Investigating on-road crash risk and traffic offences in Vietnam using the motorcycle rider behaviour questionnaire (MRBQ)

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Abstract

The factor structure of the Motorcycle Rider Behaviour Questionnaire (MRBQ) was investigated in Vietnam, a developing country with an extensive motorcycling culture. In addition, we examined which of the MRBQ factors, riding information and demographic variables predict motorists' crash risks and traffic violations. Exploratory factor analysis (EFA) of the MRBQ revealed a clear four-factor structure of 36 items (N=2.254 riders). This study highlights some critical differences between motorists from Vietnam and other countries. Vietnamese riders without a driver's licence had lower on-road crash/near-crash rates, and the use of safety equipment paradoxically increased the incidence of crash risks. Furthermore, crash/near-crash liability and offences of Vietnamese motorcyclists rose with riding years (in terms of years already riding a motorcycle). The 36-item version of the MRBQ provided in this paper may be applied to other motorcycling countries. Besides, based on the robust relationships between the MRBQ factors and accident risks, new effective on-road safety strategies can focus on minimizing the common aberrant riding behaviours such as traffic errors, control errors, speed and alcohol-related violations in Vietnam.

Keywords: motorcycling, MRBQ, on-road crash risk, traffic offences, Vietnam

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Highlights

- A representative sample of 2254 observations was collected in Danang, Vietnam.
- Factor analysis of the MRBQ showed a clear 4-factor structure of 36 items.
- Motorists often ride even when the required traffic safety conditions are not satisfied.
- Females report lower rates of collision risks and offences than males.
- Crash/near-crash liability and offences of riders increased with riding years.

1. Introduction

Motorcycles have become an essential way of ensuring active participation in social and economic activities for the vast majority of citizens living in countries where motorcycling is widespread. Nonetheless, the large number of motorcycles, in addition to the inherent dangerous characteristics of the motorcycle-traffic environment, pose substantial threats to motorists (Jadaan et al., 2018; Vlahogianni et al., 2012; WHO, 2017). World Health Organization figures show that motorcyclists account for 43% of all deaths in South-East Asia (WHO, 2018). Particularly, Vietnam's National Traffic Safety Committee reported more than 8.500 deaths each year from on-road crashes, whereas about 90% of victims were motorcyclists and their passengers. Vietnam's economic losses are more than $2 billion per year due to traffic accidents, of which the motorcycling share of about 75% (United Nations, 2018). Thus, improving safety for motorcyclists is a matter of urgency.

Aberrant riding behaviours are important contributors to traffic accidents (Evans, 1993; Lin & Kraus, 2009; Ngo et al., 2012; Kitamura et al., 2018). Many studies have highlighted the main causes of motorcycle crashes are traffic errors and violations (Vlahogianni et al., 2012). The National Traffic Safety Committee of Vietnam also reported that aberrant riding behaviours such as speeding and unsafe overtaking/lane-shifting accounted for more than 60% of all road fatalities in this country (Tuan, 2015). An understanding of riding behaviours among motorcyclists has become a prerequisite when trying to identify the causes of motorcycling accidents (Hung & Huyen, 2011; ITF, 2015).

Road safety literature has emphasized the essential role of the self-reported survey in the investigation of riding behaviour around the world (Elliott et al., 2007; Sullman & Taylor, 2010). Following the success of the Driver Behaviour Questionnaire (De Winter & Dodou, 2010; Reason et al., 1990), one of the most widely used instruments for investigating four-wheeled vehicles driving behaviours, the Motorcycle Rider Behaviour Questionnaire (MRBQ) was developed to measure motorcycle-related riding behaviours (Elliott et al., 2007). There are five factors in the original MRBQ, i.e. traffic errors (unintentional mistakes made by the rider), control errors (motorcycle handling lapses), speed violations, performance of stunts (intended excitement seeking actions) and use of safety equipment. After the creation of MRBQ, a variety of alternative factor structures were proposed, and supplementary questions were added to the initial questionnaire (Table 1). For instance, items that were perceived as "Performance of stunts" among British motorists, were classified under "Control/Safety" (acts in the context of losing control and safety) in the study

concerning Nigerian riders (Sunday, 2010). The observed distinction between "Traffic errors" and "Control errors" was not manifest among novice Australian motorists, which resulted in a single "Errors" factor (Sakashita et al., 2014).

Country (author)	**Sample size**	**% male**	**Factors**: items from Table A.8 + authors' additional items
United Kingdom (Elliott et al., 2007)	8666	92.0	Traffic errors: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 Speed violations: 14, 15, 16, 17, 18, 19, 20, 21, 22 Stunts*[1]: 23, 24, 25, 26 Control errors: 35, 36, 37, 38 Safety equipment**: 27, 28, 29, 30, 31, 32, 33, 34
Iran (Motevalian et al., 2011)	518	100.0	Traffic errors: 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 1 additional item Speed violations: 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, and 1 additional item Safety violations: 34, and 6 additional items Traffic violations: 5 additional items Stunts: 23, 24, 25, 26, 35, 36, and 1 additional item Control errors: 37, 38, 39, 40, and 2 additional items
Turkey (Özkan et al., 2012)	451	100.0	Traffic errors: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Speed violations: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 40 Stunts: 21, 23, 24, 25, 26, 42 Safety equipment: 27, 28, 29, 30, 31, 32, 33, 43 Control errors: 35, 36, 37, 38, 39
Australia (Sakashita et al., 2014)	2375	79.2	Traffic errors: 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 22, 35, 36, 37, 38 Speed violations: 14, 15, 16, 17, 18, 19, 21 Stunts: 23, 24, 25, 26 Safety equipment: 27, 28, 29, 30, 33
Malaysia (Ng et al., 2015)	204	84.8	Traffic errors: 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13 Speed violations: 14, 15, 16, 17, 18, 19, 20 Stunts: 21, 22, 23, 24, 25, 26, 41 Safety devices: 27, 28, 29, 30, 32 Control errors: 35, 36, 37, 38
Australia (Stephens et al., 2017)	470	89.0	Traffic errors: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Speed violations: 14, 15, 16, 17, 18 Stunts: 21, 23, 24 Control errors: 12, 13, 35, 36, 37, 38 Protective gear: 27, 28, 29, 30, 32
Nigeria (Oluwadiya, 2018)	500	100.0	Control/Safety: 23, 24, 26, 29, 31, 35, 38, 40, 41, and 2 additional items Stunts: 12, 13, 18, 22, 37, and 2 additional items Errors: 1, 3, 36, and 1 additional item Speeding/Impatience: 7, 10, 11, 15, 21, 25, and 1 additional item
Slovenia (Topolšek & Dragan, 2018)	205	86.3	Traffic errors: 1, 2, 3, 5, 6, 7, 11, 16 Speed violations: 18, 19, 20, 21 Stunts: 23, 25, 26, 27, 28 Safety equipment: 29, 30, 31, 32, 40, and 3 additional factors: Helmet: 3 additional items, Clothing: 3 additional items, Alcohol: 3 additional items

Table 1: The MRBQ factor structures across countries. *Performance of stunts - **Use of safety equipment

The differences in MRBQ outcomes across studies highlight important variations in on-road

traffic safety between countries, and further research should adopt the MRBQ to investigate the riding behaviours in countries with high motorcycle dependence (Hsu et al., 2003).

Various methods for determining riding behaviours and the relationship between riding behaviours and accident involvement have been suggested in previous research (Vlahogianni et al., 2012). When direct observation and official traffic records are not systematically collected due to limited resources, the ability of MRBQ, which can provide a report of how a person rides in different traffic circumstances, would improve its utility in motorcycle safety research and practice. One of the most valuable applications of the MRBQ is to identify behaviours which increase the likelihood of motorcycle accidents. For instance, traffic/control-related errors and speed violations are some of the most significant behavioural factors that affect motorcyclists' accident risks (Elliott et al., 2007; Sakashita et al., 2014; Vlahogianni et al., 2012). Meanwhile, performance of stunts was the unique MRBQ factor correlated with crash involvement among Australian motorists (Stephens et al., 2017). Similarly, this factor was the primary determinant of active accidents (i.e. hitting another road user or an obstacle) and traffic offences (related to parking, overtaking, speeding or other traffic violations) for Turkish riders (Özkan et al., 2012). The factor of using the safety equipment emerged from all of the studies mentioned above but was not likely to be a determinant of crash or near-crash incidents. Ensuring the validity and reliability of the MRBQ is of great importance for the evaluation of the interventions aimed at motorcyclists.

Most of the validation and application of MRBQ studies were conducted in high-income countries such as the United Kingdom Elliott et al. (2007), Australia (Sakashita et al., 2014; Stephens et al., 2017), Slovenia (Topolšek & Dragan, 2018), or in nations where most of the motorcyclists ride for pleasure or sensation-seeking like Iran (Motevalian et al., 2011), and Turkey (Özkan et al., 2012). There is also a need to investigate riding behaviours in low- and middle-income countries with a large dependency on motorcycles.

The Vietnam Association of Motorbike Manufacturers announced that Vietnam has more than 50 million motorcycles, and up to 79% of the population uses a motorcycle for regular riding (VAMM, 2018). This makes Vietnam one of the top countries in terms of motorcycle dependence. However, a limited number of studies concerning riding behaviours in Vietnam have been conducted and provided decisive insights for policymakers and traffic managers. Previous research efforts only focused on one specific riding behaviour, such as wearing a helmet, using a mobile phone while riding, drinking-driving or speeding (Bao et al., 2017a; Gruyter et al., 2017; Mohamad et al., 2018;

Ngo et al., 2012; Trinh & Le, 2016; Truong et al., 2016). Consequently, this research was motivated by the urgent need for a more comprehensive understanding of riding behaviours by using MRBQ and addressing motorcycling safety issues within the context of Vietnam. The purposes of this study are (i) to analyze the factor structure of Vietnamese MRBQ, and (ii) to investigate the relationships between the MRBQ factors, background variables, riding information and accident involvements and traffic violations in Vietnam.

2. Material and method

2.1. Data collection

Data collection was conducted in Vietnam, and consists of three sections: (*i*) demographic and riding experience background, (*ii*) information about self-reported traffic accidents and received violation tickets, and (*iii*) the MRBQ. Trained students from the University of Danang delivered the paper-based questionnaire to the participants at parking lots and residential areas. Only people who have ridden a motorcycle were invited to participate in this survey, and they were assured of confidentiality and anonymity. Initially, the total number of motorcyclists interviewed for this survey was 2823. The final dataset includes 2254 observations after deletion of incomplete observations. Tables 2 and 3 present the descriptive statistics of the sample.

Variable	**Description**	**N**	**Mean**	**Std. Dev.**
Age	Age of the motorcyclist	2254	24.3	5.9
Riding years	Total years of riding a motorcycle	2254	6.1	5.2
License years	Total years of holding a driver's license	2254	4.9	4.7
Mileage	Average annual mileage (km)	2233	4863.8	4769.5
Near crashes	Number of near crashes (last 12 months)	2241	1.5	3.5
Crashes	Number of crashes (last 12 months)	2253	0.9	1.8
Offences	Number of penalized traffic violations (last 12 months)	2253	0.24	0.93

Table 2: Basic descriptive statistics: continuous variables

Variable	N	Category	Frequency	Proportion (in %)
Gender	2250	Female	1650	73.3
		Male	600	26.7
Highest education level attained	2254	Elementary school	7	0.3
		Secondary school	23	1.0
		High school	82	3.6
		Bachelor / Engineer	2044	90.7
		Master / PhD	68	3.0
		Others	30	1.3
Holding a driver's license	2254	No	156	6.9
		Yes	2098	93.1
Riding frequency	2254	Everyday	1953	86.6
		Several times per week	253	11.2
		Once a week	14	0.6
		Less than once a week	34	1.5
Main riding purposes	2246	Carry for free	18	0.8
		Carry for money	13	0.6
		Others	29	1.3
		Relax / Travel / Sport	27	1.2
		To work/study places	2159	96.1
Having own motorcycle	2254	No	245	10.9
		Yes	2009	89.1
Experience near-crash in the past 12 months	2254	No	996	44.2
		Yes	1258	55.8
Experience crash in the past 12 months	2254	No	1372	60.9
		Yes	882	39.1
Have traffic offence in the past 12 months	2254	No	1918	85.1
		Yes	336	14.9

Table 3: Basic descriptive statistics: categorical variables

2.2. Measures

2.2.1. Demographic questions

The questionnaire included items asking participants' socio-demographic background, e.g. age, gender, education level, and their riding information, e.g. licence tenure, riding purpose, riding frequency, average riding distance per year and self-reported traffic accidents and traffic violations. To assess riding incidents, the following formulation was adopted: "During the last 12 months,

how many near-crashes / crashes / penalized traffic violations have you had?". In this study, we defined "near-crash" as "dangerous traffic situations where motorcyclists are fortunate enough to escape from the collision", and "crash" as "a traffic accident involvement leading to injuries, and/or material damage". Those definitions are consistent with the study in Australia (Sakashita et al., 2014), which defined "motorcycle crashes" as "collisions with someone or something, or coming off the bike but excluding dropping or knocking it over while parked" and "near-crash" as "almost had a crash but did not".

2.2.2. The Motorcycle Rider Behaviour Questionnaire (MRBQ)

The original MRBQ has 43 items, and for each item, the respondents are asked to rate the frequency of their riding behaviour during last year by choosing one option from the 6-point scale: 1=never, 2=hardly ever, 3=occasionally, 4=quite often, 5=frequently, and 6=nearly all the time. The use of this scale provided good reliability with Cronbach alpha coefficients for the five factors ranging from 0.70 to 0.84 (Elliott et al., 2007). Two researchers used the back-translation technique to translate MRBQ from English to Vietnamese. With 20 Vietnamese motorcyclists and two traffic police officers, we held focus group discussions to find out what they understood from each question and noted unclear items. We defined the final list of items by taking into account the feedback from the discussions in the focus group.

2.2.3. Methodology

Regarding the information gaps within the MRBQ, missing values were replaced by the mean of the non-missing observations for that variable. In this respect, mean imputation was performed on 190 data points, corresponding to a negligible 0.2% of the overall dataset.

Before exploring the factor structure of the MRBQ, the models presented in Table 1 were assessed using Confirmation Factor Analysis (CFA) on our collected dataset. The CFA was estimated with an asymptotically distribution-free estimation configuration. In case those existing models would poorly fit the data, Principal Axis Factoring (PAF) and Direct oblimin rotation methods were applied to investigate the factor structure of the Vietnamese MRBQ. Furthermore, the internal consistency of the MRBQ scale scores was estimated by systematically computing the Cronbach's alpha reliability coefficients.

Finally, the associations between demographic variables, riding information, MRBQ factors and self-reported yearly crash outcomes, including near-crashes, crashes and traffic offences, were

analyzed using negative binomial regression (see Figure 1).

3. Results

3.1. Sample description

A basic statistical description of the collected sample is presented in Tables 2 and 3. The mean age was 24.3 years, ranging from 20 to 71 years old, and about 73% of participants were female. Young riders and university graduates accounted for large proportions of our sample. This was the group of Vietnamese people who always wanted to contribute ideas for improving the current traffic conditions (Nguyen-Phuoc et al., 2019; Nguyen et al., 2013). Thus, they participated actively and responsibly in our survey. However, it is important to enlarge the range of demographic backgrounds when sampling of Vietnamese riders in future work.

The majority of participants held a driver's licence. 86.6% of respondents said that they rode every day, and almost 96% used the motorcycle to go to work/study sites. The average riding period was 6.1 years, and the mean duration of possessing the licence was 4.9 years. The mean annual riding distance was 4863.8 kilometres. Typically, the motorcycle is used for short trips in motorcycling countries; thus, these findings are within expectations.

In terms of crash involvement, 39.1% of the participants reported to be involved in at least one crash over the last 12 months, and 55.8% of the sample reported to have encountered at least one near-crash scenario. In addition, 14.9% of the sample was penalized for traffic violations in the last year.

3.2. MRBQ item scores

The results obtained from this research are in line with most of the previous studies (Elliott et al., 2007; Motevalian et al., 2011; Özkan et al., 2012; Sakashita et al., 2014; Stephens et al., 2017; Sunday, 2010; Topolšek & Dragan, 2018), which find that the MRBQ responses are typically between "never" and "hardly ever". Vietnamese motorists indicated that the most common behaviours were linked to safe riding. For instance, on the scale ranging from 1 (never) to 6 (almost all the time), the two highest-scoring items were item 35 “Brake or throttle back (slow down) when going around a bend” (M=4.560±1.309) and item 36 “Change gears when going around a corner or bend” (M=4.500±1.360). The motorcycle's relative lack of protection may cause riders to appreciate their additional vulnerability (Huth et al., 2014). As a result, they generally take a

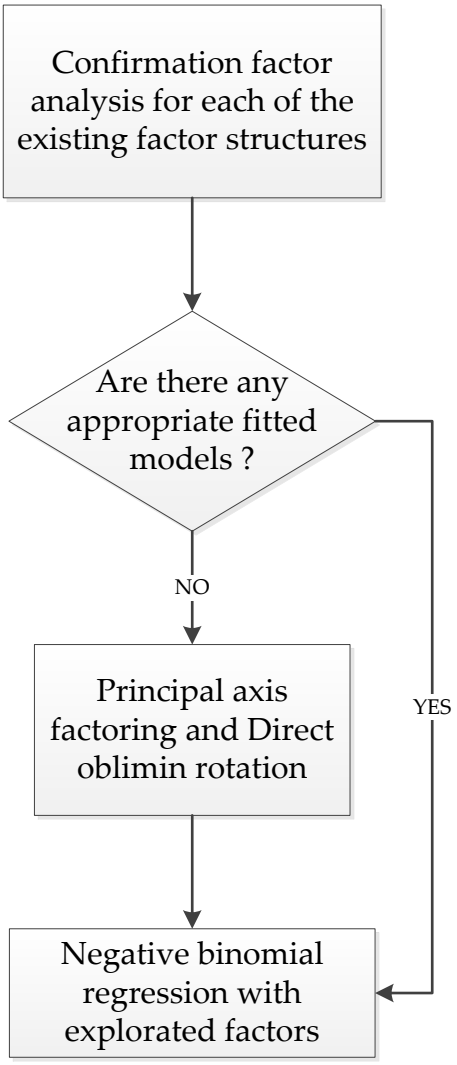

Figure 1: Factor analysis pathway

defensive approach on the road, with a tendency to be less aggressive while riding (Rowden et al., 2016).

On the other hand, items relating to the use of safety equipment had fairly low ratings, for example, item 43 "Wear bright/fluorescent clothing" (M=1.430±0.833), item 33 "Wear bright fluorescent strips/patches on your clothing" (M=1.490±0.947). Noticeably, item 31 "Wear no protective clothing", which also related to the use of protective equipment, had a high score (M=3.940±1.800). Generally, those behaviours are extremely rare among Vietnamese motorcyclists due to the lack of road traffic laws on protective gear while riding, except for the mandatory helmet legislation from August 2000 (Hill et al., 2009; Hung et al., 2008; Bao et al., 2017a).

3.3. Factor analysis of MRBQ

A CFA has been applied to validate the internal structure of the MRBQ. Model fitting is systematically evaluated with the Chi-squared/degree of freedom (χ^2/df) ratio, the Goodness-of-Fit Index (GFI), the Adjusted Goodness-of-Fit Index (AGFI), the Comparative Fit Index (CFI), the Root Mean Square Residual (RMR), and the Root Mean Square Error of Approximation (RMSEA, RMSEA CL90) (Byrne, 2016). In general, appropriate fitted models should have 2/1 or 5/1 as χ^2/df ratio, GFI >0.9 (Jöreskog & Sörbom, 1986), AGFI >0.9 (Tanaka & Huba, 1985), CFI >0.9 (preferably >0.95) (Bentler, 1990), and RMSEA and RMR <0.08 or 0.01 (preferably <0.06) indexes (Browne et al., 1993).

Since no model had given a reasonable fit of the Vietnamese sample (Table 4), this data was re-examined within an EFA framework (Hu & Bentler, 1998; Thompson, 2007). The 43 items were subjected to PAF in order to determine the factor structure. Initially, eight factors had eigenvalues higher than 1.0. Based on the Scree plot and the parallel analysis, a 4-factor solution was retained. The Direct oblimin rotation method was applied because there had been some relatively high inter-correlations. The factor analysis was then rerun designating four factors.

Model	χ^2/df	GFI	AGFI	CFI	RMR	RMSEA	LO 90	HI 90
UK	5.08	0.84	0.82	0.51	0.2	0.04	0.041	0.044
Turkey	5.65	0.82	0.8	0.44	0.2	0.05	0.044	0.047
Australia (2014)	5.91	0.79	0.76	0.44	0.21	0.05	0.045	0.048
Malaysia	5.13	0.83	0.80	0.53	0.19	0.04	0.041	0.044
Australia (2017)	5.53	0.83	0.80	0.56	0.18	0.05	0.043	0.047
Nigeria	7.22	0.87	0.87	0.42	0.21	0.05	0.050	0.055
Slovenia	5.50	0.90	0.87	0.48	0.18	0.05	0.042	0.047

Table 4: Goodness-of-fit statistics for competing models of the MRBQ

The possibility of using the factor analysis results without concerns is checked by applying the Bartlett's Test of Sphericity (BTS) and the Kaiser-Meyer-Olkin (KMO) test (Lohnes, 1971). The BTS value was noticeably significant: χ^2 (630) =37916.7 (p <0.001) and the KMO value was 0.92 >0.5. Consequently, the BTS and KMO values indicated that the EFA could be reliably used for further analysis, in accordance with the recommendations (Field, 2013).

When interpreting the rotated factor patterns, six items from original MRBQ (i.e. item 12, 13, 31, 34, 39, 40) had low weights for all factors, and item 19 "Open up the throttle and just go for it on a country road" had high cross-loading. Therefore, these items were removed from the analysis. Based on the remaining 36 MRBQ items, the four factors explained 43.5% of the total variance. Questionnaire items and the corresponding factor loadings were shown in Table 5, while a loading value of 0.3 was used as a cut-off point.

The first factor explains 25% of the total variance. It is composed of nine items related to control errors and therefore labelled "Control errors" (CE). Two items (35, 36) were considered as the actions to avoid on-road risks, so they had negative factor loadings. Factor 2 accounts for 10% of the overall variance and included 13 items. All items were related to unintended mistakes made by the riders, so factor 2 was named "Traffic errors" (TE). Eight items fall under factor 3, which explains about 5% of the total variance. This factor was referred to as "Safety equipment" (SE), which involved the use of protective gears to improve the safety of the riders. Factor 4 included six items relating to speed infringements (with the exception of item 41). Item 41 "Ride when you suspect you might be over the legal limit for alcohol" is the only item of the original MRBQ relating to drunk driving. Subsequently, this factor was labelled "Speed and Alcohol-related

Item	Mean	Std. Dev.	Control errors	Traffic errors	Safety equipments	Speed and Alcohol-related Violations
35 Brake or throttle back (slow down) when going around a bend	4.56	1.31	-0.47			
36 Change gears when going round a corner or bend	4.50	1.36	-0.46			
20 Ride between two lanes of fast moving traffic	1.52	0.83	0.47			
22 Ride so fast into a corner that you scare yourself	1.57	0.85	0.47			
26 Unintentionally do a wheel spin	1.32	0.74	0.56			
21 Got involved in racing other riders or drivers	1.39	0.78	0.58			
24 Pull away too quickly and your front wheel lifted off the road	1.29	0.71	0.65			
25 Intentionally do a wheel spin	1.26	0.72	0.65			
23 Attempt or done a wheelie	1.28	0.70	0.67			
37 Find that you have difficulty controlling the bike when riding at speed (eg steering wooble)	3.09	1.31		0.34		
10 When riding at the same speed as other traffic,	2.37	1.16		0.34		
you find it difficult to stop in time when a traffic light has turned against you						
38 Skid on a wet road or manhole cover, road making	2.63	1.11		0.38		
3 Not notice a pedestrian waiting at a crossing where the lights have just turned red	2.08	1.05		0.38		
1 Fail to notice that pedestrians are crossing when turning into a side street from a main road	2.64	0.99		0.43		
5 Miss Give Way signs and narrowly avoid colliding with traffic having right of way	2.11	1.05		0.51		
9 Attempt to overtake someone that you had not noticed to be signaling a right turn	2.24	0.97		0.51		
(in England, left turn in other countries)						
11 Ride so close to the vehicle in front that it would be difficult to stop in an emergency	2.65	1.02		0.57		
2 Not notice someone stepping out from behind a parked vehicle until it is nearly too late	2.75	1.02		0.57		
8 Distracted or pre-occupied, you suddenly realize that the vehicle in front has slowed,	2.86	0.98		0.62		
and you have to brake hard to avoid a collision						
7 Queuing to turn left (in England, turn right in other countries) on a main road,	2.58	1.00		0.62		
you pay such close attention to the mainstream of traffic that you nearly hit the car in front						
6 Fail to notice or anticipate another vehicle pulling out in front of you and had difficulty stopping	3.22	1.02		0.63		
4 Pull onto a main road in front of a vehicle you have not noticed or whose speed you misjudged	2.84	1.02		0.63		
33 Wear bright fluorescent strips/patches on your clothing	1.49	0.95			0.57	
43 Wear bright/fluorescent clothing	1.43	0.83			0.62	
32 Wear motorcycle gloves	1.84	1.16			0.66	
42 Wear a full leather-suit	1.50	0.86			0.67	
27 Wear motorcycle riding boots	1.70	1.00			0.71	
30 Wear body armour/impact protection for the elbows and shoulders	1.57	0.94			0.75	
28 Wear protective trousers leather or non leather	1.57	0.93			0.82	
29 Wear a protective jacket leather or non leather	1.54	0.87			0.91	
18 Race away from traffic lights with the intention of beating the driver next to you	1.88	0.97				0.36
41 Ride when you suspect you might be over the legal limit for alcohol	1.84	1.05				0.36
14 Exceed the speed limit on a country/rural road	2.12	1.07				0.60
17 Disregard the speed limit on a residential road	1.98	0.98				0.78
15 Disregard the speed limit late at night or in the early hours of the morning	2.25	1.11				0.86
16 Disregard the speed limit on a motorway	2.03	1.03				0.87
Cronbach's alpha			0.852	0.819	0.893	0.828

Table 5: Achieved results for the rotated factor pattern matrix

violations" (SAV), and explained a further 3.5% of the total variance.

All factors had good reliability with the Cronbach's alpha, ranging from 0.82 to 0.89, and shared weak to moderate correlations (Table 6), indicating that each factor appears to measure a conceptually distinct construct. In this context, the four-factor structure proved to be reasonably interpretable.

3.4. Predicting traffic crash accident and offences

The sample data of traffic accidents and penalized violations did not follow the normal distribution, and initially violated the assumption of equi-dispersion. In order to set up a predictive

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Age	-										
2. Gender	-0.26	-									
3. Have license	0.01	-0.04*	-								
4. License years	0.58**	-0.24**	0.45**	-							
5. Mileage	0.19**	-0.17**	0.19**	0.26**	-						
6. CE factor	0.16**	-0.14**	-0.02	0.07**	0.00	-					
7. TE factor	-0.07**	0.08**	0.06**	-0.03	0.03	-0.01	-				
8. SE factor	0.04	-0.15**	0.00	0.00	-0.02	-0.04	0.10**	-			
9. SAV factor	2	-0.20**	0.07**	0.07**	0.11**	0.02	0.35**	0.26**	-		
10. Near crashes (12 months)	-0.07**	0.04	0.07**	-0.02	0.03	-0.01	0.24**	0.01	0.13**	-	
11. Crashes (12 months)	0.04	-0.07**	0.06**	0.07**	0.06**	0.07**	0.16**	0.10**	0.12**	0.38**	-
12. Offences (12 months)	0.12**	-0.18**	0.04	0.14**	0.07**	0.07**	0.07**	0.02	0.11**	0.18**	0.25**

Table 6: The correlations among demographic variables, the number of traffic accidents, offences, and MRBQ factors. **: p <0.01; *: p <0.05; Gender: 1=Male, 2=Female; Have a driver's license: 1=Yes, 0=No

model for motorcycle accidents and offences in Vietnam, a negative binomial regression analysis was performed (Denham, 2016). The following predictors were selected in the analysis: age, gender, highest education level achieved, possession of a driver's licence, the total number of years already riding a motorcycle (riding years), years of holding a driver's licence, annual riding distance (mileage), ownership of motorcycle and MRBQ factors. The results of the negative binomial regression analysis were presented in Table 7.

As shown in Table 7, the motorcyclist's gender, age, riding years and traffic errors were the major predictors of accident involvements and traffic offences. According to the incidence rate ratios (IRR), males were expected to have higher rates than females for the annual total number of crashes, near-crashes and offences, i.e. 20%, 16% and 83.3% more, respectively. The motorcyclist's age was negatively related to the overall number of accident chances and penalized violations, whereas riding years and traffic errors had positive relationships with them. The factor of control errors was associated significantly and positively with the total number of motorcyclists' crashes and offences. Unexpectedly, 1.092 times more crashes were reported for each increment in the use of safety equipment. The total number of near-crashes and penalized violations grow by about 14%, with each rise of one unit of speed and alcohol-related violation factor. Furthermore, the analysis revealed that unlicensed riders tend to be involved in crash and near-crash circumstances at lower rates than motorists with a valid licence. Participants without private motorcycle appeared to

Parameter	**Incidence rate ratios**	**95% Wald CI**		**SD**	**Wald χ^2**	**Sig.**
DV: Number of crashs (12 months)						
Gender = Male	1.200	1.029	1.398	0.078	5.44	0.020
Have a driver's license = No	0.689	0.488	0.973	0.176	4.48	0.034
Age	0.945	0.915	0.977	0.017	11.11	0.001
Riding years	1.046	1.007	1.087	0.019	5.33	0.021
Control errors	1.133	1.069	1.201	0.030	17.51	0.000
Traffic errors	1.255	1.183	1.331	0.030	57.43	0.000
Safety equipment	1.092	1.027	1.161	0.031	7.88	0.005
DV: Number of near-crashes (12 months)						
Gender = Male	1.160	1.006	1.336	0.072	4.18	0.041
Have a driver's license = No	0.672	0.501	0.901	0.149	7.08	0.008
Having own motorcycle = No	1.236	1.027	1.487	0.095	5.02	0.025
Age	0.914	0.885	0.944	0.016	30.07	0.000
Riding years	1.085	1.047	1.123	0.018	20.45	0.000
Mileage	1.000	1.000	1.000	0.000	7.31	0.007
Traffic errors	1.215	1.154	1.279	0.026	54.87	0.000
Speed & Alcohol-related violations	1.143	1.081	1.209	0.029	21.91	0.000
DV: Number of offences (12 months)						
Gender = Male	1.833	1.462	2.297	0.115	27.66	0.000
Age	0.943	0.898	0.990	0.025	5.62	0.018
Riding years	1.107	1.046	1.172	0.029	12.35	0.000
Mileage	1.000	1.000	1.000	0.000	4.80	0.029
Control errors	1.219	1.121	1.326	0.043	21.33	0.000
Traffic errors	1.262	1.149	1.387	0.048	23.68	0.000
Speed & Alcohol-related violations	1.141	1.028	1.266	0.053	6.12	0.013

Table 7: Negative binomial regression analysis on yearly traffic accident risks and offences. DV: dependent variable

have 23.6% more near-crash experiences than owners of motorcycles.

4. Discussion

The literature review revealed a research gap on riding behaviour and its outcomes in Vietnam, a nation with 86% of the households owning at least one motorcycle (United Nations, 2018; Miaschi, 2019). Therefore, this study focused on validating the MRBQ and investigating the relationship between Vietnamese motorcyclists' demographic variables, riding information, MRBQ factors, accident risks and traffic offences. There was a difference in the composition of our data sample with respect to the higher proportion of women (73.3% of participants), whereas men predominated in previous studies (Table 1). Since we are correcting for gender, at least the main effects are taken into account, the co-occurrence between gender and other explanatory factors may be neglected, given that the variance inflation factors were all relatively close to 1. Given this study's higher percentage of females, the overall incidence of involvement in accidents is lower than expected, as males are more closely linked to motorcycle crashes (Al-Balbissi, 2003; Stanojević et al., 2018; Vlahogianni et al., 2012). In Vietnam, males participated more frequently in traffic accidents than females, and especially, men were expected to have 83.3% more than women for the annual number of penalized traffic violations (Table 7). In terms of gender differences, men also reported substantially more dangerous driving behaviours than women in prior research (Bachoo et al., 2013). Therefore, new on-road safety initiatives should be specially targeted at males in order to raise their safety awareness (Hoekstra & Wegman, 2011).

The MRBQ factor structures identified in earlier research did not apply to the sample of Vietnamese motorists. Instead, the new Vietnamese MRBQ was revealed based on the results of factor analysis, including four factors: control errors, traffic errors, safety equipment and speed & alcohol-related violations. This 4-factor structure was consistent with the Australian and Nigerian studies (Sakashita et al., 2014; Sunday, 2010). Nevertheless, the composition of the factors differed considerably between these studies.

With regard to the proposed MRBQ, the control errors factor includes nine items that have been perceived as stunts (items 21, 23, 24, 25, 26), errors (items 35, 36) or speed violations (items 20, 22) in previous studies (Table 1). Vietnamese riders recognize these items in the context of losing control or proactively keeping themselves safe instead of intentionally stunting or violating on the road (Hsu et al., 2003; WHO, 2017; **?**). This factor shows the critical distinction between

countries in riding patterns and on-road safety perceptions of motorcyclists.

Considering that traffic errors have been reported as the most frequent cause of collision involvement in previous studies (Gruyter et al., 2017; Hung & Huyen, 2011), our work further underlines the relevance of these traffic errors to the risk of traffic accidents and violations. Recall from (Table 1), that in contrast to factor structures in previous studies, in our study the traffic errors factor does not include items relating to speed infringements (item 13, 16, 22) or control errors (item 12, 35, 36). All thirteen items of the traffic errors factor were related to riders' unintended mistakes while riding. This result complements the idea that traffic errors are often associated with motorcyclists' risk perceptions or observational abilities (Sunday, 2010). It is worth noting that Vietnamese motorists were more likely to commit to traffic errors than other forms of MRBQ behaviours (Table 5). Moreover, with each increment of one unit in traffic errors, their crash, near-crash and offence rates are increasing by more than 20% (Table 7). The undesired prominence of traffic errors can be explained by the fact that riding a motorcycle is an extremely demanding task with specific skills, much more complicated than driving a car (Elliott et al., 2007). To avoid traffic errors in Vietnam, the design of on-road warning signs should be more intuitive, and the training program for motorcyclists should include the guidance to identify traffic situations that often cause these errors (Giang, 2019; Ou & Liu, 2012).

The use of personal protective clothing is extremely uncommon in countries with the highest motorcycle usage, including Thailand, Vietnam, Indonesia, Malaysia (Kumphong et al., 2018; Miaschi, 2019; Lili et al., 2016; Solah et al., 2019). Although the number of motorcycle-related accidents is abnormally high, Vietnamese motorists stated that they are not yet in the habit of using safety equipment when riding (Bao et al., 2017b; Trinh & Le, 2016). This can be explained by the fact that, aside from the mandatory use of helmets, there are no restrictions on the usage of motorcycle protective clothing in Vietnam. Especially, given the sense of increased protection by using additional protective gear, Vietnamese riders tend to commit more traffic errors, making them more likely to get involved in collisions (United Nations, 2018). This study shows that the incidence of crash risks among Vietnamese motorists rose by 9.2%, with each increment in the use of safety equipment (Table 7). These findings are different from the studies carried out in developed countries, where most motorcyclists consider the use of protective items as a prerequisite for safe riding (Stephens et al., 2017). Motorcycling in Vietnam is the result of irregular traffic patterns (Doan & Hobday, 2019; Ngoc & Thanh, 2020; Nguyen-Phuoc et al., 2020). In this regard, we

suggest further research to evaluate the effectiveness of various safety equipment for the riders in motorcycling countries (**?**).

Item 41 “Ride when you suspect you might be over the legal limit for alcohol” was dropped from most of the previous MRBQ factor structures (Table 1) due to low loading scores. In contrast, this item had a moderate factor loading in the Vietnamese MRBQ, so it was retained within the speed and alcohol-related violation (SAV) subscale. The retention of item 41 in the MRBQ is beneficial for the analysis of the association between drunk riding and the traffic risk within the Vietnamese context.

Besides, all five remaining items of the SAV factor are related to speed infringements. Our finding highlights a positive correlation between riding under the influence of alcohol and high-risk behaviours, such as speeding and violating traffic rules, which were also emphasized in other research (Cherpitel et al., 2003; Pereira et al., 2011; Tran et al., 2012; Zhao et al., 2014). While there have been "Drunk No Driving" and "Speed Limit Violations Prevention" campaigns in Vietnam, these infringements continue to be critical factors of traffic problems (Ngoc et al., 2012; Phuong et al., 2016; Vu et al., 2019). In this nation, the number of near-crashes and penalized violations increased by approximately 14%, with each rise of the SAV factor (Table 7). It is appropriate to install more speed traps and tighten control over drunk riding to improve road safety and reduce speed and alcohol-related accidents in Vietnam (Barrett et al., 2017; Mohamad et al., 2018; Stewart et al., 2012; Wickramarachchi, 2013).

In addition to the points mentioned above, the results of the negative binomial regression analysis provide some additional insights into the current motorcycling environment in Vietnam.

Young riders in Vietnam have higher rates of crash/near-crash and traffic offence (Table 7). A combination of lack of experience and a propensity to engage in risky behaviours may explain the higher risk for them, as described in prior studies (**?**). Similarly, the Vietnamese who borrows a motorcycle has a significantly higher near-crash rate on the road compared to those who own a motorcycle. This finding is in line with the results previously published (Haworth et al., 1994; Reeder et al., 1995; ITF, 2015).

Surprisingly, Vietnamese motorists without a riding licence have lower crash/near-crash rates than licensed riders. There is a different tendency in other studies, where unlicensed riders are more likely to violate traffic regulations and to be involved in accidents (Curry et al., 2015; Kraus et al., 1991; ITF, 2015). We assume that unlicensed Vietnamese motorists may be more cautious

while riding because they are concerned about being penalized by the traffic police and recognize their additional risks due to a lack of road safety knowledge. This assumption may explain the reduction in their rate of collision involvement. However, future research is suggested to assess the efficiency and effectiveness of Vietnam's motorcycle training and licensing system (Daniello et al., 2009).

The probability of motorists' crash/near-crash and offences slightly increased with the cumulative riding years in Vietnam (Table 7). In this country, where most people spend considerable time motorcycling inside a traffic system with inherent chaotic characteristics, the number of riding years may positively correlate with the likelihood of traffic accident involvement (Fagnant & Kockelman, 2015). This result poses requirements for further investigations into the relationships between Vietnamese personality traits, attitudes toward on-road safety, traffic environment and riding outcomes. Firstly, given the lack of questions in the current MRBQ to evaluate common riding behaviours in motorcycle-traffic environments, this questionnaire could be extended by adding items related to "use of cell phone while riding," "aggressive riding," "use of impaired motorcycle" or "carrier violations" for potential studies. Secondly, when using the self-reporting approach for data collection, there are some concerns regarding biases. Nevertheless, participants were carefully explained about the purposes of the study and were assured of confidentiality and anonymity; thus, the influence of social desirability bias is likely to be negligible.

5. Conclusions

The proposed version of the MRBQ was smartly adapted to investigate on-road crash risks and penalized traffic violations among Vietnamese motorcyclists. The factor analysis of the MRBQ using our collected sample data revealed a notable four-factor structure grouping a total of 36 items. This study also highlighted the robust relationships between motorists' age, gender, the MRBQ factors and accident risks and traffic offences. The findings with respect to motorcycling in Vietnam may be value for decision-makers and practitioners to improve the motorcycle training and licensing system, on-road safety campaigns and development of more effective traffic interventions. Particularly, avoiding common aberrant riding behaviours such as traffic errors, control errors and speeding and alcohol-related violations would significantly reduce the traffic risks for Vietnamese motorists. Regarding the possible recommendations, more efforts need to be directed towards quantifying and verifying the association between motorists' personality traits, risky riding

behaviours and traffic risks in countries with significant usage of motorcycles.

6. Acknowledgements

This study has been supported by the Wallonie-Bruxelles International (Project 2.17). The authors would like to thank Mr Le Quoc Dan, Deputy Director of Department of Public Security in Danang, Vietnam for his valuable comments regard the content and the validity of the questionnaire, and AMIGOS team (University of Economics – The University of Danang) for the data collection process.

Appendix A. Appendix

Item	Content
1	Fail to notice that pedestrians are crossing when turning into a side street from a main road
2	Not notice someone stepping out from behind a parked vehicle until it is nearly too late
3	Not notice a pedestrian waiting at a crossing where the lights have just turned red
4	Pull onto a main road in front of a vehicle you have not noticed or whose speed you misjudged
5	Miss "Give Way" signs and narrowly avoid colliding with traffic having right of way
6	Fail to notice or anticipate another vehicle pulling out in front of you and had difficulty stopping
7	Queuing to turn left (in England; turn right in other countries) on a main road, you pay such close attention to the mainstream of traffic that you nearly hit the car in front
8	Distracted or pre-occupied, you suddenly realize that the vehicle in front has slowed, and you have to brake hard to avoid a collision
9	Attempt to overtake someone that you had not noticed to be signaling a right turn (in England; left turn in other countries)
10	When riding at the same speed as other traffic, you find it difficult to stop in time when a traffic light has turned against you
11	Ride so close to the vehicle in front that it would be difficult to stop in an emergency
12	Run wide when going around a corner
13	Ride so fast into a corner that you feel like you might lose control

14	Exceed the speed limit on a country/rural road
15	Disregard the speed limit late at night or in the early hours of the morning
16	Disregard the speed limit on a motorway
17	Disregard the speed limit on a residential road
18	Race away from traffic lights with the intention of beating the driver next to you
19	Open up the throttle and just go for it on a country road
20	Ride between two lanes of fast moving traffic
21	Got involved in racing other riders or drivers
22	Ride so fast into a corner that you scare yourself
23	Attempt or done a wheelie
24	Pull away too quickly and your front wheel lifted off the road
25	Intentionally do a wheel spin
26	Unintentionally do a wheel spin
27	Wear motorcycle riding boots
28	Wear protective trousers – leather or non-leather
29	Wear a protective jacket – leather or non-leather
30	Wear body armour/impact protection for the elbows and shoulders
31	Wear no protecting clothing
32	Wear motorcycle gloves
33	Wear bright fluorescent strips/patches on your clothing
34	Use daytime headlights on your bike
35	Brake or throttle back (slow down) when going around a bend
36	Change gears when going round a corner or bend
37	Find that you have difficulty controlling the bike when riding at speed (e.g. steering wooble)
38	Skid on a wet road or manhole cover, road making
39	Have trouble with your visor or goggles fogging up
40	Another driver deliberately annoys you or puts you at risk
41	Ride when you suspect you might be over the legal limit for alcohol
42	Wear a full leather-suit
43	Wear bright/fluorescent clothing

Table A.8: The items related to the original MRBQ

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