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Motorcycle riders' perception of helmet use: complaints and dissatisfaction

C. Orsi[a*], A. Stendardo[a], A. Marinoni[a], M.D. Gilchrist[d] , D. Otte[b], J. Chliaoutakis[c], T. Lajunen[e], T. Özkan[e], D.J.M. Pereira[f], G. Tzamalouka[c], A. Morandi[a]

[a] *Interdepartmental Centre of study and research on road safety, Department of Applied Health Sciences, University of Pavia, Italy;* [b] *Medical School of Hannover, Germany;*[c] *Technological Educational Institute of Crete, Greece;*[d] *University College Dublin, Ireland;*[e] *Middle East Technical University, Ankara, Turkey;*[f] *Technical University of Lisbon, Portugal*

* Corresponding author

Via Bassi 21, 27100, Pavia, Italy

Tel. +39 0382 987552

Fax. +39 0382 987570

e-mail: chiaraorsi@gmail.com

Abstract. In accidents which involve two-wheeled vehicles the helmet plays a life-saving role, but very little is known about the motorcycle rider's perceptions of the helmet. We evaluated the relationships between having been involved in an accident and dissatisfaction with the helmet and between the perceptions of the motorcycle riders and the objective features of the helmet. It is a case-control study: riders of motorized two-wheelers who were involved in accidents (cases) were compared with a sample of riders interviewed as control cases. Information about the driver, the vehicle and the helmet was collected. To evaluate the relationships, logistic regressions were carried out. Dissatisfaction with the helmet is complained of by the majority of drivers, but evidence of an association with being involved in an accident was not found. The most common complaints were about noisiness, followed by the helmet visor. Complaints did not seem to be associated with the features of the helmet.

Keywords: helmet; motorcycle accident; cognitive ability; case control study; prevention; road safety

Introduction

In the states of the European Union, every year about 43,000 people die following a road accident, and about 1.8 million are injured (European road safety observatory 2008). Two-wheeled motor vehicles are involved in 14% of all traffic accidents occurring in the European Union. The associated number of fatalities is over 6000 people annually (EU Injury Database 2007).

Riding motorized two-wheeled vehicles entails a higher risk of a fatal traffic accident than from any other common mode of transport. It has been estimated that, per 100 million person travelling hours, 440 motorized two-wheeled vehicle rider fatalities occur, compared to 75 and 25 fatalities for bicyclists and car drivers, respectively (Koornstra 2003). Half of these accidents are caused by other collision participants, approximately 40% by the motorized two-wheeled vehicle rider, and the remainder are attributable to factors such as vehicle and road failures. Car drivers and passengers are well-protected compared to motorized two-wheeled vehicle riders, whose survival of an accident is most strongly guaranteed by wearing a helmet, especially a full-face motorcycle helmet. Cognitive failures on the part of the motorized two-wheeled vehicle rider are known to cause 34% of motorized two-wheeled vehicles accidents (ACEM 2004; Magazzù et al. 2006).

Several studies have shown that a helmet, in particular integral ones which have full facial protection, can be a life saver in an accident and protect against severe head injuries (Branas 2001; Christian 2003; Cui et al. 2009; Deutermann 2004; Eastridge 2006; Forero Rueda et al. 2009; Forero Rueda et al. 2010; Houston and Richardson 2008; Hundley 2004; Keng 2005; Lin 2001; Liu et al. 2008; Nakahara 2005; Norvell 2002; Oullet and Kasantikul 2006; Sauter 2005), but we know little about whether helmets can be optimised for improving motorcycle rider perception. In fact, the rider's perception can actually be influenced by some features of the helmet (noisiness, temperature, ventilation, field of vision, and size), as the following authors have found.

As regard noisiness, Carley et al. (2009) conducted a study of helmet noise mechanisms using measurements inside and outside a helmet during on-road riding; they presented evidence of the inability of a helmet to protect against hearing damage at low frequency and its tendency to attenuate acoustic signals, such as speech, at higher frequencies. In another study on the attenuation of noise by motorcycle helmets, Młynski et al. (2009) found similar results: there is no attenuation of sound below about 500Hz. Since the aerodynamically generated noise is worst in the frequency range up to about 1kHz, this means that helmets offer no noise protection in the range where it is most needed. The authors note that this combination of no attenuation at low frequency and large attenuation at higher frequency leads to the risk of hearing damage from the low frequency aerodynamic noise and also to difficulty in understanding speech because of the high frequency attenuation.

As regard ventilation and temperature problems, a study containing a literature research has been published in 2007 by the University of Heidelberg on behalf of the Bundesanstalt für Straßenwesen: it indicates that sound pressure and ventilation aspects of helmet design contribute substantially to the well-being of a driver; it also found no causal link to accidents from these ergonomic factors (Bast 2007). Bogerd and Brühweiler (2009) examined 27 modern full-face motorcycle helmets (9 flip-up and 18 integral models) from 13 manufacturers on a thermal manikin head-form. They found that most motorcycle helmets offer ventilation with generally little control of the heat transfer, as well as low scalp ventilation. In another study, the same authors investigated the relationship between perception and heat loss among other parameters, with the focus on vent-induced effects. They found that subjects are able to systematically perceive effects caused by changing the vent configuration of motorcycle helmets, under simulating riding conditions (Bogerd et al. 2009). Deetjen et al. (2005) conducted experiments on 12 different protective helmets and found inside temperatures of 20°C to 37°C at most for measured outside temperatures of 15°C to 36°C and found room for improvement because of functional and design errors (a temperature of 24°C to 27°C is classified as comfortable).

As regard visor, Buyan et al. (2006) evaluated four visor configurations, ranging from a standard clear visor to an aluminium visor, to evaluate radiant warming through visors. They found that the clear visor transmits the most radiant heating, and the aluminium-covered visor the least, with the electro-chromic foil yielding intermediate values. Subjective examinations indicated a perceptible difference between the clear visor and the electro-chromic foil, but no perceptible difference between the two electro-chromic foil configurations. Thus, while tinted helmet visors improve the optical quality for a wearer, they can also adversely lead to heat gain.

However, it remains unclear which is the rider's subjective feeling of comfort or discomfort when using the helmet, if the rider's perception of the helmet is associated with traffic accidents and how motorcycle helmets and their design could be improved in aspects other than impact protection. In order to provide knowledge on how motorcycle helmets should be improved to reduce the rider's discomfort and to facilitate the avoidance of accidents we conducted the present work, with the following specific objectives:

- to evaluate the relationship between having been involved in an accident and the perception of discomfort in wearing the helmet
- to evaluate the relationship between the riders' perception of their motorcycle helmets and the objective design features of the helmet.

Material and methods

1.1 Study background

The present study has been carried out within the European project COST 357 - PROHELM (Accident Prevention Options with Motorcycle Helmets). COST 357 – PROHELM is a 4-year (2006-09) multi-centred international research study, has been conducted across several European countries in order to systematically determine the cognitive abilities of motorized two wheeled vehicle riders are influenced by the helmet construction. The activities of COST 357-PROHELM were divided into 10 tasks, which are implemented by four working groups (WG) (Bogerd et al., 2010). This present study has been undertaken by WG 1, composed by Germany, Greece, Ireland, Italy, Portugal, and Turkey, that was charged with carrying out a study about cognitive aspects of motorcycle helmets and how these conditions influence accidents of motorcyclists (Orsi et al., 2009; Otte et al., 2010).

1.2 Study design and population

The study design is a case-control study. The cases are motorized two wheeled vehicle riders who have been involved in accidents; the control cases are a sample of motorized two wheeled vehicle riders who circulate in the same area and were not involved in the accidents studied. Control cases were not matched in age, sex, engine size or location, however the possible confounding effect of these factors has been accounted for in the statistical analysis. The inclusion criteria for the selection of the motorcycle riders was a) either having a history of at least one road traffic accident (crash) while using helmet and still possess the specific helmet or b) having no history of road traffic accident involvement. By contrast, the exclusion criterion was motorcyclists who used helmet while having a road traffic accident but had not disposed the specific helmet anymore.

Every country collected a sample of cases and a sample of control cases. A similar data sampling process was used in all countries. However, the precise methodology differed depending on the research activities and procedures in the individual countries. To collect cases, Germany and Italy have an in-depth-investigation team with access to the scene of the event directly after an accident; Greece surveys drivers retrospectively in their homes; Ireland, Portugal and Turkey carry out their activities by following the same methodology of other national research sources i.e. police surveys and accident reports, forensic expert activities. The control cases were recruited by trained staff during predefined time intervals both at petrol station, during police checkpoints, and by surveys of motorcycling enthusiasts. The test persons were asked to participate at the survey including the examination and measurement of their helmet. Motorcyclists who have given their informed consent were included in the study.

Each Investigation centre had to enrolled consecutively all cases and all control cases occurring (they have occurred during the study period). A proportional distribution among different countries were not established. The Investigation centres were mostly ready to implement the methodology and to commence investigations in March 2007. The scheduled deadline for completing data collection was the end of September 2008.

2.2 Data collection

The variables concern information about the driver, the vehicle and the helmet, perceptions and use of the helmet and accident circumstances (only for cases). Gathering information involved administering a questionnaire to the motorcycle rider and quantitatively examining the helmet using custom designed and standardized tools.

2.2.1 The questionnaire

A suitable questionnaire was developed to collect data. This considered personal data as well as general helmet data, data on helmet features, conditions, sensations, usage. Cases were also asked for the condition of the helmet before the accident and the accident situation. The motorcyclists reported any negative effects pertaining to vision, heat, ventilation, etc. and also made suggestions for further developments of helmets. This self-reported information was recorded at the same time as the measurement results, for which a separate form had been developed.

2.2.2 Measurement tools

Some measurement tools were prepared and used to determine the horizontal and vertical opening of the vision hatch, the horizontal (on the left and on the right) vision field, and the transmission and diffusion of light through the visor. A meter was used to measure the horizontal opening of the vision hatch (maximum width) and the vertical opening of vision hatch (maximum height). A special device, a so-called goniometer or perimeter, was developed to determine the horizontal vision field. To evaluate the optical quality characteristics of the visors of the examined helmets the light transmission and light diffusion were determined. The light transmission value τ indicates the amount of light that is let through the visor. For example, a value of τ =90% means that 90% of the light passes through the visor while 10% of the light is filtered by the visor. According to the UN EC regulation (ECE 22.05) a visor should have a light transmission value of more than of τ =80% and visors marked as “day time only visors” should have light transmission values between 50% and 80%.

Light diffusion of a visor indicates how clear the vision is through the helmet in terms of scratches, abrasion or dust on the visor. Light diffusion (D) is measured as the amount of light that leaves the visor as diffuse light. According to the ECE 22.05, a new visor should have no more than D=2.5% diffuse light after passing the visor. After the ECE abrasion test of the visor the light diffusion must not exceed D=20%. However in the ECE 22.05 there is no maximum diffusion specified for visors in use.

To determine the light transmission and the light diffusion of the visor, sets of different reference lenses were prepared and compared to the actual visor by holding them up together. For the determination of the light transmission a set of 6 lenses was used with the following values: 90%, 83%, 81%, 64%, 57%, 14%. For the determination of the light diffusion a set of 4 lenses was used with the following values: 2%, 8%, 16%, 25%.

2.3 Statistical analysis

To evaluate the relationship between satisfaction with the helmet (or lack of) and being involved in an accident, a logistic regression was carried out. The analysis has been performed differentiating between cases and control cases: being a case or a control was taken as the response variable. The satisfaction with the helmet was taken as independent variable: all subjects who expressed at least one complaint about the level of comfort of the helmet in relation to dimensions, features of the visor, fastener, ventilation or noisiness were judged to be dissatisfied with their own helmets. Other variables that are considered to be associated to the risk of accident or that can be associated with the dissatisfaction with the helmet have been included in the logistic regression model, as possible confounders: gender (male or female), age (<25 years or ≥25 years), body mass index (BMI, underweight/normal: <25 kg/m² or overweight/obese: ≥25 kg/m²), driver's vision defects, engine size (≤125 cc or >125 cc), type of helmet (jet or integral), previous accident record (yes or no).

To evaluate the relationship between the riders' perception of their motorcycle helmets and the objective features of the helmet, comparing objective variables (measurements and surveys of the helmet) with the perception of the helmet on behalf of the driver, various aspects have been considered. For each of these aspect, a logistic regression was carried out. The analysis has been performed in all subjects without distinction between cases and control cases.

a. Complaints related to hearing problems due to the helmet or to the noisiness of the helmet have been compared with the type of ventilation (optimal: on the head and on the chinbar / non-optimal: none or on the head or on the chinbar). Complaints related to hearing problems due to the helmet or to the noisiness of the helmet was taken as the response variable. The type of ventilation was taken as independent variable. Other variables that have been included in the logistic regression model, as possible confounders, are: gender (man or woman), age (<25 years or ≥25 years), engine size (≤125 cc or >125 cc), type of helmet (jet or integral), previous accident record (yes or no).
b. Only for helmets with a ventilation system, complaints relating to the malfunction of the ventilation system have been compared with the type of ventilation (optimal: on the head and on the chinbar / non-optimal: on the

head or on the chinbar). Complaints relating to the malfunction of the ventilation system was taken as the response variable. The type of ventilation was taken as independent variable. Other variables that have been included in the logistic regression model, as possible confounders, are: gender (man or woman), age (<25 years or ≥25 years), engine size (≤125 cc or >125 cc), type of helmet (jet or integral), previous accident record (yes or no).

c. Complaints relating to the fastener have been compared with the type of fastener (helmet spoiler/quick-release plug/double d-ring/clamp roller) and with the geometry of the chinstrap (vertical/tilted to the back). Complaints relating to the fastener was taken as the response variable. The type of fastener and the geometry of the chinstrap were taken as independent variable. Other variables that have been included in the logistic regression model, as possible confounders, are: gender (man or woman), age (<25 years or ≥25 years), engine size (≤125 cc or >125 cc), type of helmet (jet or integral), previous accident record (yes or no).

d. Complaints relative to the visor (the visor distorts the view or the visor steams up too often) have been compared with the quality of the visor (optimal: transmission=90% and diffusion=2% / non-optimal: transmission<90% or diffusion>2%). Complaints relative to the visor was taken as the response variable. The quality of the visor was taken as independent variable. Other variables that have been included in the logistic regression model, as possible confounders, are: gender (man or woman), age (<25 years or ≥25 years), vision defects (yes or no), engine size (≤125 cc or >125 cc), type of helmet (jet or integral), previous accident record (yes or no).

e. Complaints regarding comfort (the helmet is uncomfortable or the helmet is too tight or too loose) have been compared with the size of the helmet (right or not). Complaints regarding comfort was taken as the response variable. The size of the helmet was taken as independent variable. Other variables that have been included in the logistic regression model, as possible confounders, are: gender (man or woman), age (<25 years or ≥25 years), engine size (≤125 cc or >125 cc), type of helmet (jet or integral), previous accident record (yes or no). Data collected in Greece and in Turkey were excluded from the analysis related to comfort, as these countries did not measure the head circumference of riders.

Finally, the total horizontal vision field (right horizontal vision field + left horizontal vision field) have been compared with the horizontal opening of the vision hatch. The Pearson correlation coefficient and a linear regression model were used to evaluate the relationship between the total horizontal vision field and the horizontal helmet opening.

The database was developed and the data stored on Microsoft Access-Format 2003. The statistical analysis has been carried out using the software SPSS, version 15.0.

Results

The descriptive findings are summarized in Table 1. The study involved 598 subjects, 208 cases and 390 control cases. The distribution per country shows that the majority of cases was collected by Italy, Greece, followed by Turkey; controls were collected mostly by Italy and Germany, followed by Turkey. The majority of riders was man both among controls and cases, the female riders accounted only for 12.4% in the all dataset. Cases are older than controls: the percentage of people aged 25 years or older is 82.7% among cases and 72.2% among controls. Overall, the proportion of overweight or obese subjects is 47.1% and the proportion of people with vision defects is 31.3%. The data clearly indicate that riders who have had a previous accident are over represented in the accident population (80.0% versus 40.6%). The percentage of riders who drove a vehicle with engine size ≤125 cc is 38.2% and the jet helmet is slightly more frequent among the cases (42.4% versus 34.3%).

As regard the helmet characteristics, 22.6% of helmets do not have ventilation system and the distribution of ventilation types differs among cases and controls: in particular, the percentage of helmets with ventilation both on the head and on the chin is higher among controls (59.5% versus 40.9%). The majority of helmets has chinstrap with quick-release plug-fastener (74.7%) and tilted to the back (58.0%). The majority of helmets (82.6%) has a visor and, among the visors, 51.1% are optimal (transmission >=90% and diffusion <=2%). Only 29.0% of riders wear a helmet of the right size.

As regards complaints relating to the helmet, globally the drivers who report situations of discomfort using the helmet (at least one complain) are 70.1%, with similar distributions among cases and controls (69.8% versus 70.3%). The most common complaints are relating to the noisiness of the helmet (39.2%), followed by complaints relating to the visor because it steams up too often (27.8%) and to the ventilation system because it does not work adequately (27.0%). Cases complain more than controls regarding the ventilation system (34.0% versus 23.4%) and the visor because it distorts the view (22.5% versus 11.7%).

The descriptive findings were tested using multivariable models. The results are presented in tables 2-4.

Even if the majority of riders reports situations of discomfort using the helmet, both among cases and controls, there is no association with the risk of being involved in an accident (OR=0.981; p=0.932). However, an advanced age (OR=2.319, p=0.002), using a jet helmet (OR=1.733, p=0.012) and having previously had an accident (OR=6.475, p=0.000) are significantly associated with having been involved in an accident, that is accidents happen more often among people aged 25 years and older with respect to people younger than 25 years, among motorcyclists wearing jet helmet with respect to motorcyclists wearing an integral helmet and among riders having had a previous accident with respect to riders never involved in an accident before (Table 2).

Table 3 shows the relationship between complaints relating to the helmet and specific characteristics of the helmet for the hole sample. Complaints related to hearing problems due to the helmet or to the noisiness of the helmet and complaints relating to the malfunction of the ventilation do not appeared to be associate with the type of ventilation. The association between complaints relating to the fastener and the type of fastener and the geometry of the chinstrap has not been found statistically significant. Neither the association between complaints relative to the visor and the quality of the visor is statistically significant. Finally, complaints regarding comfort was not significantly associated with the size of the helmet (Table 3).

The mean horizontal vision field (measured in degree) is 154.0° and it is wider in the jet helmets with respect to the integral ones (156.2° versus 148.6°), whilst the mean horizontal opening of vision hatch (measured in centimetres) is 29.3 cm and it is wider in the integral ones (33.9 cm versus 26.7 cm). The Pearson linear correlation coefficient shows an inverse relationship between the two measurements ($r=0,271$; $p<0.001$), indicating that the horizontal vision field increases as the horizontal opening of vision hatch decreases. Similar results are found using linear regression model (Table 4).

Discussion

Dissatisfaction with the helmet is complained of by the majority of drivers (about ¾), both among cases and control cases. Our results show that the most common complaints are about noisiness of the helmet, followed by complaints about the visor, in particular because it steams up too often.

Evidence of an association between being involved in an accident and dissatisfaction with the helmet has not been found. However it is important to stress the association between older age and being involved in an accident and the predisposition of motorcycle riders who have already had an accident to being involved in another road crash. Another important finding is the association between being involved in an accident and wearing a jet helmet, also taking into account the motorcycle engine size, according to literature.

All the analyses converge towards similar conclusions: complaints related to helmets do not seem to be associated with the objective features of the helmet. In fact, adjusting for all possible confounders, none of the investigated associations has been found to be statistically significant: complaints related to hearing problems due to the helmet or to the noisiness of the helmet and type of ventilation, complaints relating to the malfunction of the ventilation system and type of ventilation, complaints relating to the fastener and type of fastener, complaints relative to the visor and quality of the visor, complaints regarding comfort and size of the helmet. So, it is reasonable to assume that complaints are related to personal and cognitive characteristics of the drivers and to individual sensations towards the helmet. It is possible to infer that some riding abilities and knowledge of their motorcycle and helmet could protect riders and prevent them from crashes. These hypothesis should be investigated with other had hoc studies.

This is an had-hoc study that allowed us to collect for each single event in the sample population more extensive and detailed information than available in police reports. The case-control study deign allow to provide a cause-effect link on the basis of disaggregated data allowing us to perform the analyses and to reach our goals. Moreover it is a multi-centre study conducted in different European countries that provides consistent results on international level.

Because of the multi-centricity of the research, the main limitation of the study is that, even if a similar data sampling process was used in each country, the precise methodologies of sampling cases and control cases were affected by the different countries research activities and procedures (Germany and Italy in-depth-investigation on site, Greece surveys retrospectively, Ireland, Portugal and Turkey police surveys and accident reports). However, each country used the same measurements tools, validated before the study, and the same standardized data collection methodologies. Thus, we think that this limitation do not affect the validity of the results. Another limitation is that there are some missing data due to the fact that same people did not fill the questionnaire in each part. For this reason, we could no conduct the multivariate analyses on the whole database. However, almost all the analyses have been carried out on the majority of subject (more than 90%), so the results are consistent. Only the analysis on comfort when wearing the helmet and size of the helmet has been performed on a small proportion of the sample (229 subjects, around 40%), due to the fact that Greece and Turkey did no collect head circumference. However we considered interesting to report the results of this analysis.

Conclusions

These results provide useful information about helmet comfort and the main causes of dissatisfaction reported by motorcycle riders and show that new optimized motorcycle helmet concepts can be developed. In this context, this information should be of value to helmet manufacturers and designers to increase the pleasure of the helmet, whose life-saving role is well known.

Moreover, some aspects of the study can be relevant for other types of protective headgear, especially bicycle helmets for which we hope that the structure of the present research will serve as an example.

Subsequent analysis of our findings will be investigated further in a further publication in order to suggest helmet design modifications and operative enhancements.

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Table 1. Frequency distribution of the study data by controls and cases

		Controls		Cases		Total	
Variable		**N**	**%**	**N**	**%**	**N**	**%**
Country	Germany	85	21.8	7	3.4	92	15.4
	Greece	52	13.3	48	23.1	100	16.7
	Ireland	43	11.0	11	5.3	54	9.0
	Italy	101	25.9	91	43.8	192	32.1
	Portugal	26	6.7	14	6.7	40	6.7
	Turkey	83	21.3	37	17.8	120	20.1
Gender	Man	337	86.9	185	88.9	522	87.6
	Woman	51	13.1	23	11.1	74	12.4
Age (years)	<25	107	27.8	36	17.3	143	24.1
	≥25	278	72.2	172	82.7	450	75.9
BMI (kg/m²)	<25	210	54.8	102	49.3	312	52.9
	≥25	173	45.2	105	50.7	278	47.1
Vision defects	Yes	113	30.8	65	32.2	178	31.3
	No	254	69.2	137	67.8	391	68.7
Previous accidents	Yes	153	40.6	165	80.5	318	54.6
	No	224	59.4	40	19.5	264	45.4
Engine size (cc)	>125	240	62.8	123	60.0	363	61.8
	≤125	142	37.2	82	40.0	224	38.2
Helmet type	Jet	131	34.3	86	42.4	217	37.1
	Integral/motocross	251	65.7	117	57.6	368	62.9
Ventilation system	Head and Chin	229	59.5	85	40.9	314	53.0
	Only head or only chin	74	19.2	71	34.1	145	24.5
	None	82	21.3	52	25.0	134	22.6
Fastener	Chinstrap with quick-release plug-fastener	282	74.2	157	75.5	439	74.7
	Chinstrap with double d-ring fastener	76	20.0	30	14.4	106	18.0
	Chinstrap with clamp roller	8	2.1	11	5.3	19	3.2
	Helmet spoiler	14	3.7	10	4.8	24	4.1
Geometry of chinstrap	Vertical	156	42.0	87	41.8	243	42.0
	Tilted to the back	215	58.0	121	58.2	336	58.0
Visor	Yes	314	80.9	178	85.6	492	82.6
	No	74	19.1	30	14.4	104	17.4
Quality of visor	Optimal	150	48.2	98	56.3	248	51.1
	Not-optimal	161	51.8	76	43.7	237	48.9
Size	Right	80	30.8	44	26.3	124	29.0
	Not right	180	69.2	123	73.7	303	71.0
Complaints relating to helmet	Problems hearing	91	23.3	50	24.0	141	23.6
	Too loud or noisy	138	35.4	59	28.4	197	32.9
	Ventilation system does not work adequately	71	23.4	53	34.0	124	27.0
	Chinstrap or fastener uncomfortable	59	15.4	28	13.8	87	14.8
	The visor steams up too often	83	26.4	54	30.3	137	27.8
	The visor distorts the view	42	11.7	42	22.5	84	15.4
	Helmet uncomfortable	27	7.0	20	9.8	47	8.0
	Too tight / loose	26	6.7	15	7.2	41	6.9
	At least one complain	116	70.3	68	67.3	184	69.2

Table 2. Relationship between the perception of discomfort in the use of the helmet and the accident, adjusted for personal, vehicle and helmet characteristics (n=536)

	Adjusted OR	CI		p
Complaints relating to helmet				
Yes→No	0.981	0.632	1.522	0.932
Gender				
Man→Woman	1.335	0.697	2.555	0.383
Age (years)				
≥25→<25	2.319	1.361	3.952	0.002
BMI (kg/m²)				
Overweight/obese (≥25)→Normal/underweight (<25)	0.816	0.534	1.247	0.347
Eyesight vision defects				
Yes→No	1.016	0.663	1.558	0.940
Engine size (cc)				
≤125→>125	1.316	0.840	2.063	0.231
Helmet type				
Jet→Integral/motocross	1.733	1.131	2.655	0.012
Previous accidents				
Yes→No	6.475	4.206	9.967	0.000

OR = Odds ratio, CI = Confidence interval

Table 3. Relationship between complaint relating to the helmet and specific characteristics of the helmet

Complaint	Helmet characteristics		Adjusted OR	95% CI		p
Problems hearing or helmet too loud/noisy (n=569) [d]	Ventilation system [a]	Head and chin [c]				
		None/only head/only chin	0.731	0.408	1.308	0.291
Ventilation does not work adequately (n=443) [d]	Ventilation system [a]	Head and chin [c]				
		Only head/only chin	1.578	0.849	2.935	0.149
Chinstrap or fastener uncomfortable (n=550) [d]	Fastener [a]	Helmet spoiler [c]				
		Quick-release plug	3.799	0.498	28.971	0.198
		Double d-ring	3.833	0.470	31.230	0.209
		Clamp roller	4.603	0.426	49.770	0.209
		Vertical				
		Titled to the back	1.426	0.857	2.372	0.172
Visor steams up too often or distorts view (n=469) [d]	Visor [b]	Optimal [c]				
		Not-optimal	1.171	0.794	1.726	0.426
Helmet uncomfortable or too tight/loose (n=229) [d]	Size [a]	Right [c]				
		Not right	1.423	0.691	2.932	0.339

OR = Odds ratio, CI = Confidence interval

[a] Other variables entered in the model: gender (man or woman), age (<25 years or ≥25 years), engine size (≤125 cc or >125 cc), helmet type (integral/motocross or jet)

[b] Other variables entered in the model: gender (man or woman), age (<25 years or ≥25 years), engine size (≤125 cc or >125 cc), helmet type (integral/motocross or jet), eyesight vision defects (yes or no)

[c] Reference category

[d] The total cases do not coincide with the data of table 1: they were selected by the logistic models

Table 4. Relationship between horizontal vision field and horizontal opening of vision hatch

	Integral helmet		Jet helmet		All helmets	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Horizontal vision field (degrees) (x)	148.6	14.7	156.2	17.3	154.0	17.1
Horizontal opening of vision hatch (cm) (y)	33.9	6.0	27.6	5.6	29.3	6.4

Pearson linear correlation coefficient: $r = -0.271$; $p < 0.001$

Linear regression line=44.89-0.101*x

SD = Standard deviation