typing. Accid Anal Prev. 1995;27(6):845-851

SARTRE-4. European road users' risk perception and mobility. The SARTRE 4 survey report. Available from: http://www.attitudes-roadsafety.eu/index.php?eID=tx_nawsecuredl&u=0&file=uploads/media/Sartre-4-report.pdf&t=1360068836&hash=4c5a87297b22eb856071ca13540bdf71 Accessed 1 February 2013

Social Attitudes towards Road Traffic Risk in Europe, SARTRE-4, 2011. Available at: http://www.attitudes-roadsafety.eu/ Accessed 18 May 2011

Steg L, Van Brussel A. (2009). Accidents, aberrant behaviours, and speeding of young moped riders. Transp Res Part F 2009;12:503–511

Ulleberg P, Rundmo T. Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. Saf Sci. 2003;41:427–443

Voas RB, Tippets AS, Fell JC. Assessing the effectiveness of minimum legal drinking age and zero tolerance laws in the United States. Accid Anal Prev. 2003;579-587

Viano DC, Culver CC, Evans L, Frick M, Scott R. Involvement of older drivers in multivehicle side-impact crashes. Accid Anal Prev. 1990;22:177–188

Woodcock K. Rider errors and amusement ride safety: Observation at three carnival midways. Accid Anal Prev. 2007;39:390–397

Yannis G, Golias J, Spyropoulou I, Papadimitriou E. Accident risk factors of young drivers and targeted counter measures. Proceedings of the 11th World Conference on Transportation Research, Berkeley, June 2007

Zambon F, Hasselberg M. Socioeconomic differences and motorcycle injuries: Age at risk and injury severity among young drivers: A Swedish nationwide cohort study. Accid Anal Prev. 2006;38:1183–1189

APPENDIX

*** Please insert Table A1 here***

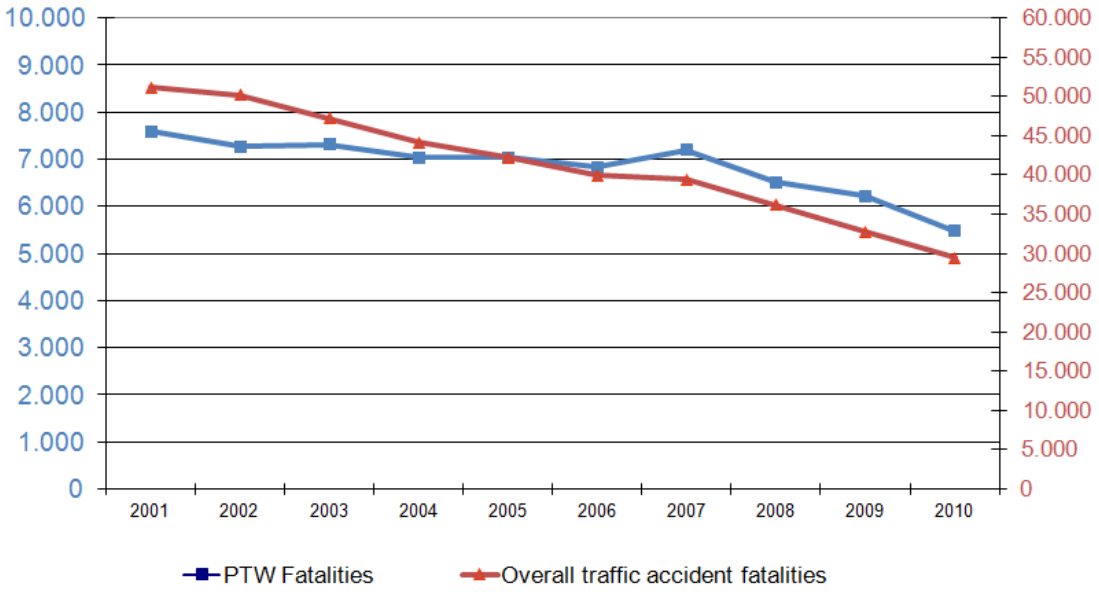

Figure 1: PTW rider fatalities as percentages of the total number of road accident fatalities in EU, 2000-2010.

Table 1: Number of PTWs, fatalities and fatality rates across European and other countries. Year 2010; Source IRTAD.

Country	Mopeds (x 1.000)	Road Fatalities	Fatalities per 10^6 mopeds	Motorcycles (x 1000)	Road Fatalities	Fatalities per 10^6 motorcycles
Austria	319	18	56	393	68	173
Czech Republic	473	4	8	430	95	221
Finland	260	9	35	227	16	70
France	1,121	248	221	1,436	704	490
Germany	2,104	74	35	3,763	635	169
Greece	1,389	36	26	1,499	372	248
Iceland	2	0	0	7	1	143
Israel	19	3	158	94	40	426
Italy	2,550	203	80	6,305	943	150
Japan	7,694	454	59	5,042	564	112
Luxemburg	26	0	0	16	1	63
Netherlands	500	44	88	623	60	96
New Zealand	27	0	0	73	50	685
Poland	922	83	90	1,013	259	256
Slovenia	41	6	146	41	17	415
Spain	2,290	100	44	2,707	386	143
Sweden	201	8	40	303	37	122
Switzerland	165	4	24	651	67	103
United Kingdom	84	10	119	1,182	403	341

Table 2: Percentages and absolute numbers of respondents on selected questions per country

Country	Drinking over the legal limit and driving a motorcycle		Drinking and driving if done carefully		Friends' drinking and driving		Overtaking when rider can just make it		Perceived risk of weaving between cars	
	% often/very often/always	absolute numbers often/very often/always	% very/fairly	absolute numbers very/fairly	% very/fairly	absolute numbers very/fairly	% often/very often/always	absolute numbers often/very often/always	% not much/not at all	absolute numbers not much/not at all
Austria	0.00%	0	5.00%	10	8.00%	16	21.50%	43	30.50%	61
Belgium	0.50%	1	12.50%	25	18.00%	36	10.50%	21	22.00%	44
Cyprus	12.25%	25	18.63%	38	41.67%	85	67.65%	138	44.12%	90
Czech Rep.	0.99%	2	9.41%	19	9.90%	20	47.03%	95	23.76%	48
Estonia	0.00%	0	5.49%	19	11.85%	41	15.61%	54	14.16%	49
Finland	0.00%	0	1.42%	3	3.32%	7	4.27%	9	14.22%	30
France	1.44%	3	6.70%	14	11.48%	24	11.96%	25	15.31%	32
Germany	0.00%	0	0.49%	1	1.96%	4	6.37%	13	17.65%	36
Greece	0.50%	1	0.99%	2	26.24%	53	50.00%	101	11.88%	24
Hungary	0.98%	2	3.43%	7	3.43%	7	9.31%	19	28.43%	58
Ireland	0.00%	0	2.00%	4	9.00%	18	9.50%	19	13.50%	27
Israel	1.98%	4	10.40%	21	9.41%	19	15.84%	32	24.26%	49
Italy	0.00%	0	35.05%	68	58.76%	114	11.34%	22	25.26%	49
Netherlands	0.48%	1	8.17%	17	9.62%	20	12.98%	27	12.98%	27
Poland	0.00%	0	2.20%	12	9.17%	50	44.40%	242	22.94%	125
Serbia	3.95%	6	9.21%	14	34.87%	53	57.24%	87	15.79%	24
Slovenia	0.49%	1	5.85%	12	16.10%	33	1.95%	4	17.07%	35
Spain	0.51%	2	3.28%	13	12.12%	48	18.43%	73	13.89%	55
Sweden	0.50%	1	1.01%	2	1.01%	2	7.04%	14	23.12%	46
Total	1.09%	49	6.71%	301	14.50%	650	23.15%	1038	20.28%	909

Table 3: Summary of components

Components	**Questions**	**Variables**	**Loading**	**Cronbach's alpha**
Component 1 "Driving while impaired and speeding accident factors."	MC26a	Motorcycling when tired	0.761	α=0.866
	MC26b	Drinking and motorcycling	0.834	
	MC26c	Following too closely the vehicle in front	0.654	
	MC26d	Driving too fast	0.529	
	MC26e	Medicines and motorcycling	0.808	
	MC26f	Drugs and motorcycling	0.818	
Component 2 "MC benefits"	MC24a	Saving time	0.753	α=0.806
	MC24c	Easier parking	0.805	
	MC24d	Cheaper	0.803	
	MC24e	Pollution reduction	0.713	
	MC24j	Avoid congestion	0.695	
Component 3 "Perceived risk of manoeuvres."	MC23a	Weaving between cars in a dense urban area	0.810	α=0.832
	MC23b	Weaving between cars on a highway	0.871	
	MC23c	Overtaking between lines on highway	0.789	
	MC23d	Overtaking on the right	0.770	
Component 4 "Sensation seeking"	MC24b	Pleasure	0.719	α=0.722
	MC24f	Biker spirit	0.773	
	MC24g	Acceleration	0.695	
	MC24k	Sense of freedom	0.768	
Component 5 "Road, Vehicle and Environmental accident factors"	MC26h	Bad weather conditions	0.786	α=0.779
	MC26j	Poorly maintained roads	0.759	
	MC26h	Poorly maintained motorcycling	0.595	
	MC26h	Traffic congestion	0.543	
Component 6 "Dangerous and angry behaviour"	MC21a	Following too closely the vehicle in front	0.700	α=0.704
	MC21c	Drive through an amber traffic light	0.723	
	MC21d	Overtake when you think you can just make it	0.670	
	MC21e	Flashed lights/anger horn	0.600	
Component 7 "No modal options"	MC24h	No car	0.869	α=0.754
	MC24i	No other options when getting to work/study	0.826	
Component 8" Attitudes towards drinking and friends-drinking"	MC10a	Drinking and motorcycling if carefully	0.815	α=0.622
	MC10d	Friends drinking and driving	0.755	

Table 4: Summary of logistic regression results

Independent Variables	B	S.E.	Sig.	Exp(B)
Perceived risk of manoeuvres score (Comp. 3)	0.123	0.059	0.037	1.131
Dangerous and angry behaviour score (Comp. 6)	0.345	0.058	0.000	1.412
Attitudes towards drinking and friends-drinking score (Comp 8.)	-0.196	0.054	0.000	0.822
Age	-0.010	0.005	0.050	0.990
Exposure	0.067	0.020	0.001	1.069
Constant	-2.539	0.263	0.000	0.079
Likelihood ratio test: 516.36, df=5				
Mc Fadden R^2: 0.289				

Table A1: Variables description

MC10	**How much do you agree or disagree with the following statements?**	Very	Fairly	Not much	Not at all		
a)	You can drink and drive if you do it carefully	1	2	3	4		
b)	Drinking and driving substantially increase the risk of an accident with another road user	1	2	3	4		
c)	If you drink and drive you will be stopped and fined by the police	1	2	3	4		
d)	Most of your motorcycle-driving friends would drink and drive a motorcycle	1	2	3	4		
MC12	**Over the last month, how often did you drive a motorcycle when you may have been over the legal limit for drinking and driving?**	Never	Rarely	Sometimes	Often	Very often	Always
		1	2	3	4	5	6
MC14	**Do you think that motorcycle drivers should be allowed to drink…**	No alcohol at all	Less alcohol than at present	As much alcohol as at present	More alcohol as at present	As much as they want	
		1	2	3	4	5	
MC19	**In the last 3 years, how many accidents have you been involved in, as the driver of a motorcycle, in which someone, including yourself, was injured and received medical attention?**	acc. (2 digits)					
MC21	**When driving a motorcycle, how often do you…?**	Never	Rarely	Sometimes	Often	Very often	Always
a)	Follow a vehicle in front too closely	1	2	3	4	5	6
b)	Give way to pedestrian at pedestrian crossings	1	2	3	4	5	6
c)	Drive through a traffic light that is on amber	1	2	3	4	5	6
d)	Overtake when you think you can just make it	1	2	3	4	5	6
e)	Flashed the lights or used the horn in anger	1	2	3	4	5	6
f)	Use phone system in helmet	1	2	3	4	5	6
g)	Use electronic tag for payment in tolls (highways, cities-tunnels etc.)	1	2	3	4	5	6
MC23	**While driving a motorcycle, how dangerous do you think is…**	Very	Fairly	Not much	Not at all		
a)	Weaving in and out between cars when traffic is dense in urban area	1	2	3	4		
b)	Weaving in and out between cars on a highway	1	2	3	4		
c)	Overtaking between lines on highway/beltway	1	2	3	4		
d)	Overtaking a vehicle on the right	1	2	3	4		
MC24	**Main reasons for driving a motorcycle. How much do you agree or disagree? Do you drive a motorcycle because...**	Very	Fairly	Not much	Not at all		
a)	Of saving time reasons	1	2	3	4		
b)	It provides pleasure (fun/recreation)	1	2	3	4		
c)	It's easier to find parking	1	2	3	4		
d)	It's cheaper to use than a car	1	2	3	4		
e)	For air pollution reduction (CO_2 emissions)	1	2	3	4		
f)	Because you have the "spirit of a biker/rider"	1	2	3	4		
g)	Enjoy acceleration and high speed	1	2	3	4		
h)	Don't have a car	1	2	3	4		
i)	No other options when getting to work/study	1	2	3	4		
j)	To avoid getting trapped in congestion	1	2	3	4		
k)	It gives you a sense of freedom	1	2	3	4		
MC26	**How often do you think each of the following factors are the cause of motorcyclists being involved in road accidents?**	Never	Rarely	Sometimes	Often	Very often	Always
a)	Motorcycling when tired	1	2	3	4	5	6
b)	Drinking and motorcycling	1	2	3	4	5	6
c)	Following too closely the vehicle in front	1	2	3	4	5	6
d)	Driving too fast	1	2	3	4	5	6
e)	Taking prescription medicines and motorcycling	1	2	3	4	5	6
f)	Taking drugs and motorcycling	1	2	3	4	5	6
g)	Traffic congestion	1	2	3	4	5	6
h)	Bad weather conditions	1	2	3	4	5	6
i)	Poorly maintained motorcycle	1	2	3	4	5	6
j)	Poorly maintained roads	1	2	3	4	5	6
SQ2	Gender	1 = male	2 = female				
SQ3a	Age	continuous	in years				
MC30	In an average year, how many months do you use a motorcycle?	continuous	in months				
MC27	What engine size is the motorcycle you usually drive?	continuous	in cc				