

MODELING MOTORCYCLE ACCIDENT SEVERITY IN THE PHILIPPINES USING HELMET USE, RIDING EXPERIENCE, AND DRIVING BEHAVIOUR

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Abstract: The study aims to characterize motorcyclists' behaviour in the Philippines and its relationship in predicting the type of injury sustained during an accident. It is hypothesized that violations are likely predictors of serious injury. A survey questionnaire was used to gather data on accident experience and severity, demography, driving experience, and helmet use. Driver behaviour was characterized using the Manchester Driver Behaviour Questionnaire. Logistic regression (LR) was used to model the chance of suffering from serious or minor injury during a MC accident. Significant predictors of serious injury are drunk driving, non-usage of helmets, and underestimating the speed of oncoming vehicle when overtaking. The first two are violations that have already been addressed enactment of laws. However, current behaviour showed that these laws did not change the behaviour of MC riders as expected. Results indicate that the use of helmets had been effective because most of the injuries were concentrated in the lower limbs. The length of MC driving experience did affect the seriousness of injury.

Keywords: motorcycle accident, Manchester driver behaviour questionnaire, logistic regression, crash typing.

1. Introduction

The rise in MC ownership in the Philippines led to the increase in the number of accidents related to its use. From 2004-2006, around 6.7% of trauma admission at the Philippine General Hospital (PGH) are victims of MC accidents (Consunji et al., 2013) and in a case study conducted in 2013 at the Manila Doctors Hospital 40.4% of injuries in the sample of 156 patient records were related to MC accidents (O'Connor and Ruiz, 2014).

MC riders get involved in different kinds of accidents ranging from minor to fatal ones. Although the reported number of accidents involving MCs in the Philippines show an increasing trend, it is believed that there are many instances that remain unreported especially minor ones. Local authorities only get involved when the accident is fatal or related to another vehicle. Thus, the nature and causes of minor MC accidents remain unknown. In the Philippines, the Metro Manila Accident Reporting and Analysis System (MMARAS) gathers data on traffic

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accidents. Fatalities and injuries are recorded but data on MCs are not segregated for further analysis.

A comparative study of different vehicle users showed that MC riders are likely to experience craniocerebral injuries during accidents (Markogiannakis *et al.*, 2006). Data collected from 70 countries on MC riders showed that the primary contributor to death rates is the helmet non-usage percentage (Abbas *et al.*, 2012). Thus, many countries enforce a helmet law to protect MC riders. Studies showed that use of helmets is associated with reduced mortality due to head and neck injury (Crompton *et al.*, 2010; Rice *et al.*, 2016). However, poor implementation of the law and the use of substandard quality of helmets adversely affect injury prevention. The use of novelty helmets that are lightweight and do not have energy absorbing liner may not give adequate protection against head injury (Erhardt *et al.*, 2016).

The Philippine government has effected the Mandatory Helmet Act in 2010 that penalizes MC riders not using helmets. The Bureau of Product Standards was also mandated to test helmets that are sold in the country (Malig, 2010). Only helmets that have the Philippine Standard (PS) mark or the Import Commodity Clearance (ICC) provided by the Department of Trade and Industry (DTI) must be used. From a survey conducted by the Metro Manila Development Authority (MMDA), 98% use helmets but only 57% use it properly and 42% did not pass the helmet standards set by authorities (World Health Organization, 2016). The Land Transportation and Traffic Code of 1991 also prohibits driving under the influence of liquor and narcotics. The effectiveness of these interventions has yet to be evaluated.

The limited experience in riding a MC had been attributed by many researchers to accidents. A study of MC accidents in a hospital in Brazil showed that young riders with less than 5 years of experience are more likely to encounter accidents (Zabeu *et al.*, 2013). The same pattern was also observed among young riders in Norway (Bjornskau *et al.*, 2012). Driving experience alone does not determine safe driving as Crundall (2013) discovered that MC riders with advance training had the fastest hazard response times compared to experienced riders. Similarly, Di Stasi *et al.*, (2011) concluded that training improved the riding ability of novice users. Magazzu *et al.*, (2006) also found out that MC riders that have experience driving cars are more likely to drive safely because of empathy.

In order to identify other methods of improving MC rider safety in the Philippines, the causes and circumstance of accident must be investigated further using current and unbiased data. The earlier claim that MC accidents are underreported in MMARAS was confirmed by the fact that in 2009, only 7% of accidents was attributed to MCs although most of them were fatal (Metro Manila Development Authority, 2011).

One way of analyzing the how and why of an accident is by means of crash typing (Preusser *et al.*, 1995). This type of analysis groups crash events based on causes such as driver behaviour, environment, and vehicle movement. Crash typing can determine the factors relevant to a crash type so that more appropriate laws for minimizing fatal accidents can be considered.

This study aims to characterize MC driver behaviour in the Philippines and its relevance in predicting the type of injury sustained

during an accident. It is hypothesized that violations are likely predictors of serious injury. Driver behaviour refers to lapses, errors, and violations (Lajunen *et al.*, 2004). They can further be broken down into speeding violation, traffic errors, control errors, inattention errors, use of safety equipment, and stunts. The lack of data that characterizes driving behaviour of Filipinos at the moment makes it difficult for local authorities to identify appropriate interventions to prevent road accidents. The current study may be useful in creating awareness on the contribution of certain behaviours to major accidents. The data obtained in the study may also be used to contextualize the training programs given to MC drivers by companies and rider associations.

2. Method

2.1. Survey Questionnaire

Participants were interviewed using a questionnaire. They were asked regarding personal information, type of injury, MC experience, use of helmet, cause of accident and response to the Manchester Driver Behaviour Questionnaire (Lajunen *et al.*, 2004). The internal reliability of the questionnaire was measured using Cronbach's alpha and the computed value is 0.86. The MDBQ is a widely-used instrument for self-reported driving behaviour in literature including MC riders (Bener *et al.*, 2007; Lajunen and Summala, 2003; Özkan *et al.*, 2006). It measures three aspects of behaviour: errors (E), lapses (L) and violations (V). The questionnaire was translated into the vernacular so it will be

easier for the interviewees to understand the questions. The questionnaire was piloted to determine if the questions had been appropriately translated and understood by potential survey respondents.

Data were collected from a convenience sample of MC riders in Metro Manila. Only drivers with at least one year experience in driving an MC were included in the survey. The survey method was chosen so that even minor accidents can be considered unlike the data reported in the MMARAS. For drivers who have encountered multiple accidents, the most severe accident encountered was asked to be recalled during the interview.

2.2. Variables and Measurements

In this study, there is only one response variable which is the type of injury sustained by the driver. Injuries were classified as serious and minor. Serious injury involves being hospitalized or failing to report for work for at least two days. Minor injury, on the other hand, involves having scratches, sprain, and small wound that do not hinder a person from working.

Independent variables used in the study include MC driving experience, helmet use, and response to the Manchester Driver Behaviour Questionnaire (MDBQ). The list of independent variables and their codes in the model are summarized in Table 1. Driving experience is quantified in years while helmet use is a categorical variable with three levels, namely; 1-never, 2-occasional and 3-all the time. Variables X_3 - X_{29} are responses to the MDBQ using a 6-point scale from 1-never to 6-nearly all the time.

Table 1
Independent Variables

Code	Behaviour Type	Independent Variable
X1		Driving experience
X2		Helmet use
X3	L	Hit something when reversing that you had not previously seen.
X4	L	Intend to drive to destination A, you “wake up” to find yourself on the road to destination B.
X5	V	Drink and drive
X6	L	Get into the wrong lane approaching a roundabout or a junction.
X7	E	Queue to turn left onto a main road, you pay such close attention to the main stream of traffic that you nearly hit the vehicle in front of you
X8	E	Fail to notice that pedestrians are crossing when turning into a side street from a main road.
X9	V	Sound your horn to indicate your annoyance to another road user or pedestrian.
X10	E	Fail to check your side-view mirrors before pulling out, changing lanes, etc.
X11	E	Brake too quickly on a slippery road or steer the wrong way in a skid.
X12	V	Pull out of a junction so far that the driver with right of way has to stop and let you out.
X13	V	Disregard the speed limit on a residential road.
X14	L	Switch one thing, such as the headlights, when you meant to switch on something else, such as the signal lights.
X15	E	Turn left or right nearly hitting a vehicle beside you.
X16	V	Swerve from one lane to another.
X17	V	Attempt to overtake someone that you had not noticed to be signaling a turn.
X18	V	Become angered by another driver and give chase with the intention of giving him/her a piece of your mind.
X19	V	Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane
X20	L	Forget where you left your motorcycle or you left the keys on the ignition.
X21	V	Overtake a slow vehicle by passing thru narrow spaces on its sides and front.
X22	V	Race away from traffic lights with the intention of beating the vehicle next to you.
X23	L	Misread the signs and exit from a roundabout on the wrong road.
X24	V	Drive so close to the vehicle in front or beside that it would be difficult to stop in an emergency and to maneuver.
X25	V	Cross a junction knowing that the traffic lights have already turned against you.
X26	V	Become angered by a certain type of a driver and indicate your hostility by whatever means you can.
X27	L	Realize that you have no clear recollection of the road along which you have just been traveling.
X28	E	Underestimate the speed of an oncoming vehicle when overtaking
X29	V	Disregard the speed limit on a motorway

2.3. Participants

Three hundred participants were recruited for the study. They were not given any incentive to respond to the survey. They are MC riders that have at least one year experience. Ninety-one percent (91%) of

participants were male and about half of them are single. The youngest participant is 16 years old while the oldest is 75. The average age is 32 years. Seventy eight percent (78%) of them encountered at least one accident in the past and suffered either minor or serious injury.

2.4. Procedure

Participants were recruited from all over Metro Manila. Prospective participants were courteously asked about the length of their experience as MC drivers in order to exclude those with less than one year experience. They were asked about their interest to participate in a safety survey and were assured that their responses will be kept confidential. Only 50% of all drivers approached expressed willingness to answer the survey.

Drivers who agreed to participate were briefed regarding the overall objective of the survey and were asked to recall the most serious accident they experienced while riding the MC. Those without accidents were also allowed to answer the survey. A briefing script was prepared to ensure the uniformity of instructions.

Three hundred drivers participated in the survey but only 233 encountered accidents and were injured. All willing participants were interviewed using the survey form developed in both English and Filipino.

2.5. Statistical Model

Logistic regression (LR) was used to model the chance of suffering from serious or minor injury during a MC accident. The logistic regression model was deemed appropriate for

analyzing the results because the dependent variable is categorical with only two levels (DeMaris, 1992). In this LR model, the “event” predicted is a serious injury. The dependent variable INJS estimates the odds (logit) of a serious injury expressed in Eq. (1):

$$INJ_s = \hat{\beta}_0 + \hat{\beta}_1 X_1 + \hat{\beta}_2 X_2 + \dots + \hat{\beta}_n X_n \quad (1)$$

The model’s goodness of fit was ascertained using Hosmer- Lemeshow (HL) test that follows chi- square distribution (Hair *et al.*, 2010). As such, the p-value must be large to indicate the model’s capability to predict actual outcome.

3. Results

3.1. Profile of Participants

The average experience of participants is 8.1 years with a maximum of 40 years. Table 2 shows the relationship between type of accident and frequency of helmet use. It can be seen that most participants (61%) encountered only minor injuries and majority (62%) always wore helmet. Of those not wearing helmets, the most common reason given is uncomfortable, hot, and heavy (74%). Those who wore helmets complied mainly due to safety reasons (80%) and the Helmet law (20%) recently implemented. Only one participant had training on safe and proper MC riding.

Table 2
Contingency Table for Helmet Use

	All the time	Sometimes	Never
Minor	37%	18%	6%
Serious	25%	12%	2%

3.2. MDBQ Statistics

Responses obtained from the MDBQ were categorized based on the type of injury sustained. Table 3 shows the means and standard deviation of ratings obtained per question. It can be seen that the average rating given to MDBQ ranged from 2 (hardly ever) to 3 (occasionally). Median rating obtained for all questions independent of injury is 2.

Considering the descriptive statistics obtained on MDBQ responses, majority of the respondents do not engage in risky behaviour.

Serious injury sustained are concentrated on the legs (36%) and knee (35%) while minor injuries were concentrated on the knee (48%). Head trauma was only suffered by 6% of participants with serious injuries.

Table 3
Descriptive Statistics for MDBQ Responses

CODE	Behaviour Type	Overall Mean	MINOR (n=142)		SERIOUS (n=91)	
			mean	SD	mean	SD
X3	L	1.75	1.73	0.64	1.78	0.71
X4	L	2.02	2.01	0.75	2.03	0.81
X5	V	2.33	2.21	0.82	2.51	0.89
X6	L	2.29	2.26	0.81	2.33	0.90
X7	E	2.28	2.31	0.82	2.24	0.91
X8	E	2.24	2.27	0.78	2.18	0.75
X9	V	2.52	2.54	0.88	2.51	0.96
X10	E	2.26	2.22	0.86	2.33	1.03
X11	E	2.06	2.06	0.74	2.08	0.76
X12	V	2.08	2.13	0.74	2.01	0.85
X13	V	2.54	2.48	0.93	2.64	0.91
X14	L	2.12	2.15	0.81	2.08	0.78
X15	E	2.37	2.40	0.71	2.33	0.68
X16	V	2.46	2.46	0.85	2.46	0.97
X17	V	2.28	2.22	0.81	2.38	0.83
X18	V	2.06	2.04	0.72	2.08	0.81
X19	V	2.18	2.15	0.70	2.22	0.85
X20	L	2.26	2.31	0.88	2.18	0.84
X21	V	2.34	2.32	0.81	2.37	0.86
X22	V	2.33	2.25	0.79	2.45	0.85
X23	L	2.11	2.11	0.68	2.11	0.81
X24	V	2.26	2.28	0.74	2.23	0.82
X25	V	2.22	2.23	0.78	2.20	0.73
X26	V	2.26	2.22	0.78	2.33	0.80
X27	L	2.09	2.10	0.82	2.07	0.80
X28	E	2.16	2.08	0.73	2.29	0.79
X29	V	2.38	2.30	0.99	2.52	1.12

3.3. Causes of Accident

Participants were asked for the cause of accident and as shown in Table 4, the most common reason is recklessness in driving. This is closely followed by environment-

related factors such as unsafe road conditions, poor street lighting at night, presence of humps and potholes and sudden appearance of road distractions. Only 9% of participants attributed their accident to drunk driving and 4% to poor vehicle maintenance.

Table 4
Causes of Accidents

Causes	Percentage
Reckless	23
Environment	22
Slipped on the road	17
Other Drivers	12
Drunk	9
Personal	6
Poor vehicle maintenance	4
Total	100

3.4. Logistic Regression

The estimated coefficients, standard error, and odds ratios of the logistic regression model is shown in Table 5. Outcome of logistic regression showed that the use of helmet, drinking and driving (X5), driving so close to the vehicle in front or beside that it would be difficult to stop in an emergency and to maneuver (X24), and underestimating the speed of an oncoming vehicle when

overtaking (X28) are significant variables in the model (LLL=-145.4, G=20.77, df=6, $p < 0.01$). Hosmer-Lemeshow test yielded a p-value of 0.208.

The base level used for helmet in the model is wearing it all the time. The negative parameter estimate indicates that occasional and not wearing helmets when riding a MC affect the chance of suffering from serious injury.

Table 5
Estimated Coefficients, Standard Error, and Odds Ratios of Reduced Logit Model

Variable	Estimated Coeff	Std Error	p-value	Odds Ratio
Constant	-2.06	0.66	0.00	
Helmet (Occasional)	-0.14	0.32	0.65	0.86
Helmet (Never)	-1.43	0.64	0.02	0.24
X5 (drink and drive)	0.48	0.18	0.01	1.62
X22 (Race away from traffic lights with the intention of beating the vehicle next to you)	0.34	0.19	0.07	1.41
X24 (Drive so close to the vehicle in front or beside that it would be difficult to stop in an emergency and to manoeuvre)	-0.49	0.21	0.02	0.61
X28 (Underestimate the speed of an oncoming vehicle when overtaking)	0.42	0.20	0.03	1.53

The logit model obtained is shown in Eq. (2):

$$\text{LN}J_s = -2.06 - 1.43 \text{ Helmet (never)} + 0.48 X5 - 0.49 X24 + 0.42 X28 \quad (2)$$

4. Discussion

The result of the study confirmed earlier studies that wearing helmet reduces the injury of MC riders in case of accidents (Savolainen and Mannering, 2007). The studies done on helmets showed its effectiveness in the prevention of fatal injuries. Fatal injuries usually involved the head and face (Fernandes et al., 2013) but the injuries suffered by the injured participants in the current study were mostly in the knees and arms which are the most common site of most MC accidents (Wladis et al., 2002). Since most of the participants interviewed wore helmets head trauma incidence was very minimal at 6% of the total number of participants. Only a small percentage (8%) did not wear helmets at all. The high compliance in wearing helmets can be traced to the recently implemented Helmet Law. In a recent report of WHO on road safety the Philippines was given a rating of 6/10 on the enforcement of this law (World Health Organization, 2015). This was not the case in 2004-2006 when only 13% of MC accident patients admitted at PGH wore helmets (Consunji et al., 2013). The high significance and the negative coefficient of the variable "never wearing a helmet" in Table 5 indicates its detrimental effect in comparison to the base level (always wearing a helmet).

Although the mean ratings obtained from MDBQ were relatively low as can be seen in Table 3, riders tended to disregard speed limit on a residential road, sound horn to express disannoyance, swerve from one lane to another, and disregard speed limit

on a motorway. Since traffic condition in Metro Manila is very poor, MC riders try to find ways to inch their way through the traffic resulting in unsafe behaviour. Recklessness was cited by participants in the sample as the major cause of accident followed by the environment which refers to road condition, lighting, sudden appearance of other vehicles/pedestrians, etc. Drivers in Metro Manila are generally described as undisciplined. Rafael (2015) explained the discipline problem in the context of implementing road regulations in different parts of the Metro. Different areas have unique traffic regulations and the manner in which authorities perform their duties influence the road behaviour of motorists.

Participants who frequently drove under the influence of alcohol suffered serious injury. Previous studies suggest that MC riders are more likely to have consumed alcohol during accidents than other vehicle drivers (Maistros et al., 2014; McLellan et al., 1993). Most fatal MC accidents also involved the use of alcohol (Williams and Hoffman, 1979) including the Philippines (Libres et al., 2008). According to the Motorcyclists' Rights Organization (MRO) and the Philippine National Police drunk driving is the top reason for MC accidents in Metro Manila (Imperio, 2015; Zurbarano, 2016). Prior to the Anti-Drunk and Drugged Driving Act of 2013 driving under the influence of alcohol was not considered a traffic violation because there were no mechanisms to define it (O'Connor and Ruiz, 2014). The law on drunk driving was only implemented in 2015 upon procurement of breath analyzers to conduct spot checks of drivers (Francisco, 2015). The law is quite new and poorly implemented so many MC riders are not frightened to drive under the influence of alcohol. The World Health

Organization gave the Philippines a rating of 1 out of 10 in the enforcement of this law in 2015 (World Health Organization, 2015).

Participants that underestimated the speed of oncoming vehicles when overtaking are more likely to suffer serious injury. Such miscalculation will cause the MC to crash with the oncoming vehicle and the severity increases in relation to speed. Leung and Starmer (2005) discovered that the speed of slower vehicles are more likely to be underestimated. A slow moving vehicle gives confidence to the rider that the gap is acceptable. Such confidence lead the rider to overtake only to realize that the time is not enough. Careless overtaking had been observed among young riders (Leung and Starmer, 2005). However, in the current study there is no significant difference in the age of participants that suffered minor and serious injury.

Driving too close to the vehicle in front or beside is a significant predictor of the chance of serious injury in the model. The behaviour of driving too close had been observed in most MC riders especially younger ones (Steg and Brussel, 2009). The negative coefficient indicates that it negatively contributes to the chance of serious injury probably because this behaviour is only exhibited during traffic jams and not when driving high speeds. Thus, when accidents occur most riders suffer only minor injury.

Based on the outcome of this study several policy recommendations can be given. Results showed that significant predictors of serious injury are violations except one error which is underestimating the speed of oncoming vehicle while overtaking. Despite the implementation of the helmet law only

62% of riders always wore helmets in the sample. WHO reported that the helmet wearing rate in the Philippines is only 51% which is low compared to its neighboring countries of Indonesia (80%), Malaysia (97%), and Vietnam (96%) (World Health Organization, 2015). Helmet wearing rate can be increased by strictly implementing the law and user education. MC riders especially younger ones are unmindful of the dangers of not wearing helmets or improperly wearing it. Thus information campaign can dwell on these two issues. Since young people tend to exhibit more risky behaviour such campaigns can be done in social media by local authorities to reach the target audience. MC riding seminars can also be conducted in large universities and offices to increase awareness on riding safety.

The local authorities can regularly conduct breath tests as means of introducing the Anti-Drunk and Drugged Driving Law to the riding population. The administration of these tests psychologically influence potential violators not to drink while driving. The tests can be conducted especially during weekends and holidays when more people are inclined to drink. The Philippine government will prioritize the procurement of these breathalyzers because as of 2017 there is a limited number available (Sauler, 2017). Recently the MMDA partnered with Manila Bulletin, a local newspaper to create awareness about drunk driving (Alavaren, 2016).

The study suffers from several limitations related to data gathering and analysis. The sample size comprise a very small percentage of MC drivers in the Philippines and they were all residing in Metro Manila. Thus, it may be argued that the behaviour do not represent MC drivers in the Philippines.

5. Conclusion

Significant predictors of serious injury are drunk driving, non-usage of helmets, and underestimating the speed of oncoming vehicle when overtaking. The first two are violations that have already been addressed enactment of laws. However, current behaviour showed that these laws did not change the behaviour of MC riders as expected. The passing of the Helmet Law slightly increased the compliance rate though. Results indicate that the use of helmets had been effective because most of the injuries were concentrated in the lower limbs. The length of MC driving experience did affect the seriousness of injury.

The driver behaviour of Filipinos was characterized in this study and the results were related to the severity of accidents that MC riders experience. Authorities may be prompted by the results to identify suitable interventions that can curb unsafe behaviour on the road and target specific groups. The government can consider policies on continuous training of MC drivers in MC handling and safe road behaviour. At present, the country does not impose mandatory training of MC drivers much so re-training them after sometime.

Future studies on motorcycle accidents can focus on understanding specific concerns of MC drivers. The current study showed that there is a problem underestimating the speed of oncoming vehicle, thus, the next study can focus on the causes of this error. Government institutions can also help consolidate data on severity of MC injuries and profile of accidents in hospitals for accident researchers to use.

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