A statistical analysis of motorcycle helmet wearing in Greece

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Abstract
Introduction: Wearing a helmet is the single most effective way of reducing head injuries and fatalities resulting from motorcycle crashes. The objective of this research is the analysis of motorcycle helmet wearing in Greece and the identification of the related determinants. *Method:* Helmet wearing in Greece was recorded through an on-site observational survey. Collected data were used for the development of a binary logistic regression model. The independent variables used were time of the day, motorcycle type, road type and riders' characteristics (gender, age and position on the motorcycle). Pseudo-elasticity values for all variables were calculated in order to quantify the impact of each one on helmet wearing. *Results:* The survey revealed low helmet wearing rates. The rates are much higher in rural than in urban areas and for drivers of large motorcycles. Based on pseudo-elasticity values the variable with the greatest impact on wearing a helmet is being the driver. *Impact on industry:* The identification of some of the parameters that have an influence on the behaviour of motorcyclists in Greece concerning helmet wearing and the consequent results can be exploited by road safety policy decision makers, as well as by motorcycle and helmet industries, in future efforts for the increase of helmet wearing in Greece. *Conclusions:* Helmet wearing should be rigorously enforced at a population level. Community education campaigns and promotion of motorcyclists' education should be considered along with enforcement. Generally, public awareness of the crash risk associated with riding without a helmet should be increased.

Keywords: motorcycle helmet; observation survey; binary logistic regression; elasticity

Introduction

Globally, there is an upward trend in the number and use of motorcycles both for transport and recreational purposes. Motorcycle riders are at an increased risk of being involved in a crash. This is because they often share the traffic space with faster-moving cars, buses and trucks, and also because they are less visible. In addition, their lack of physical protection makes them particularly vulnerable to being injured if they are involved in a collision. In most high-income countries, motorcycle fatalities typically comprise around 5% to 18% of overall traffic fatalities. This proportion reflects the combined effect of several important factors including the relatively low ownership and use of motorcycles in many developed countries, and the relatively high risk of these motorcycles being involved in crashes involving fatalities. In low-income and middle-income countries, the ownership and use of motorcycles and other two-wheelers is, generally, relatively high. Reflecting this difference, the levels of motorcycle rider fatalities, as a proportion of those injured on the roads, are typically higher in low-income and middle-income countries than in high-income countries (WHO, 2006).

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Injuries to the head and neck are the main cause of death, severe injury and disability among users of motorcycles. In European countries, head injuries contribute to around 75% of deaths among motorized two-wheeler users; in some low-income and middle-income countries head injuries are estimated to account for up to 88% of such fatalities (WHO, 2006).

It is well known that helmets are very effective in preventing or reducing the severity of injuries to the head (ERSO, 2006). Motorcycle riders who do not wear a helmet run a much higher risk of sustaining any of these head and traumatic brain injuries, or a combination of them. An international review of 61 studies on the use of a moped helmet shows that the risk of severe head injury decreases by about 69% when wearing a helmet. The risk of being killed in a motorcycle crash decreases by about 42% (SWOV, 2010). According to other studies, this risk reaches 72% (ERSO, 2006) and 50% [(ETSC 2008) and (Petridou et al, 1998)] respectively.

Helmets create an additional layer for the head and thus protect the wearer from some of the more severe forms of traumatic brain injury. The correct use of a helmet considerably decreases the risk and severity of head injuries as it reduces the deceleration of the skull, and hence the brain movement, by managing the impact. It spreads the forces of the impact over a greater surface area so that they are not concentrated on particular areas of the skull. Furthermore, it prevents direct contact between the skull and the impacting object by acting as a mechanical barrier between the head and the object (WHO, 2006).

All members of the European Union have adopted a national law on helmet wearing that applies on all riders (WHO, 2009). Yet, despite the legal obligation for all riders to wear helmets, usage rates still vary greatly across Europe. Generally, the usage rate of protective systems in the European Union (27) remains unsatisfactory low and improved only marginally in the last years (Vis & Eksler, 2008). Analytical data on helmet wearing rates in European countries, for the year 2008, are shown in Table 1.

Table 1: Overview of helmet wearing rates in European countries, in 2008 (WHO, 2009)

Country	**Estimated national helmet wearing rate (%)**
Austria	95
Belgium	-
Bulgaria	-
Cyprus	68
Czech	97
Denmark	-
Estonia	-
Finland	95
France	95
Germany	97
Greece	58
Hungary	95
Ireland	-
Italy	60
Latvia	93
Lithuania	-
Luxembourg	-
Malta	-
Netherlands	92
Norway	100
Poland	-
Portugal	-
Romania	90
Slovakia	-
Slovenia	-
Spain	98
Sweden	95
Switzerland	100
UK	98

The variation of helmet wearing rates may be the result of the variation of enforcement level as well as of the compliance to the law in the different European countries. Experience has shown that road safety legislation cannot be effective if it is not properly enforced. To some extent, this is because riders do not always realize the risks involved and the benefits of the protective measures, contained in the legislation. Therefore, they do not always support laws designed to improve their own safety on the roads (WHO, 2006). Besides, helmet wearing rates are associated to the existing road safety culture level in each country and it is well known that this differs significantly across Europe.

In the Netherlands, compulsory helmet wearing became generally accepted after its introduction, in 1975. In spite of this, about 25% of moped riders and 13% of motorcyclists admitted to hospital after a crash, still have severe head/skull injuries. This may partly be caused by the helmet not being fastened properly. When a helmet is worn without a fastened chin strap, the effectiveness of protection in a crash is limited. Even though the most recent data is from the 1980s, it showed that 2% of helmet wearers did not have their chin strap fastened and that 13% wore it too loose. In 1984, about 100% of the Dutch moped riders and passengers wore a helmet, but in 2002 the wearing percentages were 91% for riders and 74% for passengers. In 2008, the percentages of helmet wearing increased to 96% for riders and 84% for passengers, probably because of the intensified police enforcement (SWOV, 2010).

In the USA, the use of Department of Transport (DOT) - compliant motorcycle helmets stood at 67% in 2009, a gain from 63% in 2008. Nevertheless, it decreased significantly to 54% in 2010. As DOT - compliant helmet wearing decreased in 2010, the percentage of motorcyclists who were not wearing any helmets increased from 24% in 2009 to 32% in 2010. The decline in helmet wearing, in 2010, occurred in many groups of motorcyclists, including motorcycle riders and passengers, in States with and without universal helmet laws, in rural areas, during weekdays and weekends and on surface streets, meaning all roadways except from expressways (NHTSA, 2010b).

When mandatory helmet laws are enforced, helmet-wearing rates have been found to increase to 90% or higher. When such laws are repealed, wearing rates fall back to generally less than 60% (WHO, 2006). Studies, in States that enacted universal helmet laws, observed wearing rates of 90% or higher immediately after the law, compared to 50% or lower before the law. States that repealed universal helmet laws saw the exact opposite effect, as wearing rates dropped from over 90% to about 50% (NHTSA, 2010a).

Data from Greece regarding helmet wearing by accident-involved motorcycle and moped drivers inside and outside urban areas, as well as the severity of road accidents for the period 2000-2009 are shown in Table 2.

Table 2: Motorcycle and moped drivers involved in road accidents per area type and accident severity in Greece for years 2000-2009 (Source: Hellenic Statistical Authority - EL.STAT. Processing: NTUA)

		Helmet worn										Total 2000-2009			
Area type	**Accident severity**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**Helmet worn**	**Helmet not worn**	**Unknown**	**Total number**
Inside urban area	**Driver not killed or injured**	26%	33%	43%	51%	49%	48%	50%	58%	61%	55%	46%	19%	35%	10,075
	Driver killed	9%	8%	21%	25%	21%	27%	21%	25%	28%	27%	21%	62%	16%	2,497
	Driver seriously injured	10%	13%	19%	22%	24%	24%	21%	27%	24%	28%	20%	58%	22%	6,286
	Driver slightly injured	23%	28%	40%	47%	45%	46%	47%	56%	61%	60%	44%	27%	28%	58,153
Outside urban area	**Driver not killed or injured**	26%	26%	28%	43%	29%	37%	39%	53%	60%	57%	38%	34%	28%	592
	Driver killed	12%	20%	32%	29%	33%	38%	39%	39%	42%	40%	32%	56%	13%	1,501
	Driver seriously injured	15%	18%	20%	30%	38%	34%	42%	40%	38%	32%	28%	57%	15%	2,148
	Driver slightly injured	22%	25%	38%	43%	47%	50%	55%	62%	65%	66%	45%	37%	17%	6,355

Even though the percentage of unknown cases is significant, there is a clear increasing trend of helmet wearing within accident-involved drivers during the specific period. Inside urban areas, the percentage of drivers who wore a helmet and were neither killed nor injured is more than double the percentage of those who did not wear one. Similar results are observed regarding slightly injured drivers. Respectively, killed or seriously injured drivers that wore their helmet are almost one third of those who did not. Outside urban areas, for cases with no fatality or injury, the percentages of drivers wearing and not wearing a helmet are slightly different. However, when fatalities or serious injuries are examined, the percentages of drivers that did not wear helmets are almost double compared to those who did. Generally, inside urban areas, drivers who were not killed or injured are much more than those killed or seriously injured. Outside urban areas the results are the opposite since the number of drivers who were killed or injured is higher than the number of uninjured drivers. This can probably be explained by taking into consideration the higher speeds outside urban areas in combination with the fact that the effectiveness of helmets depends on speed.

Factors that have been identified to be associated with helmet wearing are weather conditions, road type, area type and time of the day. Likewise, some individual-related variables such as education level, gender and age, have been defined as markers of differences among people sharing the same background and environment. Other individual-related variables influencing helmet wearing, are closely related to the road user profile including having or not having a driver's license and the type of motorcycle (Ledesma & Peltzer, 2008). Other factors that helmet wearing is known to be associated with are position of the person on the motorcycle, whether the trip is during the week (Monday–Friday), the nature of the trip, a history of motorcycle injury and the level of enforcement [(Viet Hung, Stevenson & Ivers , 2008) and (Gkritza, 2009)].

More specifically, higher rates of helmet wearing have been seen among women rather than among men [(Skalkidou et al, 1999), (Ledesma - Peltzer, 2008) and (Viet Hung, Stevenson & Ivers, 2008)]. In addition, helmet users are more likely to be older. In Argentina, it was reported that 8 out of every 10 adolescent motorcycle drivers or passengers always wear a helmet. However, the rate of helmet wearing is lower in Italy where only four out of every 10 young people reported using a helmet regularly when riding a motorcycle [(Fuentes et al, 2010) and (Viet Hung, Stevenson & Ivers, 2008)].

A study conducted in Greece, in 1999, revealed that helmet wearing ranged from 9.7% on small suburban roads to 50.8% on highways (Skalkidou et al, 1999). Other studies have also found that helmet users are more likely to be travelling on highways or freeways [(Ledesma & Peltzer, 2008), (Viet Hung, Stevenson & Ivers, 2008) and (Gkritza, 2009)]. A strong predictor of helmet wearing is the length of the trip. As reported by Viet Hung, Stevenson & Ivers (2008), motorcyclists on long trips (longer than 10 km) were more than 20 times more likely to wear a helmet as compared to those travelling on short trips (less than 2 km).

With regard to the type of motorcycle, a significant reduction in helmet wearing was seen among users of cross motorcycles and scooters (Ledesma & Peltzer, 2008).

Motorcycle helmet wearing rates by both drivers and passengers are statistically lower on sunny days (Gkritza, 2009). A study in Argentina showed that motorcyclists are eight times more likely to wear helmets under "rainy" conditions than under good weather conditions (Ledesma & Peltzer, 2008).

When helmet wearing is examined in combination with time parameters, it is found that the likelihood of helmet wearing is lower during weekends, when many crashes occur, and during the night hours, when the severity of these injuries is generally higher (Skalkidou et al, 1999).

Helmet users are more likely to be drivers (Viet Hung, Stevenson & Ivers, 2008). However, it has also been reported that driver and passenger helmet wearing rates are strongly correlated. It is estimated that motorcycle helmet wearing decisions by drivers and passengers are simultaneously determined, and that driver helmet wearing rates can be higher in the presence of a helmeted passenger (Gkritza, 2009).

Legislation has a significant influence on helmet wearing, yet its effect is greater in higher income countries where compliance reaches nearly 100%, as compared to low and middle-income countries (Viet Hung, Stevenson & Ivers, 2008). Furthermore, motorcyclist education increases helmet wearing. Drivers and passengers with a two wheel motorized vehicle driving license and/or understanding of the function of a helmet are more likely to wear one [(Skalkidou et al, 1999) and (Viet Hung, Stevenson & Ivers, 2008)].

In a previous study in Greece, the majority of those who did not wear a helmet (46%) indicated that "the helmet made them feel uncomfortable", particularly in warm weather, whereas 18% claimed that there was little need for a helmet in low speed riding (Skalkidou et al, 1999). Other reported reasons for lower helmet wearing are a negative social perception and the inconvenience of helmets particularly in relation to storage of helmets when not riding. In some high-income countries, helmet wearing has been described as a violation of personal freedom, as well as suggesting that helmets impair vision and hearing (Viet Hung, Stevenson & Ivers, 2008).

Objectives and methodology

Within this context, the objective of this research is the analysis of motorcycle helmet wearing in Greece and the identification of the related determinants. The results of this analysis may be proven very useful for the identification of the problem and of the respective countermeasures, given that the non-wearing of helmet is considered as one of the most important reasons behind the poor road safety performance of Greece, in comparison with the other European countries (NTUA, 2005).

For this purpose, motorcycle helmet wearing in Greece was recorded through a national field survey. This survey was carried out on different days, during different hours of the day and on different types of road network. Rider and motorcycle characteristics were also recorded. The analysis of the results was conducted through the development of a binary logistic regression model, allowing for the quantification of the impact of each parameter to helmet wearing in Greece.

Observation survey

Helmet wearing by motorcycle drivers and passengers in Greece was recorded through an observational survey. A significant advantage of the method was that actual - not self-reported - rates of helmet wearing are recorded; therefore, data of high accuracy and reliability are obtained.

Data recorded during the observational survey are:

- Registry details: day, time and specific location.
- Vehicle's characteristics: cubic capacity (large or small motorcycle).
- Driver's characteristics: gender, estimated age (young 16-24, middle aged 25-54, older 55+) and helmet wearing.
- Passenger's characteristics: gender, estimated age (young children 3-8, children 9-15, young 16-24, middle aged 25-54, older 55+) and helmet wearing.

The relevant questionnaire was inserted in portable computers using specialised software (Computer Aided Personal Interviewing - C.A.P.I.). Representative data from all over Greece were obtained by selecting fourteen observation locations in urban areas as well as on the national and rural road network. In urban areas, observation locations were along several different types of roads in order to record motorcyclists' behaviour in various road and traffic conditions (different speeds and flow levels). Similarly, on the national road network the survey took place along the two main highways that lead to the capital (Athens) and the second largest city of Greece (Thessaloniki). As far as observations on rural road network are concerned, these were made within the wider area of Larissa, one of the main cities of Greece, where agriculture is one of the main professional activities and thus traffic volumes on the rural network present the necessary variation.

In addition, observation locations were selected based on expected traffic volumes in order to record motorcyclists' behaviour in different traffic conditions. More details regarding the observation locations can be found in the final deliverable of the relevant project (NTUA, 2009). In order to provide sufficient time for accurate observation of all the required data, only mandatory stopping spots such as traffic lights, stop signs or toll stations were selected as observation locations. Random sampling was achieved using the following routine: at each location, observers choose and record the characteristics of the first motorcycle on the right lane. Then, the second motorcycle on the second lane is chosen etc.

The survey was conducted from April 3rd to April 18th in 2009, from Monday to Saturday and there were three different 4-hour shifts: 10:00 to 14:00, 14:00 to 18:00 and 18:00 to 22:00. A total of 3.852 motorcycle drivers and 809 motorcycle passengers were recorded.

An important limitation of any observational study of motorcycle helmet wearing is that estimates may be biased if helmet wearing is inaccurately reported or the data items are not reported consistently across observations (Gkritza, 2009). In order to eliminate such problems, special attention was given to the selection and training of the observers. Most of them had previous experience in field studies. Regardless of previous experience, all observers attended an intense informational/educational training. The observers' work, during data collection, was supervised by a superintendent to a percentage up to 90%.

Basic characteristics of the sample of the survey are presented in Table 3. These characteristics concern the type of motorcycle, the gender, the estimated age of the driver, and the area type of each recorded case.

Table 3. Distribution (%) of the characteristics of the survey sample (NTUA, 2009)

	Motorcycle type		**Driver's Gender**		**Driver's Age**			**Area type**	
	Large	**Small**	**Male**	**Female**	**Young 16-24**	**Middle aged 25-54**	**Older 55+**	**Urban**	**Rural**
Percentage	40%	60%	73%	27%	16%	79%	5%	92%	8%
Error	±1.55%	±1.55%	±1.40%	±1.40%	±1.16%	±1.29%	±0.69%	±0.86%	±0.86%

Helmet wearing rates per gender and age of the driver, motorcycle type, area type and position on the motorcycle are shown in Tables 4, 5 and 6. In each case, the reliability was tested by calculating the error for a 95% interval, using the following formula:

$$E = K \sqrt{\frac{p \cdot q}{n}} \qquad (1)$$

where: E: error

K = 1.96: constant corresponding to a 95% interval (U distribution)

p: percentage of observations with specific characteristics

q = 1- p

n : number of observations

Table 4. Distribution (%) of helmet wearing by drivers, per gender and age (NTUA, 2009)

	Male	**Female**	**Total**

	16-24	25-54	55+	Male Total	16-24	25-54	55+	Female Total	
Helmet wearing by the driver	61%	79%	67%	75%	44%	82%	non signif.	70%	75%
Error	±4.25%	±1.53%	±6.72%	±1.44%	±8.68	±4.52	non signif.	±4.41	±1.37%

Table 5. Distribution (%) of helmet wearing by drivers, per motorcycle type (NTUA,2009)

	Large	Small	Total
Helmet wearing by the driver	80%	72%	75%
Error	±2.01%	±1.83%	±1.37%

Table 6. Distribution (%) of helmet wearing per area type and position on the motorcycle (NTUA, 2009)

	Urban area		Rural area		Total	
	Driver	**Passenger**	**Driver**	**Passenger**	**Driver**	**Passenger**
Helmet wearing by the driver	73%	41%	96%	91%	75%	46%
Error	±1.46%	±3.57%	±2.27%	±6.12%	±1.37%	±3.43%

In total, 75% (±1.37%) of the motorcycle drivers did wear a helmet. The descriptive statistics showed a 75% (±1.4) helmet wearing percentage for males whereas the respective percentage for females was 70% (±4.4). However, when these total figures are disaggregated into various age groups, the relationship of these percentages between males and females differ. For ages 16 to 24 years old, males wear the helmet more often than females.

Drivers of small motorcycles wear the helmet less than those driving large motorcycles.

In urban areas 73% (±1.46%) of the drivers and 41% (±3.57%) of the passengers wear their helmet. In rural areas, the usage rates are much higher for both drivers and passengers [96% (±2.27%) and 91% (±6.12%) respectively].

The calculation of helmet wearing by motorcycle drivers, on different days of the week (working day or Saturday) and hours of the day showed that helmet wearing was increased in the morning (from 10.00 to 14.00) on working days and in the afternoon (from 14.00 to 18.00) on Saturdays.

Model development

The method that was used for the development of a statistical model that can describe motorcycle helmet wearing in Greece is binary logistic regression. The method was chosen for its simplicity and adequateness.

The dependent variable of the binary logistic regression model was helmet use (no or yes). The independent variables and the respective categories for each one of them were:

- the day of the week (working day or Saturday),
- time interval (10.00-14.00, 14.00-18.00 or 18.00-22.00),
- the type of motorcycle (large or small),
- the road type (urban, national or rural),
- the gender of each rider (male, female)
- the age of each rider (3-8, 9-15, 16-24, 25-54 and 55+)
- the position of each rider on the motorcycle (driver or passenger).

All independent variables are categorical and many of them have more than two categories each. For each independent variable with k categories, k-1 dummy variables were used to investigate all the differences in the categories with respect to the dependent variable. The last category of each variable was used as the baseline category. The results of the binary logistic regression are shown in Table 7.

The corresponding model is the following:

$$U = -0.200*x_1+0.336*x_2-1.099*x_3+2.080*x_4-0.204*x_5-0.364*x_6+0.480*x_7+1.482*x_8 \quad (2)$$

where U : logit (wearing helmet)
x_1 : time (14.00-18.00)
x_2 : large motorcycle
x_3 : urban road
x_4 : national road
x_5 : gender (male)
x_6 : age (16-24)
x_7 : age (25-54)
x_8 : driver

Table 7. Binary logistic regression results

variable	**baseline category**	**B**	**p-value**	**Exp(B)**	**e_i**	**e_i***
working day	Saturday	0.110	0.174	1.116	-	-
period 10.00-14.00	period 18.00-22.00	-0.101	0.254	0.904	-	-
period 14.00-18.00	period 18.00-22.00	-0.200	0.020	0.819	0.067	1.00
large motorcycle	small motorcycle	0.336	0.000	1.399	0.399	5.95
urban road	rural road	-1.099	0.001	0.333	0.259	3.87
national road	rural road	2.080	0.000	8.001	0.549	8.19
gender (male)	female	-0.204	0.037	0.816	0.068	1.01
age 3-8	age 55+	0.428	0.588	1.534	-	-
age 9-15	age 55+	0.631	0.093	1.880	-	-
age 16-24	age 55+	-0.364	0.330	0.695	0.131	1.95
age 25-54	age 55+	0.480	0.003	1.616	0.206	3.07
driver	passenger	1.482	0.000	4.402	0.995	14.83
constant	-	0.417	0.265	1.518	-	-

The classification results show that the model is mostly effective in predicting helmet wearing (94.1% correct prediction). Although the correct percentage of non wearing prediction is significantly lower (25.4%), the overall percentage remains satisfactorily high (73.4%) and higher than 65% which is a generally accepted percentage. Furthermore, the Likelihood Ratio Test criterion is met since LRT = -2*(L(0)-L(b)) = 5,709.143 – 5,098.499 = 610.644 > 21.06 = x^2 for 12 degrees of freedom and for a 95% interval. This indicates that the model is statistically preferred compared to the one without the used variables. Moreover, the variables are found to be statistically significant on the basis of the Wald test results (Washington, Karlaftis & Mannering, 2003).

Special attention was given to the estimation of the responsiveness and sensitivity of the dependent variable with respect to changes in each independent variable. This allows the comparison of the impact of different variables on wearing a helmet. For this purpose, the elasticity of each independent variable can be calculated (Washington, Karlaftis & Mannering, 2003). For continuous variables, elasticity is defined as the percentage change in the dependent variable resulting from small, incremental changes in an independent variable; this figure can be particularly useful because it is dimensionless, unlike any estimated coefficient of regression parameter, which depends on the units of measurement of each parameter.

However, elasticity of discrete variables cannot be defined in the standard way, and therefore pseudo-elasticity is used instead. This describes the change in choice probability when the discrete variable changes from one value to another [(Shankar & Mannering, 1996) and (Chang & Mannering, 1999)]. The direct pseudo-elasticity, $E_{x_{ink}}^{P(i)}$, of the k-th variable from the vector x_n, denoted x_{nk}, with respect to the probability, P_{ni}, of person n experiencing outcome i is computed as (Ulfarsson & Mannering, 2004):

$$E_{x_{ink}}^{P(i)} = e^{\beta_{ik}} \frac{\sum_{i'=1}^{I} e^{\beta'_i x_n}}{\sum_{i'=1}^{I} e^{\Delta(\beta'_i x_n)}} - 1 \qquad (3)$$

where I is the number of possible outcomes, (β_{ixn}) is the value of the function determining the outcome, s_{ni}, after x_{nk} has been changed from 0 to 1 whereas β_{ixn} is the value when $x_{nk} = 0$, x_n is a vector of K explanatory variables shared by all outcomes, β_i is a vector of estimated coefficients on the K variables for outcome i, and β_{ik} is the coefficient on x_{nk} in outcome i. Since equation (3) refers to each individual (n) in the sample, the calculated pseudo-elasticity refers to the sensitivity of the specific case towards the change of the value of the variable and thus is a disaggregate elasticity. In order to calculate the aggregate elasticity $E_{x_{ik}}^{P(i)}$, which expresses the sensitivity of the whole sample towards the examined change, the corresponding total change of the probability of an outcome is calculated using the formula (4) the components of which have been described above (Ben-Akiva & Lerman, 1985):

$$E_{x_{ik}}^{P(i)} = \frac{\sum_{n=1}^{N} P_n(i) E_{x_{ink}}^{P_n(i)}}{\sum_{n=1}^{N} P_n(i)} \qquad (4)$$

Consequently, the aggregate elasticity of the sample towards the examined change in a variable is the weighted mean of the individual elasticity based on the corresponding choice probabilities.

Apart from the pseudo-elasticity (e_i) of each variable, the relevant pseudo-elasticity (e_i^*) was also calculated. The relevant pseudo-elasticity of each variable is calculated by dividing the pseudo-elasticity of the specific variable by the pseudo-elasticity of the variable with the lowest impact on the dependent variable. This allows for the classification of variables with respect to the magnitude of their effect on the dependent variable in a straightforward way. The pseudo-elasticity and the relevant pseudo-elasticity value for each independent variable used in the model are also shown in Table 7.

Model application

The sign (±) of the coefficient of each independent variable in the model indicates the kind of impact that the corresponding variable has on the dependent variable. Specifically, variables with a positive sign increase the probability of helmet wearing while those with a negative sign decrease it. Based on that and according to the developed model, riding a large motorcycle, on a national road, being between 25 and 54 years old and being the driver have a positive effect on helmet wearing. On the contrary, riding in the afternoon (14.00-18.00), in urban areas, being male and between 16 and 24 years old contribute negatively to the probability of wearing a helmet.

The different probabilities of wearing a helmet that correspond to the various categories of each dependent variable can be compared to each other using the relevant odds ratios, defined as the exponentials of parameter estimates exp(B), which are shown in Table 7. Specifically, when time intervals are examined, it is found that time interval “14.00-18.00” that contrasts with “18.00-22.00” has an odds ratio of 0.819. This means that riders were 20% less likely to wear a helmet between 14.00 and 18.00 hours, compared to 18.00 to 22.00 hours having allowed for the day of the week, the motorcycle type, the road type, the gender and the age of the rider and position on the motorcycle.

Considering the type of motorcycle, it is shown that people who ride large motorcycles are 39.9% more likely to wear their helmets compared to those riding small motorcycles, taking into account all the other examined parameters.

Results regarding the type of road show that, when travelling on an urban road, riders are 66.7% less likely to wear a helmet compared to those travelling on a rural road. The difference is much greater on national roads where the probability of wearing a helmet is approximately 8 times higher compared to rural roads. Again, these results apply when time of the day, day of the week, motorcycle type, gender and age of the rider and his/her position on the motorcycle are also taken into account.

As far as the personal characteristics of the rider are considered, and allowing for the rest of the examined parameters, it was found that males are 18.4% less likely than females to wear a helmet. In addition, helmet wearing is 30.5% less likely and 61.6% more likely for riders aged 16-24 and 25-54 years old respectively, compared to people over 55 years old. Finally, the probability of drivers wearing their helmets is almost 4.4 times higher than that of passengers allowing for time of the day, day of the week, motorcycle type, gender and age of the rider.

The impact that each dependent variable has on the independent can be further explored using the calculated pseudo-elasticity values. As shown in Table 7, the dependent variable with the highest pseudo-elasticity value is being the driver. Hence, this variable has the greatest impact on wearing a helmet, compared to the rest of the examined variables. Being the driver of a motorcycle has a 14.83 times greater impact on wearing a helmet than riding between 14.00 and 18.00 hours. Furthermore, riding on a national road has a 2.12 times greater impact on wearing a helmet than riding on an urban road. As far as the age of the rider is concerned, it was found that being between 25 and 54 years old has a 1.57 greater impact on wearing a helmet than being between 16 and 24 years old. In general, it can be supported that the time of the day and the rider’s gender and age have smaller impact on wearing a helmet than the type of the motorcycle, the type of the road and the position on the motorcycle.

Conclusion

Wearing a helmet is the single most effective way of reducing head injuries and fatalities resulting from motorcycle crashes. There is considerable research conducted on the effects of wearing a helmet on the risk of a head injury as a result of a collision (WHO, 2006). Nevertheless, wearing helmet rates vary significantly worldwide and in many countries, it is not even possible to calculate such rates. In Greece, data on wearing motorcycle helmets are not collected on a systematic basis. The objective of this research was the examination of motorcycle helmet wearing in Greece and particularly the identification of the parameters with an impact on motorcyclist helmet wearing in Greece. The necessary data was obtained through a national field survey on motorcycle helmet wearing.

The exploration of the impact of several parameters on wearing a motorcycle helmet, in Greece, was achieved through the development of a binary logistic regression model. Each category of each independent variable used in the model was compared to a reference category based on the calculated odds ratios. Pseudo-elasticities and relative pseudo-elasticities were also exploited to further explore parameters affecting helmet wearing in Greece.

According to the survey results, 75% of the drivers and 46% of the passengers of motorcycles wear a helmet. It is also noted that enforcement measures taken in the specific locations during the survey, may have positively affected the observed rates of motorcycle helmet wearing. These results reveal an important increase in usage rates compared to the results of previous studies in Greece. According to previous findings, helmet wearing was stable during the period 1985-1994 at about 15% for drivers and 8% for passengers (Petridou et al., 1998). Nevertheless, in Greece, helmet wearing remains unsatisfactorily low.

As suggested in many studies, there is a clear imperative for policymakers to enforce helmet wearing at a population level. For this purpose, measures to increase helmet wearing, such as legislation for compulsory helmet wearing and its enforcement, along with community education campaigns and promotion of motorcyclists' education should be considered [(WHO, 2006), (Viet Hung, Stevenson & Ivers, 2008) and (Ledesma & Peltzer, 2008)].

Furthermore, it was found that 73% of the drivers and 41% of the passengers of motorcycles wear their helmet in urban areas while the corresponding rates are much higher in rural areas (96% and 91%). It is noted that the majority of the observations were recorded in urban areas, where increased mobility of motorcycles is to be expected.

Moreover, drivers of small motorcycles wear their helmet less than those who drive motorcycles of larger cubic capacity. These results can probably be attributed to the general wrong perception that helmet is not necessary for short trips and low speeds. In order to deal with such behaviours it is suggested that, in addition to targeting licensed motorcyclists, motorcycle safety information and education programs should increase general public awareness of the crash risk associated with riding without a helmet. It is suggested that motorcycle helmet wearing campaigns target those riders who, possibly because of lower risk perception, would not wear a helmet on lower-speed facilities and when travelling shorter distances (Gkritza, 2009).

The exploration of helmet wearing by drivers, on different days of the week and hours of the day, showed that helmet wearing was increased in the morning on working days and in the afternoon on Saturdays.

The developed model permitted the identification of parameters that have a positive effect on helmet wearing. Such parameters are riding a large motorcycle, travelling on a national road, being between 25 and 54 years old and being the driver. On the other hand, riding in the afternoon, in urban areas, being male and between 16 and 24 years old have a negative impact on wearing a helmet. More specifically, the analysis of the calculated odds rations showed that riders are less likely to wear a helmet in the afternoon than in the evening. In addition, riders of large motorcycles are more likely to wear their helmets more often than those riding smaller motorcycles. Furthermore, the probability of wearing a helmet varies significantly depending on the type of the road, since helmet wearing is less likely on urban roads than on rural roads and it becomes 8 times higher on national roads compared to rural roads. Finally, regarding personal characteristics it was found that males are less likely than females to wear helmets. In addition, young riders wear helmets less than older riders. However, the latter are also less likely to wear a helmet than the middle-aged. Position on the motorcycle also plays a role, since drivers are more likely than passengers to wear a helmet.

The calculation of pseudo-elasticity values leads to the conclusion that the dependent variable with the greatest impact on wearing a helmet, compared to the rest of the examined variables, is being the driver. In general, it can be supported that the time of the day and the rider's gender and age have a smaller impact on wearing a helmet than the type of the motorcycle, the type of the road and the position on the motorcycle.

This research permitted the identification of some parameters that have an influence on the behaviour of motorcyclists in Greece concerning helmet wearing and its results can be exploited by road safety policy decision makers in future efforts for the increase of helmet wearing in Greece. Efforts to increase helmet wearing would need to focus on increasing community perceptions about the protection that helmet offers. However, it is probably true to say that, in the absence of rigorously enforced universal helmet legislation, it is unlikely that the prevalence of helmet wearing will increase. Since motorcycle helmet laws can be enforced easily and at low cost, during regular traffic patrol operations, it is necessary that enforcement of helmet wearing is continuous.

A limitation of the roadside observational surveys of helmet wearing is that other factors that could affect helmet wearing such as rider characteristics, traffic volumes and type of helmet cannot be accurately recorded (Gkritza, 2009). Furthermore, the behavioural details of motorcycle riders, which could provide justification for adjustments in driver behaviour in the presence of passengers, could not be determined either. Therefore, such factors were not included in the analysis presented in this paper. Further research, using additional data on rider characteristics and traffic conditions as well as the use of different analysis methods may lead to the identification of more parameters that affect helmet wearing and to the development of models that will assist in predicting future trends and selecting the most appropriate countermeasures and policies.

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Impact on industry

The identification of some of the parameters that have an influence on the behaviour of motorcyclists in Greece concerning helmet wearing and the consequent results can be exploited by road safety policy decision makers, as well as by motorcycle and helmet industries, in future efforts for the increase of helmet wearing in Greece.

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