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Original Article

Utilizing Beta Regression in Predicting the Underlying Factors of Motorcycle Rider Behavior

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ABSTRACT

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Introduction: Motorcyclists have the highest proportion of casualty toll caused by street accidents in Iran, and they endanger themselves and others by those risky behaviors. Health and safety education will not be sufficient without knowing the causes of such behaviors. Since no studies have been carried out based on accurate statistical methods on bounded response variables for motorcyclists' high-risk behaviors in Iran, this study aimed to predict MRBQ by ADHD and the underlying predictors using the Beta Regression as an alternative strategy.
Methods: The present sectional study included 311 Motorcyclists randomly selected using a cluster sampling method in Bukan city to evaluating the relationship between the limited response MRBQ with ADHD and its subscales. We used an innovative beta regression method for the analysis and carried out unadjusted and adjusted modeling.
Results: Direct and significant relationships were observed between MRBQ score and ADHD score and its subscales, including (DSS score) (coefficients ranged over 0.01 to 0.6, All P<0.05). Additionally, the riding period (coefficients ranged over -0.32 to -0.48, P<0.05), hours of riding (coefficients ranged over: 0.31 to 0.34, P<0.05), using the helmet (coefficients: 0.26 to 0.31, P<0.05), and sub-accident (coefficients ranged over 0.35 to 0.37, P<0.05) also turned out to be significant predictors of MRBQ score.
Conclusion: ADHD score and riding parameters can be taken into account when contriving actions on the motorcycle rider behaviors as measured by MRBQ.

Introduction

For nearly a decade, the motorcycle has become widely used among young people as one of the most desired vehicles. Compared to a car, its low-cost price has led many middle class and poor people to choose it as their vehicles for transportation (1, 2). Also, heavy traffic and the implementation of traffic plans have made people more likely to use motorcycles (3). Every year around 1.2 million people die from fatal accidents, and 20 to 50 million people are hindered (4).

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Meanwhile, death tolls from traffic accidents in Iran are 25.8 per 100,000 population. The importance of the issue in Iran can be investigated when it is compared with the world figure(19.9%), low-income countries (20.7%), and eastern Mediterranean countries (15.2%) (5). In Iran, motorcyclists account for the largest proportion of accidents on the streets of the city and the village (61%) (6). Researchers believe that motorcyclists are among the most vulnerable road groups with a high priority to study and intervene among other groups (6-8).

Although health education is an essential strategy for modifying risk behaviors, health education experts have had much contact with preventing unintentional injuries (8). The factors that change harmful behavioral patterns are unknown (9).

According to the road deaths census, 25% of all deaths are caused by injuries. Research has shown that human factors (behavioral) constitute a significant determinant factor and affective factor in 60% of traffic accidents and 95% of accidents, respectively. In such a situation, a particular group of people is more likely to experience more traffic accidents than others with other personality traits (10, 11). Of the most important aspects attached to the role of the human as a factor, cognitive attention is the leading cause of traffic accidents in a way that it comprises 20- 50% of accidents (12). A factor contributing to road traffic injuries and accidents is Attention Deficit Hyperactivity Disorder (ADHD), a developmental chronic nervous disorder. Individuals dealing with this disorder will encounter significant difficulties in various aspects of their lives. As a factor, motorcyclist riding behavior is the last ring of human causal and psychological factors concerning accident (13, 14). When examining the absolute position of humans in the series of events directing to the accident, recognizing this factor is considered a practical action in traffic safety (15).

Sidewalks, freeways, unidirectional streets, air pollution… None of these death factors is driven by the fact that their accident statistics and regular charges have already alarmed it, but what should we do?

One of the main goals of health education is to change behavior, but safety and health education will not be sufficient without knowing about behavioral factors. Since the action in different societies is different and reflects various causes and characteristics, it is imperative to recognize this alien network to influence behavior. The scope of the system is so broad that it varies from person to person and from group to group (16).

Considering the importance of human health in medical and epidemiologic studies, the accuracy of the results is more important. Thereby those statistical models that have the lowest degree of bias and error ought to be used. Implementing statistical models without this standard may not be adapted for such data and may prompt bias in results and decision making (17). Most of the previous consequential analyses on MRBQ were based on normal Generalized Linear Models (GLM), which did not consider the limitation of the bounded nature of response variables within their models. They may lead to bias in findings (18-20). So specific statistical methods are required to completely address the issue and risk factors of major road traffic accidents and their consequences (21, 22).

Here and now, a question arises: how should one perform a regression analysis in which the dependent variable adopts values in the bounded interval? In this regard, probit and logistic, logistic quantile regression (LQR) methods have been suggested for modeling doubly bounded random variables. We turn our lenses to focus on the most popular parametric model, the so-called "beta regression". Beta regression employs doubly bounded continuous dependent variables; i.e., those possess both a lower and an upper bound, where the boundary cases are real. In as much as these data concentrate on a certain sub-gap of a specific range of changes (i.e., the distribution of such data is significantly disrupted), this method yields more reliable results than above mentioned. In this case, LQR, like other competing methods maybe has two significant problems: First, the regularity conditions for maximum likelihood estimation may no longer hold, and also, it still does not provide heteroscedasticity to be explicitly modeled, although for beta regression, they do since the expected values have been transformed (by the link function) instead of the data themselves (22). Also, according to a previous study, it appears that the LQR model has a poor performance on account of the wide range of the variable-band response. Therefore, it is presumed that using the popular beta regression method leads to more reliable results (23).

Therefore, the present study was conducted to investigate the predictive factors of motorcycle behaviors (using MRBQ) based on a valid statistical analysis of beta regression. It was of interest that beta regression provides more optimal results compared to other statistical models.

Materials and methods

Participants and procedures

A total of 311 Iranian male motorcyclists participated in this cross-sectional study according to a cluster sampling design in the Bukan, northwest of Iran, in 2016. The Bukan is located in West Azerbaijan province. Its population is 224628 based on the general census of the Iranian statistical center in 2011. We divided the whole city into 14 homogeneous clusters, and then 7 clusters were randomly chosen. Afterward, considering each cluster, needed samples were gathered to achieve the determined sample size. Data were collected by referring to homes and motorcycles shops. Some adjustments were applied by sampling design and sample selection for plausibility to perform sampling. The inclusion criteria were: utilizing motorcycle (no less than three times each month), age of +15 years, dwelling in Bukan, and being conscious and aware when completing the questionnaire. The exclusion criteria were: the absence of inspiration to participate and to fill out the questionnaires in a self-descriptive manner.

The ethical committee of Tabriz University of Medical Sciences approved the study's protocol, and all methods were performed under the relevant guidelines and regulations. The participants could participate in the study at will. The collected data was used just for scientific purposes, and privacy was preserved at the same time. All participants ultimately agreed to informed consent and permission. For the illiterate people, the informed consent form was read by the researcher or someone to whom s/he relies. Then fingerprints were taken instead.

The sample size was determined using preliminary information extracted from the study by Abedi et al. (19). Considering 95% confidence level and 80% power, the sample was estimated to be 227 subjects according to the odds ratio (OR), about 1.4 as the effect size. The sample size was increased to 296 cases considering a design effect of 1.3 and then increased to 311 for more accuracy (19).

Study variables and measurements

The main variables of this study are MRBQ as the outcome and ADHD as the predictor of MRBQ. Data were collected in a self-descriptive manner employing MRBQ (with

48-items) and Conner's short-form ADHD questionnaires to assess motorcyclist behaviors and Attention-Deficit/Hyperactivity Disorders, respectively.

In this study, the MRBQ was used to assess motorcyclist behavior as the outcome variable. For the first time, MRBQ was built in 2007 by Elliott et al., developed by Kahn et al. (24, 25). In this study, the internal consistency reliability evaluated by Cronbach's alpha was favored for MRBQ (α= 0.896). The participants were asked to report back the frequency of their behaviors a year ago by choosing one of the 5 points scales (0=never, 1=hardly ever, 2=occasionally, 3=quite often 4=nearly all the time). Then, totaling up the items gives the MRBQ score. The scores fluctuate within 0-192, wherein the higher scores indicate that less attention is linked to the traffic rules.

The ADHD questionnaire was also translated, and its' validity and reliability were assessed and confirmed in a study by Amiri et al. (26). In this research, the internal consistency reliability was supported for the ADHD scale (α= 0.891) and for all ADHD subscales (0.643-0.899). ADHD comprises four subscales; subscale A: measuring inattention (I1 +I9 +I13 +I14 +I19 +I21 +I26 +I29 +I30), subscale B: measuring hyperactivity, impulsivity (I2 + I4 + I6 + I8 + I16 + I18 + I22 +I25 +I27), subscale C (A +B), and subscale D: measuring ADHD index (I3 +I5 +I7 +I10 +I11 +I12 +I15 +I17 +I20 +I23 +I24 +I28). The symptomatology linked to the scale is based on the DSMIV (Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition). The diagnostic criteria for ADHD are similarly comparable to those in the DSMV(27). Rating scales will inquire the respondents to score behaviors on a 4-point frequency scale ranging from 0=never/rarely to 3=very often. Regarding its all subscales, ADHD scale scores were computed by summing over the items (ranges over 0-90 for total score, 0-27 for A and B subscales, 0-54 for C subscale, and 0-36 for D subscale). The severity of the symptom increases as the score goes high.

The MRBQ predictors in this study were Age, Marital status, Educational level, Job status, Income level, House Price level, Motorcycling aim, Car price level, Hygiene cost level, using the helmet, having a riding license, riding license period, riding period, Hours of riding, number of days used, Sub accident, Vehicle type, Cell phone answering.

Considering the above predictors, both trend effect and effect compared to a reference category were regarded as the LQR models. When an entire set of quintiles demonstrated a significant relationship with MRBQ, we considered it significant. The missing values were deleted listwise, and the effect of missing values was ignorable since they were less than 5 percent.

Statistical Analyses

Data were summed up and presented subsequently using the mean (SD) or the median (25^{th} percentile -75^{th} percentile) along with (Minimum-Maximum) for numeric values and the frequency (percent) for categorical variables, respectively.

The present study offered the Beta regression model, unlike the regression models, which are usually used to analyze data related to a set of explanatory variables. However, required data assumptions were met in this study, fortunately. Still, the model is fitted considering the normality assumption for the response variable. In some cases, transformations may be required to make the variance constant. In some other situations, the response variable might be constrained in the interval (0,1), and out-of-range predictions may be obtained using a regression model. These conventional statistical methods do not provide complete coverage for consequences due to the bounded nature of the outcome and cause the structural problem of non-equity of the two sides of the equations. Because they do not anticipate these effects within their range, they cause problems. In cases like this, the use of normal regression models is not suitable, and the beta regression model is proposed instead (22).

Therefore, with regards to the limitations mentioned, the objective of the present study was to use a valid and appropriate statistical method of beta regression for investigating the relationship between MRBQ and its' underlying predictors and provide a prediction for it. Also, the response variable was confined within a boundary of the interval (0, 192). In this regard, we first narrowed our response variable using logit transforms within the range (0, 1), and then we fit the beta regression model to obtain the desired goal.

In this model, ADHD is a predictor of MRBQ. The bounds were set as y_{min} = 0 and y_{max}= 192. Moreover, the standard error and p-values were attained using 1000 bootstrap samples. The model parameters were achieved using the betareg package in Stata 14 software (Stata Corp, College Station, Texas 77845 USA), using the betareg code, and then the bootstrap standard errors are attained (21, 28). In the beta regression model, variables with $p<0.1$ in univariate analysis were entered in the multivariate model. The variables including education, income level, using the helmet, having a riding license, riding license period, hours of riding, riding period, sub Accident, answering a cell phone, ADHD, and ADHD subscales. In the multivariate modeling strategy, four models were fitted using beta regression and GLM, and the results were compared. Statistical significance was set at 0.05. In model 1, the MRBQ was modeled with significant background variables in the univariate analyses. In model 2, the ADHD score was added in model 1. In model 3, the subscales of ADHD, including BSS and ASS, were added in model1. Finally, in model 4, the subscale DSS was added in model1. In each model, confidence intervals and P-values were calculated. Extra to the analysis finished by categorical indicator variables, trend analyses were completed by directly injecting the ordinal categorical variables into the models.

Results

A total of 311-man motorcyclists were surveyed from Bukan, of which 222 people (71.38%) did not have a riding license. At the same time, a number of 252 (81.03%) people had more than two years of motorcycle riding experience, and also the primary purpose of the 219 persons (70.42%) was recreation and journey. Table 1 provides a summary of the demographic characteristics of these motorcyclists.

Table 1. Descriptive characteristics of the study's participants and frequency and percent of MRBQ in each level of predictive variables

Variables	n (%)	Variables	n (%)
Education level		**Using the Helmet**	
Illiterate	22 (7.07)	Always	47 (15.11)
Primary	44 (14.15)	Often	59 (18.97)

Diploma	141 (45.34)	Sometimes	59 (18.97)
Diploma+	44 (14.15)	Seldom	91 (29.26)
BSC+	60 (19.29)	Never	55 (17.685)
Job-status		**Having riding license**	
Worker	90 (28.94)	Have	89 (28.62)
Market	29 (9.32)	Not Have	222 (71.38)
Service	45 (14.47)	**Riding license period**	
free	132 (42.44)	< 1 year	10 (11.36)
government	15 (4.42)	1-3 years	24 (27.27)
Income level		3-5 years	21 (23.86)
< 600	40 (12.86)	> 5 years	33 (37.50)
600-1000	72 (23.15)	**Riding period**	
1000-1500	81 (26.05)	< 1 year	59 (18.97)
1500-2000	91 (29.26)	> 2 days	252 (81.03)
2000-5000	27 (8.68)	**Hours of riding**	
House Price level		< 2 hours	29 (9.32)
Not Have	146 (46.95)	2-5 hours	247 (79.42)
< 100	63 (20.26)	> 5 hours	35 (11.25)
100-200	72 (23.15)	**Sub Accident**	
> 200	30 (9.65)	Have	70 (22.51)
Car Price level		Not Have	241 (77.49)
Not Have	235 (75.56)	**Vehicle Type**	
< 10	48 (15.43)	Pedestrian	5 (7.25)
> 10	28 (9.00)	Motorcycle	9 (13.04)
Hygiene Cost level		Car	34 (49.28)
< 10	94 (30.23)	Lorry	21 (30.43)
10-20	135 (43.41)	**Cell Phone Answering**	
20-40	64 (20.58)	Always	49 (15.76)
> 40	18 (5.79)	Often	77 (24.76)
Number of days used		Some Times	68 (21.86)

< 4 days in the month	100 (32.16)	Seldom	63 (20.26)
4-6 days in the month	130 (41.80)	Never	54 (17.36)
≥ 7 days in the month	81 (26.05)	**Motorcycling Aim**	
		Recreation, Journey, Recreation & Journey	219 (70.42)
		Work & Profession, Work Journey Recreation	92 (29.58)

The listed measure of MRBQ outcome and the main predictor, i.e., ADHD and its subscales, are presented in Table 2. The mean and standard deviation of the ADHD population were 27.8 & 12.6, and the results showed that in MRBQ and ADHD scores and its subscales which were less than the possible average score, could be achieved as presented in Table 2.

Table 2. Summary statistics of main study variables (n=311)

	Mean	Standard Deviation	Minimum	Maximum
MRBQ Score	63.3	22.8	0	126
ADHD Score	27.8	12.6	0	66
ASS Score	7.6	4.2	0	21
BSS Score	9.1	4.1	0	19
CSS Score	16.7	7.7	0	36
DSS Score	11.1	5.4	0	30

MRBQ: Motorcycle Rider Behavior Questionnaire; ADHD: Attention Deficit Hyperactivity Disorder; ASS Score: A subscale score measuring inattention; BSS score: B subscale score measuring hyperactivity, impulsivity; CSS Score: C subscale score the sum of A and B subscales; DSS Score: D subscale score measuring ADHD index; MRBQ ranges over (0, 192) and ADHD ranges over (0, 90); ASS and BSS ranges over (0, 27); CSS ranges over (0, 54); DSS ranges over (0, 36)

The proposed multivariate analysis includes four different models, which are presented in Tables 4-7. Based on model 1, which was intended to predict explanatory variables for MRBQ, demographic variables comprising education level, using the helmet, riding period, hours of riding, and sub accident were significantly determined by beta regression and using the helmet, riding period, and hours of riding were significantly determined by GLM, as shown in table 4.

In model 2, controlling for the variables of model 1, the relationship between the MRBQ as the response variable and the ADHD was investigated. The results indicated significant relationships between them using GLM and beta regression methods, as shown in table 5.

Table 3. Relationship between MRBQ as outcome variable with ADHD and underlying predictors of MRBQ using beta regression

Variables	**B**	**90% CI**	**P-value**
Education level	**-0.05**	**(-0.10 to -0.01)**	**0.081**
Income level	**-0.05**	**(-0.10 to -0.01)**	**0.078**
< 600	Referent	Referent	Referent
600-1000	-0.08	(-0.27 to 0.11)	0.511
1000-1500	0.05	(-0.13 to 0.24)	0.635
1500-2000	-0.07	(-0.25 to 0.11)	0.523
2000-5000	**-0.38**	**(-0.63 to -0.13)**	**0.012**
House Price level			
Not Have	Referent	Referent	Referent
< 100	-0.01	(-0.16 to 0.14)	0.913
100-200	0.05	(-0.09 to 0.19)	0.541
> 200	**-0.20**	**(-0.40 to -0.01)**	**0.098**
Hygiene Cost level			
< 10	Referent	Referent	Referent
10-20	-0.08	(-0.21 to 0.05)	0.324
20-40	0.09	(-0.06 to 0.24)	0.334
> 40	**-0.56**	**(-0.83 to -0.29)**	**0.001**
Using the Helmet	**0.11**	**(0.07 to 0.15)**	**<0.001**
Always	Referent	Referent	Referent
Often	0.46	**(0.27 to 0.65)**	**<0.001**
Sometimes	0.64	**(0.45 to 0.83)**	**<0.001**
Seldom	0.56	**(0.39 to 0.74)**	**<0.001**
Never	0.57	**(0.37 to 0.76)**	**<0.001**
Having riding license			
Have	Referent	Referent	Referent
Not Have	**0.20**	**(0.08 to 0.33)**	**0.007**
Riding license period			
< 1 year	Referent	Referent	Referent
1-3 years	**-0.53**	**(-0.99 to -0.07)**	**0.060**
3-5 years	0.04	(-0.42 to 0.51)	0.881

> 5 years	-0.37	(-0.82 to 0.07)	0.164
Hours of riding	**0.39**	**(0.28 to 0.51)**	**<0.001**
< 2 hours	Referent	Referent	Referent
2-5 hours	**0.67**	**(0.47 to 0.87)**	**<0.001**
>5 hours	**0.86**	**(0.62 to 1.11)**	**<0.001**
Riding period			
< 1 year	Referent	Referent	Referent
> 2 year	**-0.37**	**(-0.51 to -0.24)**	**<0.001**
Vehicle Type			
Pedestrian	Referent	Referent	Referent
Motorcycle	**-1.05**	**(-1.75 to -0.36)**	**0.012**
Car	**0.14**	**(-0.41 to 0.69)**	**0.678**
Lorry	**-0.19**	**(-0.76 to 0.39)**	**0.598**
Cell Phone Answering	**-0.10**	**(-0.14 to -0.06)**	**<0.001**
Always	Referent	Referent	Referent
Often	**-0.01**	**(-0.18 to 0.17)**	**0.946**
Some Times	**-0.03**	**(-0.21 to 0.15)**	**0.791**
Seldom	**-0.16**	**(-0.35 to 0.02)**	**0.136**
Never	**-0.43**	**(-0.63 to -0.24)**	**<0.001**
Sub Accident			
Have	Referent	Referent	Referent
Not Have	**0.15**	**(0.02 to 0.29)**	**0.063**
ADHD Score	**0.01**	**(0.01 to 0.02)**	**<0.001**
ASS Score	**0.04**	**(0.03 to 0.05)**	**<0.001**
BSS Score	**0.04**	**(0.03 to 0.05)**	**<0.001**
CSS Score	**0.02**	**(0.02 to 0.03)**	**<0.001**
DSS Score	**0.03**	**(0.02 to 0.04)**	**<0.001**

B: Coefficient; CI: Confidence Interval
MRBQ: Motorcycle Rider Behavior Questionnaire; ADHD: Attention Deficit Hyperactivity Disorder; ASS Score: A subscale score measuring inattention; BSS score: B subscale score measuring hyperactivity, impulsivity; CSS Score: C subscale score the sum of A and B subscales; DSS Score: D subscale score measuring ADHD index

Table 4. Model 1: Relationship between background variables and MRBQ Outcome variable using beta regression and GLM

beta regression				GLM			
Variables	**B**	**95% CI**	**P-value**	**Variables**	**B**	**95% CI**	**P-value**
Education level	**-0.11**	**(-0.22 to -0.01)**	**0.004**	**Education level**	-0.76	(-2.85 to 1.34)	0.479
Using the Helmet	**0.31**	**(0.019 to 0.42)**	**<0.001**	**Using the Helmet**	**4.17**	**(2.35 to 5.98)**	**<0.001**
Always	Referent	Referent	Referent	Always	Referent	Referent	Referent
Often	**0.48**	**(0.15 to 0.81)**	**0.004**	Often	5.46	(-2.59 to 13.50)	0.183
Sometimes	**0.83**	**(0.45 to 1.21)**	**<0.001**	Sometimes	**17.26**	**(9.22 to 25.31)**	**<0.001**
Seldom	**1.08**	**(0.67 to 1.50)**	**<0.001**	Seldom	**16.48**	**(8.91 to 24.05)**	**<0.001**
Never	**0.94**	**(0.22 to 1.65)**	**0.010**	Never	**14.76**	**(6.46 to 23.06)**	**0.001**
Hours of Riding	**0.31**	**(0.08 to 0.54)**	**0.008**	**Hours of Riding**	**9.58**	**(4.29 to 4.86)**	**<0.001**
< 2 hours	Referent	Referent	Referent	< 2 hours	Referent	Referent	Referent
2-5 hours	**0.47**	**(0.05 to 0.90)**	**0.029**	2-5 hours	**12.71**	**(4.58 to 20.83)**	**0.002**
> 5 hours	**0.64**	**(0.15 to 1.13)**	**0.011**	> 5 hours	**19.20**	**(8.65 to 29.75)**	**<0.001**
Riding period				**Riding period**			
< 1 hours	Referent	Referent	Referent	< 1 hours	Referent	Referent	Referent
> 2 hours	**-0.48**	**(-0.80 to -0.17)**	**0.003**	> 2 hours	**-18.82**	**(-25.24 to -12.40)**	**<0.001**
Sub Accident				**Sub Accident**			
Have	Referent	Referent	Referent	Have	Referent	Referent	Referent
Not Have	**0.37**	**(0.10 to 0.68)**	**0.019**	Not Have	1.63	(-3.98 to 7.24)	0.568

B: Coefficient; CI: Confidence Interval
MRBQ: Motorcycle Rider Behavior Questionnaire

Table 5. Model 2: Relationship between background variables and ADHD total score with MRBQ Outcome variable using beta regression and GLM

beta regression				GLM			
Variables	**B**	**95% CI**	**P-value**	**Variables**	**B**	**95% CI**	**P-value**
Using the Helmet	**0.27**	**(0.15 to 0.38)**	**<0.001**	**Using the Helmet**	**3.16**	**(1.38 to 4.93)**	**<0.001**
Always	Referent	Referent	Referent	Always	Referent	Referent	Referent
Often	**0.43**	**(0.12 to 0.74)**	**0.007**	Often	5.00	(-2.71 to 12.71)	0.203
Sometimes	**0.73**	**(0.36 to 1.10)**	**<0.001**	Sometimes	**14.65**	**(6.90 to 22.41)**	**<0.001**
Seldom	**0.86**	**(0.44 to 1.28)**	**<0.001**	Seldom	**13.68**	**(6.36 to 21.00)**	**<0.001**
Never	**0.74**	**(0.01 to 1.47)**	**0.048**	Never	**11.37**	**(3.33 to 19.41)**	**0.006**
Hours of Riding	**0.34**	**(0.11 to 0.56)**	**0.003**	**Hours of Riding**	**9.50**	**(4.47 to 14.56)**	**<0.001**
< 2 hours	Referent	Referent	Referent	< 2 hours	Referent	Referent	Referent

2-5 hours	**0.62**	**(0.20 to 1.04)**	**0.004**	2-5 hours	**11.38**	**(3.59 to 19.17)**	**0.004**
> 5 hours	**0.77**	**(0.29 to 1.25)**	**0.002**	> 5 hours	**19.02**	**(8.92 to 29.13)**	**<0.001**
Riding period				**Riding period**			
< 1 hours	Referent	Referent	Referent	< 1 hours	Referent	Referent	Referent
> 2 hours	**-0.35**	**(-0.66 to -0.03)**	**0.030**	> 2 hours	**-14.86**	**(-21.17 to -8.54)**	**<0.001**
Sub Accident				**Sub Accident**			
Have	Referent	Referent	Referent	Have	Referent	Referent	Referent
Not Have	**0.36**	**(0.07 to 0.66)**	**0.015**	Not Have	1.64	(-3.72 to 7.01)	0.547
ADHD Score	**0.01**	**(0.01 to 0.02)**	**0.018**	**ADHD Score**	**0.50**	**(0.31 to 0.68)**	**<0.001**

B: Coefficient; CI: Confidence Interval
MRBQ: Motorcycle Rider Behavior Questionnaire; ADHD: Attention Deficit Hyperactivity Disorder

Table 6. Model 3: Relationship between background variables and ADHD ASS and BBS subscale scores with MRBQ Outcome variable using beta regression and GLM

beta regression				**GLM**			
Variables	**B**	**95% CI**	**P-value**	**Variables**	**B**	**95% CI**	**P-value**
Using the Helmet	**0.27**	**(0.16 to 0.38)**	**<0.001**	**Using the Helmet**	**2.93**	**(1.15 to 4.72)**	**0.001**
Always	Referent	Referent	Referent	Always	Referent	Referent	Referent
Often	**0.41**	**(0.09 to 0.72)**	**0.012**	Often	4.76	(-2.92 to 12.45)	0.224
Sometimes	**0.76**	**(0.39 to 1.12)**	**<0.001**	Sometimes	**14.33**	**(6.59 to 22.07)**	**<0.001**
Seldom	**0.87**	**(0.45 to 1.29)**	**<0.001**	Seldom	**13.29**	**(5.98 to 20.60)**	**<0.001**
Never	**0.75**	**(0.10 to 1.48)**	**0.044**	Never	**10.24**	**(2.17 to 18.32)**	**0.013**
Hours of Riding	**0.33**	**(0.11 to 0.56)**	**0.004**	**Hours of Riding**	**9.83**	**(4.79 to 14.86)**	**<0.001**
< 2 hours	Referent	Referent	Referent	< 2 hours	Referent	Referent	Referent
2-5 hours	**0.55**	**(0.12 to 0.98)**	**0.013**	2-5 hours	**11.76**	**(3.99 to 19.52)**	**0.003**
> 5 hours	**0.74**	**(0.24 to 1.23)**	**0.003**	> 5 hours	**19.68**	**(9.61 to 29.76)**	**<0.001**
Riding period				**Riding period**			
< 1 hours	Referent	Referent	Referent	< 1 hours	Referent	Referent	Referent
> 2 hours	**-0.37**	**(-0.69 to -0.06)**	**0.019**	> 2 hours	**-15.27**	**(-21.54 to -9.00)**	**<0.001**
Sub Accident				**Sub Accident**			
Have	Referent	Referent	Referent	Have	Referent	Referent	Referent
Not Have	**0.35**	**(0.05 to 0.64)**	**0.020**	Not Have	1.50	(-3.85 to 6.85)	0.582
ASS Score	**0.06**	**(0.01 to 0.11)**	**0.032**	**BSS Score**	**1.574**	**(0.73 to 2.42)**	**<0.001**

B: Coefficient; CI: Confidence Interval
MRBQ: Motorcycle Rider Behavior Questionnaire; ASS Score: A subscale measuring inattention; BSS score: B subscale score measuring hyperactivity, impulsivity

Table 7. Model 4: Relationship between background variables and ADHD DDS subscale scores with MRBQ Outcome variable using beta regression and GLM

beta regression				**GLM**			
Variables	**B**	**95% CI**	**P-value**	**Variables**	**B**	**95% CI**	**P-value**
Using the Helmet	**0.26**	**(0.14 to 0.38)**	**<0.001**	**Using the Helmet**	**3.46**	**(1.69 to 5.23)**	**<0.001**
Always	Referent	Referent	Referent	Always	Referent	Referent	Referent
Often	**0.43**	**(0.12 to 0.74)**	**0.007**	Often	5.43	(-2.33 to 13.20)	0.170
Sometimes	**0.71**	**(0.34 to 1.10)**	**<0.001**	Sometimes	**15.08**	**(7.27 to 22.88)**	**<0.001**
Seldom	**0.79**	**(0.36 to 1.23)**	**<0.001**	Seldom	**14.31**	**(6.96 to 21.67)**	**<0.001**
Never	**0.74**	**(0.02 to 1.47)**	**0.045**	Never	**12.73**	**(4.69 to 20.78)**	**0.002**
Hours of Riding	**0.31**	**(0.09 to 0.54)**	**0.006**	**Hours of Riding**	**9.20**	**(4.12 to 14.28)**	**<0.001**
< 2 hours	Referent	Referent	Referent	< 2 hours	Referent	Referent	Referent
2-5 hours	**0.59**	**(0.18 to 1.00)**	**0.005**	2-5 hours	**11.38**	**(3.53 to 19.23)**	**0.005**
> 5 hours	**0.69**	**(0.22 to 1.16)**	**0.004**	> 5 hours	**18.42**	**(8.24 to 28.60)**	**<0.001**
Riding period				**Riding period**			
< 1 hours	Referent	Referent	Referent	< 1 hours	Referent	Referent	Referent
> 2 hours	**-0.32**	**(-0.64 to -0.01)**	**0.049**	> 2 hours	**-15.15**	**(-21.51 to -8.78)**	**<0.001**
Sub Accident				**Sub Accident**			
Have	Referent	Referent	Referent	Have	Referent	Referent	Referent
Not Have	**0.37**	**(0.08 to 0.66)**	**0.013**	Not Have	1.70	(-3.70 to 7.11)	0.535
DSS Score	**0.03**	**(0.01 to 0.06)**	**0.014**	**DSS Score**	**1.06**	**(0.63 to 1.49)**	**<0.001**

B: Coefficient; CI: Confidence Interval
MRBQ: Motorcycle Rider Behavior Questionnaire; DSS Score: D subscale measuring ADHD index

Discussion

The current research investigated the underlying factors of motorcycle rider behavior using beta regression. The univariate model showed that lower levels of education, riding period, vehicle type, cell phone answering, income, house price, hygiene cost, and riding license period were associated with increases in MRBQ while increasing in ADHD and its subscales, using the helmet, having a riding license, hours of riding, and sub accident were related to increasing in MRBQ. Most of the variables of the univariate model were significant and entered into the multivariate model.

This study demonstrated the application of beta regression in describing the relationship between MRBQ as a bounded outcome and fundamental predictors with the following concerning:

1- The beta regression represents a useful methodology to calculate the distribution of MRBQ as a bounded outcome considering a set of risk factors. The expected results are valid in the sense of any primary distribution, and the outcome predictions are restricted to the standard unit interval (0, 1) (22).

2- The model is established upon the assumption that the response variable is Beta distributed. Its mean is connected to a set of explanatory variables through a linear structure and a logit link function (22).

In some cases, such as proportions and rates, the response variable may be limited to intervals (1 and 0). Predictions may be obtained outside the defined interval by fitting a regression model. For performing a regression analysis in this kind of data, the first option springing to mind is using logistic or probit regression models. However, since the distribution of response variable in these cases is usually severely skewed, so these models are not suitable. In these cases, the use of standard regression models is not appropriate, and the use of a beta regression model is proposed (22). Since this study, the response variable, namely, MRBQ, could take values in the specified interval, beta regression model was used to examine the influential variables.

Furthermore, considering multivariate modeling, it can be said that an increase in ADHD and all its subscales refer back to the rise in MRBQ. The results highlight a more robust interconnection between DSS subscale with MRBQ than the ASS subscale. A remarkable point regarding the results is that the BSS subscale has no considerable interconnection. Differently, this study also found that the B subscale measuring hyperactivity was not for prevention. In contrast, ADHD and other subscales (ASS and DSS) were regarded as determinants of motorcycle riding behavior. The present finding is inconsistent with previous studies that significantly reported BSS and considered it a risk factor for motorcycle behavior injuries (23). Sadeghi et al. in 2015 studied the relationship between motorcyclists' behavior and ADHD with motorcycle traffic injuries using the standard Binary Logistic Model. They argued that riding behavioral scale and ADHD subscale B scored by age, educational level, and the reason for motorcycle riding are potential determinants of motorcycle injuries that could be taken into accounts (19). The differences observed in the studies carried out with this study may be the population studied. Still, the more important cause of this study is a different and accurate statistical method and sensitivity of beta regression (outcome predictions are restricted to the standard unit interval (0, 1) and not qualitatively, such as logistic regression).

In the study of Nazari et al., the most critical cause of death was traumatic injuries (29). In the Zhou et al. study, 58.5% of people with head and neck trauma died (30). One of the reasons for the high mortality rate is the lack of use of the helmet. In line with this study, the use of the helmet was significant in all of the examined models.

Another sub-theme extracted from the category of individual factors influencing risk behavior was the possession of a motorcycle riding license. This finding was consistent with other studies (31-33). However, this issue has not been considered an accident or high-risk behaviors' factor (34). Barbie et al. in Australia in 2007 showed that most motorcyclists (99%) had motorcycle licenses (33). This issue is less critical in a country like Iran, which most motorcyclists ride without permission.

The Canadian riding controlled ADHD as an item to go through the riding test (35). Training safe riding behavior, training riding techniques and skills and how to ride vehicle in different situations, and use of planned behavior approach theory can change people's attitude. It can be considered as a very formidable variable on safety riding.

This issue finally prepares for a setting to decrease traffic risks and physical injury by using safety equipment. In this case, behavioral training is necessary to control risks triggered by beginners and riders with ADHD (36). As the certification process in Iran, getting a motorcycle license would be subject to theoretical and practical courses. Perhaps with this, many motorcyclists realized that motorcycles like cars and vehicles are subject to regulations.

The risk of death in motorcyclists volunteering study was 2.49 times higher than that of drivers. Drivers are 1.31 times more likely to die than riders (37) due to the high rates of motorcycle and bicycle users in the community and the lack of pedestrian safety equipment for motorcyclists and cyclists, which is consistent with the existing studies. According to the survey results, Saber Ghaffari fam et al. in 2015 showed that even 40% of other groups used cell phones during the accident, which caused approximately 47% of the damage to pedestrians on the road and the authorized route by the motorcyclist (38).

According to the results of this study, patients with ADHD were more likely to be involved in road traffic injuries than children without this disorder (39). Perhaps this is due to the lack of a protective shield against a collision with vehicles prone to the most severe injuries in road traffic accidents (40). To prevent motor vehicle injuries and pedestrians on the road, improving people's social and economic status, applying the principles of urban engineering, and appropriate education in schools on how to deal adequately with important and stressful life events can be useful in preventing injuries in the pre-incident stage. High prevalence of post-traumatic stress disorders and other symptoms resulting from emotional disturbances concerning road traffic accidents have seen among the injured bodies (41).

Several epidemiological studies have shown that male gender, Low economic level, and low age range are related to the prevalence of ADHD. The results of some meta-analysis studies showed that people with ADHD have a lower level of IQ than the general population (42, 43). In other studies, a positive relationship was found between attention deficit disorder and the injuries of drivers of four-wheel and two-wheel vehicles(20). There was a greater risk of injury in people with ADHD than those without these disorders (44). The results of this study are consistent and confirm the validity of the effects of these studies.

Researches confirm that people with ADHD are usually more desirous of taking risks even though most of these risks are conscious. This issue should be considered risky behavior as it is the main reason for about 25 to 30% of road accidents in Iran (19). Also, in all models, the riding period demonstrated a significant and direct relationship with the MRBQ score (19).

In general, the results showed that personality trait plays a role in risky riding. Regarding the prevalence of hazardous riding behaviors and venturesome riding and increasing the number of accidents, it is recommended that to reduce the risk, a physical and psychological assessment of riders must be carried out in kind. It is also essential to identify high-risk riders, provide them with advice and guidance, and special train them via the police. Encouraging excited riders to stay in controlled spaces such as motor racing, motorcycling can meet the needs of their excitement and experience, which can reduce risky riding behaviors. Over the past 30 years, many high-income countries have significantly reduced road accidents and injuries through a sustained commitment to targeted and documented injury prevention programs. Knowing the efforts made by the middle and low-income countries to implement the best practices, setting ambitious goals, and continuous monitoring of road casualties seems necessary.

Study limitations

In this study, we put the modeling into a limited frame by employing the logit link and other studies that utilized the beta regression to model bounded outcomes (21, 45). The logit link function is a real and straightforward transformation of the prediction curve. It also caters to odds ratios. These two features have made it well-liked among researchers. In future studies, instead, it is suggested to consider the modeling of such outcomes using probit and identity link functions, predicting the underlying latent variable and log-log complementary link function in the bid to achieve extreme asymmetric distributions (46). Supplementally, Boosted beta regression models can be proposed in this setting, which interprets the parameters in terms of the mean of the bounded outcome. Boosted beta regression models are perhaps unsurprisingly heteroskedastic and easily give room for asymmetries (47, 48). MRBQ has a wide range and notwithstanding the bounded nature which comes up with the linear regression model with the structural problem of non-equity of the two sides of the equations. However, the basic assumptions of linear regression were satisfied for our data, and we moved to beta regression because of the structural problem. For this reason, the current method has a practical drawback.

Of other limitations, the first one was the self-descriptive nature of the questionnaires, which are common in such studies. The results may not be generalizable to other parts of Iran since the data were limited to a sample of motorcycle riders in a small city in the northwest of Iran.

Besides, the model may perform extensively in an optimal way in a more limited bound of the outcome variable; therefore, it is recommended to be studied in the future.

Conclusion

According to the model for bounded outcomes, utilizing the generalized beta model recommends more valid results for decision. The present study demonstrated the application of beta regression in describing ADHD, its subscales, including BSS score, and underlying predictors of the MRBQ as a bounded outcome. It is considering the predictive aptitude of ADHD and its subscales and education level, hours of Riding, riding period, sub accident, and using the helmet for MRBQ, which potentially caused road traffic injury among motorcyclists, the fundamental factors can be useful. This issue might be suggested for better planning and also designing educational programs by relevant organizations and policymakers.

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Authors' contributions

All authors read and approved the final manuscript. MAJ and HSB conceived of the study and participated in the design and data collection. MAJ, MB, and ZI participated in the data analyses and MS preparation.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Ethical Considerations

The ethical committee of Tabriz University of Medical Sciences approved the study protocol (**Grant No: 67732**). The participants freely participated in the study, and the collected information was just used for scientific purposes, and privacy was preserved meanwhile. All participants filled and signed the informed consent and permission.

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