Analysis of Heterogenous Motorcycle Risk Perception and Crash Exposure in Developing Country's Urban Driving Environment : Precursors and Policy Implications Using Structural Equation Modeling

Md. Mushtaque Tahmid
Student, Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh
Email: sayeemss21@gmail.com

Md Asif Raihan*
Associate Professor, Accident Research Institute (ARI)
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh
Email: raihan@ari.buet.ac.bd
Contact: +8801911142802

Sadia Salam
Student, Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh
Email: sadiace691@gmail.com

Asif Muktadir
Student, Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh
Email: asifmuktadir17@gmail.com

Md. Shamsul Hoque
Professor, Department of Civil Engineering
Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh
Email: shamhoque84@gmail.com

*Corresponsing Author

Word Count: 6,222 words + 5 table (250 words per table) = 7,472 words

ABSTRACT

Bangladesh has the world's greatest death rate from motorcycle accidents, which account for the vast majority of all traffic crashes in Bangladesh. The rate has also been increasing over the past few years. Despite the increase in accidents, there is also a rising trend in the use of motorcycles because of demand, accessibility, affordability, ridesharing, and several other factors. Therefore, motorcycle crash risk factors, risk assessment, and policy implications must be studied. Data on perceived risk was collected from 1,559 participants via offline and online questionnaires for this investigation. Age, gender, occupation, residence division, usage classifications, ridesharing app usage frequency, and ratings of the perceived risk of 38 precursors to motorcycling crashes in Dhaka's urban environment were collected. Structural Equation modeling (SEM) was used to develop six empirical models from six different domains of dataset to detect ranking and contributions of different precursors on safety status and crash exposure after calibrating with collected data. 'OnstreetParking', 'SideRoadEntry', and 'CutinMovement' ranked in the top three with perceived risk coefficients of 0.633, 0.623, and 0.620, respectively, in the SEM model with overall dataset. Policy implications considering Safe System Approach have been analyzed from significance and ranking of precursors. As road safety is a shared responsibility for all road users, any developing country's urban context will benefit tremendously to enhance safety from the provided SEM analysis for crash analysis and prevention after implementing data from road users.

Keywords: Perceived Risk, Structural Equation Modeling, Policy Implications.

INTRODUCTION

As Human Development Index (HDI) rises, motorbike usage rates climb in developing countries (*1*). In Bangladesh, a developing country of South Asia, the demand for motorbikes is rising daily due to the ride-sharing programs, convenience and independence motorbikes provide. The poor quality of service offered by public transportation, inefficient management, congestion, and inefficiency during peak and off-peak hours are the main causes of the growing popularity of motorcycles. Bikes are convenient, comfortable, and economical. Furthermore, there are more bikes in Bangladesh than ever before due to accessibility, affordability, improved short-distance mobility, ride-sharing app usage (Uber, Pathao, etc.), increased imports, local manufacturing, and supportive government policies. The number of registrations is increasing rapidly (*2*). E-commerce companies improved bikes' accessibility during the COVID epidemic and after the outbreak by providing reduced prices and more manageable installments. The use of ride-sharing apps has increased along with rising unemployment (*3*). Bangladesh did not have technology-driven ride-sharing services until 2015. Between 2023 and 2027, the Bangladeshi shared ride market would grow 8.20% to USD 643.80 million (*4*). In Dhaka, the number of motorbike journeys has dramatically grown with the growth of ride-sharing services (*5*). According to "Ride Sharing Market, 2021-2028," the global ride-sharing market would expand 16.3% from 2021 to 2028, reaching USD 242.73 billion (*6*).

However, motorcycle riders and users are among the most vulnerable road users worldwide who account for most road accident fatalities. In Bangladesh, Motorbikes accounted for 62% of all vehicles on the roads, with 28.4 accidents occurring for every 10,000 motorcycles (*7*). Majority of the deceased are young people. Fifty percent of bikers in Bangladesh do not have licenses (*8*). Motorcycle-hailing services' rapid rise threatens road safety due to riders' traffic offenses and irresponsibility. Vietnam and Japan have taken initiatives to reduce motorbikes, whereas in Bangladesh, affordability is increasing day by day (*9*).

Meanwhile, there are lack of research and policy implications on motorbike accident. Most of the research are based on crash data. There is less focus on driving environment, weather, traffic control, driving behavior, and pedestrian-related features simultaneously in the previous research. Moreover, various precursors for motorbike accidents cannot be determined after analyzing post-accident data. Incorrect recording in developing countries can also cause issues. The data also prevents precursor analysis. Thus, questionnaire survey analysis may play a significant role in analyzing precursors and their influence. Ratings from the people who encountered accidents and general road users can effectively make a trustworthy model of precursors that can be implemented in design, management, planning, and policy for motorbike accidents. This research examines the factors influencing the perceived risk of motorbike mobility, accident experience and analyzes the relationships between various constructs and variables. Additionally, the study intends to investigate the impact of heterogeneity among different variables on perceived risk and accident exposure in the urban driving environment of Bangladesh, using Structural Equation Modelling (SEM). This research's SEM model and policy implications in terms of 'Safe System Approach' can help operators and policymakers evaluate bike mobility safety based on road user perception. Thus, ameliorating such precursors may considerably enhance bike safety, prevent crashes, enable fast results and sustainable transportation fulfilling SDG goals.

LITERATURE REVIEW

Numerous studies have examined how different elements affect motorcycle safety. An innovative investigation was conducted into the problems surrounding motorbike accidents in Thailand and the variables affecting severity were identified (*10*). In Bali, it was looked at how local motorcycle riders perceived several aspects of road safety by SEM and found that motorcyclists' sensation-seeking behaviors impact locals' views of risky riding (*11*). The elements influencing the seriousness of bicycle riders' injuries in bicycle-motor vehicle collisions implementing police reported data were examined (*12*). Abdul Manan et al. (2013) used negative binomial regression to predict fatal motorbike accidents on Malaysian key highways (*13*). Musselwhite et al. (2012) examined motorbike safety attitudes, empathy, and skill, as well as road user safety perceptions (*14*). Using a multimodal approach, Di Stasi et al. (2009) examined how mental workload affected hazard perception during a static motorbike riding simulation (*15*). Besides, relationship between Driving-violation Behaviors and Risk Perception in motorcycle accidents (*16*) and the significance of environmental variables, risk perception, attitudes, and lifestyle choices on turn signal usage among motorcyclists and car drivers have been analyzed (*17*). Several studies have been conducted on various aspects related to passenger safety in ride-sharing services (*18*). Additionally, there has been research exploring the connections between motorcycle-based ride sourcing, motorcycle taxis, and public transportation in the Jakarta Metropolitan Area (*19*). Furthermore, investigations have been carried out to understand the motives behind individual's participation in ridesharing (*20*), explore the factors influencing non-users' inclination to use ride-sharing services, focus specifically on the perceived value and perceived risk dimensions (*21*), Structural equation modelling for unsafe driving in clear and bad weather (*22*) .

Consumer behavior research have frequently used SEM. It has grown in popularity in transportation field recently. Perceived service quality (SQ) of passengers on Taiwan's high-speed rail (HSR) services (*23*), SQ of intercity train service (*24*), connections between the key factors that influence bus transit's SQ (*25*) have been studied.

Moreover, the influence of sociotechnical and individual traits on workplace accidents in mines (*26*), analyzing severity of pedestrian crushes(*27*), analysis of factors behind rear- end crash severity (*28*), analysis of precursors of pedestrian accidents (*29*) have been developed using SEM.

Even though there have not been much research on perceived motorcycle risk globally, to the authors' knowledge, this is the first investigation into this issue in Bangladesh. Despite being in its early phases, this study can be seen as a novel attempt to increase the safety of motorbikes in developing nations.

DATA AND RESEARCH METHODOLOGY

Survey Administration & Descriptive Statistics

The data collection method was an online and offline based questionnaire survey. In online 'Google forms' platform was used for the preparation of the questionnaire. This method was chosen because it saves cost, can be supplied through online media: WhatsApp, Mail, Teams, QR code, Facebook Groups, Messenger, and other social media platforms very rapidly with the help of the internet. It also provided flexibility for respondents to fill out the form at their convenient time. Though there are a few problems regarding this procedure: understanding and interpretation problems; it was tried to overcome with figures, illustrations, formatting, styles, and translations to the native language. An offline survey form was also designed to collect data offline.

There were seven sections in the questionnaire survey. First section consisted of demographic data: Gender, age, division, usage of motorbike, occupation, bike-sharing app usage frequency, and preferable trips by bike. There were questions regarding observed variables from the second section to the seventh section. Attributes were selected from literature reviews, newspapers, bikers' interviews, academicians, policymakers, and discussions with road users. In the last section, there was space for writing personal opinions. After structuring the form, it was circulated. Contents of the Questionnaire survey and collected data distribution are portrayed in Figure 1. After filtering the remaining sample size was 1559. Detailed information on the observed variables of the respondents is given in Table 1.

Proposed SEM Models

A multivariate statistical analysis method called structural equation modeling combines multiple regression modeling and factor analysis. This method explores the structural relationship between observed variables and latent constructs. The SEM methodology incorporates path analyses and confirmatory factor analyses. The reason behind using SEM in this study was its appropriateness for determining unobserved parameters from observed questionnaire items and to assess the association between these unobserved parameters and target variables. The model used in this research consists of forty observed parameters and five unobserved or latent parameters. The proposed SEM model for the overall dataset is shown in Figure 2 .

SEM, however, performs effectively when the sample size exceeds 200 (*30*). A general rule of thumb is that the sample size to the number of observed parameters might range from 5 to 1(*31*) to 20 to 1 (*32*). Considered sample sizes for each model satisfied all the above requirements.

Factor Analysis and Measurement Model

Confirmatory factor analysis (CFA) was used to reduce 38 precursors to a set of five factors. Principal component analysis with VARIMAX rotation was carried out using the SPSS 16.0 package. According to Bryant & Yarnold (1995) , the eigenvectors (factors) are rotated during rotation in an effort to achieve a simple structure (*33*). The factors are chosen depending on whether they are thought to be associated (oblique) or uncorrelated (orthogonal), according to Vogt & Johnson (2011) (*34*) . The optimum orthogonal rotation technique is the VARIMAX approach, according to Dielman et al. (1972)(*35*) . Five factors with eigen values greater than one were extracted from the results of the factor analysis. Those five factors were considered as latent variables in the model. The results showed that 43.066 % of the variation could be explained, which is greater than 40% (*36*). The factor analysis can be considered propitious according to the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy value of 0.915 and the Bartlett's Sphericity Test was also found significant ($p<0.05$). It is feasible to classify the KMO value as "Normal" between 0.5 and 0.7, "Good" between 0.7 and 0.8, "Great" between 0.8 and 0.9, and "Superb" above 0.9 (*37*). In Rotated Component Matrix, observed variables were arranged and latent variables were defined in STATA which utilizes maximum likelihood estimation. Later structuring SEM models with target variables : “Accident Experience”, “Perceived Risk” along with other observed variables, were completed on STATA and models were run for the results. Those five latent constructs (Weather, Driving Behavior, Pedestrian, Driving Environment, and General Risk) plus the underlying observable variables make up the measurement model. The SEM path diagram shown in Figure 2 was ultimately developed by the CFA.

ANALYSIS, RESULT INTERPRETATION AND DISCUSSION

Structural Equation Model was used in this research for 6 different domains from dataset. Those six sets were from overall respondents, capital city dwellers, noncapital city dwellers, female, bikers, students respectively. Heterogeneity was realized by partitioning the sample based on gender, region, and occupation. Heterogeneity mostly manifests as variation in factor loadings and ranks. Fit indices satisfied prescribed values and ranges for each of the model. Heterogenous SEM models may be used in decision-making and planning to lower accident and accident costs. After estimating the models, outcomes are presented in Table 2 to Table 4. Goodness of fit values are shown in Table 5.

The relationships between the target variable and other observed and latent variables were discerned from models. Two-tailed t-test for a 95% confidence interval was used to confirm a parameter's significance. Forty observed variables and five latent variables were used in each model. Only two of the observed variables were endogenous. Endogenous observed variables were “Accident Experience” and “Perceived Risk”. Latent variables are “Weather”, “Driving Behavior”, “General Risk”, “Driving Environment”, and “Pedestrian”.

Figure 1 Questionnaire survey and data distribution

TABLE 1 Descriptive Statistics of Observed Variables

V	R	F	V	R	F	V	R	F	V	R	F	V	R	F
MoreCcBike	1	106	TrafficLaw Disregard	1	36	PanicBraking	1	18	Mech.Problem	1	34	Inexperience	1	27
	2	313		2	38		2	93		2	137		2	47
	3	499		3	115		3	367		3	223		3	189
	4	499		4	632		4	703		4	747		4	681
	5	142		5	738		5	378		5	418		5	615
PedestrianActivity Footpath	1	58	MobilePhone	1	89	Overconfidence	1	22	Rainyweather	1	49	Overloading	1	60
	2	115		2	41		2	38		2	196		2	117
	3	313		3	94		3	158		3	576		3	257
	4	703		4	566		4	616		4	523		4	691
	5	370		5	769		5	725		5	215		5	434
Overspeed	1	39	FogDust	1	24	HighTemp	1	71	LevelCrossing	1	19	DividerMedian Guardrail	1	7
	2	27		2	118		2	324		2	63		2	51
	3	47		3	376		3	792		3	362		3	295
	4	406		4	698		4	308		4	761		4	768
	5	1040		5	343		5	64		5	354		5	438
DistressDrainage	1	11	Curve	1	5	Heterogenous Traffic	1	8	Lighting	1	13	Flyoverbridge Culvert	1	15
	2	33		2	28		2	57		2	52		2	68
	3	143		3	153		3	297		3	218		3	397
	4	795		4	757		4	665		4	844		4	719
	5	577		5	616		5	532		5	432		5	360
OnstreetParking BusStop	1	13	Intersection Problem	1	8	SignMark	1	10	RightturnMerge Movement	1	18	SideRoadEntry	1	7
	2	41		2	32		2	72		2	36		2	36
	3	290		3	131		3	381		3	345		3	316
	4	760		4	747		4	767		4	803		4	778
	5	455		5	641		5	420		5	357		5	422
SameDirection Pedestrian	1	114	Problematic Curb	1	21	CutinMovement	1	5	CutoutMovement	1	7	PedestrianCrossing	1	80
	2	204		2	154		2	29		2	38		2	156
	3	564		3	534		3	208		3	244		3	355
	4	490		4	613		4	642		4	685		4	660
	5	187		5	237		5	675		5	585		5	308
TwowayTraffic	1	17	CompetitiveRiding	1	42	ReverseDirection Pedestrian	1	182	LawEnforcement Lack	1	16	Unsmooth transitions	1	12
	2	117		2	19		2	342		2	39		2	65
	3	435		3	39		3	528		3	259		3	395
	4	683		4	354		4	342		4	527		4	774
	5	307		5	1105		5	165		5	718		5	313
TravelDistance	1	272	DrugAddiction	1	44	Overtaking	1	31	AccidentExperience	1	619	PerceivedRisk	1	33
	2	340		2	64		2	18		2	386		2	109
	3	309		3	194		3	54		3	262		3	283
	4	355		4	504		4	395		4	56		4	604
	5	283		5	753		5	1061		5	236		5	530

Note: ‘V’ represents Variable, ‘F’ representss Frequency, ‘R’ represents Rating

.

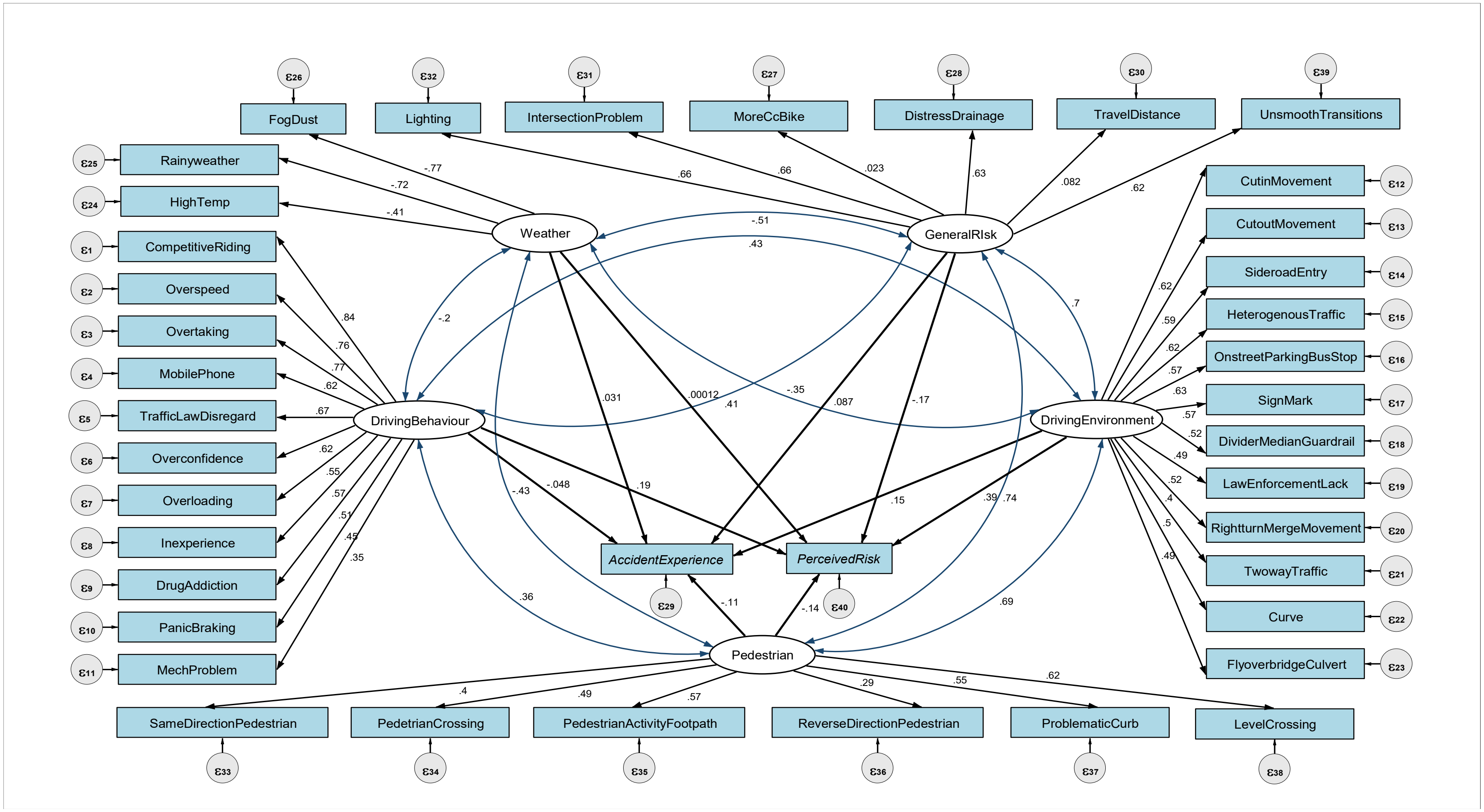

Figure 2 Proposed Structural Equation Model (for full dataset)

TABLE 2 Model Results (from full dataset and from bikers)

Model 1 (from full datset)						Model 2 (from bikers)					
LV	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**
DrivingBehaviour	CompetitiveRiding	0.839	**DrivingEnvironment**	OnstreetParkingBusStop	0.633	**DrivingBehaviour**	CompetitiveRiding	0.886	**DrivingEnvironment**	OnstreetParkingBusStop	0.654
	Overtaking	0.772		SideroadEntry	0.623		Overspeed	0.811		SideroadEntry	0.651
	Overspeed	0.762		CutinMovement	0.620		Overtaking	0.789		SignMark	0.586
	TrafficLawDisregard	0.670		CutoutMovement	0.590		Inexperience	0.682		CutoutMovement	0.576
	MobilePhone	0.620		SignMark	0.574		TrafficLawDisregard	0.680		LawEnforcementLack	0.576
	Overconfidence	0.618		HeterogenousTraffic	0.571		MobilePhone	0.644		CutinMovement	0.563
	Inexperience	0.569		DividerMedianGuardrail	0.520		Overconfidence	0.637		DividerMedianGuardrail	0.548
	Overloading	0.546		RightturnMerge	0.520		Overloading	0.629		RightturnMerge	0.539
	DrugAddiction	0.507		Curve	0.500		DrugAddiction	0.509		FlyoverbridgeCulvert	0.500
	PanicBraking	0.454		LawEnforcementLack	0.500		PanicBraking	0.500		HeterogenousTraffic	0.483
	MechProblem	0.346		FlyoverbridgeCulvert	0.488		MechProblem	0.464		Curve	0.478
Weather	FogDust	-0.766		TwowayTraffic	0.403	**Weather**	FogDust	-0.747		TwowayTraffic	0.406
	Rainyweather	-0.715	**Pedestrian**	LevelCrossing	0.616		Rainyweather	-0.747	**Pedestrian**	Ped.ActivityFootpath	0.638
	Hightemp	-0.407		Ped.ActivityFootpath	0.568		Hightemp	-0.300		PedestrianCrossing	0.584
GeneralRisk	Lighting	0.664		ProblematicCurb	0.555	**GeneralRisk**	MoreCcBike	0.143		ProblematicCurb	0.528
	IntersectionProblem	0.663		PedestrianCrossing	0.493		TravelDistance	-0.124*		LevelCrossing	0.487
	DistressDrainage	0.626		SameDir.Pedestrian	0.405		UnsmoothTransition	-0.605		SameDir.Pedestrian	0.401
	UnsmoothTransition	0.619		ReverseDir.Pedestrian	0.292		DistressDrainage	-0.650		ReverseDir.Pedestrian	0.230
	TravelDistance	0.080					Lighting	-0.746			
	MoreCcBike	0.023*					IntersectionProblem	-0.850			
OV	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**
Experience	DrivingEnvironment	0.15	**PerceivedRisk**	DrivingEnvironment	0.39	**Experience**	DrivingEnvironment	0.423*	**PerceivedRisk**	DrivingEnvironment	0.603
	GeneralRisk	0.09*		DrivingBehaviour	0.19		DrivingBehaviour	0.044*		GeneralRisk	0.355
	Weather	0.03*		Weather	0.00*		GeneralRisk	-0.077*		DrivingBehaviour	0.274
	DrivingBehaviour	-0.05*		Pedestrian	-0.14		Weather	-0.266		Weather	0.00*
	Pedestrian	-0.11*		GeneralRisk	-0.17		Pedestrian	-0.54*		Pedestrian	-0.319*

Note: ‘LV’ represents Latent Variable, ‘OV’ represents Observed Variable, (*) represents statistical insignificance for 95% confidence interval

TABLE 3 Model Results (from capital city dwellers and from female)

Model 3 (from capital city dwellers)						Model 4 (from female)					
LV	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**
DrivingBehaviour	CompetitiveRiding	0.850	**DrivingEnvironment**	OnstreetParkingBusStop	0.622	**DrivingBehaviour**	CompetitiveRiding	0.804	**DrivingEnvironment**	OnstreetParkingBusStop	0.677
	Overtaking	0.781		CutinMovement	0.620		Overspeed	0.772		DividerMedianGuardrail	0.629
	Overspeed	0.767		SideroadEntry	0.607		Overtaking	0.699		HeterogenousTraffic	0.614
	TrafficLawDisregard	0.653		CutoutMovement	0.574		MobilePhone	0.667		CutinMovement	0.579
	MobilePhone	0.622		SignMark	0.558		TrafficLawDisregard	0.663		FlyoverbridgeCulvert	0.540
	Overconfidence	0.618		HeterogenousTraffic	0.535		Overconfidence	0.585		SideroadEntry	0.538
	Inexperience	0.555		RightturnMerge	0.505		DrugAddiction	0.567		CutoutMovement	0.534
	Overloading	0.540		Curve	0.502		Inexperience	0.549		SignMark	0.533
	DrugAddiction	0.513		DividerMedianGuardrail	0.500		Overloading	0.528		Curve	0.520
	PanicBraking	0.438		FlyoverbridgeCulvert	0.488		PanicBraking	0.471		LawEnforcementLack	0.503
	MechProblem	0.345		LawEnforcementLack	0.475		MechProblem	0.175		RightturnMerge	0.502
Weather	FogDust	-0.769		TwowayTraffic	0.403	**Weather**	FogDust	-0.752		TwowayTraffic	0.358
	Rainyweather	-0.694	**Pedestrian**	LevelCrossing	0.634		Rainyweather	-0.705	**Pedestrian**	LevelCrossing	0.575
	Hightemp	-0.406		ProblematicCurb	0.577		Hightemp	-0.339		ProblematicCurb	0.571
GeneralRisk	Lighting	0.640		Ped.ActivityFootpath	0.549	**GeneralRisk**	IntersectionProblem	0.714		PedestrianCrossing	0.541
	IntersectionProblem	0.633		PedestrianCrossing	0.466		Lighting	0.701		SameDir.Pedestrian	0.524
	DistressDrainage	0.606		SameDir.Pedestrian	0.373		DistressDrainage	0.682		Ped.ActivityFootpath	0.504
	UnsmoothTransition	0.596		ReverseDir.Pedestrian	0.284		UnsmoothTransition	0.578		ReverseDir.Pedestrian	0.424
	TravelDistance	0.095					MoreCcBike	0.092*			
	MoreCcBike	0.022*					TravelDistance	0.084*			
OV	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**
Experience	DrivingEnvironment	0.159	**PerceivedRisk**	DrivingEnvironment	0.396	**Experience**	DrivingEnvironment	0.477	**PerceivedRisk**	DrivingEnvironment	0.392
	GeneralRisk	0.091*		DrivingBehaviour	0.168		Weather	0.031*		DrivingBehaviour	0.143
	Weather	0.033*		Weather	0.004*		DrivingBehaviour	0.008*		Pedestrian	0.005*
	DrivingBehaviour	-0.048*		Pedestrian	-0.146		GeneralRisk	-0.154*		Weather	0.000*
	Pedestrian	-0.116*		GeneralRisk	-0.155		Pedestrian	-0.351		GeneralRisk	-0.176*

Note: 'LV' represents Latent Variable, 'OV' represents Observed Variable, (*) represents statistical insignificance for 95% confidence interval

TABLE 4 Model Results (from non-capital city dwellers and from students)

Model 5 (from non-capital city dwellers)						Model 6 (from students)					
LV	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**	**LV**	**Observed Variable**	**Coeff.**
DrivingBehaviour	CompetitiveRiding	0.806	**DrivingEnvironment**	HeterogenousTraffic	0.689	**DrivingBehaviour**	CompetitiveRiding	0.818	**DrivingEnvironment**	OnstreetParkingBusStop	0.634
	Overtaking	0.747		SideroadEntry	0.688		Overtaking	0.745		SideroadEntry	0.608
	Overspeed	0.747		OnstreetParkingBusStop	0.666		Overspeed	0.738		CutinMovement	0.614
	TrafficLawDisregard	0.731		CutoutMovement	0.639		TrafficLawDisregard	0.638		CutoutMovement	0.576
	Overconfidence	0.622		SignMark	0.638		MobilePhone	0.605		SignMark	0.592
	MobilePhone	0.618		CutinMovement	0.623		Overconfidence	0.614		HeterogenousTraffic	0.575
	Inexperience	0.617		DividerMedianGuardrail	0.591		Inexperience	0.550		DividerMedianGuardrail	0.523
	Overloading	0.567		RightturnMerge	0.567		Overloading	0.541		RightturnMerge	0.502
	PanicBraking	0.505		LawEnforcementLack	0.558		DrugAddiction	0.531		Curve	0.497
	DrugAddiction	0.484		FlyoverbridgeCulvert	0.494		PanicBraking	0.425		LawEnforcementLack	0.500
	MechProblem	0.350		Curve	0.485		MechProblem	0.334		FlyoverbridgeCulvert	0.474
Weather	FogDust	0.768		TwowayTraffic	0.397	**Weather**	FogDust	-0.733		TwowayTraffic	0.388
	Rainyweather	0.765	**Pedestrian**	Ped.ActivityFootpath	0.634		Rainyweather	-0.738	**Pedestrian**	LevelCrossing	0.600
	Hightemp	0.402		PedestrianCrossing	0.583		Hightemp	-0.405		Ped.ActivityFootpath	0.587
GeneralRisk	IntersectionProblem	0.750		LevelCrossing	0.556	**GeneralRisk**	Lighting	0.657		ProblematicCurb	0.542
	Lighting	0.737		SameDir.Pedestrian	0.501		IntersectionProblem	0.648		PedestrianCrossing	0.502
	UnsmoothTransition	0.704		ProblematicCurb	0.482		DistressDrainage	0.590		SameDir.Pedestrian	0.409
	DistressDrainage	0.682		ReverseDir.Pedestrian	0.301		UnsmoothTransition	0.609		ReverseDir.Pedestrian	0.301
	TravelDistance	0.053*					TravelDistance	0.065			
	MoreCcBike	0.02*					MoreCcBike	0.031*			
OV	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**	**OV**	**Latent Variable**	**Coeff.**
Experience	DrivingEnvironment	0.114*	**PerceivedRisk**	DrivingEnvironment	0.367	**Experience**	DrivingEnvironment	0.129	**PerceivedRisk**	DrivingEnvironment	0.412
	GeneralRisk	0.068*		DrivingBehaviour	0.299		GeneralRisk	-0.006*		DrivingBehaviour	0.181
	Weather	-0.026*		Weather	0.064*		Weather	0.041*		Weather	0.000*
	DrivingBehaviour	-0.041*		Pedestrian	-0.081*		DrivingBehaviour	-0.026*		Pedestrian	-0.154
	Pedestrian	-0.075*		GeneralRisk	-0.305		Pedestrian	-0.008*		GeneralRisk	-0.166

Note: ‘LV’ represents Latent Variable, ‘OV’ represents Observed Variable, (*) represents statistical insignificance for 95% confidence interval

In model of full dataset for the target variable “Accident Experience”, the feature variables “General Risk”, “Weather”, “Driving Behavior”, and “Pedestrian” were statistically insignificant at 5% significance level. Only “Driving Environment” was found to be significant variable for “Accident Experience”. So, it is reflected that respondents who encountered accidents gave opinion that “Driving Environment” was the only factor behind accident exposure. Therefore, it can be remarked that in hazardous road locations and accident hotspots, “Driving Environment” related problems played dominant role. An investigation report of ARI on the crash that occurred on Dhaka-Bhanga Expressway in Madaripur also revealed that the accident did not occur because of driver or mechanical problem of bus (*38*). On the contrary, according to studies, there is also direct connection between driving behaviour and accidents (*39*). Moreover, for the target variable “PerceivedRisk”, “Driving Environment” and “Driving Behavior” were significant statistically. People are also not considering pedestrian-related features and “General Risk” as impactful on motorbike accidents. However, SEM model from bikers reflected that no factor is significant to them for impacting “Accident Experience”. But interestingly, with driving environment and driving behavior latent variable “General Risk” was statistically significant and positively had effect on “PerceivedRisk”. Among the observed variables of “General Risk”, only “More Cc Bike” was found to be significant only. Therefore, from the drivers’ opinion bikes with more cubic capacity are riskier. It was discovered that given poor environmental circumstances, drivers were more likely to participate in unsafe driving behaviors (*40*). Thus, bikers' perception of little risks is a serious problem. According to study the motorcyclists who were engaged in collisions exhibited more belligerent and ordinary driving-violation behaviors (*41*). These riders also showed a lower perception of the risk associated with driving factors. These riders were more likely to categorize danger in terms of belief-related factors, such as evil spirit, bad luck etc. For the lower risk perception towards driving behavior, bikers may lead to high speed, law disregard and other risky driving behavior. SEM from the capital city dwellers, divulged “Driving Environment” as significant latent variable for Accident Experience. So, in accident hotspots of Dhaka, perceived risk is higher due to problems related to the features of Driving Environment in Dhaka city. Like the previous two models, “Driving Environment” impacts perceived risk more than “Driving Behavior”. Females also opined that driving environment related features were dominant reasons behind their accident experience with increased factor loading (coefficient: 0.477) than all other models. In noncapital regions, no significant variable was available impacting accident exposure. For target variable “Perceived Risk” latent variable “Driving Behavior” was significant with highest loading value (coefficient: 0.299) than the previous models due to less dense noncapital regions. Since students made up the bulk of the sample, the relationship between the latent variable and the target variable in the SEM model for them is fairly similar to the SEM model for the entire dataset.

Each table from SEM analysis presented in this research is also reflecting ranking of underlying observed variable of the latent variables. The variables on the upper portion have greater influence than the lower ones. In model of full dataset among the observed features of “Driving Behavior”, “Competitive Riding” (coefficient: 0.839), “OverTaking” (coefficient:0.772), “Over Speed” (coefficient: 0.762), and “Traffic Law Disregard” (coefficient: 0.67) are the major problems perceived by road users. These problems are also similar in other studies. Speeding has been identified as a critical predictor of crash injury severity among dangerous driving behaviors (*42*). Speeding is a serious safety hazard, especially in developing countries where motorcycle and pedestrian deaths are more frequent (*43*). Moreover, blogging, mobile phone usage, calling, music, lack of training are also pronounced precursors. The effects of using a mobile device while driving have also been studied more recently (*44*). In Bangladesh, panic braking (coefficient: 0.454) problem are not frequent and servicing of the motorcycle by the users for overcoming mechanical problem (coefficient: 0.346) is also in good condition according to the model. Drug addiction (coefficient: 0.346) is not also a concerning issue for motorbike riders. Tendency of influenced motorcycle driving is lesser in amount according to models.

From all of the models, pedestrian crossing, inadequate footpath, problematic curb and level crossing problems are not striking factor for the perceived risk. It can be because of heavily dense areas in Bangladesh and motor bikers are habituated with the situation . The significance of weather-related elements was also disproved in all the models.

From models it is also noticed that lighting problem is not serious in Bangladesh's situation. Afternoons turned out to be the most dangerous time for motorcycle riders in a recent study. During that time, there were 29.37% of accidents, whereas there were 25.02%, 20.17%, 10.04%, and 15.33% accidents reported in the morning, noon, evening, and night, respectively (*45*). It is because of abundance of street lighting in urban areas and lesser generation of trips at night.

Although Bangladesh has several issues with poorly managed, unplanned intersections, lack of traffic police, signals, and traffic control equipment, according to the models, perceived risk is unaffected by these issues. It can be due to a lack of information regarding the significance of intersection capacity and safety. Congestion is now considered to be typical by people in general here. According to models except for bikers, motorbikes with increased cubic capacity (cc) are not risky. Behind this reflection there are problems regarding unawareness of public. With increased cubic capacity, higher speed can be gained, high noise is made. Those motorbikes are used by well-off people for show-off, luxury, attraction. These are used in incompatible road environments and face accident. Sudden bumps, potholes, uneven surfaces like unsmooth transitions and distress, and drainage problems are not even impacting perceived risk of models because those are very frequent in the urban road network in Bangladesh. So, drivers are alert and that's how there are lower risks. But this lower risk perception of bikers can lead them to risky approach in roads. Long distance travel is not a significant precursor for motorbike crashes as motorbike is rarely used in long distance travel in Bangladesh.

In model of full dataset on-street parking, irregular bus stops, frequent roadside entrance from feeders, and cut in movement are the top three impactful antecedents among the observed variables of the latent variable "Driving Environment". Misjudging speed and distance, being careless, and having trouble seeing while entering from side roads have a big influence here. Other factors like lack of proper sign, marking is a serious problem in Bangladesh and consciousness about it is also very rare. Besides, non-lane based heterogenous traffic is problematic issue in urban areas. It creates congestion and accident simultaneously. In relation to curve problems, law enforcement issues, and mobility issues over flyovers and bridges, loading factors are around 0.5. There is lack of proper sign marking in curves. It might be difficult to maintain mobility and speed on a flyover or bridge since the center of gravity for two-wheelers can alter with varied curves, scarcity of lighting and security.

The ranking of attributes from the "Driving Environment" and "Driving Behavior" sections of the SEM model for bikers also varied from the SEM model for the entire database. Factor loading increased for inexperience, as bikers are concerned more about it. Factor loading for sign marking, lack of law enforcement also uplifted. Bikers opined that cut in movement is less risky than cut out movement, so a tendency of frequent changing lanes near to the footpath and sometimes usage of footpaths for maneuvering is not uncommon in Bangladesh. The observed variables are ranked according to the issues in Dhaka city in the SEM model created by responses from residents of capital cities. In cities outside of the capital non-lane based heterogeneous traffic problems provide the biggest threat to perceived safety. Cut out movement is riskier than in capital because of low density of traffic and high speed. Law enforcement lack is also a serious issue outside of Dhaka.

For females, ranking of the "Divider Median Guardrail" (coefficient: 0.629) and "Heterogenous Traffic" (coefficient: 0.614) made significant effects on accident exposure and perceived risk. Women are more likely to use rickshaws than males, thus they are more worried about issues such on-street parking, heterogeneous traffic, and cut in movement. Gender equality is reportedly a crucial factor to consider while planning a sustainable transportation infrastructure in a society that values inclusion.

Goodness of fit :

The models were also subjected to goodness of fit and values are shown in Table 5. Due to the complexity of the SEM structure, more than one measure was required to demonstrate fit. The values conformed to the standard values. The RMSEA values were in the range between 0.05 to 0.08 indicating fair fit (*46*). The SRMR scores, which were less than 0.10 and suggest that the data are well-fitted (*47*). The CFI values were very close to good fitting model value of 0.95 (*48*) .The TLI values were also found to be close to the prescribed good fit model value of 0.95 (*49*).

TABLE 5 Goodness of Fit

Fit Indices	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
RMSEA	0.053	0.061	0.053	0.062	0.058	0.053
SRMR	0.051	0.070	0.052	0.072	0.066	0.052
CFI	0.82	0.802	0.812	0.765	0.815	0.811
TLI	0.81	0.790	0.798	0.749	0.800	0.800

CONCLUSIONS & POLICY IMPLICATIONS

App-based ride sharing services have grown in developing nations like Bangladesh due to digitization and internet penetration. Bangladesh should approach bike-sharing programs cautiously. Due to increase in motorcycle demand, a worrying number of young people are at risk of traffic accidents. Two-wheeled vehicles can disrupt pedestrians and commuters. A business and consumer-friendly regulatory environment that supports transportation expansion and sustainability is needed. This research may help by recommending policy-related remedial steps.

According to models, haphazard parking, frequent roadside entry, cut-in and cut-out movement, absence of sign marking, heterogenous traffic, and other driving environment features offer a significant risk to motorcycle safety and accident exposure for all road users. Riders' risk perception was also lower due to irresponsible driving.

Accident expenses cost emerging economies more than 2% of their GDP, compared to affluent countries, due to poor data analysis, under-reporting, lower political priority, less funding, and poor execution. (*50*). "Vision Zero" and "Safe System" approaches view the traffic system more holistically. Cooperation and data exchange should apply developed country policies to developing nations, according to WHO.

Safe drivers understand their duty to protect others. In this study, perceived driving danger is lower and inexperience affects safety. Thus, education interventions and virtual reality training to train road users' risky behavior toward traffic safety and its consequences are needed to improve poor risk perception toward risky driving behaviors like inattention, high speed, influenced driving, phone distraction, and entertainment. A driving curriculum that emphasizes traffic laws, hazard awareness, and emergency response is needed. Competent staff and technology may make education interactive. Risk awareness, mitigating car reliance, fostering public transportation, walking, and cycling campaigns can work.

Lack of law enforcement was striking for safety threat in the models. Well-trained traffic police equipped for law enforcement are required. Accidents can be reduced via road safety audits. In Bangladesh, more than one pillion on a motorcycle is illegal, yet it's common. Implementing the Road Transport Act properly, monitoring, and punishing can reduce casualties. It's crucial to digitize registration, fitness, and driving license data. Policy can be introduced against the use of footpaths by bikers.

Non-lane based Heterogenous traffic also impacted safety noticeably among users. Separating distinct types of road users and traffic moving in opposite directions or at varying speeds can be constructive to ensure safe roads and roadsides. Motorbike lanes reduce accidents. Lane positioning, breadth, physical separation (painted, flexible posts, curbs), management, and monitoring are essential.

Lack of sign marking, on-street parking, and bus stops were among the top five accident precursors. Signage, rumble strips, colored surfacing, reflective markers, and parking are needed. Road stud lights display pavement markings to drivers in low-light conditions. It may also reduce weather-related accidents. Driver drowsiness is fixable. It helps understand curve behavior in nighttime and bad weather. Safety barriers, guardrails, and drainage are needed. Proper usage and management of on-street parking by law enforcement agencies, parking space and facilities for off-street parking, center line rumble strip, and edge line rumble strip in two ways can play an essential role in reducing crashes. In Bridges, level-crossing and curves; rumble strips, sign marking, speed control, and removing plants/ obstacles to ensure sight distance can be guaranteed. Retro-reflective sign marking, lighting, delineators can be effective. Curb installation, safety management in flyovers and bridges, divider, median, guardrail, and rigid pavement in level crossings must be done correctly. Bus lay can be placed where needed. Passengers can swap bus routes or modes at it. It can have shelters, seating, and driver resting areas. Overpass, underpass can be helpful to reduce accidents in blackspots.

Another objective of the Safe System is to determine suitable speed restrictions based on the characteristics of the route, its purpose, and the physical tolerance of its users. Speed management strategies, speed monitoring, and speed control devices are to be used as overspeeding is also one of the most potential precursors from driving behaviour from model.

Antilock Braking System (ABS) can be useful for bike safety concerns. It can prevent locking of wheel. Faster stop without losing grip are possible. Turning signal before changing lanes can prevent crashes. Legal action can be taken to guarantee the availability and use of proper quality helmets. Retro-reflective stickers (Reflector) can be used in vehicles.

From responses, perception regarding intersection risk is minimal, but it is a risky zone for accident and proper intersection geometry (*51*), capacity improvement, signal optimization can be implemented. Prioritization of policy implications and investment according to emerged risk ranking of precursors may play significant role.

These models can be created for a particular network, region, or corridor that aims to reduce accidents. For Bangladesh, a larger database and funds can improve interpretation and results. Similar analyses can be conducted for various modes of transportation, such as buses and cars. Machine learning, deep learning, and artificial intelligence can be applied to this dataset or an updated dataset to improve crash prediction in numerous contexts, decision-making and planning (*52*, *53*, *54*, *55*). As this is one of the first researches on perceived motorcycle risk in urban context of a developing country, it might serve as the basis for more in-depth research.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Md, Mushtaque Tahmid, Md Asif Raihan, Md. Shamsul Hoque; data collection: Md. Mushtaque Tahmid, Asif Muktadir; analysis and interpretation of results: Md. Mushtaque Tahmid; draft manuscript preparation: Md. Mushtaque Tahmid, Md Asif Raihan, Sadia Salam, Asif Muktadir. All authors reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Bastos, S. Q. A., F. Gama, T. de Paula Assis, and M. Milosz. Is There a Relationship between the Use of Motorcycles and the Level of Development of Countries? *Bulletin of Geography. Socio-economic Series*, No. 50, 2020, pp. 43–54.
2. Adhikary, T. S. Bike Numbers, Risk Rising. *The Daily Star*. https://www.thedailystar.net/news/bangladesh/news/bike-numbers-risk-rising-2933936. Accessed June 28, 2023.
3. Motorbike Ridesharing Services Surge in Popularity in Dhaka - South Asia News. https://www.wionews.com/south-asia/motorbike-ride-sharing-a-panacea-for-dhaka-traffic-chaos-252618. Accessed July 31, 2023.
4. Shared Rides - Bangladesh | Statista Market Forecast. *Statista*. https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/bangladesh. Accessed July 31, 2023.
5. Rahman, M. H., N. M. Zafri, T. Akter, and S. Pervaz. Identification of Factors Influencing Severity of Motorcycle Crashes in Dhaka, Bangladesh Using Binary Logistic Regression Model. *International journal of injury control and safety promotion*, Vol. 28, No. 2, 2021, pp. 141–152.
6. Insights, F. B. Ride Sharing Market Size Worth USD 242.73 Billion, Globally, by 2028 at a CAGR of 16.3%. *GlobeNewswire News Room*. https://www.globenewswire.com/news-release/2023/02/22/2612873/0/en/Ride-Sharing-Market-Size-worth-USD-242-73-Billion-Globally-by-2028-at-a-CAGR-of-16-3.html. Accessed July 31, 2023.
7. Nguyen, H. H. *Improving Urban Road Safety in Vietnam Focusing on Motorcycles: A Case Study in Ho Chi Minh City*. PhD Thesis. Prince of Songkla University, 2015.
8. Adhikary, T. S. Boom of Unlicensed Bikers. *The Daily Star*. https://www.thedailystar.net/news/bangladesh/news/boom-unlicensed-bikers-3020251. Accessed June 28, 2023.
9. Kieu, M., E. Wanjau, A. Comber, K. Bratkova, H. N. T. Thuy, T. B. Quang, P. H. Huu, and N. Malleson. Case Studies on Transport Policy.
10. Iamtrakul, P., Y. Tanaboriboon, and K. Hokao. Analysis of Motorcycle Accidents in Developing Countries: A Case Study of Khon Kaen, Thailand. *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 5, 2003, pp. 147–162.
11. Wedagama, D. M. P., and D. Wishart. Analysing Local Motorcyclists' Perception towards Road Safety. No. 276, 2019, pp. 03002.
12. Kim, J.-K., S. Kim, G. F. Ulfarsson, and L. A. Porrello. Bicyclist Injury Severities in Bicycle–Motor Vehicle Accidents. *Accident Analysis & Prevention*, Vol. 39, No. 2, 2007, pp. 238–251.
13. Abdul Manan, M. M., T. Jonsson, and A. Várhelyi. Development of a Safety Performance Function for Motorcycle Accident Fatalities on Malaysian Primary Roads. *Safety Science*, Vol. 60, 2013, pp. 13–20. https://doi.org/10.1016/j.ssci.2013.06.005.
14. Musselwhite, C. B., E. Avineri, Y. O. Susilo, and D. Bhattachary. Public Attitudes towards Motorcyclists' Safety: A Qualitative Study from the United Kingdom. *Accident Analysis & Prevention*, Vol. 49, 2012, pp. 105–113.
15. Di Stasi, L. L., V. Álvarez-Valbuena, J. J. Cañas, A. Maldonado, A. Catena, A. Antolí, and A. Candido. Risk Behaviour and Mental Workload: Multimodal Assessment Techniques Applied to Motorbike Riding Simulation. *Transportation research part F: traffic psychology and behaviour*, Vol. 12, No. 5, 2009, pp. 361–370.
16. Cheng, A. S. K., K. P. Y. Liu, and N. Tulliani. Relationship between Driving-Violation Behaviours and Risk Perception in Motorcycle Accidents. *Hong Kong Journal of Occupational Therapy*, Vol. 25, No. 1, 2015, pp. 32–38. https://doi.org/10.1016/j.hkjot.2015.06.001.

17. Nguyen-Phuoc, D. Q., C. De Gruyter, O. Oviedo-Trespalacios, S. Diep Ngoc, and A. T. P. Tran. Turn Signal Use among Motorcyclists and Car Drivers: The Role of Environmental Characteristics, Perceived Risk, Beliefs and Lifestyle Behaviours. *Accident Analysis & Prevention*, Vol. 144, 2020, p. 105611. https://doi.org/10.1016/j.aap.2020.105611.
18. Chaudhry, B., S. El-Amine, and E. Shakshuki. Passenger Safety in Ride-Sharing Services. *Procedia computer science*, Vol. 130, 2018, pp. 1044–1050.
19. Irawan, M. Z., P. F. Belgiawan, A. K. M. Tarigan, and F. Wijanarko. To Compete or Not Compete: Exploring the Relationships between Motorcycle-Based Ride-Sourcing, Motorcycle Taxis, and Public Transport in the Jakarta Metropolitan Area. *Transportation*, Vol. 47, 2020, pp. 2367–2389.
20. Amirkiaee, S. Y., and N. Evangelopoulos. Why Do People Rideshare? An Experimental Study. *Transportation research part F: traffic psychology and behaviour*, Vol. 55, 2018, pp. 9–24.
21. Wang, Y., J. Gu, S. Wang, and J. Wang. Understanding Consumers' Willingness to Use Ride-Sharing Services: The Roles of Perceived Value and Perceived Risk. *Transportation Research Part C: Emerging Technologies*, Vol. 105, 2019, pp. 504–519.
22. Das, A., and M. M. Ahmed. Structural Equation Modeling Approach for Investigating Drivers' Risky Behavior in Clear and Adverse Weather Using SHRP2 Naturalistic Driving Data. *Journal of Transportation Safety & Security*, 2022, pp. 1–32.
23. Chou, P.-F., C.-S. Lu, and Y.-H. Chang. Effects of Service Quality and Customer Satisfaction on Customer Loyalty in High-Speed Rail Services in Taiwan. *Transportmetrica A: transport science*, Vol. 10, No. 10, 2014, pp. 917–945.
24. Hadiuzzaman, M., N. P. Farazi, S. Hossain, and D. G. Malik. An Exploratory Analysis of Observed and Latent Variables Affecting Intercity Train Service Quality in Developing Countries. *Transportation*, Vol. 46, 2019, pp. 1447–1466.
25. Hadiuzzman, M., T. Das, M. M. Hasnat, S. Hossain, and S. Rafee Musabbir. Structural Equation Modeling of User Satisfaction of Bus Transit Service Quality Based on Stated Preferences and Latent Variables. *Transportation Planning and Technology*, Vol. 40, No. 3, 2017, pp. 257–277.
26. Paul, P. S., and J. Maiti. The Synergic Role of Sociotechnical and Personal Characteristics on Work Injuries in Mines. *Ergonomics*, Vol. 51, No. 5, 2008, pp. 737–767. https://doi.org/10.1080/00140130701747483.
27. Kashani, A. T., M. Jafari, and M. A. Bondarabadi. A New Approach in Analyzing the Accident Severity of Pedestrian Crashes Using Structural Equation Modeling. *Journal of injury and violence research*, Vol. 13, No. 1, 2021, p. 23.
28. Boonyoo, T., and T. Champahom. ANALYSIS OF FACTORS AFFECTING REAR-END CRASH SEVERITY USING STRUCTURAL EQUATION MODELING. Vol. 29, No. 1, 2022.
29. Sheykhfard, A., F. Haghighi, T. Nordfjærn, and M. Soltaninejad. Structural Equation Modelling of Potential Risk Factors for Pedestrian Accidents in Rural and Urban Roads. *International Journal of Injury Control and Safety Promotion*, Vol. 28, No. 1, 2021, pp. 46–57. https://doi.org/10.1080/17457300.2020.1835991.
30. Lei, P.-W., and Q. Wu. Introduction to Structural Equation Modeling: Issues and Practical Considerations. *Educational Measurement: issues and practice*, Vol. 26, No. 3, 2007, pp. 33–43.
31. Bentler, P. M., and C.-P. Chou. Practical Issues in Structural Modeling. *Sociological methods & research*, Vol. 16, No. 1, 1987, pp. 78–117.
32. Tanaka, J. S. " How Big Is Big Enough?": Sample Size and Goodness of Fit in Structural Equation Models with Latent Variables. *Child development*, 1987, pp. 134–146.
33. Bryant, F. B., and P. R. Yarnold. Principal-Components Analysis and Exploratory and Confirmatory Factor Analysis. 1995.
34. Vogt, W. P., and B. Johnson. *Dictionary of Statistics & Methodology: A Nontechnical Guide for the Social Sciences*. Sage, 2011.

35. Dielman, T. E., R. B. Cattell, and A. Wagner. Evidence on the Simple Structure and Factor Invariance Achieved by Five Rotational Methods on Four Types of Data. *Multivariate Behavioral Research*, Vol. 7, No. 2, 1972, pp. 223–242.
36. Zaltman, G., and P. Burger. *Marketing Research: Fundamentals and Dynamics*. Dryden Press, 1975.
37. Hutcheson, G. D., and N. Sofroniou. *The Multivariate Social Scientist: Introductory Statistics Using Generalized Linear Models*. Sage, 1999.
38. ARI-BUET | Accident Research Institute. https://ari.buet.ac.bd/#/research/2. Accessed July 31, 2023.
39. Lucidi, F., A. M. Giannini, R. Sgalla, L. Mallia, A. Devoto, and S. Reichmann. Young Novice Driver Subtypes: Relationship to Driving Violations, Errors and Lapses. *Accident Analysis & Prevention*, Vol. 42, No. 6, 2010, pp. 1689–1696.
40. Weng, J., and Q. Meng. Effects of Environment, Vehicle and Driver Characteristics on Risky Driving Behavior at Work Zones. *Safety science*, Vol. 50, No. 4, 2012, pp. 1034–1042.
41. Cheng, A. S., K. P. Liu, and N. Tulliani. Relationship between Driving-Violation Behaviours and Risk Perception in Motorcycle Accidents. *Hong Kong Journal of Occupational Therapy*, Vol. 25, 2015, pp. 32–38.
42. Abegaz, T., Y. Berhane, A. Worku, A. Assrat, and A. Assefa. Effects of Excessive Speeding and Falling Asleep While Driving on Crash Injury Severity in Ethiopia: A Generalized Ordered Logit Model Analysis. *Accident Analysis & Prevention*, Vol. 71, 2014, pp. 15–21.
43. Afukaar, F. K. Speed Control in Developing Countries: Issues, Challenges and Opportunities in Reducing Road Traffic Injuries. *Injury control and safety promotion*, Vol. 10, No. 1–2, 2003, pp. 77–81.
44. Truong, L. T., H. T. Nguyen, and C. De Gruyter. Mobile Phone Use While Riding a Motorcycle and Crashes among University Students. *Traffic injury prevention*, Vol. 20, No. 2, 2019, pp. 204–210.
45. 1,026 Lives Lost in Motorcycle Accidents in 10 Months. *Dhaka Tribune*. https://archive.dhakatribune.com/bangladesh/2020/11/12/1-026-lives-lost-in-motorcycle-accidents-in-10-months?fbclid=IwAR1PM6hQGYpdrKnlMpPhPPePZ0yksvvjUSiCBspaYI-vWBdZ9V3-BgHLAv0. Accessed Jan. 15, 2023.
46. Browne, M. W. Structured Latent Curve Models. In *Multivariate analysis: Future directions 2*, Elsevier, pp. 171–197.
47. Vandenberg, R. J., and C. E. Lance. A Review and Synthesis of the Measurement Invariance Literature: Suggestions, Practices, and Recommendations for Organizational Research. *Organizational research methods*, Vol. 3, No. 1, 2000, pp. 4–70.
48. Hu, L., and P. M. Bentler. Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria versus New Alternatives. *Structural equation modeling: a multidisciplinary journal*, Vol. 6, No. 1, 1999, pp. 1–55.
49. Marsh, H. W., K.-T. Hau, and Z. Wen. In Search of Golden Rules: Comment on Hypothesis-Testing Approaches to Setting Cutoff Values for Fit Indexes and Dangers in Overgeneralizing Hu and Bentler's (1999) Findings. *Structural equation modeling*, Vol. 11, No. 3, 2004, pp. 320–341.
50. Jadaan, K., E. Al-Braizat, S. Al-Rafayah, H. Gammoh, and Y. Abukahlil. Traffic Safety in Developed and Developing Countries: A Comparative Analysis. *Journal of Traffic and Logistics Engineering Vol*, Vol. 6, No. 1, 2018, p. 157.
51. 4. Countermeasures | FHWA. https://highways.dot.gov/safety/local-rural/intersection-safety-manual-local-rural-road-owners/4-countermeasures. Accessed July 31, 2023.
52. Tahmid, M. M., F. Al Mahmud, O. Chowdhury, and M. A. Raihan. Analysis of Mode Reliability Factors among Off-Campus Students Using Structural Equation Modeling in Dhaka City. *Engineering Proceedings*, Vol. 56, No. 1, 2023, p. 259.

53. Noman, G. A., Md. M. Tahmid, Md. A. Raihan, and Md. S. Hoque. Artificial Intelligence-Based Perceived Motorcycle Risk Prediction in Bangladesh's Urban Driving Environment. In *Proceedings of the 2nd International Conference on Advances in Civil Infrastructure and Construction Materials (CICM 2023), Volume 2* (M. S. Alam, G. M. J. Hasan, A. H. M. M. Billah, and K. Islam, eds.), Springer Nature Switzerland, Cham, pp. 379–388.
54. TAHMID, M. M., G. A. Noman, and A. Mahmud. Perceived Motorcycle Risk Prediction Using Structural Equation Modeling and Artificial Intelligence in the Urban Driving Environment of Bangladesh. 2023.
55. Tahmid, M. M. Regression Analysis of Superconductivity Data. *Available at SSRN 5617850*, 2025.