Effect of Wearing a Helmet on the Occurrence of Head Injuries in Motorcycle Riders in Benin: A Cohort-nested Case-control Study

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Abstract

Background: In Benin, motorcycles are the main means of transport for road users and are involved in more than half of accidents. This study aims to determine the effect of wearing a helmet on reducing head injuries in road accidents in Benin.

Methods: This cohort-nested case-control study took place in 2020 and focused on road trauma victims. The sample consisted of 242 cases for 484 controls. A logistic regression model was performed.

Results: Fewer of the subjects with a head injury were wearing a helmet at the time of the accident 69.8% (95% CI = 63.6 - 75.6) compared to those without a head injury 90.3% (95% CI = 87.3 - 92.8). Adjusting for the other variables, subjects not wearing helmets were at greater risk of head injuries (OR = 3.8, 95% CI (2.5 - 5.7)); the head injury rating was 2.0 (95% CI = 1.2 - 3.2) times higher in subjects who were fatigued during the accident than among those who were not and 2.1 (95% CI = 1.2 - 3.3) times higher than in subjects with no medical history.

Conclusion: Failure to wear a helmet exposes motorcyclists to the risk of head injuries during accidents. It is important to increase awareness and better target such initiatives at the subjects most at risk.

Background

Road traffic accidents have a heavy burden of disease and mortality around the world. These accidents are the leading cause of injury and are the eighth leading cause of death worldwide. Each year, they are responsible for 1.25 million deaths. The highest mortality rates are observed in the African region of the World Health Organization (WHO), with 26.6 deaths per 100,000 inhabitants in this region against 17.4 deaths per 100,000 inhabitants worldwide (1).

Those most exposed to road accidents, serious injuries and deaths from road accidents are vulnerable users such as pedestrians, cyclists and riders of motorised two-wheelers and their passengers (1–5). These road users account for half of those killed on the road in the African region. In this region, 7% of road deaths are among motorcyclists (1, 5). In Benin, each year, from 2010 to 2016, two-wheelers were involved in around 50% of accidents (6). The increase in the number of motorcycles and motorcycle trips in the African region is one of the factors contributing to the growth of road accidents (1, 5). Among these motorcyclists, although limb trauma is the most common injury in traffic accidents, head injuries are more serious. They are responsible for around half of the deaths (2).

The main causes of these accidents are speeding, driving under the influence of alcohol or any psychoactive substance, the lack of a helmet, seat belt, or safety devices for children, and driving distractions such as mobile phones. In addition to these behavioural factors, there are those related to the condition of the roads or the condition of the vehicles (1). Some authors have noted several factors that can influence the attitudes and behaviours of drivers, such as driver inexperience, driving long hours in a day, working late hours, the territorial context in which the drivers live, driver training, compliance with laws on lighting and visibility, and possession of an individual driver's license, up-to-date parts and motorcycle insurance (7–11).

The WHO recommends the use of helmets as one of the main means of preventing road traffic injuries (1, 12). Several authors have confirmed the importance of helmet use in reducing head injuries and fatalities among cyclists (2, 13–16). Wearing a helmet reduces the risk of death and head trauma, brain contusion and intracranial haemorrhage among motorcyclists in traffic accidents (15, 17). It also reduces the severity of trauma and is associated with a significantly lower Glasgow score in cyclists involved in road accidents (14, 16).

In Benin, a Decree of April 1972 established the compulsory wearing of helmets by drivers and passengers of two-wheeled vehicles or the like. For decades, this law was not enforced. Since 2014, several actions have been carried out to ensure its effective implementation by motorcycle drivers in large cities. One year before the implementation of this law, 96% of motorcyclists admitted to the National Hospital-University Centre of Cotonou for cranio-encephalic trauma caused by road accidents did not wear a helmet (18). One year later, after increased checks on the wearing of helmets, there was not only an increase in the proportion of head trauma victims wearing helmets, but also a reduction in the frequency of these injuries (19). It is relevant, after several years of application of this law on the wearing of helmets in Benin, to verify whether the subjects wearing helmets are less at risk of head injuries, and to identify the other factors likely to influence the occurrence of those head injuries. The objective of this study was to determine the effect of wearing a helmet on the occurrence of head injuries in road accidents in Benin.

Materials And Methods

Type of study

This is a cohort-nested case-control study that took place in 2020 (see Fig. 1).

Study population, inclusion and exclusion criteria

The target population consisted of motorised two-wheeled vehicle drivers who were victims of road traffic injuries. The cases included were those with head injuries, and the controls were those without. The diagnosis of head injuries was made on clinical examination, whether or not the diagnosis was confirmed by paraclinical examinations (imaging) such as radiography. Subjects for whom information related head injuries was not provided in the medical file and those who did not give their consent were not included in the study.

Data source and selection of participants

The present study was carried out on the cohort of road traffic injuries called TraumAR, set up by a team of researchers with the support of the Multidisciplinary Research Project for the Prevention of Road Accidents (ReMPARt). It was formed through the recruitment of subjects in two hospitals in the north of

Benin (Boko district hospital and the Regional Teaching Hospital of Borgou in Parakou) and three in the south (Menontin district hospital, the National Teaching Hospital Hubert Koutoukou Maga of Cotonou, the Regional Teaching Hospital of Ouémé in Porto-Novo). These hospitals were selected on the basis of traffic statistics for trauma caused by road accidents. In these hospitals, the subjects admitted for road accident trauma were recruited from 01 July 2019 to 31 January 2020. After obtaining their free and informed written consent, each patient submitted to a questionnaire to prospectively collect the exhaustive data needed to create the cohort. These data collected from the subjects were supplemented by other data obtained from the medical record and from observation. All the data recorded, which made it possible to establish the TraumAR database, related to general information, accident risk factors, severity factors, clinical, paraclinical, therapeutic and monitoring information, and patient outcome.

The subjects were divided into two groups: the group of cases presenting with head injuries (306 individuals) and the group of controls without head injuries (484). In order for the number of cases to correspond to half of the total number of controls, a simple random selection without replacement of 242 cases was carried out using the “sample” command in Stata.

Sample size

In order to define the number of subjects necessary for our study, we used the formula developed by Machin et al (20). To do this we considered one (1) case for two (2) controls ($\varphi = 2$), a power of 80% ($1-\beta$), a confidence level of 95% ($\alpha = 5\%$), a minimum difference in odds ratio expected between the groups OR_{plan} of 1.8. In the absence of previous research on motorcycle riders without experiencing head injuries while wearing a helmet, we took 50% as a probability of exposure in controls π_2.

A minimum sample size of 142 cases and 284 controls was required. We were able to include 242 cases and 484 controls in the study.

Variables

To perform this study, the binary dependent variable was “head injuries”. Four groups of factors likely to explain the occurrence of head injuries in motorcyclists who experienced trauma were identified, as independent variables, following a review of the literature. The socio-demographic and economic factors were age, sex, body mass index (BMI), which is weight in kilograms divided by height in square meters, ethnicity, professional situation, marital status, household size and the number of dependent children aged 0–18. Another group of factors was the history, such as medical history, history of traffic accidents, driving experience, and use of drugs, stimulants, alcohol or tobacco. The road and environmental factors used were the type of road, the condition of the road, other involvement in the accident, the weather conditions, the time of day, and the level of visibility. Behavioural factors were helmet use, telephone use, distraction and fatigue/drowsiness at the time of the accident. The main exposure sought was the wearing of helmets.

Data processing and analysis

Stata 15.1 was used for data processing and analysis. Variables were described for cases and controls. The quantitative variables were expressed as a mean followed by their standard deviation because their distributions, verified graphically (histogram, box-plot), were normal. The qualitative variables were described by their frequencies. The dependent variable, head injuries was cross-tabulated with each of the independent variables. Chi-square statistical test was used for comparison of proportions when conditions were true. Student's test was used for the comparison of continuous variables. For this test, equality of variances was tested using Levene's robust test. If this test was significant, the Hartley test was performed. A logistic regression was also performed in a univariate analysis. For this regression, the indicator to measure the association was the odds ratio (OR) followed by its 95% confidence interval (95% CI).

Modelling was done to assess the shape of the association between the independent variables and the dependent variable using a binary logistic regression. The option chosen was a step-by-step, explanatory model. The variables entered in the multi-variable model were those with a p-value ≤ 0.1 on univariate analysis. In the final model, collinearity between the variables was sought. The residuals (Pearson, standardised and deviance) were calculated to identify influencing values and outliers. The model's goodness of fit was checked with the Hosmer-Lemeshow test as well as its specification (linktest). The model was adequate for a p-value > 0.05. The significance level retained was 5% for all the tests.

Results

Sociodemographic and economic characteristics of the subjects

Apart from gender, the socio-demographic characteristics of motorbike riders traumatised in road accidents who experienced a head injury were not different from those of riders who did not experience a head injury (Table 1). The majority of study subjects were male in both groups: 93.4% in the group with head injuries versus 88.6% in the subjects without head injuries ($p < 0.05$). The mean age of the subjects did not differ in the two groups (35.7 ± 12.8 years for those with head injuries versus 36.7 ± 12.1 years for those without head injuries). However, although the difference was not significant, the proportion of women under 30 with head injuries was greater compared to that of men (Fig. 3). The Fon or related ethnic group (64.4% in the cases and 70.4% in the controls) was the most represented. The majority (about 83%) of the cases and controls were in employment. Married subjects were more numerous in both groups. The average household size was around 5 people and the number of dependent children under 18 was on average 2 in both groups. The mean BMI was normal in both groups at around 23 kg/m^2.

Table 1
Distribution of trauma victims in the TraumAR cohort according to socio-demographic and economic factors

Variables	**Head injuries (% or Mean ± sd)**		**p-value**
	Yes (n = 242)	**No (n = 484)**	
Sex			0,042
Female	6,6	11,4	
Male	93,4	88,6	
Ethnic group			0,102
Bariba	8,3	6,2	
Dendi	2,5	3,3	
Fon and related	64,4	70,4	
Peulh	7,0	2,9	
Nago and related	11,6	12,2	
Other ethnicities	6,2	5,0	
Professional situation			0,455
Unemployed	2,1	3,9	
In employment	82,6	83,3	
Training	15,3	12,8	
Employment sector			0,615
Public or denominational	12,6	11,2	
Private	87,4	88,8	
Marital status			0,922
Single	30,6	29,3	
Married or engaged	66,9	68,4	
Divorced or widowed	2,5	2,3	
BMC	23,4(3,8)	23,7(3,5)	0,329
Age	35,7(12,8)	36,7(12,1)	0,278
Household size	5,0(2,6)	4,9(2,8)	0,633
Number of children < 18 years	2,0(1,7)	1,9(1,6)	0,308

Attitudes and behaviours of motorcycle riders

The majority of the study subjects wore helmets, but the proportion was higher in the group without head injuries (90.3% vs. 69.8%; p = 0.000) (Table 2). In addition, the proportion of women wearing helmets exceeded that of men (Fig. 4). More subjects who had a head injury (cases) drove in a state of fatigue or drowsiness than the controls (16.9% vs 9.3%; p = 0.003). Very few subjects regularly adopted certain risky behaviours such as distracted driving or using the telephone while driving. Of the subjects who had head injuries, 3.3% were using their phones at the time of the accident compared to only 0.8% of those who did not have head injuries (p = 0.01). In contrast, there was not a significant difference between the two groups with regard to distracted driving (16.1% of those with head injuries versus 13.8% of those without head injuries) (Table 2).

Table 2
Distribution of trauma victims in the TraumAR cohort according to behavioural factors

Variables	**Head injuries (% or Mean ± sd)**		**p-value**
	Yes (n = 242)	**No (n = 484)**	
Helmet use			0,000
Yes	69,8	90,3	
No	30,2	9,7	
Distracted during the accident			0,414
Yes	*Yes*	*Yes*	*Yes*
No	*No*	*No*	*No*
Telephone use during the accident			0,014
Yes	3,3	0,8	
No	96,7	99,2	
Fatigue/drowsiness during the accident			0,003
Yes	16,9	9,3	
No	83,1	90,7	

Road and environmental factors

Almost half of the subjects' accidents occurred during the day (45.9% for those with head injuries compared to 54.5%). Other involvement in the accident was more often a moving vehicle, both for the subjects with head injuries (67.8%) and those without (78.5%). However, the cases had more accidents where there was no other involvement compared to the controls (p = 0.017). Overall, visibility during the crashes was good (64.5% among cases versus 76.3% among controls). The subjects who had head injuries had more accidents when the level of visibility was medium or poor ($p = 0.003$). The weather conditions during the accident were good in more than 91% of cases for both the subjects who had head injuries and those who did not. Generally, the road surface was in good condition at the time of the accident (78.9% for those with head injuries compared to 79.6% for those without). More than half of the accidents occurred in alleyways (57.3% for all subjects). The occurrence of head injuries did not depend on the time of day, weather conditions, road conditions, and even less on the type of road on which the accident occurred (Table 3).

Table 3
Distribution of trauma victims according to factors related to the road and the environment

Variables	**Head injuries (% or Mean ± sd)**		**p-value**
	Yes (n = 242)	**No (n = 484)**	
Type of road			0,370
National Inter-State Road	18,6	13,8	
Rural track	5,8	5,2	
National road	21,5	22,1	
Alley	54,1	58,9	
Road condition			0,857
Good	78,9	79,6	
Poor	17,4	16,1	
Under construction	3,7	4,3	
Other involvement			0,017
No	18,6	11,8	
Stationary vehicles or obstacles	6,6	4,3	
Moving vehicles	67,8	78,5	
Pedestrians, animals or moving objects	7,0	5,4	
Weather conditions			0,925
Good	91,7	91,5	
Bad	8,3	8,5	
Visibility			0,003
Good	64,5	76,2	
Acceptable	14,4	11,0	
Poor	21,1	12,8	
Time of day			0,070
Dusk	14,9	15,1	
Dawn	6,2	6,2	
Day	45,9	54,5	

Variables	Head injuries (% or Mean ± sd)		p-value
	Yes (n = 242)	No (n = 484)	
Night	33,0	24,2	

Motorcycle rider history

The percentage of head trauma patients with a medical history was 11.2% and 19.8% for the cases and the controls, respectively (p = 0.003). The use of sleeping pills, stimulants or tobacco was infrequent among both the cases and the controls. For sleeping pills, this consumption was less than 3% in the two groups. The consumption of stimulants varied between 5% in the subjects with head injuries and 6.2% in the subjects without head injuries. Tobacco was consumed by 10.7% of the cases versus 12% of the controls. Consumption of alcoholic beverages was common (65.3% in the subjects with head injuries versus 67.8% in the subjects without head injuries). Driving experience was approximately 16 years in both groups. More than a third of the subjects had already been in a traffic accident before the current accident (39.2% versus 35.3%). There was no difference between the two groups regarding the consumption of the different substances, their years of driving experience or their history of traffic accidents (Table 4).

Table 4

Distribution of trauma victims in the TraumAR cohort according to history

Variables	Head injuries (% or Mean ± sd)		p-value
	Yes (n = 242)	No (n = 484)	
Medical history			0,003
Yes	11,2	19,8	
No	88,8	80,2	
History of traffic accidents			0,301
Yes	39,3	35,3	
No	60,7	64,7	
Sleeping pill consumption			1,000
Yes	2,9	2,9	
No	97,1	97,1	
Consumption of stimulants/doping substances			0,500
Yes	5,0	6,2	
No	95,0	93,8	
Consumption of alcoholic beverages			0,503
Yes	65,3	67,8	
No	34,7	32,2	
Tobacco consumption			0,623
Yes	10,7	12,0	
No	89,3	88,0	
Motorcycle riding experience (years)	15,6(10,4)	16,8(10,2)	0,156

Factors associated with traumatic brain injury

The factors associated with head injuries in two-wheel motorcycle riders in Benin are: wearing a helmet, driving while tired or drowsy, and a medical history. Considering the medical history and the notion of driving in a state of fatigue, subjects who did not wear helmets were at greater risk of head injuries than those who wore helmets (OR = 3.8 (95% CI = 2.5–5. 7)). Individuals driving in a state of fatigue were 2.0 (95% CI = 1.2–3.2) times more likely to have head injuries than those who did not drive in a state of fatigue, taking into account helmet wearing and medical history. Adjusting for the other variables, subjects with no medical history were 2.1 (95% CI = 1.2–3.3) times more likely to have head injuries compared to those with a medical history (Table 5).

Table 5

Factors associated with head injuries in trauma patients in the TraumAR cohort, in univariate and multivariate analysis

Variables	OR (IC à 95%)	ORaj (IC à 95%)
Helmet use		
Yes	1	1
No	4,1 (2,7–6,0) ***	3,8 (2,5–5,7) ***
Fatigue/drowsiness during the accident		
Yes	1	1
No	2,0 (1,3–3,1) **	2,0 (1,2–3,2) **
Medical history		
Yes	1	1
No	2,0 (1,2–3,1) **	2,1 (1,2–3,3) **
Sex		
Female	1	
Male	1,8 (1,0–3,2) **	
Telephone use during the accident		
Yes	1	
No	4,1 (1,2–13,8) **	
Other involvement		
No	1	
Stationary vehicles or obstacles	1,8 (1,2– 2,8) **	
Moving vehicles	1,8 (0,9–3,5) *	
Pedestrians, animals or moving objects	1,5 (0,8–2,9)	
Time of day		
Dusk	1	
Dawn	1,2 (0,7–1,9)	
Day	1,2 (0,6–2,3)	
Night	1,6 (1,1–2,3) **	

* P < 0.1; ** P < 0.05; *** P < 0.001.

Variables	OR (IC à 95%)	ORaj (IC à 95%)
Visibility		
Good	1	
Acceptable	1,6 (1,00–2,5) *	
Poor	1,9 (1,3–3,00) **	
* P < 0.1; ** P < 0.05; *** P < 0.001.		

Discussion

Driver characteristics

The motorcycle riders in this study were relatively young, which is consistent with the findings of the WHO and several authors who have pointed out that young people are most affected by road traffic injuries (1, 4, 7, 21–23). Thus, in their multicentre study, Lam et al. obtained a mean age of 37.7 years among light motorcycle riders (24). This same trend was observed by Xiong et al. in China (25) and by Brown et al. who noted that the average age of motorcycle trauma victims involved in road accidents is 38 years (14). In Benin, Hodé et al. as well as Tidjani et al. obtained a mean age of 33 years, while Chalya et al. found a median age of 26 years (18, 19, 26). Tumwesigye et al. also noted in Kampala, Uganda, that more than half of motorcycle taxi drivers, among both the cases and controls, were between 25 and 34 years old (7). As observed in our study, others have noted that the majority of motorcycle trauma victims are men (14, 18, 19, 24, 25, 27–29). The majority of the cases and controls were married (70.7% vs. 67.30%) and there was no difference between the two groups. Tumwesigye et al. also observed a high proportion of married drivers (66% vs 81%) but, unlike in our study, there was a significant difference in favour of the controls (7). The proportion of subjects wearing a helmet is much higher than that observed among drivers and passengers of motorbike riders who had head injuries in Benin in 2013 (3.5%), and even in 2014 when this rate rose to 34.5% with the enforcement of the helmet law. This shows that the wearing of helmets by motorcycle riders in Benin has improved over the years thanks to enforcement of the law and awareness raising. The reduction of the risk of head injuries in road accidents among motorcyclists by wearing helmets has been demonstrated by WHO and several authors (2, 11, 12, 17).

Factors associated with head injuries

Our study confirmed that in Benin, motorcycle riders traumatised in road accidents while wearing helmets were less likely to have head injuries. Several other authors have come to similar conclusions (14, 30, 31). For instance, using hospital data from four hospitals in Kenya, Bachani et al. noted that subjects wearing helmets had a lower risk of head trauma (OR = 0.478) than those who did not (30). The same result was found by Kamulegeya et al. in Kampala among motorcycle taxi drivers. Drivers who did not wear helmets were 2.3 times more likely to have head injuries than those who did (p = 0.004) (31). Singleton found this significant association, regardless of the type of head injury (uncomplicated concussion, brain contusion, intracranial haemorrhage and skull fracture) (15). Brown et al. and Phillips et al. observed in the USA that different lesions with intracranial trauma were significantly more present in subjects not wearing a helmet than in those who did (14, 32). For other authors, there was a relationship between injury severity (AIS) and helmet use (24–26, 33), and not wearing a helmet would increase the risk of sustaining road traffic injuries (7) or the risk of death from road accidents among motorcyclists (34, 35).

Bachani et al. found other factors, such as the time of day of the accident, and the age and type of user (30). Like Bachani et al., both Xiong et al. and Lam et al. reported age as a factor (24, 25). These factors were not found in our study. Baru et al. also found the time of day of the accident and the consumption of alcohol to be factors of accident severity (33). In our study, neither the time of day of the accident nor alcohol consumption were factors associated with the occurrence of head injuries. As in our study, Kamulegeya et al. did not observe an association between the occurrence of head injuries and ethnicity, but they found other involvement in the accident as an association factor (31). The influence of other involvement and/or the cause of the accident was also identified by Xiong et al. and Lam et al. in factors associated with severe injury in road traffic injuries. These authors also found other factors such as visibility and fatigue while driving (24, 25). In our adjusted model, fatigue was associated with the occurrence of head injuries in our study.

Limitations Of The Study

The data was collected in five hospitals that are not necessarily representative of the country. Many data were collected from the casualties, so there is a possibility of information bias related to the fact that all of these variables were entered based on the declarations of the targets. The retrospective nature of some data can also cause recall bias. In addition, the reluctance of some people to give their personal information resulted in some missing data, especially regarding certain behavioural variables such as the consumption of alcohol or psychoactive substances before driving, respect for signs and priorities, excess speed, etc.

Conclusion

This study showed that not wearing a helmet is one of the main risk factors for the occurrence of head injuries in motorcycle riders in a road accident along with other behavioural factors, such as driving while fatigued, or non-behavioural factors, such as medical history.

In view of these results, helmet wearing should continue to be enforced in Benin and extended to motorcycle passengers. Motorcyclists should be educated to avoid riding in a state of fatigue.

Abbreviations

WHO
World Health Organization

Declarations

Ethics approval and consent to participate

This study is part of a doctoral thesis. The thesis project is submitted to the ethics committee of the University of Parakou (Benin). The free and informed written consent of all subjects included in the study was obtained. The data was treated confidentially.

Consent for publication

Not applicable.

Availability of data and materials

The data and materials of this study will be available from the main author, but also from the ReMPARt project. To have access to these data, contact the main author.

Competing interests

The authors state that there is no competing interest.

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Authors' contribution

BHDS designed the study and wrote the article. DD and BHDS set up the TraumAR cohort. YGA and AK coordinated the set-up of the cohort. YGA, AK, EL and IC helped design the study. All authors have amended the article and approved its final version.

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Figures

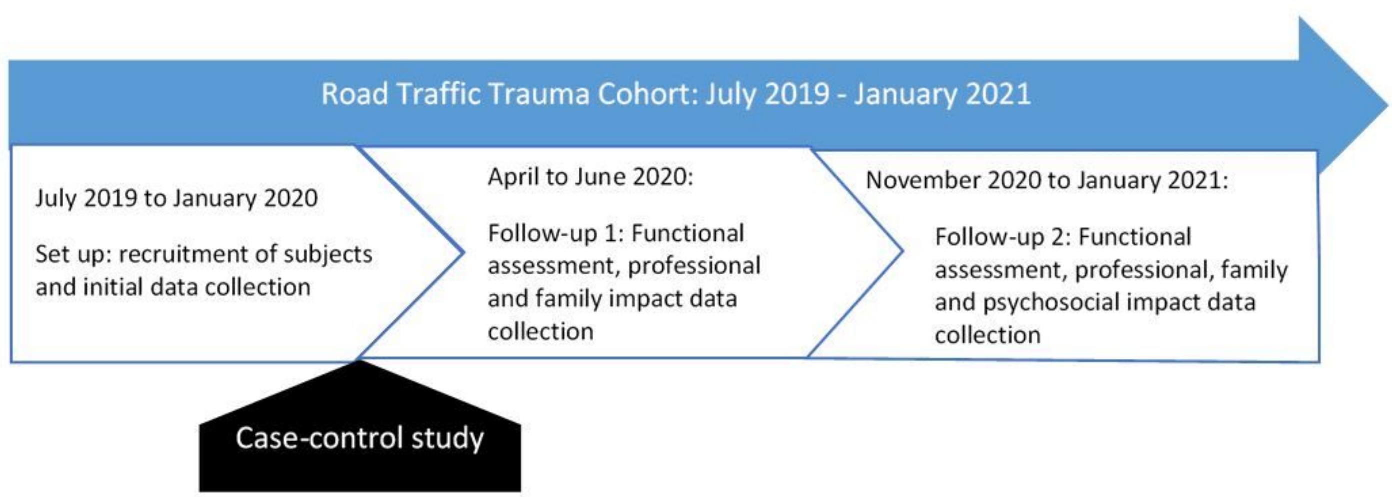


Figure 1

Positioning of the case-control study in the cohort

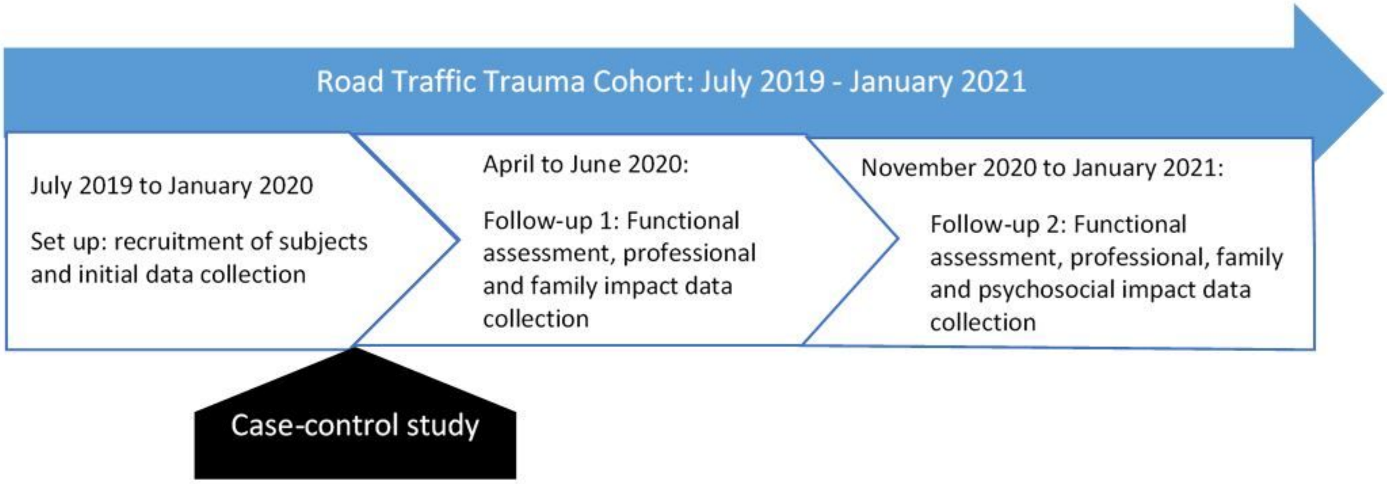


Figure 1

Positioning of the case-control study in the cohort

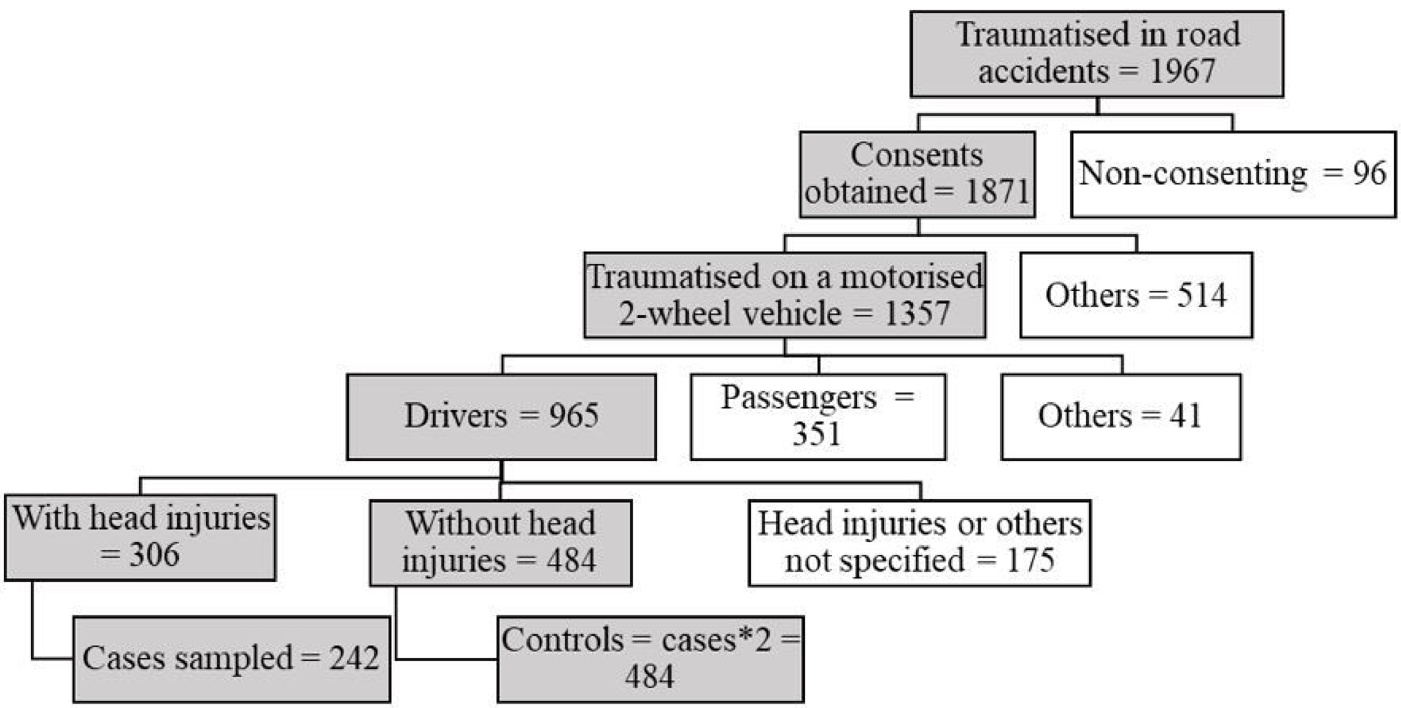
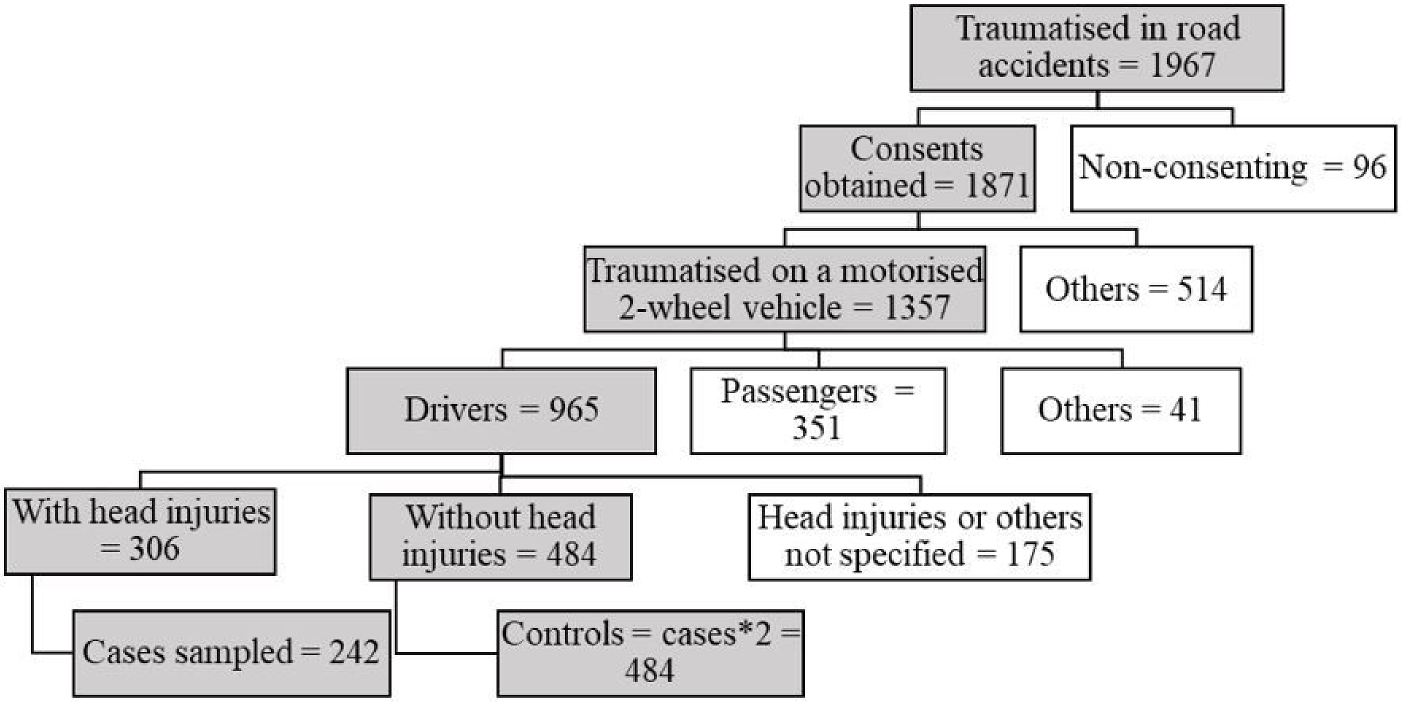


Figure 2

Selection process for cases and controls in the TraumAR cohort (non-eligible records have a white background)



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Selection process for cases and controls in the TraumAR cohort (non-eligible records have a white background)

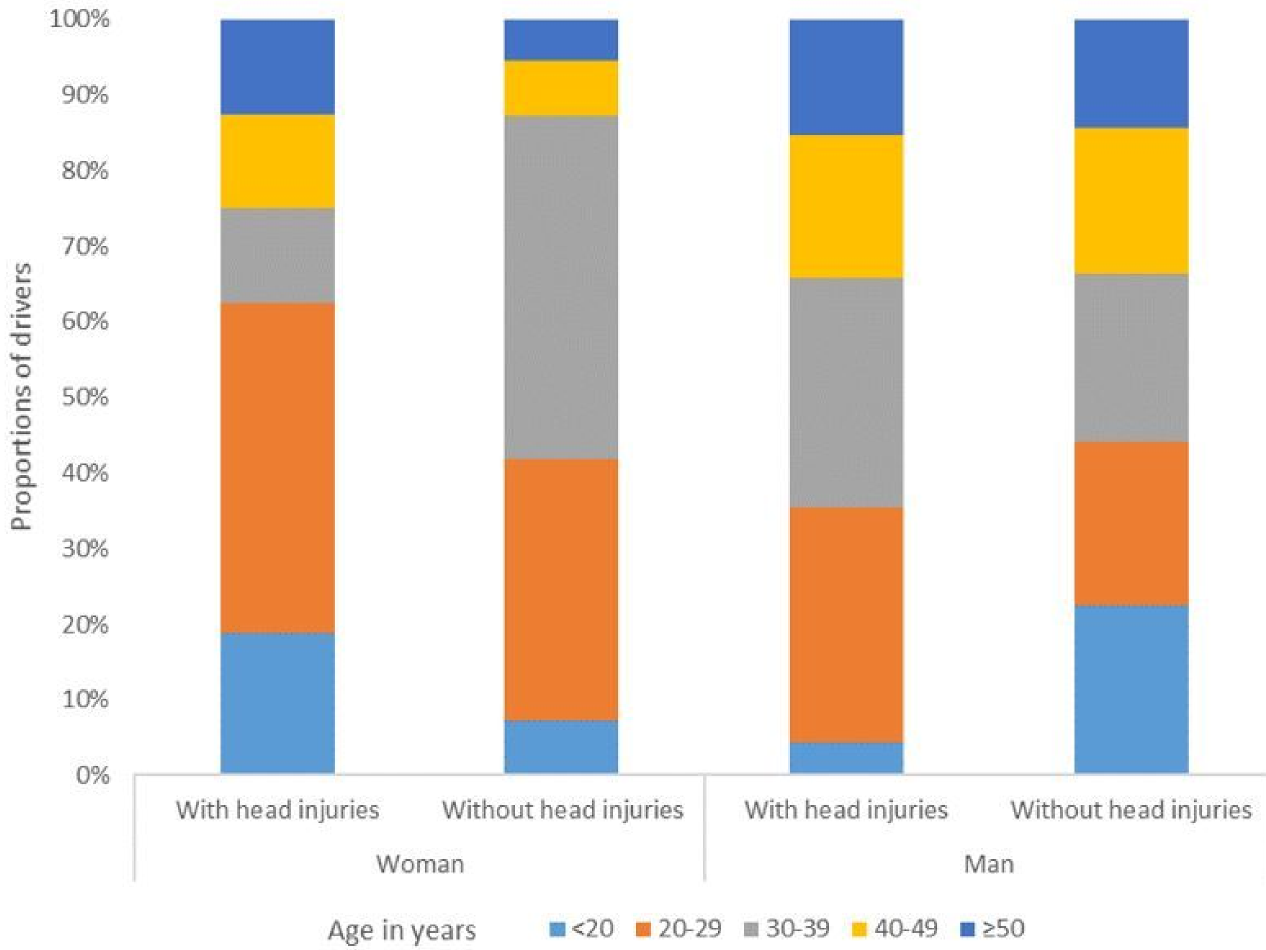
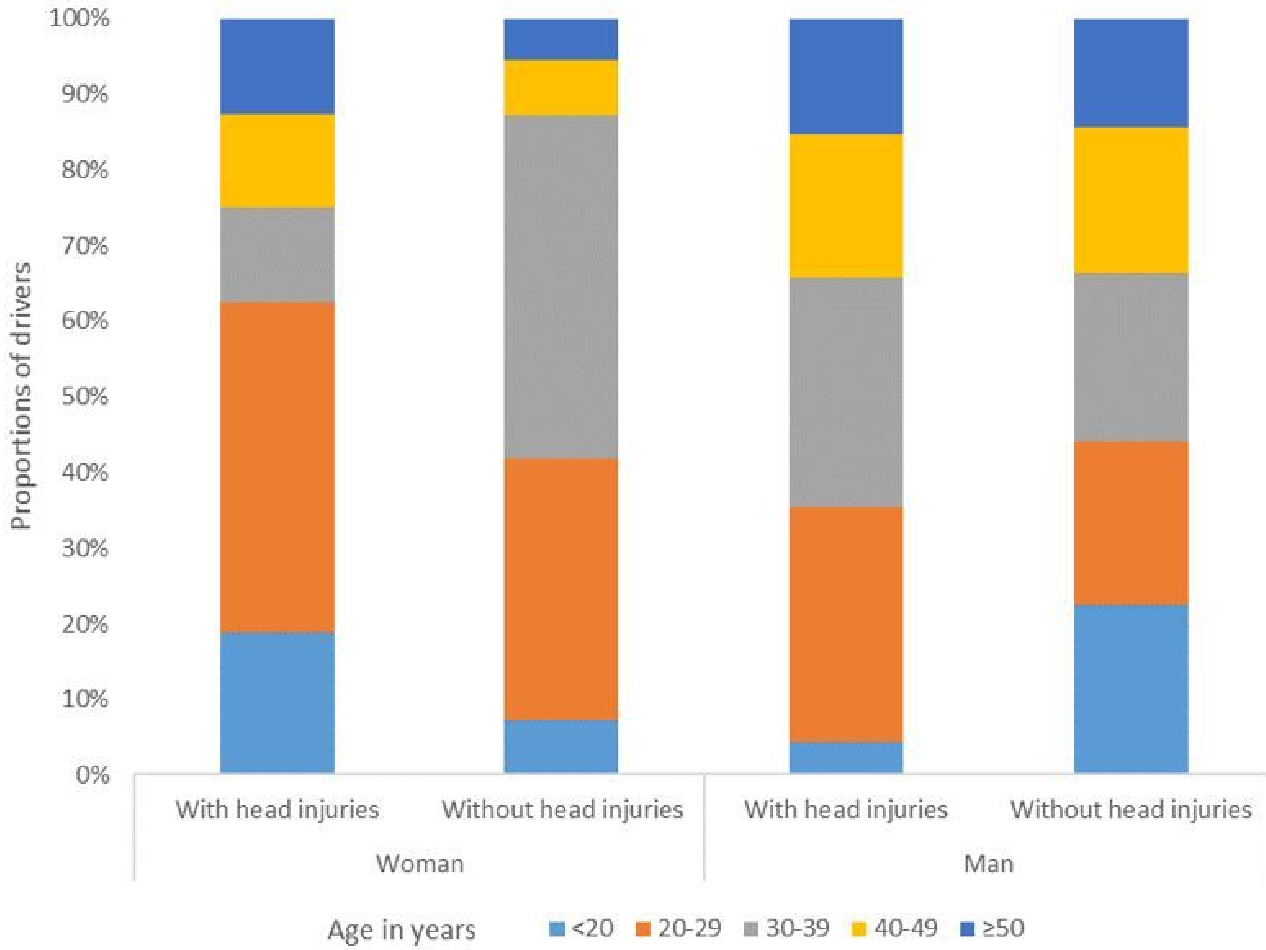


Figure 3

Distribution of cases and controls according to their sex and age



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Distribution of cases and controls according to their sex and age

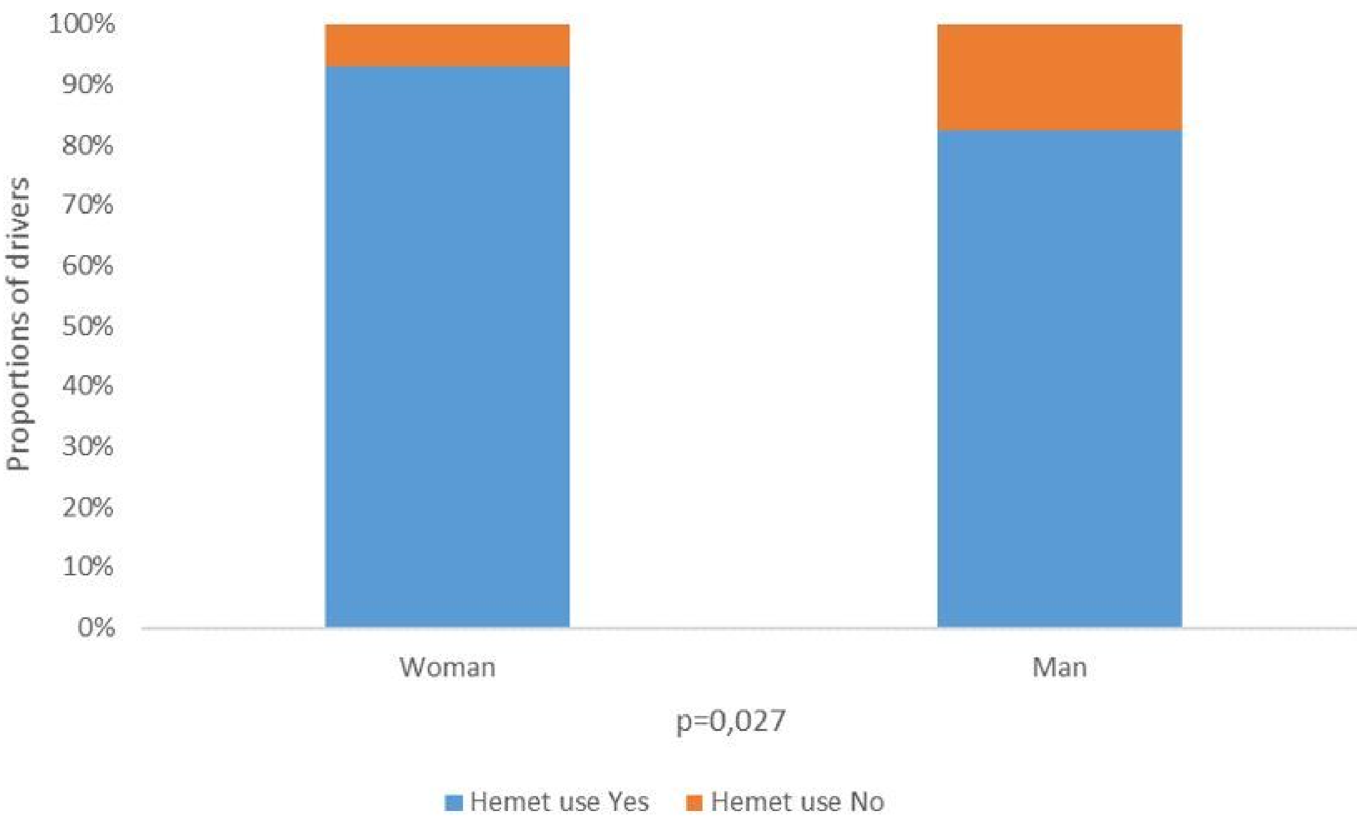
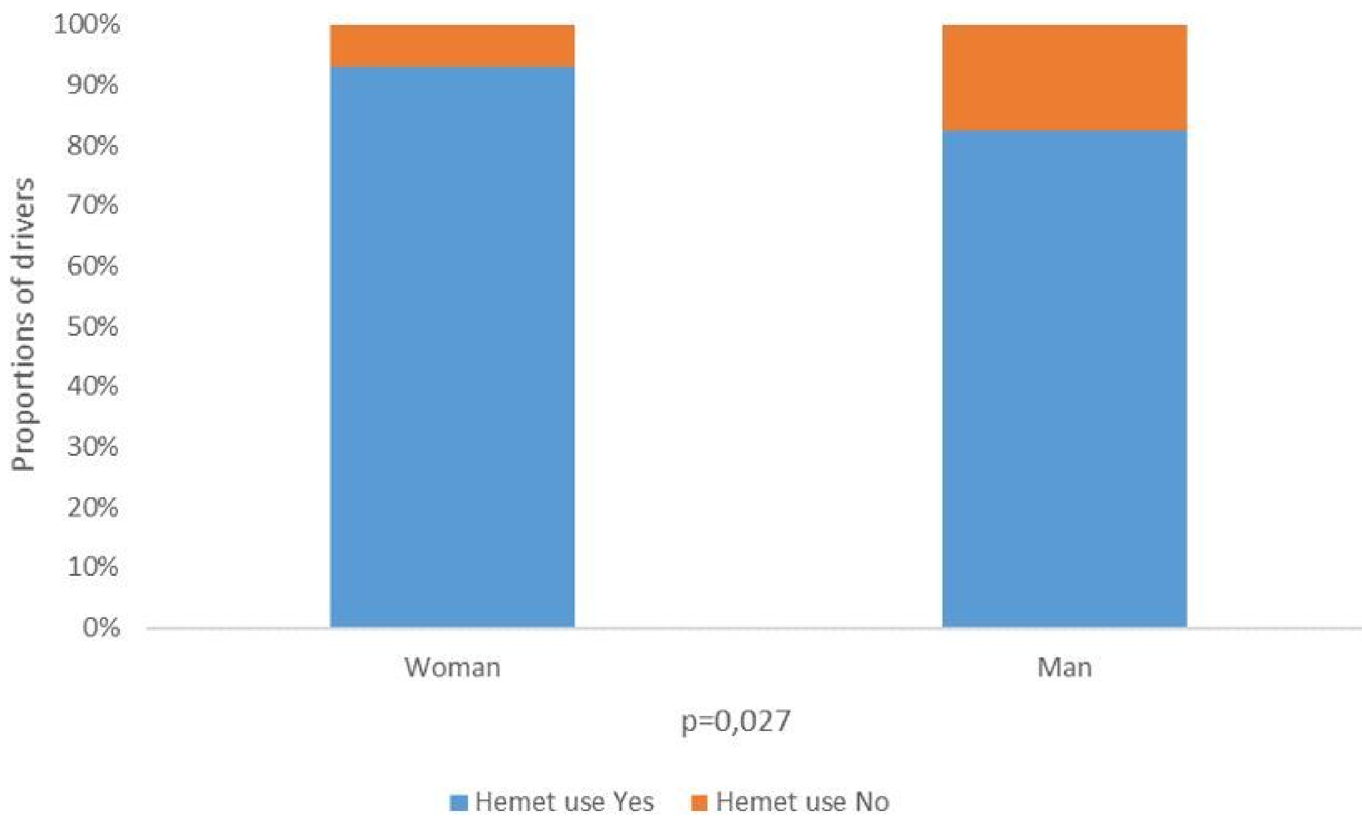


Figure 4

Distribution of drivers by sex and helmet use



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