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Role of ADHD in risky riding behavior: a statistical modeling

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ABSTRACT Attention Deficiency and Hyperactivity Disorder (ADHD), as a predictor of injuries in motorcyclists, affects the risky behavior. Since there was no pre-established conceptual model, this study aimed at exploring a conceptual model. Following this model, the Structural Equation Modeling (SEM) was utilized to find the predictors of Motorcycle Riding Behavior (MRB), as well as the mediators and moderators of ADHD-MRB relationship. In the current cross-sectional study, 340 motorcyclists in Bukan city, Iran, were recruited through a randomized cluster sampling. A simple conceptual model was explored and utilizing the goodness of fit indices in SEM, an optimal model was chosen. Then, utilizing 3-step hierarchical regressions and SEMs, the relationship between ADHD and MRB was assessed by modeling the possible mediators/moderators such as answering the cell phone and using the helmet. The results of hierarchical regression showed that answering the cell phone had both moderating and mediating effects on the relationship between ADHD (and the ASS subscale) with MRB. The final SEM, by introducing the mediating role of underlying variables, had a good fit on data (Normed Chi2 = < 5.0, RMSEA < 0.08, SRMR < 0.05, CFI and TLI > 0.90), wherein ADHD score (and the subscales) predicted the MRB score directly/indirectly ($P < 0.05$). A simple conceptual model was found to assess the mediating role of ADHD in motorcyclist risky behavior. Based upon the findings, training the techniques of and/or enforcement for controlling and improving riding behaviors and skills among ADHD motorcyclists, those who answer their cell phones while riding, un-experienced riders, and those who ride without wearing the helmet is strongly recommended.

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Introduction

Road traffic injury is a global problem. World Health Organization (WHO) reported that road traffic injury kills 1,270,000 people annually and leaves 20–50 million people injured or disabled (WHO, 2017). Accidents are the ninth leading cause of mortality worldwide and it is predicted to be the seventh leading cause in 2030 (Mahdieh Rad et al., 2016), additionally, accidents are placed first among young drivers aged 15 to 29 (Alinia et al., 2015). Iran ranks fifth among the countries with a higher rate of mortality due to road traffic accident (RTA). Although Iran comprises less than one-hundredth of the world's population, it consists of one-fiftieth of RTAs (Ghorbani, 2011). Though the mortality rates due to RTA have decreased recently, however, after cardiovascular disease and stroke, it is the third cause of mortality in Iran (Mahdian et al., 2015). In addition, since the RTA mortality rate in Iran is twenty times more than the world's averages (Fadaye Vatan et al., 2012), therefore, it requires more attention.

Riding a motorcycle carries a much higher risk of RTA than driving the same distance in a car. (Barros et al., 2003, Horswill and Helman, 2003 and Peden et al., 2004). Especially in lower-income countries, the majority of RTAs are related to motorcycle riders (Graziano et al., 2015), which consist of 90% of RTA mortality worldwide. Also in Iran, motorcycle riders are responsible for more than 51% of RTAs (Naghavi et al., 2004). Hence, this emphasizes the role of motorcycle riders in RTA mortality.

The motorcycle, as a low-priced and more convenient form of transportation, has some advantages over the car which emphasizes on the importance of motorcycle to the daily life and economic activities, particularly in low and middle-income countries. This includes lower prices, fuel economy, lower maintenance costs, lower environmental impact, as well as not getting stuck in traffic due to its maneuverability and quick access to customers' orders (Pirsig, 1999). In furthermost low and middle-income countries, a greater proportion of road users are pedestrians, bicyclists and motorcyclists and half of lethal road traffic injuries occur among motorcyclists. Regarding the socio-cultural difference, motorcycle death risk in low and middle-income countries is much higher than in high-income countries (Abedi et al., 2015b). This issue is so important in Iran, especially for low-income cities like Bukan.

Among the human factors, which is the main source of RTA (Evans, 1996, Kopits and Cropper, 2003), cognitive attention has a major contribution (Ranney et al., 2000). Attention Deficit or Hyperactivity Disorder (ADHD), as a developmental chronic nervous complaint, plays a key role in RTA (Motevalian et al., 2011). Riders with ADHD are 3–4 times more likely to get into an accident than riders without ADHD (Barkley et al., 1993). Other studies also reported ADHD as a predictor of injuries in motorcyclists (Sadeghi-Bazargani et al., 2015a, Abedi et al., 2015a). Identifying the role of ADHD can be regarded as a valuable achievement in traffic safety (Shappell and Wiegmann 2012, Weiss et al., 1979) both directly and by mediating via other variables.

Another human factor, which may contribute to crash risk, is the motorcycle rider behavior (MRB), which consist of behaviors that are either intentional (like violations of road and speed regulations and stunts) or unintentional (like errors relating to traffic or control of the motorcycle), along with protective behaviors associated to use of safety equipment (Stephens et al., 2017). Sakashita et al. (2014) reported the drink and riding, not wearing a helmet, answering the cell phone, high speed, carrying more than one passengers and road rule offense as the predictors of MRB among the novice riders (Sakashita et al., 2014). Similarly, in the study by Özkan et al. (2012), higher scores on the speed violations and the stunts scales of MRB were significantly related to more self-reported offenses (Özkan et al., 2012). The other studies reported the same set of predictors and mainly ADHD (and the subscales) as the determinates of risky riding behavior in Iran (Sadeghi-Bazargani et al., 2015b, Sadeghi-Bazargani et al., 2019, Safiri et al., 2013). MRB may intentionally or unintentionally lead to or prevent RTA (Haque et al., 2010, Sadeghi-Bazargani et al., 2015b, Stephens et al., 2017, Truong et al., 2018).

On the other hand, choosing optimal statistical techniques is crucial to achieving minimum bias and guarantees lower error probability and hence better decision making (Anderson, 1996). All previous studies utilized Generalized Linear Models (GLM) (Sadeghi-Bazargani et al., 2015a, Sakashita et al., 2014, Safiri et al., 2013, Babajanpour et al., 2017, Abedi et al., 2015a) which have some limitations. These models did not take into account the measurement error and the causality in the relations. Structural Equation Modeling (SEM) can cover these shortcomings by considering a conceptual model. SEM simultaneously models the relationships by a single model and provides more comprehensive insights in relations and has no added false positive rate. Moreover, SEM provides both direct and indirect paths among variables offering more details on the relationship. Furthermore, the mediator/moderator role of the variables could be also simply assessed by SEM (Weston and Gore, 2006). Since there was no pre-established conceptual model (if any) in this regard, this study aimed at exploring a conceptual model and utilizing SEM to find the predictors of MRB, as well as the mediating factors of ADHD-MRB relationships.

Methods

Participants and procedures. Bukan is situated in West-Azerbaijan province with a population of 224,628 (the general census of Iran Statistical Center, 2019). The city was divided into 14 consistent clusters and then 7 clusters were randomly selected. Next in each cluster, the samples were gathered to reach the estimated sample size. A total of 340 motorcyclists participated in the current cross-sectional study by a cluster sampling procedure in Bukan, Iran in 2016. Data were gathered from homes and motorbike shops. The inclusion criteria were using motorcycle at least three times per month, age higher than 15 years, living in Bukan, and being conscious and aware of the study. Those who did not want to participate in the study and to those who unwilling to fill out the measures were excluded.

The sample size was calculated utilizing the information on the main outcome, the relation between MRB and ADHD, and the information was attained from the study by Abedi et al. (Sadeghi-Bazargani et al., 2015a). By the confidence level of 95 and 80% power, 227 subjects were estimated to participate in the study. Considering sampling design, the samples increased to 318 and by considering the design effect of 1.4, the sample size finally reached 340 for further precision.

The human participants (ethics). The protocol was approved by the institutional review board (IRB) of Tabriz University of Medical Sciences (IRB no.: TBAMED.REC.194.783). Informed consent was confirmed (or waived) by the IRB. All participants filled and signed the informed consent and assent. For the illiterate people, the informed consent form was read by the researcher or someone to whom he/she trust and instead of signing, fingerprints were taken from participants.

Study variables and measurements. Data were collected using the Motorcycle Rider Behavior Questionnaire (MRBQ) (with 48-items) and Conner's short-form ADHD questionnaires in a self-administrative way, respectively. MRBQ was first constructed in 2007 by Elliott et al. as an appropriate measure for different kinds of behaviors (Elliott et al., 2007, Özkan et al., 2012). The MRBQ has been used and validated by other researchers (Stephens et al., 2017, Hosseinpourfeizi et al., 2018, Sakashita et al. 2014, Özkan et al., 2006). Cronbach's alpha was calculated to assess the internal consistency reliability ($\alpha = 0.89$). The participants reported the occurrence of their behaviors throughout the last year through a five-point Likert scale (0 = never, 1 = hardly ever, 2 = occasionally, 3 = quite often, and 4 = nearly all the time). All items have been summed to compute the MRB score, range from 0 to 192, with higher scores indicating those participants who have less consideration for traffic rules.

ADHD questionnaire has been translated and validated (Sadeghi-Bazargani et al., 2014). In this research, the internal consistency reliability was satisfactory for ADHD whole scale ($\alpha = 0.89$) and all subscales (range over 0.64–0.90). ADHD has four subscales, including assessing the inattention (ASS), assessing the hyperactivity and impulsivity (BSS), ASS + BSS (CSS), and assessing the ADHD index (DSS). The symptomatology of the ADHD is centered on the DSM-IV. The respondents scored the activities on a 4-point Likert scale (0 = never/rarely to 3 = very often). The scores for ADHD and all the subscales were calculated by summing over the corresponding items (ADHD score: 0–90 ASS and BSS: 0–27, CSS: 0–54, and DSS: 0–36), with higher scores indicating more severity of the symptoms.

Potential predictors for MRBQ were age (years), education, marital status, income, job position, hygiene budget, car value, house value, the aim of motorcycle riding, using the helmet, the sub-accident, type of vehicle, answering the cell phone, riding license, the period of having riding license, riding period, hours of riding, number of riding days.

Statistical analyses. Data were expressed by the mean (SD) and frequency (percent) for numeric and categorical data, respectively. Pearson test was utilized to assess the correlations among MRB with ADHD and the subscales. To find the best set of moderating variables in the final model, a 3-step hierarchical modeling strategy was adopted. In this strategy, ADHD and its subscales were entered first in the models, and in the second step, utilizing a forward selection strategy, variables with $P < 0.1$ entered in the model, and in the next step, the interaction of ADHD (and the subscales) by variables of the second step, were come into the model. Answering the cell phone, riding period, hours of riding, using the helmet, Socio-Economic Status (SES), owning the riding license, the period of having the riding license, the aim of motorcycle riding, the number of days used and having any kind of sub-accident were considered as the potential predictors. In the second step, just answering the cell phone, riding period, hours of riding and using the helmet were candidates to be entered in the model.

Since there was no pre-established conceptual model, data-driven models were explored using the goodness of fit (GOF) indices. Many models were investigated and the optimal models (with better GOFs) were finally reported. Then, the relationship between the endogenous variable MRB with exogenous variables ADHD and background variables including answering the cell phone, riding period, hours of riding and using the helmet was evaluated by the SEM. A multi-step model building process was adopted: model specification, identification, estimation, and testing and modification. A maximum likelihood estimation method was adopted and the models were evaluated by the goodness of fit indices and finally, the modification indices were used to modify the model. The measure of the model's goodness of fit was considered to judge how well the proposed model captured the covariance between all the items or measures in the model. Since the quality of fitted models are accepted to be influenced by the sample size, multiple model fit indices were estimated (with the values showing the reasonable model fit) which are as follow: χ^2 ($P > 0.05$), χ^2/degrees of freedom (Normed Chi2: CHI2/DF < 5), the Root Mean Square Error of Approximation (RMSEA ≤ 0.08), the Standardized Root Mean Square Residual (SRMR ≤ 0.05), the Comparative Fit Index (CFI ≥ 0.90), Tucker-Lewis index (TLI ≥ 0.90) (Weston and Gore, 2006). Missing data were deleted listwise. Since there was less than five percent of missing data, the influence was ignorable. Statistical analysis was performed using STATA14 (Stata Corporation, College-station, Texas, USA). *P*-values < 0.1 in regression modeling and less than 0.05 in other analyses were considered to be significant.

Results

A total of 33.4% of the participants were between 25–28 years of age. Primary (elementary education level), diploma (high school degree) and university degrees in education comprised 21.2, 45.3, and 33.5% of persons, respectively. Most of the participants were in the low SES level (65.9%), 42.5% were self-employed, 62.2% earned less than <15,000 thousand IRL, 46.9% do not own a house and 75.6% of participants did not have a car. Most of them (70.4%) used the motorcycle for recreation and/or journey purpose and 65.9% did not use or sometimes used the helmet. There was no riding license for furthermost of the participants (81.0%), 71.4% had riding period of more than two years, 84.6% used cell phone when riding, 67.8% ride the motorcycle for more than 4 days per week and most of them had not any kind of crashing experience (77.5%) (Fig. 1).

The distribution of main outcome variables MRB score and the main predictor ADHD and its subscales along with their reliability statistics (Cronbach's α and item-total correlations) are presented in Table 1. The scores ranged below the midpoints of the score range. High values of reliability statistics (>0.7 for α and $r > 0.3$), are the indications of a fair level of reliability for the (sub) scales.

The findings concerning the relationship between scores indicated a significant and direct correlation between MRB and ADHD and all its subscales (Table 2).

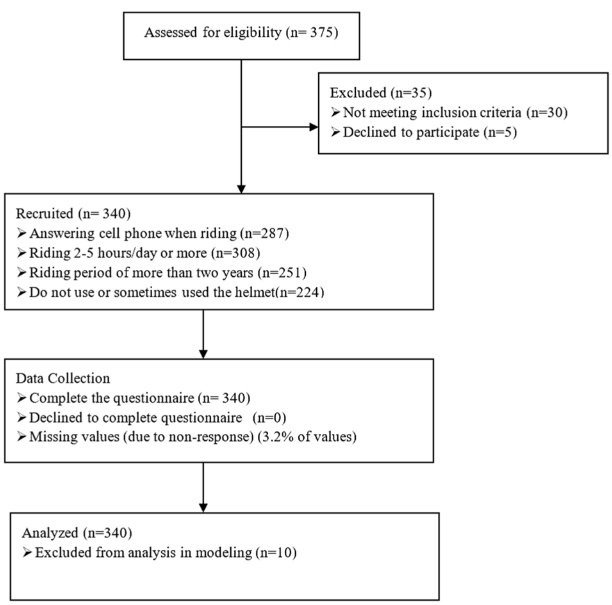

Fig. 1 Study flow diagram

Table 1 Summary statistics of the main study variables ($n = 340$)

	Mean	SD	Minimum	Maximum	No. of Items	Cronbach's α	Item—total correlation
MRB score	63.3	22.8	0	126	52	0.89	0.33-0.66
ADHD score	27.8	12.6	0	66	30	0.89	0.31-0.54
ASS	7.6	4.2	0	21	9	0.72	0.30-0.52
BSS	9.1	4.1	0	19	9	0.64	0.30-0.42
CSS	16.7	7.7	0	36	18	0.82	0.32-0.53
DSS	11.1	5.4	0	30	12	0.77	0.33-0.54

MRB 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)
CI confidence interval, *MRB* motorcycle rider behavior, *ADHD* attention deficit hyperactivity disorder, *ASS* A subscale score assessing inattention, *BSS* B subscale score assessing hyperactivity, impulsivity, *CSS* C subscale C the sum of A and B subscales, *DSS* D subscale score assessing ADHD index

Table 2 Correlation between MRB and ADHD and all its subscales ($n = 340$)

	MRB score	ADHD score	ASS score	BSS score	CSS score
ADHD score	0.36*				
ASS score	0.30*	0.92**			
BSS score	0.36*	0.91**	0.76**		
CSS score	0.34*	0.94**	0.80**	0.78**	
DSS score	0.35*	0.97**	0.94**	0.94**	0.84**

MRB motorcycle rider behavior, *ADHD* attention deficit hyperactivity disorder, *ASS* A subscale score assessing inattention, *BSS* B subscale score assessing hyperactivity, impulsivity, *DSS* D subscale score assessing ADHD index
*$P < 0.05$, **$P < 0.01$

Results of 3-step hierarchical regression modeling. The results of the 3-step hierarchical modeling showed that in the first step, ADHD positively and significantly predicts the MRB. In the second step, answering the cell phone, riding period, hours of riding, and using the helmet significantly incorporated in the model (F for the Step = 16.3, $P < 0.001$) and in this step ADHD still positively and significantly predict the MRB with a relatively weaker beta indicating of the portion of the effect of control variables. In addition, considering the interaction effect in the 3rd step, a significantly negative beta was found for the interaction of answering the cell phone with ADHD, while a significant positive beta was estimated for the main effect of answering the cell phone. But in this step, the main effect of the ADHD was not significant. The results showed that answering the cell phone had both moderating and mediating effects on the relationship between ADHD and MRB, whereas riding period, hours of riding and using the helmet did not bring such effects (Table 3).

Besides, considering the ADHD subscales in the first and second steps, only BSS positively and significantly predict the MRB, individually, as well as by controlling for hours of riding, riding period, answering the cell phone and using the helmet, respectively. However in the second step, after coming into the interaction effects, a significantly negative beta was found for the interaction of answering the cell phone with ASS, while a significant positive beta was estimated for the main effect of answering the cell phone. But in this step, the main effect of the ADHD subscales was not significant. The results showed that answering the cell phone had both moderating and mediating effects on the relationship between just ASS subscale and MRB, whereas riding period, hours of riding and using the helmet did not bring such effects (Table 4).

Table 3 Regression modeling of MRB score on ADHD controlling for motor-riding related factors ($n = 340$)

	Step1	Step2	Step3
ADHD score	0.36***	0.24***	0.51
Answering the cell phone (ACP)		0.23***	0.56***
Riding period (RP)		−0.25***	−0.1
Hours of riding (HR)		0.17**	0.03
Using the helmet (UH)		−0.10+	−0.14
ADHD × ACP			−0.51*
ADHD × RP			−0.28
ADHD × HR			0.29
ADHD × UH			0.09
F for the step	46.90***	16.3***	4.32**
F for regression	46.90***	24.3***	15.99***
R-squared	0.132	0.285	0.324

Dependent variable: MRB score
MRB motorcycle rider behavior, *ADHD* attention deficit hyperactivity disorder, *ASS* A subscale score assessing inattention, *BSS* B subscale score assessing hyperactivity, impulsivity; *DSS* D subscale score assessing ADHD index
+$P < 0.1$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Results of SEM on conceptual models. Figure 2 shows that the model did not fit the data well (Normed Chi2 > 5.0, RMSEA > 0.08, SRMR > 0.05, both CFI and TLI < 0.90) and hence; the data did not support the conceptual model without direct path from ADHD to MRB (Fig. 2).

Figure 3 shows that the model fitted the data well (Normed Chi2 = 2.19 < 5.0, RMSEA = 0.062 < 0.08, SRMR = 0.021 < 0.05, both CFI = 0.99 and TLI = 0.92 > 0.90) and hence; the data supported the conceptual model with direct path from ADHD to MRB. In this model, all paths were significant (All $P < 0.05$) except the path from ADHD to hours of riding; there were significant paths from ADHD to using the helmet, riding period and answering the cell phone (All $P < 0.05$), as well there was a significant direct path form ADHD to MRB ($P < 0.05$). Moreover, using the helmet and riding period significantly but negatively predicted the MRB while hours of riding and answering the cell phone significantly and positively predicted the MRB (Fig. 3).

Figure 4 shows that the model with latent fitted the data well (Normed Chi2 = 1.91 < 5.0, RMSEA = 0.054 < 0.80, SRMR = 0.027 < 0.05, both CFI = 0.99 and TLI = 0.97 > 0.90) and hence; the data supported the conceptual model with ADHD as a latent variable. In this model, all paths were significant (All $P < 0.05$) except the path from ADHD latent to hours of riding. Further, all ADHD loadings on ASS, BSS and DSS were all significant (All $P < 0.05$). There were significant paths from ADHD latent to using the helmet, riding period and answering the cell phone (All $P < 0.05$), as well there was a significant direct path form ADHD latent to MRB ($P < 0.05$). Moreover, using the helmet and riding period significantly and negatively predicted the MRB while hours of riding and answering the cell phone significantly and positively predicted the MRB (Fig. 4).

Table 4 Regression modeling of MRB on ADHD subscales controlling for motor-riding related factors (*n* = 340)

	Step1	Step2	Step3
ASS	−0.04	−0.05	0.17
BSS	0.26**	0.19*	0.48
DSS	0.18+	0.13	−0.10
Answering the cell phone (ACP)		0.22***	0.50**
Riding period (RP)		−0.25***	0.03
Hours of riding (HR)		0.17**	−0.07
Using the helmet (UH)		−0.10+	−0.14
ASS × ACP			−0.64*
ASS × RP			−0.15
ASS × HR			0.47
ASS × UH			−0.11
BSS × ACP			−0.11
BSS × RP			−0.50
BSS × HR			0.40
BSS × UH			−0.14
DSS × ACP			0.25
DSS × RP			0.27
DSS × HR			−0.51
DSS × UH			0.34
F for the step	17.01***	15.90***	1.99*
F for regression	17.01***	17.80***	8.07***
R-squared	0.143	0.291	0.258

Dependent variable: MRB score
MRB motorcycle rider behavior, *ADHD* attention deficit hyperactivity disorder, *ASS* A subscale score assessing inattention, *BSS* B subscale score assessing hyperactivity, impulsivity; *DSS* D subscale score assessing ADHD index
+*P* < 0.1, **P* < 0.05, ***P* < 0.01, ****P* < 0.001

Summing up the findings of the 3-step regression model and SEM. The results of 3-step regression modeling indicated that answering the cell phone both moderates and mediates the relationship between ADHD and its ASS subscale with MRB. SEM showed that there were significant paths from ADHD to using the helmet, riding period and answering the cell phone, also there was a significant and direct path form ADHD to MRB (All $P < 0.05$). Moreover, using the helmet and riding period significantly and negatively predicted the MRB while hours of riding and answering the cell phone significantly and positively predicted the MRB.

Discussion

Some conceptual models have been explored to establish the relationships between MRB and the underlying factors, utilizing 3-step hierarchical regressions and SEMs, which lead to models that have been finalized and presented in this study. The results of hierarchical regression modeling showed that answering the cell phone both moderated and mediated the relationship between ADHD (and its ASS subscale) with MRB, whereas riding period, hours of riding, and using the helmet did not bring such effects. Surprisingly, SEM fitted the data well and adding the direct path of ADHD to MRB improved the model fit massively. The results of SEM showed that some of the motorcycle riding factors such answering the cell phone, riding period and using the helmet had the mediating effect on the relationship between ADHD (and subscales) with MRB. In addition, ADHD directly predicted the MRB.

Our rationale in utilizing SEM (besides the regression modeling) to predict MRB by ADHD and underlying factors were: (1) taking into account the causality of relations by the conceptual model may solve the problem of cause and effect relation in a cross-sectional study (Hoyle, 1995; Lin and Hsieh, 2010). (2) considering the measurement error may solve the problem of correlation attenuation in the case of the incomplete reliability of the measurements (Fan, 2003). (3) modeling the relationships simultaneously in a single model may solve the problem of added false positive rate caused by single regression models and provide a more comprehensive pattern of relations (Cheng, 2001), and (4) providing both direct and indirect paths among variables could

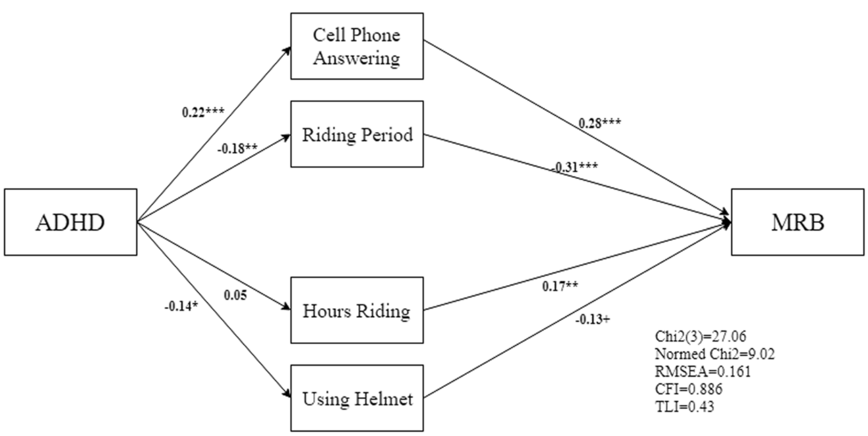

Fig. 2 Path diagram of the conceptualized relationship of MRB with underlying factors. Chi2(3) = 27.06, Normed Chi2 (Chi2/df) = 9.02, RMSEA = 0.161, 90% CI: (0.109 to 0.219), CFI = 0.886, TLI = 0.430, SRMR = 0.052. MRB motorcycle rider behavior Questionnaire, ADHD attention deficit hyperactivity disorder. +*P* < 0.1, **P* < 0.05, ***P* < 0.01, ****P* < 0.001

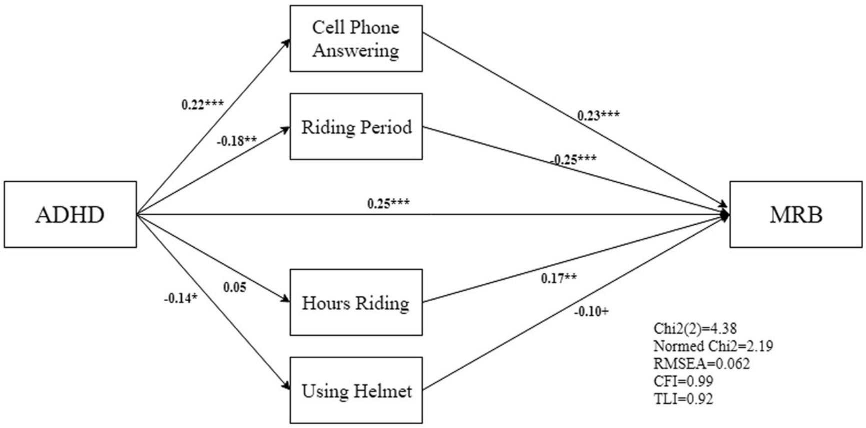

Fig. 3 Path diagram of the conceptualized relationship of MRB with underlying factors with the direct path of ADHD to MRB. Chi2(2) = 4.38, Normed Chi2 (Chi2/df) = 2.19, RMSEA = 0.062, 90% CI: (0.000 to 0.142), CFI = 0.989, TLI = 0.915, SRMR = 0.021. MRB motorcycle rider behavior questionnaire, ADHD attention deficit hyperactivity disorder. $^+P < 0.1$, $^*P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

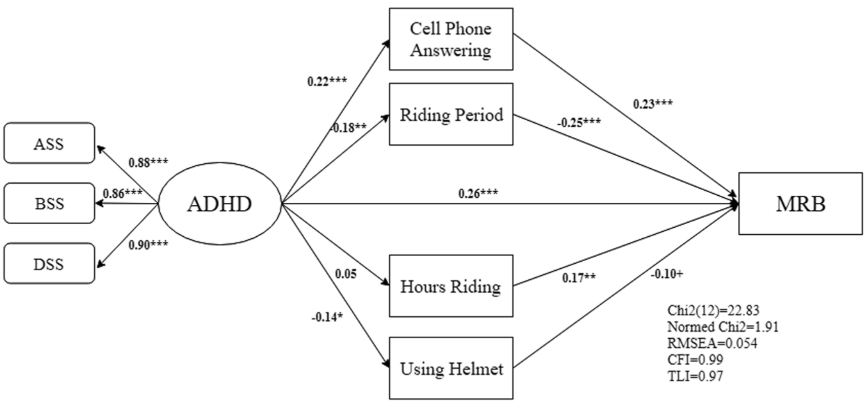

Fig. 4 Path diagram of the conceptualized relationship of MRB with underlying factors with direct relationship of ADHD. Chi2(12) = 22.83, Normed Chi2 (Chi2/df) = 1.91, RMSEA = 0.054, 90% CI: (0.017 to 0.087), CFI = 0.987, TLI = 0.971, SRMR = 0.027. MRB motorcycle rider behavior questionnaire, ADHD attention deficit hyperactivity disorder, ASS A subscale score assessing inattention, BSS B subscale score assessing hyperactivity, impulsivity; DSS D subscale score assessing ADHD index $^+P < 0.1$, $^*P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

offer the mediator/moderator role of the variables (Gunzler et al., 2013). Interestingly, this was more informative than just finding the "risk factor to outcome" relationship in our study.

To the best of our knowledge, based on an extensive search, there was no study (if any) to utilize this methodology to take into account the mediating roles on ADHD-MRB relationships. Hence, we compared the findings of our study by other relevant studies that utilized other methodologies (Sadeghi-Bazargani et al., 2015a, Sakashita et al., 2014, Safiri et al., 2013, Babajanpour et al., 2017), which did not take into the account the above mentioned concerns (Weston and Gore, 2006).

We found that higher ADHD, directly and indirectly, predicted the higher MRB. Abedi et al. showed that BSS and ASS subscales were significantly correlated to MRB (Sadeghi-Bazargani et al., 2015a, Abedi et al., 2015a). The similarity between the two studies may be supported due to the similar sample sizes and the same behavior of the Iranian motorcyclists. Another study concluded that behavioral education is essential to control the risks in the beginners and those riders with ADHD (Watson et al., 2007) (Abedi et al., 2015a, Sadeghi-Bazargani et al., 2015b).

Moreover, we found that ADHD and MRB paths were mediated by answering the cell phone, riding period and using the helmet in all SEMs. Similar results were found by other studies (Sadeghi-Bazargani et al., 2015a, Sadeghi-Bazargani et al., 2014, Abedi et al., 2015a). It is an important part of our findings because ADHD-MRB relations might be a trigger and hence an initiator of injury in motorcyclists (Sadeghi-Bazargani et al., 2015a, Abedi et al., 2015a).

Study limitations. There were several limitations to this study. Utilizing self-administrative questionnaires was one of the limitations of the study which is common in these types of scientific researches (Sadeghi-Bazargani et al., 2015a, Sakashita et al., 2014, Safiri et al., 2013, Abedi et al., 2015a). The respondent may be motivated to provide more socially acceptable responses regarding their risky behaviors while riding (Truong et al., 2019), so the prevalence of risky riding behaviors may be underestimated. In addition, we did not seek to check the personality complaints that could affect risky riding behaviors. We used a sample of motorcycle riders from Bukan which may limit the generalizability of the results due to the existing diversity in behaviors of different localities. As stated above, cause and effect relationships in a cross-sectional study should be inferred cautiously. A conceptual model was found in the exploratory and data-driven way, which may not be a standard and a final model. More studies are recommended to be conducted in the future to cover the limitations of the study.

Policymaking. Motorcyclist safety is a major concern but a neglected emerging public health problem in Iran (Abedi et al., 2015a, Babajanpour et al., 2017, Sadeghi-Bazargani et al., 2015b, Sadeghi-Bazargani et al., 2014, Sadeghi-Bazargani et al., 2019, Safiri et al., 2013) and in many developing countries (Bolbol and Zalat, 2018, De Gruyter et al., 2017, Haque et al., 2010, Stephens et al., 2017, Truong et al., 2018). Although there may be differences because of attitude, awareness, and cultural differences between these countries, since behavioral factors are major contributors to RTAs, likely similar patterns of risky behavior are usually observed among these populations, for example, the majority of riders, as in our study (about 81%), have not professional training and riding license, most of them are youth (like in our study: about 60% under the 28 years old) with more energy, irresponsibility, and tendency to stunt and fun with motorcycle (Bolbol and Zalat, 2018). Therefore, approximately similar policies and proper safety education would be recommendable in these countries in reducing the incidence of the RTAs.

According to this study, motorcyclists with ADHD experienced more risky behaviors than others. Sadeghi-Bazargani et al. indicated that riders with ADHD are usually more ready to take risks and most of these risks are conscious. Since risky behavior is accountable for about 25 to 30% of road accidents in Iran, this issue should be concerned carefully (Sadeghi-Bazargani et al., 2015a) and could be suggested that the controlled ADHD be conditioned as an item to permit the riding exam in Iran, such as in Canadian driving center (Coopersmith et al., 1989) which could play a significant role in reducing the risky riding behaviors and subsequent crashes and injuries (Sadeghi-Bazargani et al., 2019).

Results show that answering the cell phone while riding is the main moderating and mediating factor of MRB. Also, this factor had a prevalence of about 85% which is higher than what found by another study, about 74% in university students in Vietnam (Truong et al., 2018) and ~40% among student motorcyclists in Vientiane, Laos (Phommachanh et al., 2017). These rates of mobile phone use are alarming in Iran, as well as in other developing countries which indicates that existing enforcement regulations may not be adequate/effective. This fact is even though answering the cell phone while riding is illegal in Iran and many other countries. Therefore, maybe the penalties for risky riding behaviors such as mobile phone use while riding, not wearing the helmet is relatively low or they are not inhibitive enough to give the riders a somewhat low perceived risk of being punished for conducting such behavior.

A more experienced rider is more expected to participate in risky behaviors since they sense more confident in controlling the motorcycle and hence neglect risks. On the other hand, more experienced riders are more expected to use the helmet which could be explained by their higher level of knowledge of much stringent police enforcement of helmet use (Truong et al., 2018). This recommends the requirement for continuous police enforcement on risky riding behaviors. It is important to make aware of the risky riders of the consequence of their risky behavior to not be under-estimated by the riders (Truong et al., 2018). The findings enthusiastically emerge the need for current enforcement practices, educational programs, and publicity programs, especially by the public media, to arise in the setting of targeting risky riding behaviors more effectively and ultimately reducing crashes and then injuries. Continues assessment of riders' behavior in the appropriate time intervals may provide a basis for evaluation of interventions as well. Strong enforcement of risky behaviors and educational campaigns that focus on multiple risk-taking behaviors may result in a high level of regularizing the behaviors in developing countries.

Conclusion

This study utilized SEM to predict the ADHD-MRB relationship by exploring a conceptual model which took into account the mediating role of factors related to motorcycle riding risky behavior. The results of hierarchical regression modeling showed that answering the cell phone had both moderating and mediating effects on the relationship between ADHD (and its ASS subscale) with MRB. The results of SEM showed that some of the motorcycle riding factors including answering the cell phone, riding period and using the helmet had the mediating effect on the relationship between ADHD (and subscales) with MRB. Considering the results, better planning and designing educational programs by responsible organizations, public media, and policymakers, as well as enforcement by police is highly recommended to control the risky behaviors and improve the behavior among motorcyclists. This action is ever more essential, assuming that the number of motorcycle riders on the road network in developing countries is increasing.

Data availability

The data that support the findings of this study are available from MAJ but restrictions are applied to the availability of these data, which were used under license for this study, and are not publicly available. Data are, however, available from the authors upon reasonable request by MAJ.

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Author contributions

All authors studied and approved the final version of the paper to be published and are in agreement to be accountable for all aspects of the work. MAJ and HSB perceived the study and contributed to the design of the study and data gathering. MAJ, HSB, and AASF contributed to the analyses of data and MAJ, HSB, AASF, NS, ZI, NN, GKH, PS and ELN participated in the preparation, drafting and revising of the paper.

Competing interests

The authors declare no competing interests.

Additional information

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