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1                   **Which unsafe riding behaviours are associated with traffic offences and**  
2                   **crashes? A study of young Indonesian motorcyclists**

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5                   **Abstract**

6                   Indonesia has high motorcycle dependence, especially among young riders who rely on  
7                   them for access to education. The number of young riders aged 15-19 involved in crashes  
8                   is higher than in any other age group. Despite this, there have been limited attempts to  
9                   comprehensively understand the behaviour of these road users. This study is the first to  
10                  use the Motorcycle Rider Behaviour Questionnaire (MRBQ) to determine which rider  
11                  behaviours may predict crash risk in an Indonesian population. In addition, the impact of  
12                  demographic variables such as age, gender, licensing status (licensed or unlicensed) and  
13                  area of residence (urban or rural) on young Indonesian riders (N= 7,081) crash risk was  
14                  also examined. Negative binomial regression analysis revealed that crash risk was  
15                  positively associated with both intentional and unintentional unsafe behaviours, including  
16                  “errors”, “speed”, and “unsociable riding”. Interestingly, a common theme in the “errors”  
17                  identified involved the participant not paying attention to their surroundings. This suggests  
18                  that even though these errors may be unintentional, there is a possibility to develop  
19                  targeted safety interventions, such as combined rider awareness and riding skills training.  
20                  Finally, the results revealed that many of those surveyed were riding on public roads  
21                  before they reached the legal age for riding, and failed to obtain a license even when they  
22                  could legally do so. Overall, this study provides valuable insights into the factors affecting  
23                  the safety of young motorcyclists in Indonesia, taking into account the culture and  
24                  environmental considerations unique to this country.

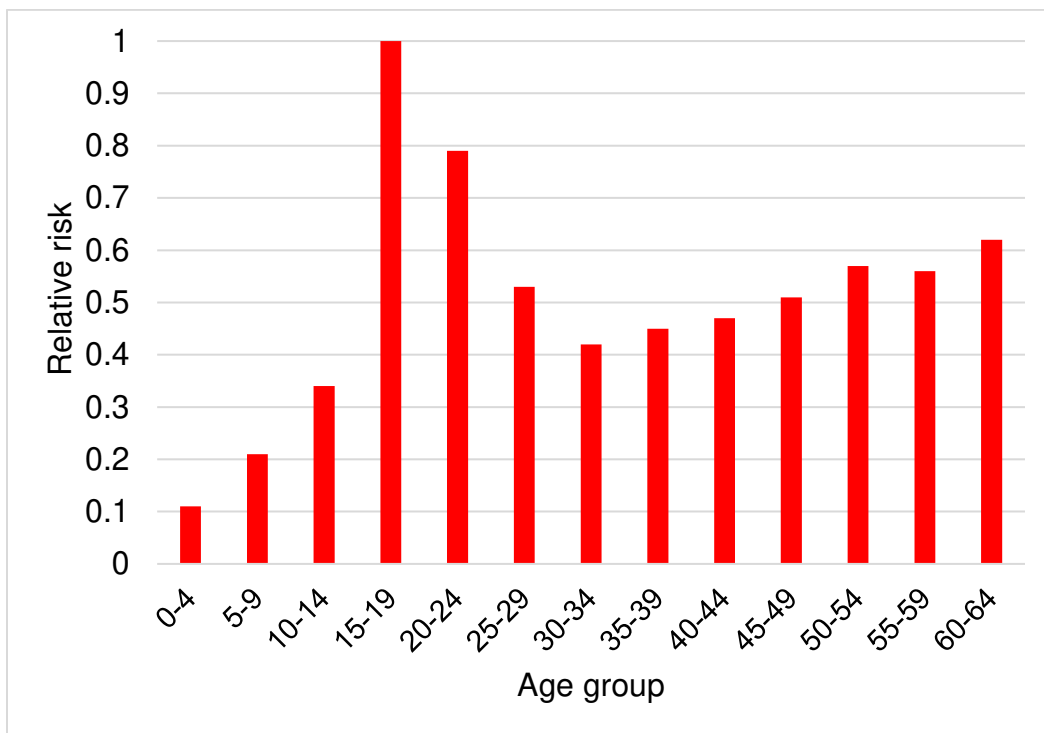
25  
26                  **Keywords**

27                  Motorcycle Rider Behaviour Questionnaire; Young Rider; Developing Country;  
28                  Motorcycle Crash; Traffic Offence.

29 **1. Introduction**

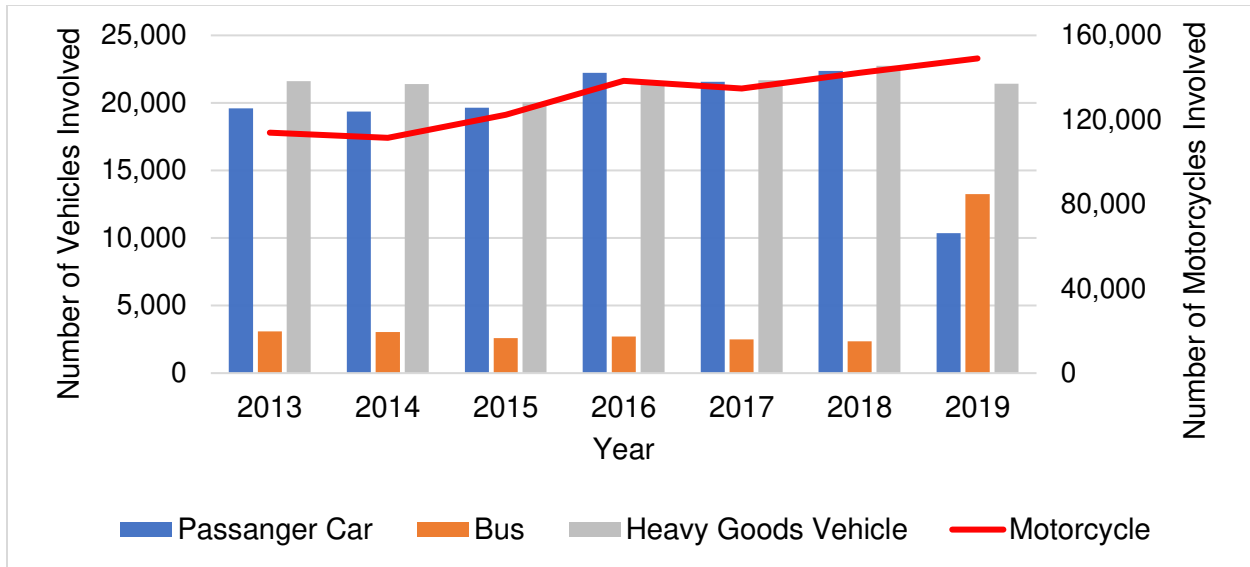
30 As reported in the Global Status Report on Road Safety (World Health Organization,  
31 2023), there have been slight reductions in the number of annual road traffic deaths, from  
32 1.35 million to 1.19 million between 2018 and 2023. However, among children and young  
33 people aged 5 to 29, traffic-related injuries remain to be the major cause of death.  
34 Indonesia is the largest country in the region of South-East Asia (Zain et al., 2021) and  
35 the fourth most populated country in the world (World Bank Group, 2023) with a  
36 population of around 270 million in 2020 (Indonesia Central Bureau of Statistics, 2021).  
37 In 2018, the 15-19 years old group was the most crash-involved age group (see Figure  
38 1), while motorcyclists were the most involved user group (see Figure 2).

39



40

*Figure 1: Relative risk of crashes by age group in 2018 with 15-19 as reference (Indonesia National Traffic Police, 2019)*



41  
 42 *Figure 2: Number of vehicles involved in a crash by vehicle category (scale for passenger*  
 43 *cars, buses, and heavy goods vehicles on the left of the figure, while the scale for*  
 44 *motorcycle involvement is on the right)*

45 Young people's extensive involvement in crashes is a complex problem that requires a  
 46 comprehensive approach (Cassarino & Murphy, 2018). However, developing a  
 47 comprehensive approach for young Indonesian riders has unique challenges. Generally,  
 48 the contributory factors to road crashes are categorised into three main factors: (1) road  
 49 environment factors, (2) vehicle factors, and (3) human factors (Indriastuti and Sulistio,  
 50 2010 and Setyowati et al., 2018). The Republic of Indonesia Police Regulation (PERPOL)  
 51 No.5 of 2021 Article 8 verse A states that 17 is the minimum age to apply for a motorcycle  
 52 license in Indonesia (PERPOL, 2021). However, insufficient public transport  
 53 infrastructure, school environments / access to education, and family factors means that  
 54 young, unlicensed riders are frequently present on public roads (Yeh et al., 2008; Nurlia  
 55 et al., 2017; Anggraeni, 2019). Based on Legislation No. 22 of 2009 Article 77 verse 1  
 56 about Traffic and Road Transport (Republic of Indonesia, 2009), it is stated that every  
 57 person driving a motorised vehicle on the road is required to have a driving license

58 following the type of motor vehicle being driven. In reality, although riders aged 17 and  
59 above are eligible for a license, many riders do not apply for various reasons, including a  
60 belief that it is a complicated procedure (Siswantoro, 2018).

61 While 57% of two-vehicle crashes involving a motorcycle are caused by car drivers  
62 (Shaheed et al., 2013), research has also shown that motorcyclist risk-taking behaviour  
63 has been found to play a major role in motorcycle crashes (Lin and Kraus, 2009). Risk-  
64 taking behaviour in general increases during adolescence as a result of biological  
65 changes in the brain's socio-emotional system, exhibiting a greater reward-seeking  
66 desire, especially in the presence of peers, environmental exposures, and cultural and  
67 familial influences (Steinberg, 2008).

68 Understanding what causes crashes amongst young riders can be key in improving traffic  
69 safety strategies (Dobson et al., 1999; Lin et al., 2003). However, there has been little  
70 research on the safety of young motorcyclists in Low- and Middle-Income Countries  
71 (Akasreku et al., 2023). The necessity for a tool that enhances knowledge of the  
72 significance of human factors in motorcycle crashes led to the development of the  
73 Motorcycle Rider Behaviour Questionnaire (MRBQ). The MRBQ was first developed by  
74 Elliott et al. (2007) in the UK to measure and determine which rider's behaviour may  
75 predict crash risk, along similar lines to the Driver Behaviour Questionnaire developed by  
76 Reason et al. (1990). Since the development of MRBQ for UK riders in 2007, many  
77 researchers have used it to study motorcyclist behaviour. The research has ranged from  
78 testing its applicability in different countries (Ozkan et al., 2012; Trung Bui et al., 2020;  
79 Uttra et al., 2020), predicting the occurrence of crashes, near-crashes and traffic offences

80 (Sakashita et al., 2014; Stephens et al., 2017; Schreurs et al., 2023), and exploring the  
81 risky riding behaviour of the riders (Chouhan et al., 2021).

82 However, mixed findings about which MRBQ factors can better predict crash involvement  
83 were found (Stephens et al., 2017; Sakashita et al., 2014; Sunday and Akintola 2011).  
84 The diverse MRBQ findings across regions reflects the significant differences among  
85 socio-economic and demographic factors in traffic safety (Chakraborty and Maitra, 2024).  
86 Furthermore, several studies have facilitated the idea of adopting the MRBQ to analyse  
87 the behaviour of riders in countries with high motorcycle dependence (Hsu et al., 2003),  
88 between countries with different cultures (Özkan et al., 2012) and with large samples  
89 (Chouhan et al., 2023).

90 To our knowledge, there are only three studies which have applied the MBRQ in the  
91 Indonesian context (Setyowati et al, 2024; Putranto et al. 2014; Putranto and Anjaya  
92 2014). However, all these three previous studies only used the MRBQ to assess rider's  
93 attitude and behaviour and did not attempt to discover the relationship between MRBQ  
94 factors and crash involvement. Therefore, in the Indonesian context, it is still unknown  
95 which factors can best predict crash involvement.

96 Gaining a deeper understanding about this relationship is important for Indonesian  
97 practitioners and policymakers to enhance the safety of young motorcyclists, an area  
98 which has consistently been a road safety issue in Indonesia. Additionally, previous  
99 research argued for additional validation of the MRBQ in other geographic settings due  
100 to the cross-national discrepancies that have been recorded in the previous studies  
101 (Schreurs et al., 2023). With this background, the aims of current study are to: (a)

102 investigate the most appropriate factor structure of the modified MRBQ among young  
103 riders from Indonesia; and (b) investigate whether or not the extracted factors are  
104 associated with traffic offences, near crash, and crash experience among young  
105 Indonesian riders.

## 106 **2. Methodology**

107

### 108 *2.1. Development of the questionnaire*

109

110 The first MRBQ contained 43 items that measure aberrant riding behaviours and the use  
111 of safety equipment. The most recent study concluded that the MRBQ has its merits in  
112 terms of both construct and predictive validity (Schreurs et al., 2023). Indeed, a recent  
113 meta-analysis study by Chouhan et al. (2023), which argued that MRBQ has a low  
114 predictive ability for crashes, still found that the “*speed violation*” factor could significantly  
115 predict self-reported crashes.

116 Because the original MRBQ study was designed to investigate rider behaviour in a  
117 developed country (UK), it was anticipated that there would be some characteristics of  
118 riders in developing countries that were not mentioned in the original survey. Two items  
119 from the original study were not included in the present study. The item “exceed the speed  
120 limit on a motorway” was excluded because the speed limit and the definition of motorway  
121 in UK road is similar to the toll road in Indonesia where motorcycles (regardless of their  
122 engine capacity) being prohibited to enter the road, and the item “wear a leather one-  
123 piece suit” was also removed because it is highly unlikely for students to wear such safety  
124 equipment due to the climate in Indonesia. Items related to wearing leather suits were  
125 also not considered in India’s MRBQ study due to the weather (Chouhan et al., 2021).

126 Furthermore, 13 additional items were included in the final survey - nine items from a  
 127 previous Indonesian MRBQ study by Putranto and Anjaya (2014); and four items  
 128 gathered from informal conversations with Indonesian traffic police. In total, for the  
 129 present study, 54 items were used. There were three items that could pose difficulty in  
 130 interpretation due to them being unusual in the Indonesian riding context. These were re-  
 131 worded to be more easily understood (see Table 1). The list of 54 items is presented in  
 132 Table 8 in the appendix. The items were first translated from English to Bahasa (Indonesia  
 133 language) and back-translated to English by another person who was fluent in both  
 134 languages to check for correct translation.

135 *Table 1: Modified MRBQ items*

<b>Original MRBQ</b>	<b>Modified Indonesian MRBQ</b>
Wear bright/fluorescent clothing	Wear bright/fluorescent clothing when riding at night
Another driver deliberately annoys you or puts you at risk	You get annoyed when other road users put you at risk
Ride when you suspect you might be over the legal limit for alcohol	Ride after having an alcohol drink

136  
 137  
 138 Besides the MRBQ items, the questionnaire also included items regarding rider's  
 139 demographics, riding activity, traffic violation, near crash and crash involvement in the  
 140 past 12 months. The questions included demographic variables such as age, gender,  
 141 licensing status (licensed or unlicensed) and area of residence (urban or rural). The  
 142 information about the area of residence was used as a proxy for where the riders mostly  
 143 rode their motorcycle, based on the premise that the Minister of Education and Culture of  
 144 the Republic of Indonesia Regulation (PERMENDIKBUD) Number 14 of 2018 states that  
 145 90% of a school's capacity should consist of students who live in the proximity  
 146 (PERMENDIKBUD, 2018). For the details related to their riding activity, participants were

147 asked to provide information about their motorcycle, the main purpose of riding, average  
148 riding hours per week and average kilometres per week. Information about how long they  
149 have been riding actively on public roads was also obtained to estimate riding experience.  
150 Moreover, participants were also asked to provide information about their traffic violations  
151 that received a fine from the traffic police, as well as near crash and crash experiences in  
152 the past twelve months measured as 0 (never), 1 (once), 2 (twice), and 3 or more. The  
153 occurrence of crashes is limited, and previous studies found that there is an association  
154 between reported traffic offences and reported crashes (Lawton et al., 1997a; Parker et  
155 al., 1995) as well as strong frequency relationship between crashes and near- crashes  
156 (Guo et al., 2010; Wu et al., 2014). Therefore, separating these three aspects could  
157 provide a more comprehensive understanding of the factors contributing to road safety  
158 among young people. A crash in this study refers to a situation where the rider hit  
159 something (including single-vehicle crashes where no-one else was involved), whilst a  
160 near-crash refers to where the rider was able to just avoid a crash. The description of  
161 crashes and near-crashes were provided in the questionnaire.

162

## 163 *2.2. Participants and procedure*

164 Data collection was conducted in three different provinces on Java, Indonesia. Java was  
165 chosen as the study location because more than 56% of the total Indonesian population  
166 lives there (Indonesia Central Bureau of Statistics, 2021). Among the six provinces in  
167 Java, the provinces of East Java, DKI Jakarta, and Central Java were selected as  
168 research locations because of the following characteristics: (a) East Java has the highest  
169 crash rates based on 2019 Indonesia National Traffic Police data; (b) DKI Jakarta has the

170 highest motorcycle ownership based on the latest Electronic Registration and  
171 Identification data, and; (c) Central Java has the highest number of motorcycle traffic  
172 violations based on 2020 Indonesia National Traffic Police data (Indonesia National  
173 Traffic Police, 2020). Thus, these provinces provide a representative sample of the at-  
174 risk Indonesian population.

175 Ethical approval for this study was obtained from the University of Leeds Business, Earth  
176 and Environment and Social Sciences Joint (AREA) Faculty Research Ethics Committee  
177 (reference number AREA 21-172). Participants were senior high school students, and the  
178 eligibility criteria were (a) aged between 17 to 19 years old and (b) currently ride a  
179 motorcycle. A convenience sampling technique was used to recruit young motorcyclists  
180 from various senior high schools in the three chosen provinces. The researcher  
181 approached the prospective participants in their school, gave an explanation about the  
182 study and the questionnaire was distributed to the participants in the form of an online  
183 survey link through the student's WhatsApp group. The survey was filled out by the  
184 participants themselves in the own time at their convenience within a one-week  
185 timeframe.

186 To maintain confidentiality and anonymity no names were recorded. Of those  
187 approached, 7,340 students met all the eligibility criteria. To ensure data reliability,  
188 unobtrusive methods of detecting low quality data were implemented. The methods  
189 involve recording response time (Berry et al., 1992) and consecutive identical responses  
190 or "long string" (Meade and Craig, 2012). After deletion of missing data, the final dataset  
191 includes 7,081 samples. The data collection took place between December 2022 and  
192 February 2023.

### 193 2.3. Data handling and analysis

194 There were 259 responses that did not pass the data quality check, and these were  
195 excluded from the analysis, leading to a total of 7,081 responses. Exploratory Factor  
196 Analysis (EFA) was selected as the most appropriate analysis to determine factor  
197 structure in the present study due to the exploratory nature of the study. As previously  
198 stated, 13 new items were included in this study, and one of the objectives was to  
199 investigate the most appropriate factor structure of this modified version of the MRBQ for  
200 young Indonesian riders. The analysis was completed using IBM's statistical package  
201 SPSS version 26 (for Exploratory Factor Analysis) and R Studio version 2022 (for  
202 Negative Binomial Regression Analysis).

203 Firstly, the factor structure of the 54 MRBQ items was determined using exploratory factor  
204 analysis with Principal Axis Factoring (PAF) and the Direct Oblimin method to ensure that  
205 the sample size was adequate and appropriate for data reduction. Items with factor  
206 loadings greater than 0.3 were retained as suggested by Hair et al. (2010). The averaged  
207 summed items within each factor were used to calculate factor scores. Higher factor  
208 scores, with the exception of the "*safety equipment*" factor, imply more frequent aberrant  
209 behaviour. Secondly, given the five MRBQ factors were not normally distributed, the  
210 difference between MRBQ scores across rider demographics were explored using a non-  
211 parametric test (Mann Whitney U Test for two independent groups, Kruskal-Wallis for  
212 more than two independent groups). And finally, because the dependent variables of this  
213 study (traffic violation, near crash and crash experience in the past 12 months) were found  
214 to be not normally distributed and demonstrated over-dispersion, they were predicted

215 using negative binomial regression (NBR). The cut-off for the p-value was set at 0.05,  
216 and the odds ratio for each independent variable was calculated at a 95% confidence  
217 interval.

### 218 **3. Result and discussion**

#### 219 *3.1. Sample characteristics*

220 Before investigating the most appropriate factor structure of the modified MRBQ among  
221 young riders from Indonesia, this section first gives a brief overview of the study sample  
222 in terms of demographics, riding experience and violation, near crash and crash  
223 involvement.

224 The descriptive statistics are mentioned in Table 2. Table 2 shows that the gender ratio  
225 of male to female participants is almost equal, with males making up 52.2% and females  
226 47.8%. More than half of the riders (56.9%) mainly rode in urban areas. Half of the sample  
227 reported riding for less than 5 hours per week, and almost half (49.4%) rode less than 50  
228 kilometres per week. In terms of traffic violations, the majority (81%) had not received any  
229 tickets in the past 12 months. However, 23.5% and 20.9% of the sample reported  
230 experiencing at least one near-crash and crash, respectively, in the past 12 months. More  
231 than 75% of the participants reported that they had been riding for more than 2 years,  
232 suggesting that many of those surveyed were riding on public roads before they reached  
233 the legal age for riding. It is worth mentioning that the sample description revealed that  
234 the majority of the riders did not hold a motorcycle license (71%), despite being eligible  
235 to do so.

236 *Table 2: Sample descriptions*

	<b>N</b>	<b>Percentage</b>
<b>Age</b>		
17	1,142	16.1%
18	4,744	67%
19	1,195	16.9%
<b>Gender</b>		
Male	3,697	52.2%
Female	3,384	47.8%
<b>Province</b>		
DKI Jakarta	2,325	32.8%
Central Java	2,268	32.1%
East Java	2,488	35.1%
<b>License Status</b>		
Unlicensed	5,029	71%
Licensed	2,052	29%
<b>Area of residence</b>		
Rural	3,052	43.1%
Urban	4,029	56.9%
<b>Riding experience</b>		
0 - 1 year	1,529	21.6%
2 - 3 years	2,822	39.9%
4 - 5 years	1,662	23.5%
More than 5 years	1,068	15.1%
<b>Average hours riding per week</b>		
Less than 5 hours	3,735	52.7%
5-10hours	2,337	33%
10-20hours	710	10%
More than 20hours	299	4.2%
<b>Average kilometres per week</b>		
Less than 50 km	3,497	49.4%
51-100 km	2,303	32.5%
101-200 km	806	11.4%
201-300 km	251	3.5%
More than 300 km	224	3.2%
<b>Traffic violation in the past 12 months</b>		
None	5,739	81%
One	877	12.4%
Two	239	3.4%
Three or more	226	3.2%
<b>Near-crash in the past 12 months</b>		
None	3,432	48.5%
One	1,667	23.5%
Two	974	13.8%
Three or more	1,008	14.2%
<b>Crash in the past 12 months</b>		
None	4,731	66.8%
One	1,481	20.9%
Two	592	8.4%
Three or more	277	3.9%

237 3.2. Rider behaviour based on MRBQ items

238 Individual item scores from the MRBQ were analysed to explore self-reported rider  
239 behaviour. When the entire sample from the three different provinces was combined, on  
240 the scale ranging from 1 (never) to 6 (almost all the time), the three most frequently  
241 reported items were “Brake or throttle-back when going round a corner or bend”, “You get  
242 annoyed when other riders put you at risk”, and “Wear shoes” (see Table 3). On the other  
243 hand, the least frequent riding behaviours were “Ride your motorcycle after having an  
244 alcoholic drink”, “Intentionally do a wheel spin”, and “Attempt to do, or actually do, a  
245 wheelie”.

246 However, even though the mean scores only differed very slightly, young riders in Central  
247 Java reported slightly different behaviour compared to the other two provinces. The 3<sup>rd</sup>  
248 most frequent riding behaviour among Central Java riders was “Change gear when going  
249 round a corner or bend” and the 3<sup>rd</sup> least frequent behaviour was “Get involved in  
250 unofficial ‘races’ with other riders or drivers”.

251 *Table 3: Most and least frequent MRBQ items*

<b>Most frequent riding behaviour</b>	
<b>1<sup>st</sup></b>	Brake or throttle-back when going round a corner or bend (M = 5.18)
<b>2<sup>nd</sup></b>	You get annoyed when other riders put you at risk (M = 4.4)
<b>3<sup>rd</sup></b>	Wear shoes (M = 3.92)
<b>Least frequent riding behaviour</b>	
<b>1<sup>st</sup></b>	Ride your motorcycle after having an alcoholic drink (M = 1.08)
<b>2<sup>nd</sup></b>	Intentionally do a wheel spin (M = 1.08)
<b>3<sup>rd</sup></b>	Attempt to do, or actually do, a wheelie (M = 1.17)

252

253 What stands out from this study is “you get annoyed when other riders put you at risk”  
254 was observed to be the second most frequent behaviour among young riders. It could  
255 conceivably be hypothesised that young riders can easily be emotionally distracted whilst  
256 riding, which further supports the study of Sumit et al. (2021) that found that it can be  
257 challenging for teenagers to self-regulate impulsive behaviours because of the  
258 maturational gap between their social-affective brain system and the cognitive control  
259 system. This may account for young riders performing risky riding behaviour, such as  
260 speeding or competing with other riders on the road. The third most frequent behaviour  
261 was “wear shoes” and related to the voluntary use of safety equipment. This finding is not  
262 surprising because the sample was exclusively senior high school students, and it is  
263 mandatory for them to wear shoes in school.

### 264 *3.3. Exploratory Factor Analysis of the MRBQ*

265 The first research aims were to determine the most appropriate factor structure of a  
266 modified version of the MRBQ to be used among young riders in Indonesia. The 54 items  
267 of the modified MRBQ were subjected to Exploratory Factor Analysis with Principal Axis  
268 Factoring (PAF) and Direct Oblimin method to determine the factor structure. Item  
269 interrelationships were examined before the factor analysis and four items were found to  
270 have very few significant relationships with other items. These four items were excluded  
271 from further analysis. Initially, PAF produced eleven factors with an eigenvalue greater  
272 than 1. However, after examining a scree plot, Monte Carlo parallel analysis and Minimum  
273 Average Partial test, a 5-factor solution from the Minimum Average Partial test was  
274 adopted. Factor scores were created from the average summed items within each factor.

275 Higher factor scores indicate more frequent aberrant behaviour, except for the safety  
276 equipment factor. The final five-factor solution is displayed in Table 4.

277 The Kaiser-Meyer-Olkin test of sampling adequacy was good (0.895), and Bartlett's test  
278 of sphericity was significant ( $X^2(496, N = 7,081) = 58542.14 (p < 0.001)$ ) showing that the  
279 data were suitable for PAF and can be used for further factor analysis, following the  
280 recommendation of Field (2013). Fourteen items had factor loadings below 0.3 (item 5,  
281 16, 23, 31, 38, 39, 40, 41, 42, 43, 45, 48, 52, and 53) and so were omitted from further  
282 analysis. Four items (item 8, 11, and 17) were found to be cross-loading so were also  
283 removed from the analysis.

284 The final five-factor solution consisted of 32 items and explained 45.61% of the variance.  
285 Factor 1 comprised of nine items and accounted for 20.51% of the total variance that  
286 seem to reflect mostly speeding behaviour and thus was labelled "*speed*". Factor 2  
287 explained a further 8.6% of the total variance and contained four items all from the original  
288 safety equipment factor (Elliot et al., 2007). Therefore, the label "*safety equipment*" was  
289 assigned to this factor. Factor 3, accounted for a further 6.4% of the total variance and  
290 contained seven items all from the original traffic errors factor. Thus, factor 3 was named  
291 "*errors*". There was no evidence to support the inclusion of two separate "*errors*" factors  
292 among young Indonesian riders. Factor 4 explained another 5.35% of the total variance.  
293 Interestingly, this factor contained five items which were newly included in this study (item  
294 47: carry a passenger who does not wear a helmet, item 36: riding without a helmet, item  
295 46: carry more than one passenger with your motorcycle, item 35: using helmet without  
296 chin straps or not fastening it, item 49: riding in the opposite direction of the roadway).

297 This factor was referred as “traffic violation” in the context of Indonesia and is the most  
298 different to previous research.

299 Factor 5 explained a further 4.7% of the total variance and consisted of five items that  
300 were originally classified as “stunts” behaviour and two new items. The two new items  
301 that loaded onto this factor are item 50 (riding with an unroadworthy motorcycle) and item  
302 51 (smoking while riding). Riding unroadworthy motorcycles and smoking while riding are  
303 riding behaviours that can easily be observed in Indonesia. However, instead of “*stunts*”,  
304 the addition of these two new items in this factor suggests that “*unsociable riding*” is a  
305 more appropriate factor name in the present study.

306 All factors had good reliability with Cronbach’s alpha, ranging from 0.68 to 0.80, and  
307 shared weak to moderate Pearson correlations (Table 5), indicating that each factor  
308 appears to measure a conceptually distinct construct. The strongest relationship was  
309 between “*speed*” and “*unsociable riding*” ( $r = 0.493$ ) and between “*speed*” and “*errors*” ( $r$   
310  $= 0.455$ ) although these relationships were only of moderate strength. In this context, the  
311 five-factor structure proved to be reasonably interpretable. Table 4 also shows that the  
312 most frequent type of behaviour, albeit still relatively uncommon, were traffic violations  
313 ( $M = 2.05 \pm 0.689$ ). Therefore, riders in the current sample, on average, tended to engage  
314 in aberrant behaviours very infrequently.

315

316

317

318

Table 4: Final results of rotated factor pattern matrix for young Indonesian riders

MRBQ items	Mean	S.D.	Speed	Safety equipment	Error	Traffic violation	Unsociable riding
Item 15: Disregard the speed limit late at night or in the early hours of the morning	2.68	1.45	0.62				
Item 12: Run wide when going round a corner	1.72	1.14	0.58				
Item 54: Riding zig-zag (move between lane quickly) to find road gaps	2.12	1.28	0.58				
Item 18: Open up the throttle and just 'go for it' on country roads	1.48	0.78	0.57				
Item 19: Ride between two lanes of moving traffic	2.90	1.40	0.53				
Item 13: Ride so fast into a corner that you feel like you might lose control	1.44	0.77	0.52				
Item 14: Exceed the speed limit on a country/rural road	1.81	1.07	0.41				
Item 10: Not slow down when approaching a yellow light	2.03	1.27	0.41				
Item 21: Ride so fast into a corner that you scare yourself	1.52	0.86	0.38				
Item 33: Wear bright/fluorescent strips/patches on your clothing	1.33	0.77		0.82			
Item 34: Wear bright/fluorescent clothing when riding at night	1.33	0.78		0.76			
Item 30: Wear body armour (elbow pads, shoulder pads, knee pads, etc)	1.29	0.77		0.57			
Item 26: Wear riding boots	1.27	0.74		0.50			
Item 3: Not notice a pedestrian waiting to cross at a zebra crossing, or a pelican crossing that has just turned red	1.45	0.95			0.71		
Item 2: Not notice someone stepping out from behind a parked vehicle until it is nearly too late	1.50	0.85			0.66		
Item 1: Fail to notice that pedestrians are crossing when turning into a side street from a main road	1.75	1.23			0.55		
Item 4: Pull out on to a main road in front of a vehicle that you had not noticed, or whose speed you have misjudged	1.42	0.86			0.47		
Item 6: Fail to notice or anticipate that another vehicle might pull out in front of you and have difficulty stopping	1.99	1.05			0.47		
Item 7: Queuing to turn left on a main road, you pay such close attention to the main traffic that you nearly hit the vehicle in front	1.54	0.84			0.46		
Item 9: Attempt to overtake someone that you had not noticed to be signalling a right turn	1.73	0.91			0.34		
Item 47: Carry a passenger who has not worn a helmet	2.74	1.18				0.69	
Item 36: Riding without a helmet	2.26	1.07				0.63	
Item 46: Carry more than one passenger with your motorcycle	1.97	1.01				0.51	
Item 35: Using helmet without chin straps or not fastening it	1.64	1.07				0.36	
Item 49: Riding in the opposite direction of the roadway	1.64	0.84				0.36	
Item 22: Attempt to do, or actually do, a wheelie	1.17	0.62					0.73
Item 20: Get involved in unofficial 'races' with other riders or drivers	1.17	0.61					0.60
Item 24: Intentionally do a wheel spin	1.08	0.43					0.59
Item 44: Ride your motorcycle after having an alcoholic drink	1.08	0.43					0.51
Item 51: Smoking while riding	1.30	0.87					0.48
Item 25: Unintentionally do a wheel spin	1.39	0.74					0.36
Item 50: Riding with unroadworthy motorcycle	1.57	0.93					0.31
Cronbach's Alpha			0.80	0.76	0.75	0.68	0.74
Mean			1.97	1.63	1.31	2.05	1.25
S.D.			0.70	0.61	0.58	0.69	0.43

323 *Table 5: Pearson correlations between MRBQ factors*

	Speed	Safety equipment	Errors	Traffic violation	Unsociable riding
Speed	1				
Safety equipment	0.024*	1			
Errors	0.455*	0.049*	1		
Traffic violation	0.406*	-0.038*	0.296*	1	
Unsociable riding	0.493*	0.186*	0.308*	0.318*	1

324 \*  $p < 0.05$  level (2-tailed)

325

326 Despite the number of factors being similar to the original MRBQ study by Elliot et al.  
 327 (2007), the findings of this study clearly show that the five-factor structure found for  
 328 experienced riders in the UK (Elliot et al.,2007), Turkish riders (Özkan et al., 2012),  
 329 licensed riders in Australia (Stephens et al., 2017) and young riders in India (Sumit et al.,  
 330 2021) was not replicated for the sample of young riders in the current study. The inclusion  
 331 of several new MRBQ items in the present study likely altered the factor structure.

332 In contrast to earlier studies, significant differences have been found. All the items that  
 333 loaded in the “*safety equipment*” factor in this modified Indonesian MRBQ were items that  
 334 rarely exist in the Indonesia context (for example: wear body armour) and therefore shows  
 335 a relatively low mean score whilst the use of “*safety equipment*” is the factor that usually  
 336 shows a higher mean in earlier studies (for example in Sumit et al., 2021). Furthermore,  
 337 the current study added items related with helmet wearing because they were not  
 338 included in the original study of UK riders and being an essential safety equipment for  
 339 motorcycle riders. However, instead of loading onto the “*safety equipment*” factor, the  
 340 items related to helmet wearing were loaded onto “*traffic violation*” factors in this study.  
 341 These results could indicate that young Indonesian riders seem to consider the use of

342 such safety-equipment (except helmet wearing) as voluntary. Taken together, the “safety  
343 equipment” factor in this study is different to previous studies.

#### 344 *3.4. Comparison of MRBQ scores across rider characteristics*

345 In order to examine the differences between MRBQ scores across rider’s characteristics,  
346 factor scores were compared by rider gender, reason for riding, licensing status, average  
347 riding hours and distance per week, area of residence, and riding experience. Given the  
348 non-normal distributions of the five MRBQ factors, non-parametric tests (Mann Whitney  
349 U Test for two independent groups, Kruskal-Wallis for more than two independent groups)  
350 were used. Furthermore, to reduce the probability of Type I error because of multiple  
351 comparisons, a Bonferroni correction was applied and therefore the significance level  
352 adjusted to  $p < 0.01$ . Table 6 show the results of these non-parametric tests, by comparing  
353 the mean of summed factor scores between rider’s characteristics.

354

355 Table 6: MRBQ factors scores by rider's characteristics

		Speed	Safety equipment	Errors	Traffic violation	Unsociable riding
Gender	Male (n= 3,697)	2.11	1.42	1.68	2.06	1.38
	Female (n= 3,384)	1.81	1.19	1.56	2.04	1.12
	Sig	0.001*	0.001*	0.001*	0.177	0.001*
	z	-17.564	-17.563	-8.706	-1.351	-29.146
	r	-0.209	-0.209	-0.103	-0.016	-0.346
Reason	School (n= 5,461)	1.97	1.31	1.62	2.00	1.24
	Shopping (n= 303)	1.63	1.32	1.53	2.19	1.15
	Recreation (n= 724)	2.03	1.31	1.71	2.29	1.33
	Other (n= 593)	2.01	1.26	1.63	2.17	1.30
	Sig	0.001*	0.056	0.001*	0.001*	0.001*
	X2 (3)	100.148	7.559	28.361	138.338	55.093
Licensing status	Unlicensed (n= 5,029)	1.93	1.28	1.63	2.08	1.26
	Licensed (n= 2,052)	2.06	1.38	1.62	1.98	1.24
	Sig	0.001*	0.001*	0.828	0.001*	0.005*
	z	-6.776	-6.408	-0.218	-5.109	-2.823
	r	-0.081	-0.076	-0.003	-0.061	-0.034
Average hours	Less than 5 hours (n=3,735)	1.82	1.30	1.58	2.03	1.21
	5-10hours (n=2,337)	2.07	1.29	1.65	2.07	1.27
	10-20hours(n=710)	2.27	1.35	1.73	2.11	1.35
	More than 20hours (n=299)	2.31	1.40	1.73	2.09	1.46
	Sig	0.001*	0.032	0.001*	0.004	0.001*
	X2 (3)	413.233	8.838	82.947	13.462	209.326
Average distance	Less than 50 kilometres (n=3,497)	1.81	1.28	1.56	2.03	1.19
	51-100 kilometres (n=2,303)	2.07	1.32	1.66	2.07	1.28
	101-200 kilometres (806)	2.20	1.34	1.70	2.08	1.34
	201-300 kilometres (251)	2.28	1.42	1.76	2.06	1.40
	More than 300 kilometres (224)	2.22	1.29	1.83	2.04	1.37
	Sig	0.001*	0.001*	0.001*	0.142	0.001*
	X2 (4)	399.671	18.006	108.544	6.883	214.268
Area of residence	Rural (n=3,052)	2.04	1.26	1.64	1.95	1.31
	Urban (n=4,029)	1.91	1.35	1.61	2.12	1.21
	Sig	0.001*	0.001*	0.001*	0.001*	0.001*
	z	-9.631	-5.971	-5.71	-9.605	-16.211
	r	-0.114	-0.071	-0.068	-0.114	-0.193

356

357 Firstly, a significant effect of gender was found on rider's engagement in all five MRBQ  
 358 factors except the "traffic violation" factor. Prior studies that have examined the effect of  
 359 gender usually have a male-skewed sample. Given this study used a large and gender-

360 balanced sample, the finding that males still significantly engaged more in all behaviours  
361 compared to females, supports previous research in the motorcycle domain (Sexton et  
362 al., 2004; Lin and Kraus, 2009; Stephens et al., 2017).

363 It is worth noting that where respondents live (and therefore ride) is associated with rider's  
364 engagement in all MRBQ factors. Riders who live in rural areas engage in "*speed*", "*error*"  
365 and "*unsociable riding*" behaviour more frequently compared to riders who live in urban  
366 areas. On the other hand, riders who live in urban areas report "*safety equipment*" and  
367 "*traffic violation*" behaviours more frequently. Prior MRBQ studies have not examined the  
368 relationship between where riders use their motorcycle (urban or rural area) and their  
369 behaviour. It is possible that these results are due to stricter traffic enforcement in urban  
370 areas which could increase young rider's willingness to use safety equipment.

371 When the reason for riding is examined, the analysis revealed that riders who ride for  
372 recreational purposes reported higher engagement with all risky riding behaviour. This  
373 finding raises the possibility that students behave differently when they ride for school  
374 and outside school hours.

375 Forty percent of the sample reported riding for more than two years and more than 70%  
376 of the study population were unlicensed riders. Interestingly, it was the licensed riders,  
377 not unlicensed riders, that were found to have significantly higher involvement in "*speed*"  
378 behaviour. A possible explanation for this result is that the confidence of licensed riders  
379 has resulted in a greater intention to "push my limits" (Watson et al., 2007) that could  
380 lower their concern about getting caught by the police given they are legally allowed to  
381 be on a motorcycle, compared to unlicensed riders. Furthermore, the findings shows that

382 riders with higher average hours of riding reported engagement with “speed”, “errors” and  
383 “unsociable riding” more frequently compared to those with fewer average hours. These  
384 findings broadly supports the work of other studies in this area linking exposure with risky  
385 riding behaviour (Truong et al., 2018; Kontaxi et al., 2021). This finding poses an  
386 important issue for future research related to the relationship between Indonesian rider’s  
387 attitudes toward road safety.

### 388 *3.5. Prediction of traffic offences and crash involvement in the past 12 months*

389 Having examined rider’s riding behaviour by their characteristics, it is now necessary to  
390 discuss the association between rider’s riding behaviour and their traffic offence and  
391 crash history. Negative binomial regression analyses were conducted to investigate the  
392 association between three outcome variables of interest: 1) traffic offences in the past 12  
393 months; 2) near-crashes in the past 12-months; 3) crashes in the past 12-months; and  
394 MRBQ factor scores, see Table 7.

395 The final model for predicting traffic offences in the last 12 months was statistically  
396 significant ( $\chi^2(4, N = 7,081) = 322.874, p < .0001$ ) and showed that riding experience,  
397 average distance travelled weekly, frequency of “errors”, and “unsociable riding” are the  
398 main contributory factors associated with traffic offences among young riders. According  
399 to the incidence rate ratios (IRR), each increase in additional year of riding experience  
400 was associated with a 9.6% increase in reported traffic offences. Each 50 kilometres  
401 increase in average distance travelled weekly was also positively related to the likelihood  
402 of reporting traffic offences with a 10.6% increase. Moreover, the likelihood of reporting a  
403 traffic offence increased by 34% and 51.8% with each increase in mean propensity  
404 towards “errors” and “unsociable riding”, respectively.

405 In terms of self-reported near-crash involvement, the final model was also statistically  
406 significant ( $\chi^2(7, N = 7,081) = 563.442, p < .001$ ). According to IRR in Table 7, an increase  
407 of average weekly hours and distance spent riding, gender, area of riding, and increased  
408 frequency of *speed*, *errors* and *traffic violation* were all found to be positively associated  
409 with experiencing a near-crash in the past 12 months. Male riders reported higher  
410 numbers of near crashes (1.144 times) than female riders. Young riders in rural areas  
411 reported 1.204 times higher near-crash experiences than riders in urban areas. Moreover,  
412 an increase mean propensity towards “*speed*”, “*errors*” and “*traffic violation*” behaviour  
413 was associated with an increased reporting of near crashes with 43%, 9.3% and 15.5%  
414 increase, respectively.

415 The final model for predicting crash involvement was statistically significant ( $\chi^2(5, N =$   
416  $7,081) = 312.985, p < .0001$ ). Table 7 shows that riding experience, average distance  
417 travelled weekly, “*speed*”, “*errors*”, and “*unsociable riding*” are the major predictors of  
418 crash involvement. The cumulative years of riding experience was associated with a  
419 likelihood of 2% increased reporting of crash involvement. Looking at riding behaviour,  
420 for each increase in mean propensity towards “*speed*”, “*errors*”, and “*unsociable riding*”  
421 behaviour, the probability of being involved in a crash increased by 26%, 19% and 27%,  
422 respectively.

423

424

425

426

427 *Table 7: Negative binomial analysis of traffic offences, near-crashes and crashes in the*  
 428 *past 12 months (only significant result shown)*

Predictor	B	Incidence rate ratio (IRR)	95% Wald CI (Lowest - Highest)	S.E.	Wald X <sup>2</sup>	Sig.
<b>Dependent Variable: Self-reported traffic offences in the past 12 months</b>						
Riding Experience	0.091	1.096	1.069 - 1.123	0.0125	53.574	0.000
Average Distance	0.101	1.106	1.055 - 1.16	0.0244	17.149	0.000
Errors (MRBQ factor)	0.292	1.34	1.24 - 1.447	0.0394	55.037	0.000
Unsociable riding (MRBQ factor)	0.417	1.518	1.371 - 1.681	0.052	64.417	0.000
<b>Dependent variable: Self-reported near-crash in the past 12 months</b>						
Average Distance	0.051	1.052	1.014 - 1.092	0.0189	7.243	0.007
Average Hours	0.093	1.098	1.049 - 1.148	0.023	16.409	0.000
Gender = Male	0.134	1.144	1.066 - 1.227	0.036	13.94	0.000
Area = Rural	0.186	1.204	1.123 - 1.291	0.0358	26.954	0.000
Speed (MRBQ factor)	0.362	1.437	1.355 - 1.524	0.03	146.303	0.000
Errors (MRBQ factor)	0.088	1.093	1.026 - 1.163	0.032	7.646	0.006
Traffic violation (MRBQ factor)	0.144	1.155	1.092 - 1.221	0.0285	25.634	0.000
<b>Dependent variable: Self-reported crash in the past 12 months</b>						
Riding Experience	0.022	1.022	1.001 - 1.043	0.0107	4.07	0.044
Average distance	0.103	1.109	1.065 - 1.154	0.0205	25.404	0.000
Speed (MRBQ factor)	0.232	1.261	1.176 - 1.351	0.0352	43.168	0.000
Errors (MRBQ factor)	0.175	1.191	1.109 - 1.278	0.0363	23.166	0.000
Unsociable riding (MRBQ factor)	0.238	1.269	1.15 - 1.4	0.0502	22.596	0.000

429

430 Among all MRBQ factors, “errors” was the only one associated with the involvement in all  
 431 three outcomes of interest: self-reported traffic offences, near-crash and crash experience  
 432 in the past 12 months. Errors are broadly defined as the “failure of planned actions to  
 433 achieve their intended consequences” (Reason et al., 1990, p. 1315). It was evident that  
 434 “errors” among young Indonesian riders involved non-intentional behaviour relating to not  
 435 paying attention (for example: “pull out on to a main road in front of a vehicle that you had  
 436 not noticed, or whose speed you have misjudged”). The original MRBQ study and earlier  
 437 studies also found “errors” to be the leading cause of crash involvement (Elliott et al.,

438 2007; Hung and Huyen, 2011; Gruyter et al., 2017). Whilst the use of “*safety equipment*”  
439 does not reduce crash involvement, “*traffic errors*” or “*stunts*” could increase the odds of  
440 crash risks (Stephens et al., (2017). As mentioned earlier in the introduction, the  
441 inconsistencies of which MRBQ factors can better predict crash involvement are evident  
442 and findings from this study further corroborates the argument that there are some MRBQ  
443 factors that remain consistently associated with crash involvement (Stephens et al.,  
444 2017).

445 In addition, when only the odds of crash involvement are considered, “*speed*”, “*errors*”,  
446 and “*unsociable riding*” were found to be the most likely associated. “*Speed*” and “*errors*”,  
447 not including “*unsociable riding*”, were also associated with the increased odds of a near-  
448 crash. A possible explanation for this might be that because “*unsociable riding*” in this  
449 study has a more direct role in the occurrence of actual crashes compared to near  
450 crashes. That being said, it could also mean that engaging in unsociable riding leads to  
451 higher possibility to not being able to avoid the crash. While “*unsociable riding*” factor in  
452 this study did not appear in the previous studies, the items that loaded onto this factor are  
453 similar to the previously named “*stunts*” factor in earlier studies. Comparing the findings  
454 from previous MRBQ studies in developing countries, “*speed*” and “*unsociable riding*”  
455 factors were also predictors for crash and/or traffic offences involvement. For example,  
456 “*errors*” were found to be associated with crash involvement in India (Chouhan et al.,  
457 2021), Vietnam (Trung Bui et al., 2020) and Turkey (Özkan et al., 2012). These similarities  
458 could suggest that there are similar characteristics between countries from developing  
459 countries with high levels of motorcycle dependency.

460 The most recent MRBQ study by Chouhan et al., (2023) questioned whether MRBQ could  
461 predict crash involvement. In their meta-analysis, even though their model observed a  
462 significant effect of “*speed violation*” on crashes, they concluded that MRBQ has limited  
463 ability to predict crashes. Furthermore, they suggest that further study with a larger  
464 sample and including items related with distraction is needed to enhance the predictive  
465 ability of MRBQ. Chouhan et al. (2023) used 11 MRBQ studies with sample sizes ranging  
466 from 146 to 2,399 with the samples biased towards male or female participants. The  
467 current study recruited 7,081 participants with a balanced proportion in gender (52.2%  
468 male and 47.8% female). This study also included items related to distraction (for  
469 example: mobile phone use, smoking while riding and carrying large baggage). Therefore,  
470 this study somewhat addresses Chouhan et al.’s (2023) criticisms and indicates that the  
471 MRBQ can be used as a robust instrument for researching rider behaviour. However, it  
472 should be noted that the MRBQ model in this study only explained 45.61% of the variance  
473 in crash risk which means other factors outside MRBQ factors must be considered (e.g.,  
474 road and vehicle characteristics).

475 Finally, the relationship between risky riding behaviour and the risk of crash involvement  
476 has been the subject of considerable discussion in the literature (Lawton et al., 1997b;  
477 Ambo et al., 2020; Chouhan et al., 2021; Setoodehzadeh et al., 2021; Das, 2021). The  
478 results from the current study regarding the association between MRBQ factors and traffic  
479 offences and crash involvement further supports the relationship.

480

481

#### 482 **4. Conclusion**

483 The findings from this study have three implications. Firstly, this study strengthens the  
484 idea that MRBQ can be used as a robust instrument for investigating riders' behaviour  
485 and their association with traffic offences and crash, but it is sensitive to geographical and  
486 demographic characteristics of the riders. In addition, these findings highlight the  
487 usefulness and the applicability of the MRBQ in identifying risky riding behaviours that  
488 have an underlying association with traffic offences and crash involvement. Also, this  
489 study appears to be the first study to investigate the association between risky riding  
490 behaviour with traffic offences and crash involvement in the context of Indonesia.

491 Secondly, that "*speed*" and "*errors*" were associated with increased risk of self-reported  
492 near-crash and crashes is interesting because these two behaviours have been defined  
493 differently in previous studies. "*Speed*" behaviour is an intentional behaviour, while  
494 "*errors*" are referred to unintentional behaviours (Sumit et al. (2021) and are broadly  
495 defined as the "failure of planned actions to achieve their intended consequences"  
496 (Reason et al., 1990, p. 1315). Despite the nature of "errors", the fact that a common  
497 theme in "*errors*" among young Indonesian riders involved not paying attention to their  
498 surroundings, indicates that even though they may be unintentional, there is a possibility  
499 to develop safety interventions linked with "*speed*" and "*errors*". Possible examples of this  
500 include combining road safety training that targets improving rider awareness and riding  
501 skills (for example: hazard perception training, control skills training such as cornering  
502 and speed) and road safety campaigns that focus on increasing young riders' willingness  
503 to ride safely instead of scaring them with "fear appeal" campaigns (Shanahan et al.,  
504 2000; Witte and Allen, 2000). Supporting this suggestion, the EU Advanced Project (Bartl

505 et al., 2002) concluded that road safety training should not only focus on improving skills  
506 but also on improving riders' understanding and knowledge related to risk and the  
507 perception of their own level of ability (for example: how rider and motorcycle  
508 characteristics can influence their overall road safety).

509 Finally, it is worth mentioning that the results revealed that many of those surveyed were  
510 riding on public roads before they reached the legal age for riding. The opportunity of  
511 accessing the public road without a license before the legal age could explain why many  
512 Indonesian riders do not have a strong willingness to get a license when they reach 17  
513 years old. As mentioned in the introduction section, urban forms of transport and the need  
514 for travel for education makes young unlicensed riders a complex issue in Indonesia. The  
515 fact that unlicensed riders were found to have higher engagement with "*traffic violation*"  
516 and "*unsociable riding*" and these two types of risky behaviour were associated with traffic  
517 offences and crash involvement in the past 12 months, has significant implications for  
518 understanding how to develop effective interventions. It seems obvious that everyone  
519 needs to be licensed to improve safety. However, taking the culture and environment into  
520 consideration, increasing perceived enforcement and focused educational programs  
521 aimed at reducing the social acceptability of these "traffic violations" and "unsociable  
522 riding" behaviours could be more appropriate in improving road safety for young  
523 Indonesians.

## 524 **5. Limitations and future research**

525 The reader should bear in mind this study was designed to specifically investigate young  
526 rider's behaviour in a limited age range (17 to 19 years old) and place (Java, Indonesia).  
527 Therefore, the findings from this paper cannot be simply generalised to other riders.

528 However, given that similar to the findings of other LMIC countries with high dependency  
529 on motorcycles (Chouhan et al., 2021; Trung Bui et al., 2020; Özkan et al., 2012), “errors”  
530 were associated with reported crashes, it is possible that the findings from this study could  
531 be applied to other developing countries with high motorcycle use or dependency.

532 To gain a more comprehensive understanding of the influence of age on the MRBQ factor  
533 structure in Indonesia, further research with a wider age range is recommended.  
534 Nevertheless, the large sample size of 7,081 participants enhances the robustness and  
535 reliability of the findings. Further research with a broader age range could complement  
536 these findings and extend their generalisability.

537 Furthermore, we acknowledge that heterogeneity exists in behavioural data. NBR  
538 accounts for overdispersion but does not directly control for all forms of heterogeneity,  
539 particularly unobserved heterogeneity. Therefore, future research should consider this  
540 issue to improve the reliability of predictive models.

541 Finally, the self-report approach used in this study could encourage socially desirable  
542 responses (Cerri et al., 2019; Bergen and Labonté, 2020). To minimise this potential  
543 social-desirability bias, the survey completion instructions were provided by the  
544 researcher before the questionnaire was distributed. The respondents were told that there  
545 were no sanctions for filling out the questionnaire honestly because the feedback is  
546 anonymous, whilst filling it out honestly could help provide the best solutions for the  
547 current road safety problem in Indonesia. However, future studies on the current topic  
548 using police-reported data are recommended. The lack of detailed data is a shortcoming

549 of the crash database in Indonesia, and having this data available would enable more  
550 targeted interventions.

## 551 **Declaration of Competing Interest**

552 The authors declare no competing financial interests or personal relationships that may  
553 have had any influence on the work presented in this paper.

## 554 **6. References**

555  
556 Akasreku, B., Rwejumura, G., Maroko, A., Nyanza, R., Malekela, G., Kalolo, S.,  
557 Yokeeswaran, U., Fiori, K.P., Abwe, F. and Teasdale, C.A. 2023. Road traffic  
558 injuries in Tanzanian children and adolescents: A cross-sectional household survey.  
559 *Injury*. **54**(1), pp.160–167.

560 Ambo, T.B., Ma, J. and Fu, C. 2020. Investigating influence factors of traffic violation using  
561 multinomial logit method. *International Journal of Injury Control and Safety*  
562 *Promotion*. **28**(1), pp.78–85.

563 Anggraeni, M. 2019. Fenomena Pengendara Sepeda Motor Anak Di Bawah Umur Dan  
564 Upaya Penanggulangannya Di SMPN 2 Sanden Kabupaten Bantul. *E-societas*  
565 *Jurnal Pendidikan Sosiologi*. **8**(5).

566 Bartl, G., Baughan, C., Fougere, J.-P., Gregersen, N.-P., Nyberg, A., Groot, H., Sanders,  
567 N., Keskinen, E., Hatakka, M., Pannacci, M., Willmes-Lenz, G., Bahr, M. and  
568 Stummvoll, G. 2002. *The EU ADVANCED Project : description and analysis of post-*  
569 *licence driver and rider training : final report* [Online]. Rijswijk. Available from:  
570 [https://www.cieca.eu/sites/default/files/documents/projects\\_and\\_studies/1ADVANC](https://www.cieca.eu/sites/default/files/documents/projects_and_studies/1ADVANC)  
571 [EDFinalReportEn.pdf](#).

572 Berry, D.T., Wetter, M.W., Baer, R.A., Larsen, L., Clark, C. and Monroe, K. 1992. MMPI-  
573 2 random responding indices: Validation using a self-report  
574 methodology. *Psychological assessment*, **4**(3), p.340.

575 Cassarino, M. and Murphy, G. 2018. Reducing young drivers' crash risk: Are we there  
576 yet? an ecological systems-based review of the last decade of research.  
577 *Transportation Research Part F: Traffic Psychology and Behaviour*. **56**, pp.54–73.

578 Chakraborty, A. and Maitra, B. 2024. Riding behaviours of motorcyclists in mixed traffic  
579 condition and its association with crash risk. *Case Studies on Transport Policy*. **16**,  
580 article no: 101177.

581 Chouhan, S.S., Kathuria, A. and Sekhar, C.R. 2021. Examining risky riding behavior in  
582 India using Motorcycle rider behavior questionnaire. *Accident Analysis & Prevention*.  
583 **160**, article no: 106312.

584 Chouhan, S.S., Kathuria, A. and Sekhar, C.R. 2023. The motorcycle rider behaviour  
585 questionnaire as a predictor of crashes: A systematic review and meta-analysis.  
586 *IATSS Research*. **47**(1), pp.61–72.

587 Cundill, B. and Alexander, N.D., 2015. Sample size calculations for skewed  
588 distributions. *BMC Medical Research Methodology*, **15**, pp.1-9.

589 Das, S. 2021. Identifying key patterns in motorcycle crashes: findings from taxicab  
590 correspondence analysis. *Transportmetrica A: Transport Science*. **17**(4), pp.593–  
591 614.

592 Dobson, A., Brown, W., Ball, J., Powers, J. and McFadden, M. 1999. Women drivers'  
593 behaviour, socio-demographic characteristics and accidents. *Accident Analysis &*  
594 *Prevention*. **31**(5), pp.525–535.

595 Elliott, M.A., Baughan, C.J. and Sexton, B.F. 2007. Errors and violations in relation to  
596 motorcyclists' crash risk. *Accident Analysis & Prevention*. **39**(3), pp.491–499.

597 Gruyter, C. De, Truong, L.T. and Nguyen, H.T.T. 2017. Who's calling? Social networks  
598 and mobile phone use among motorcyclists. *Accident Analysis & Prevention*. **103**,  
599 pp.143–147.

600 Guo, F., Klauer, S.G., Hankey, J.M. and Dingus, T.A., 2010. Near crashes as crash  
601 surrogate for naturalistic driving studies. *Transportation Research Record*, **2147**(1),  
602 pp.66-74.

603 Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. 2010. *Multivariate data analysis :  
604 a global perspective* Seventh edition. Upper Saddle River, N.J. ; Pearson.

605 Hsu, T.-P., Sadulla, A.F.M. and Dao, N.X. 2003. *A comparative study on motorcycle traffic  
606 development of Taiwan, Malaysia and Vietnam* [Online]. Available from:  
607 [https://www.researchgate.net/publication/284685742\\_A\\_comparative\\_study\\_on\\_m  
608 otorcycle\\_traffic\\_development\\_of\\_Taiwan\\_Malaysia\\_and\\_Vietnam](https://www.researchgate.net/publication/284685742_A_comparative_study_on_motorcycle_traffic_development_of_Taiwan_Malaysia_and_Vietnam).

609 Hung, K.V. and Huyen, L.T. 2011. Education influence in traffic safety: A case study in  
610 Vietnam. *IATSS Research*. **34**(2), pp.87–93.

611 Indriastuti, A. and Sulistio, H. 2010. Influencing factors on motorcycle accident in urban  
612 area of Malang, Indonesia. *International Journal of Academic Research*. **2**(5),  
613 pp.252-255.

614 Indonesia Central Bureau of Statistics 2021. *Land Transportation Statistics*. BPS -  
615 Statistics Indonesia.

616 Indonesia National Traffic Police. 2019. Road Traffic Accidents Annual Report.  
617 Unpublished.

618 Indonesia National Traffic Police. 2020. Road Traffic Accidents Annual Report.  
619 Unpublished.

620 Kontaxi, A., Ziakopoulos, A. and Yannis, G. 2021. Investigation of the speeding behavior  
621 of motorcyclists through an innovative smartphone application. *Traffic Injury*  
622 *Prevention*. **22**(6), pp.460–466.

623 Lawton, R., Parker, D., Stradling, S.G. and Manstead, A.S.R. 1997a. Predicting road  
624 traffic accidents: The role of social deviance and violations. *British Journal of*  
625 *Psychology*. **88**(2), pp.249–262.

626 Lawton, R., Parker, D., Manstead, A.S.R. and Stradling, S.G. 1997b. The Role of Affect  
627 in Predicting Social Behaviors: The Case of Road Traffic Violations. *Journal of*  
628 *Applied Social Psychology*. **27**(14), pp.1258–1276.

629 Lin, M.-R., Chang, S.-H., Pai, L. and Keyl, P.M. 2003. A longitudinal study of risk factors  
630 for motorcycle crashes among junior college students in Taiwan. *Accident Analysis*  
631 *& Prevention*. **35**(2), pp.243–252.

632 Lin, M.-R. and Kraus, J.F. 2009. A review of risk factors and patterns of motorcycle  
633 injuries. *Accident Analysis & Prevention*. **41**(4), pp.710–722.

634 Meade, A.W. and Craig, S.B., 2012. Identifying careless responses in survey  
635 data. *Psychological methods*, **17**(3), pp.437–455.

636 Motevalian, S.A., Asadi-Lari, M., Rahimi, H. and Eftekhar, M. 2011. Validation of a persian  
637 version of motorcycle rider behavior questionnaire. *Annals of advances in automotive*  
638 *medicine. Association for the Advancement of Automotive Medicine. Annual*  
639 *Scientific Conference*. **55**, pp.91–98.

640 Nurlia, D.A., Komariah, S. and Waluya, B. 2017. Faktor-faktor penyebab maraknya

641 pengendara motor di bawah umur di Desa Rancamanyar Kecamatan Baleendah  
642 Kabupaten Bandung. *E-societas Jurnal Pendidikan Sosiologi*. **7**(2).

643 Özkan, T., Lajunen, T., Doğruyol, B., Yıldırım, Z. and Çoymak, A. 2012. Motorcycle  
644 accidents, rider behaviour, and psychological models. *Accident Analysis &*  
645 *Prevention*. **49**, pp.124–132.

646 Parker, D., Reason, J.T., Manstead, A.S. and Stradling, S.G., 1995. Driving errors, driving  
647 violations and accident involvement. *Ergonomics*, **38**(5), pp.1036-1048.

648 Putranto, L.S. and Anjaya, I.S. 2014. Initial development of Indonesian motorcycle rider  
649 behaviour *In: Proceedings of the 9th Asia Pacific Conference on Transportation &*  
650 *the Environment* [Online]. Department of Civil Engineering, University of Moratuwa,  
651 pp.229–233. Available from: <http://dl.lib.mrt.ac.lk/handle/123/13545/20.pdf>.

652 Putranto, L.S., Setyarini, N., Rostiana, R. and Bunawan, R. 2014. Motorcycle Rider  
653 Behaviour of Tarumanagara University Lecturer and Employee *In: 17th International*  
654 *Symposium of Inter-University Transportation Study Forum* [Online]. Available from:  
655 <http://repository.untar.ac.id/id/eprint/1833>.

656 Reason, J., Manstead, A., Stradling, S., Baxter, J. and Campbell, K. 1990. Errors and  
657 violations on the roads: a real distinction? *Ergonomics*. **33**(10–11), pp.1315–1332.

658 Republic of Indonesia. 2009. *Legislation No. 22 of 2009 about Traffic and Road Transport*.  
659 [Online]. [Accessed 7 August 2023]. Available from: [https://korlantas.polri.go.id/wp-](https://korlantas.polri.go.id/wp-content/uploads/2021/03/uu_no_22_tahun_2009.pdf)  
660 [content/uploads/2021/03/uu\\_no\\_22\\_tahun\\_2009.pdf](https://korlantas.polri.go.id/wp-content/uploads/2021/03/uu_no_22_tahun_2009.pdf).

661 Republic of Indonesia Police Regulation (PERPOL) Number 5. 2021. *The issuance and*  
662 *marking of driving licenses*. [Online]. [Accessed 7 August 2023]. Available from:  
663 <https://korlantas.polri.go.id/wp-content/uploads/2021/03/PERPOL-NO-5-TH-2021->

664 TTG-PENERBITAN-DAN-PENANDAAN-SIM.pdf

665 Minister of Education and Culture of the Republic of Indonesia Regulation  
666 (PERMENDIKBUD) Number 14. 2018. *Acceptance of New Students in Kindergarten,*  
667 *Elementary School, Junior High School, Senior High School, Vocational High School,*  
668 *or Other Equivalent Forms.* [Online]. [Accessed 10 September 2023]. Available from:  
669 <https://peraturan.bpk.go.id/Details/138190/permendikbud-no-14-tahun-2018>.

670 Sakashita, C., Senserrick, T., Lo, S., Boufous, S., Rome, L. de and Ivers, R. 2014. The  
671 Motorcycle Rider Behavior Questionnaire: Psychometric properties and application  
672 amongst novice riders in Australia. *Transportation Research Part F: Traffic*  
673 *Psychology and Behaviour.* **22**, pp.126–139.

674 Schreurs, K.V, Ross, V. and Brijs, K. 2023. Investigating the relationship between self-  
675 reported (near) crashes, fined traffic offences, and risky riding behaviours among  
676 Flemish motorcyclists using the motorcycle rider behaviour questionnaire.  
677 *Transportation Research Part F: Traffic Psychology and Behaviour.* **98**, pp.337–353.

678 Setoodehzadeh, F., Ansari-Moghaddam, A., Okati-Aliabad, H., Khammarnia, M. and  
679 Mohammadi, M. 2021. Self-reported Motorcycle Riding Behavior in Southeast of Iran.  
680 *Health Scope.* **10**(3).

681 Setyowati, D.L., Setyaningsih, Y., Suryawati, C. and Lestantyo, D., 2024. Indonesian  
682 version of the motorcycle rider behaviour questionnaire: cross-cultural adaptation  
683 and validation. *International Journal of Public Health,* **13**(3), pp.1276-1285.

684 Sexton, B., Baughan, C., Elliott, M.A. and Maycock, G. 2004. *The accident risk of*  
685 *motorcyclists - Prepared for Road Safety Division, Department for Transport* [Online].  
686 Available from: <https://strathprints.strath.ac.uk/20274/1/strathprints020274.pdf>.

- 687 Shaheed, M.S.B., Gkritza, K., Zhang, W. and Hans, Z. 2013. A mixed logit analysis of  
688 two-vehicle crash severities involving a motorcycle. *Accident Analysis & Prevention*.  
689 **61**, pp.119–128.
- 690 Shanahan, P., Elliott, B. and Dahlgren, N. 2000. *Review of public information campaigns*  
691 *addressing youth risk-taking: A report to the National Youth Affairs Research*  
692 *scheme*. Australia: Published for the National Youth Affairs Research Scheme by the  
693 Australian Clearinghouse for Youth Studies.
- 694 Siswantoro, H. 2018. *Upaya peningkatan kesadaran hukum masyarakat dalam proses*  
695 *ujian teori surat izin mengemudi di Polres Bantul* [Online]. STIE Widya Wiwaha.  
696 Available from: <http://eprint.stieww.ac.id/id/eprint/674>.
- 697 Steinberg, L. 2008. A social neuroscience perspective on adolescent risk-taking.  
698 *Developmental Review*. **28**(1), pp.78–106.
- 699 Stephens, A.N., Brown, J., de Rome, L., Baldock, M.R.J., Fernandes, R. and Fitzharris,  
700 M. 2017. The relationship between Motorcycle Rider Behaviour Questionnaire  
701 scores and crashes for riders in Australia. *Accident Analysis & Prevention*. **102**,  
702 pp.202–212.
- 703 Sumit, K., Ross, V., Brijs, K., Wets, G. and Ruiters, R.A.C. 2021. Risky motorcycle riding  
704 behaviour among young riders in Manipal, India. *BMC Public Health*. **21**(1), article  
705 no: 1954.
- 706 Sunday, O., and Akintola, L. 2011. The motorcycle rider behaviour questionnaire (MRBQ)  
707 and commercial motorcycle riders in Nigeria. *Driver behaviour and training*. **4**,  
708 pp.193–209.
- 709 Trung Bui, H., Saadi, I. and Cools, M. 2020. Investigating on-road crash risk and traffic

710 offences in Vietnam using the motorcycle rider behaviour questionnaire (MRBQ).  
711 *Safety Science*. **130**, article no: 104868.

712 Truong, L.T., Nguyen, H.T.T. and De Gruyter, C. 2018. Correlations between mobile  
713 phone use and other risky behaviours while riding a motorcycle. *Accident Analysis &*  
714 *Prevention*. **118**, pp.125–130.

715 Uttra, S., Jomnonkwao, S., Watthanaklang, D. and Ratanavaraha, V., 2020. Development  
716 of self-assessment indicators for motorcycle riders in Thailand: Application of the  
717 motorcycle rider behavior questionnaire (MRBQ). *Sustainability*, **12**(7), article no:  
718 2785.

719 Watson, B., Tunnicliff, D., White, K., Schonfeld, C. and Wishart, D. 2007. *Psychological*  
720 *and social factors influencing motorcycle rider intentions and behaviour*.

721 Witte, K. and Allen, M. 2000. A Meta-Analysis of Fear Appeals: Implications for Effective  
722 Public Health Campaigns. *Health Education & Behavior*. **27**(5), pp.591–615.

723 World Bank Group. 2023. *The World Bank In Indonesia*. [Online]. [Accessed 12  
724 December 2023]. Available from:  
725 <https://www.worldbank.org/en/country/indonesia/overview>.

726 World Health Organization. 2023. *Global status report on road safety 2018*. [Online].  
727 [Accessed 23 February 2024]. Available from:  
728 <https://www.who.int/publications/i/item/9789240086517>.

729 Wu, K.-F., Agüero-Valverde, J. and Jovanis, P.P. 2014. Using naturalistic driving data to  
730 explore the association between traffic safety-related events and crash risk at driver  
731 level. *Accident Analysis & Prevention*. **72**, pp.210–218.

732 Yeh, T.-H., Chang, H.-L. and Chang, H.-W. 2008. Initial age of unlicensed motorcycling

733 experience for a cohort of high school students. *Accident Analysis & Prevention*.  
734 **40**(2), pp.511–517.

735 Zain, S.M.S.M., Latif, M.T., Baharudin, N.H., Anual, Z.F., Mohd Hanif, N. and Khan, M.F.  
736 2021. Atmospheric PCDDs/PCDFs levels and occurrences in Southeast Asia: A  
737 review. *Science of The Total Environment*. **783**, pp.1–14.

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740 *Table 8: Final MRBQ items used in present study*

No	Items	Source
1	Fail to notice that pedestrians are crossing when turning into a side street from a main road	Elliot et al., 2007
2	Not notice someone stepping out from behind a parked vehicle until it is nearly too late	Elliot et al., 2007
3	Not notice a pedestrian waiting to cross at a zebra crossing, or a pelican crossing that has just turned red	Elliot et al., 2007
4	Pull out on to a main road in front of a vehicle that you had not noticed, or whose speed you have misjudged	Elliot et al., 2007
5	Narrowly avoid colliding as a result of intentionally keep riding when you know that it is not your right of way	Elliot et al., 2007
6	Fail to notice or anticipate that another vehicle might pull out in front of you and have difficulty stopping	Elliot et al., 2007
7	Queuing to turn left on a main road, you pay such close attention to the main traffic that you nearly hit the vehicle in front	Elliot et al., 2007
8	Distracted or pre-occupied, you belatedly realise that the vehicle in front has slowed and you have to brake hard to avoid a collision	Elliot et al., 2007
9	Attempt to overtake someone that you had not noticed to be signaling a right turn	Elliot et al., 2007
10	Not slow down when approaching a yellow light	Elliot et al., 2007
11	Ride so close to the vehicle in front that it would be difficult to stop in an emergency	Elliot et al., 2007
12	Run wide when going round a corner	Elliot et al., 2007
13	Ride so fast into a corner that you feel like you might lose control	Elliot et al., 2007
14	Exceed the speed limit on a country/rural road	Elliot et al., 2007
15	Disregard the speed limit late at night or in the early hours of the morning	Elliot et al., 2007
16	Exceed the speed limit on a residential road	Elliot et al., 2007
17	Race away from traffic lights with the intention of beating the driver/rider next to you	Elliot et al., 2007
18	Open up the throttle and just 'go for it' on country roads	Elliot et al., 2007
19	Ride between two lanes of moving traffic	Elliot et al., 2007

20	Get involved in unofficial 'races' with other riders or drivers	Elliot et al., 2007
21	Ride so fast into a corner that you scare yourself	Elliot et al., 2007
22	Attempt to do, or actually do, a wheelie	Elliot et al., 2007
23	Pull away too quickly and your front wheel comes off the road	Elliot et al., 2007
24	Intentionally do a wheel spin	Elliot et al., 2007
25	Unintentionally do a wheel spin	Elliot et al., 2007
26	Wear riding boots	Elliot et al., 2007
27	Wear shoes	From informal conversation with police colleague
28	Wear protective trousers (leather or non-leather)?	Elliot et al., 2007
29	Wear a protective jacket (leather or non-leather)?	Elliot et al., 2007
30	Wear body armour (elbow pads, shoulder pads, knee pads, etc)	Elliot et al., 2007
31	Wear no protective clothing?	Elliot et al., 2007
32	Wear protective gloves?	Elliot et al., 2007
33	Wear bright/fluorescent strips/patches on your clothing	Elliot et al., 2007
34	Wear bright/fluorescent clothing when riding at night	Elliot et al., 2007 (Re-phrased)
35	Using helmet without chin straps or not fastening it	Putranto et al., 2014
36	Riding without a helmet	Putranto et al., 2014
37	Use dipped headlights on your bike?	Elliot et al., 2007
38	Brake or throttle-back when going round a corner or bend	Elliot et al., 2007
39	Change gear when going round a corner or bend	Elliot et al., 2007
40	Find that you have difficulty controlling the bike when riding at speed (e.g. steering wobble)	Elliot et al., 2007

41	Skid on a wet road or manhole cover	Elliot et al., 2007
42	Have trouble with your visor or goggles fogging up	Elliot et al., 2007
43	You get annoyed when other riders put you at risk	Elliot et al., 2007
44	Ride your motorcycle after having alcohol drink	Elliot et al., 2007
45	Call with a mobile phone while riding	Putranto et al., 2014
46	Carry more than one passenger with your motorcycle	Putranto et al., 2014
47	Carry a passenger who has not worn a helmet	Putranto et al., 2014
48	Cross junction when the traffic light is red	Putranto et al., 2014
49	Riding in the opposite direction of the roadway	Putranto et al., 2014
50	Riding with unroadworthy motorcycle	Putranto et al., 2014
51	Smoking while riding	Putranto et al., 2014
52	Carry a passenger who sit on one side (usually when woman wearing skirt)	From informal conversation with police colleague
53	Carry a big carriage or big stuff with your motorcycle	From informal conversation with police colleague
54	Riding zig-zag (move between lane quickly) to find road gaps	From informal conversation with police colleague