FACTORS AFFECTING BICYCLING EXPERIENCE IN A DEVELOPING COUNTRY

Nazmus Sakib*[1], Md Istiaque Ahmed[2] and Khondhaker Al Momin[3]

[1] *Department of Civil Engineering, Ahsanullah University of Science and Technology (AUST), Bangladesh, email: nazmussakib.austce@gmail.com*
[2] *Department of Civil Engineering, Ahsanullah University of Science and Technology (AUST), Bangladesh, email: istiaqueahmed.ce@gmail.com*
[3] *School of Civil Engineering and Environmental Science, University of Oklahoma, USA, email: momin@ou.edu*

***Corresponding Author**

ABSTRACT

Bicycling is an eco-friendly and sustainable mode of transportation that holds significant potential for addressing urban mobility challenges in developing countries. A comprehensive grasp of the determinants influencing bicycling tendencies is imperative for refining related infrastructure and advocating for active transit modalities. This research aims to elucidate the factors affecting bicycling experience to inform the development of appropriate and effective strategies to increase bicycling use and promote the health of individuals, as well as the environment. The research has a specific focus on the context of developing countries like Bangladesh. This study extensively investigates the impact of twelve distinct independent variables, each quantified via a 5-point Likert scale. Data collection for the analysis was conducted by employing an online questionnaire survey using Google Forms. Leveraging the Ordinal Logistic Regression (OLR) and Bayesian Ordinal Logistic Regression (BOLR) analytical frameworks, the research underscores intricate interrelations among the identified factors and varying levels of bicycling experiences. Both OLR and BOLR model results depict that among the twelve independent attributes, only seven attributes are positively significant on Overall Bicycling Experience (OBE) namely bicycle lanes availability, bicycle parking facility, bicycle repair-shop availability, road surface condition, safety at intersection crossing, journey comfort, and air quality. Based on model fitness, BOLR presents better results compared to OLR The findings of this study provide insights to promote bicycle adoption and enhance user satisfaction, with important implications for urban planning strategies, policy measures, and government interventions in the context of a developing country like Bangladesh. This study contributes significantly to the ongoing conversation on sustainable urban mobility by thoroughly assessing the various factors influencing bicycling behavior.

Keywords: *Bicycling Experience, Developing Country, Ordinal Logistic Regression, Bayesian Ordinal Logistic Regression, Sustainable Urban Mobility*

1. INTRODUCTION

As cities in developing countries grapple with rapid urbanization and environmental challenges, bicycling emerges as a beacon of sustainable urban mobility (Silva et al., 2023). Offering a viable, eco-friendly alternative to motorized vehicles, bicycling reshapes the urban transport landscape. It not only promotes sustainability but also offers significant health benefits (Monga et al., 2023). However, there are several factors that hinder the adoption of bicycling, such as perceptions of rider safety and the design of road infrastructure (Aras et al., 2023). To overcome these challenges, specific infrastructural investments, such as protected intersections, dedicated bicycle lanes, and parking facilities, can be made to enhance the attractiveness of non-motorized mobility (Brait et al., 2023). Evaluating and improving existing cycling infrastructure is also crucial, especially in small towns where public transport is limited (Pandit & Sharma, 2022). In developing countries like Bangladesh, where urban transport infrastructure development has favored motorized vehicles, context-specific bicycle infrastructure design strategies are needed to improve the overall bicycling experience (Zhivkov & Simidchiev, 2022).

Assessment of factors influencing bicycling experience is essential for transportation agencies to monitor and prioritize improvements to infrastructure for cyclists. There have been some studies on bicycling experience around the world. Landis et al. (1997) explored bicycle level of service (BLOS) in United States (US) utilizing statistically calibrated level-of-service model. This study reveals that factors like pavement-surface conditions and striping of bicycle lanes are important for the quality of service. Kang & Lee (2012) developed a bicycle level of service (LOS) model from the user's perspective using an ordered probit model. The results show that the bicycle LOS is largely determined by the width of the road on which the bicycle is ridden. Other factors like road type, the total number of lanes on the approach to the intersection, and the number of encounters found as statistically significant. Lowry et al. (2012) assessed the quality of bicycle travel in a community in of Idaho, US, demonstrating how the Highway Capacity Manual (HCM)'s bicycle level of service (BLOS) can be calculated across a community with a geographic information system (GIS) and then used to calculate bikeability. Griswold et al. (2018) applied a latent class choice model to identify potential cyclists' classes based on stated preferences and develop an empirically-based performance measure for cyclist user experience in the San Francisco Bay Area. The result reveals that factors such as standard bikeway, buffered bikeway, bicycle boulevard, bikeway width positively affect bicycling for neighborhood and urban cyclists.

There have been some studies on bicycling experience in Europe. Jensen. (2007) utilized cumulative logit regression to explore bicyclist level of service on roadway segments in Denmark. The results reveal that factor such as motorized traffic volume and speed, urban land uses, rural landscapes, the types and widths of pedestrian and bicycle facilities, the numbers and widths of the drive lanes, the volumes of pedestrians, bicyclists, and parked cars, and the presence of median, trees, and bus stops were significantly influenced the level of satisfaction. Zhang et al. (2016) utilized a GIS based approach to the modelling of BLOS in Enschede, Netherland. The model results depicts that the factors shortest distance and shortest travel time dominate cyclists' routes choice in the morning peak. Pritchard et al. (2019) uses empirical bicycle route choice data to test the applicability of Bicycle Level of Service (BLOS) rating schemes for the estimation of whole-journey route choice in Trondheim, Norway. Some studies carried out in developing countries like India, such as the work by Majumdar & Mitra (2015), who performed analytical hierarchy process (AHP), have revealed that physical factors, safety-related concerns, and route topography constitute the key and common set of parameters influencing bicycle choice, both from the user's and expert's perspectives.

Building on the insights found from the studies conducted in various parts of the world, especially in the developed countries like the north American countries (US, Canada) and European countries, this research shifts its focus towards developing countries, with a specific focus on Bangladesh. This transition allows us to explore the unique challenges and opportunities that developing countries encounter in promoting bicycling as a mode of transportation. While the studies by Griswold et al. (2018); Jensen. (2007); Kang & Lee. (2012); Landis et al. (1997), and others provide a broad understanding of factors influencing bicycling experiences in more developed contexts, this study aims to investigate how these factors manifest differently in a developing and low- and middle-income (LMIC) country setting. This study aims to bridge the gap in research between developed and developing countries by providing a comprehensive viewpoint that includes diverse urban landscapes. This approach is critical as it recognizes the diverse infrastructural, cultural, and economic factors that influence bicycling experiences globally, with a particular emphasis on the unique circumstances in developing nations.

In this study, the authors have focused on the critical factors that influence bicycling tendencies in LMICs countries. This research considered Bangladesh as a case study in this case. The authors have considered distinctive environmental challenges and socio-technical opportunities LMICs face, seeking to offer the actionable insights to establish a bicycle-friendly atmosphere. This study investigates the Overall Bicycling Experience (OBE) in urban settings by examining twelve key factors such as bike lane accessibility, parking options, road conditions, and air quality. Using a 5-point Likert scale, it measures and quantifies these factors to understand levels of satisfaction and adequacy among cyclists. By spotlighting these key factors, this research offers a roadmap for city planners, policymakers, and government stakeholders to develop strategies to promote bicycling as one of the mainstream modes of transportation. The study advocates for strategic interventions that not only support sustainable development but also significantly improve the quality of urban life.

2. METHODOLOGY

2.1 Survey Design

A web-based survey was used to capture opinions of respondents hailing from diverse socio-economics backgrounds on frequency of travel using bicycle for variety of trip purpose. The online survey was created using Google Forms, incorporating both English and Bengali versions to ensure user-friendliness. The survey link was subsequently shared across social media, and email channels within Bangladesh bicyclist communities. Especially, it promoted through the personal and professional networks of the authors. After manually data screening with care, the survey carried out between 15th September 2023 to 1st November 2023 (7 weeks) produced 520 valid responses.

The survey questionnaire comprises two sections. The first section extracted respondents’ basic information on demographic characteristics: location, gender, age, education, employment status, income level, and travel characteristics: trip purpose and frequency of travel using bicycle. The second section asked to rate twelve different bicycling experience attributes along with overall bicycling experience (OBE) based on the 5-point Likert scale ranging from 1 = very dissatisfied to 5 = very satisfied. The literature suggests that a five-point scale appears to be less confusing and increases the response rate as respondents have choices without becoming overwhelmed (Bouranta et al., 2009; Saleh et al., 2023). Moreover, the bicycling experience attributes have been selected based on the present literature and consultation with transportation experts.

2.2 Sample Characteristics

Demographic attributes of the respondents of the questionnaire survey are summarized in Table 1. It can be seen that majority of the respondents are from Dhaka (63.1%). The most of the respondents are male (96.9%) with a dominant age group 15-30 years (79.8%). In terms of education most of the participants are completed higher education (87.3%). Regarding employment status students are the most active respondents and majority of the respondents earn bellow 10,000 BDT. Concerning trip purpose most of the respondents use bicycle for recreation purpose or as a hobby (68.5%).

Table 1: Sample Characteristics of Demographic Variables

Demographic Variable	Categories	Count (N=520)	Percentages
Location	Dhaka	328	63.1
	Chittagong	43	8.3
	Other City	149	28.7
Gender	Male	504	96.9
	Female	16	3.1
Age (years)	15-30 (young)	415	79.8
	30-50 (adult)	101	19.4
	>50 (elderly)	2	0.4
Education	Primary Education	15	2.7
	Secondary Education	52	10.0
	Higher Education	454	87.3
Employment Status	Service holder	145	27.9
	Student	280	53.8
	Food/Courier Delivery	10	1.9
	Unemployed	39	7.5
	Others	46	8.8
Income Level (BDT/Month)	<10,000	282	54.2
	10,001-25,000	97	18.7
	25,001-50,000	57	11.0
	50,001-100,000	53	10.2
	>100,000	31	6.0
Trip Purpose	Work	66	12.7
	Study	51	9.8
	Hobby/Recreation	356	68.5
	Others	47	9.0
Frequency of Travel Using Bicycle	Daily	142	27.3
	1-2 times a week	109	21.0
	3-4 times a week	88	16.9
	Occasionally	181	34.8

3 RESULTS and DISCUSSION

3.1 Descriptive Statistics

The category of four performance measures (Bicycle Infrastructure, Route & Road Characteristics, Safety & Security, and Comfort & Environment) into twelve variables, and a brief description of the variable along with mean and standard deviation in the bicycling experience assessment is provided in Table 2. 12 variables are categorized using a five-point Likert scale (five ratings: very dissatisfied, dissatisfied, neutral, satisfied and very satisfied). It can be seen from the Table 2 that Journey Comfort has the highest mean rating (3.89). On the contrary, Bicycle Lanes Availability (1.32), Security for Bicycle Theft (1.48) and Traffic Congestion Condition (1.58) received the lowest mean rating out of twelve independent attributes. It is very concerning that out of twelve variables only three variables have a mean rating of more than 3 and on average none of the factors reported as satisfied or very satisfied based on respondents' response. This indicates the bicycling experience is not very good on the perspective of the bicyclists. Furthermore, Cronbach's alpha was used to test the reliability of the data. The reliability of the data is 0.854 which is more than standard value 0.8 (Sakib et al., 2024; Ursachi et al., 2015).

Table 2: List of Performance Measures and Their Components with Summary

Factors	Independent Variables	Description	Mean	SD
Bicycle Infrastructure	X1: Bicycle Lanes Availability	Availability of designated bicycle lanes for cycling	1.32	0.78
	X2: Bicycle Parking Facility	Accessibility and availability of parking space for bicycles	1.52	0.87
	X3: Bicycle Repair-shop Availability	Accessibility to bicycle repair or maintenance services	3.02	1.10
Route & Road Characteristics	X4: Traffic Congestion Condition	Traffic congestion condition during travelling using bicycle	1.58	0.99
	X5: Road Surface Condition	The road's surface quality for safe bicycling	2.17	1.02
	X6: Street Drainage Facilities	The condition of drainage systems' effectiveness on cycling routes	1.78	0.92
Safety & Security	X7: Lighting Facilities	Adequacy of lighting along bicycle paths, especially at night.	2.45	1.07
	X8: Safety at Intersection Crossing	Perceived safety when crossing intersections while cycling	1.91	1.02
	X9: Security for Bicycle Theft	Measures available to prevent bicycle theft or vandalism	1.48	0.92
Comfort & Environment	X10: Journey Comfort	Comfort level experienced during bicycle journeys	3.89	1.20
	X11: Weather Condition	Assessing the influence of weather conditions on the overall cycling experience	3.85	1.15
	X12: Air Quality	Assessing the influence of air quality on the overall cycling experience	2.04	1.35
	Cronbach's Alpha = 0.854			

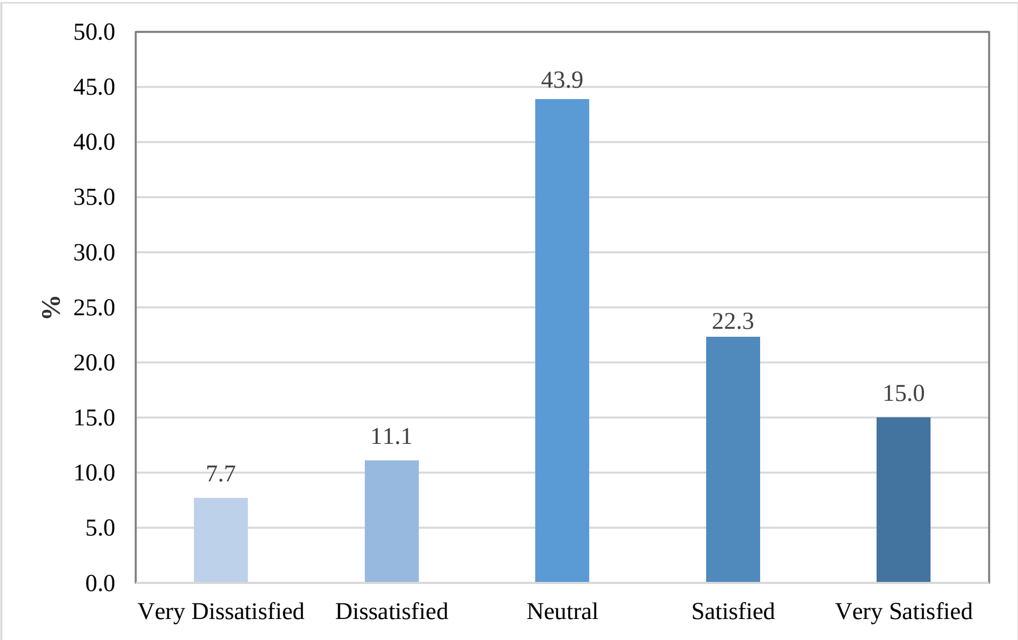

Figure 1 Perception Distribution of Overall Bicycling Experience (OBE)

The perception distribution of Overall Bicycling Experience (OBE) presented in Figure 1. The survey utilized a five-point Likert scale, categorizing responses into A: Very Satisfied, B: Satisfied, C: Neutral, D: Dissatisfied, and E: Very Dissatisfied. Notably, Neutral (OBE C) emerged as the most prevalent rating, representing the peak in the perception distribution (mean = 3.26, SD = 1.095). Bicyclists generally perceived the bicycling experience as Neutral, with infrequent occurrences of Very Satisfied (A) and Very Dissatisfied (E) ratings.

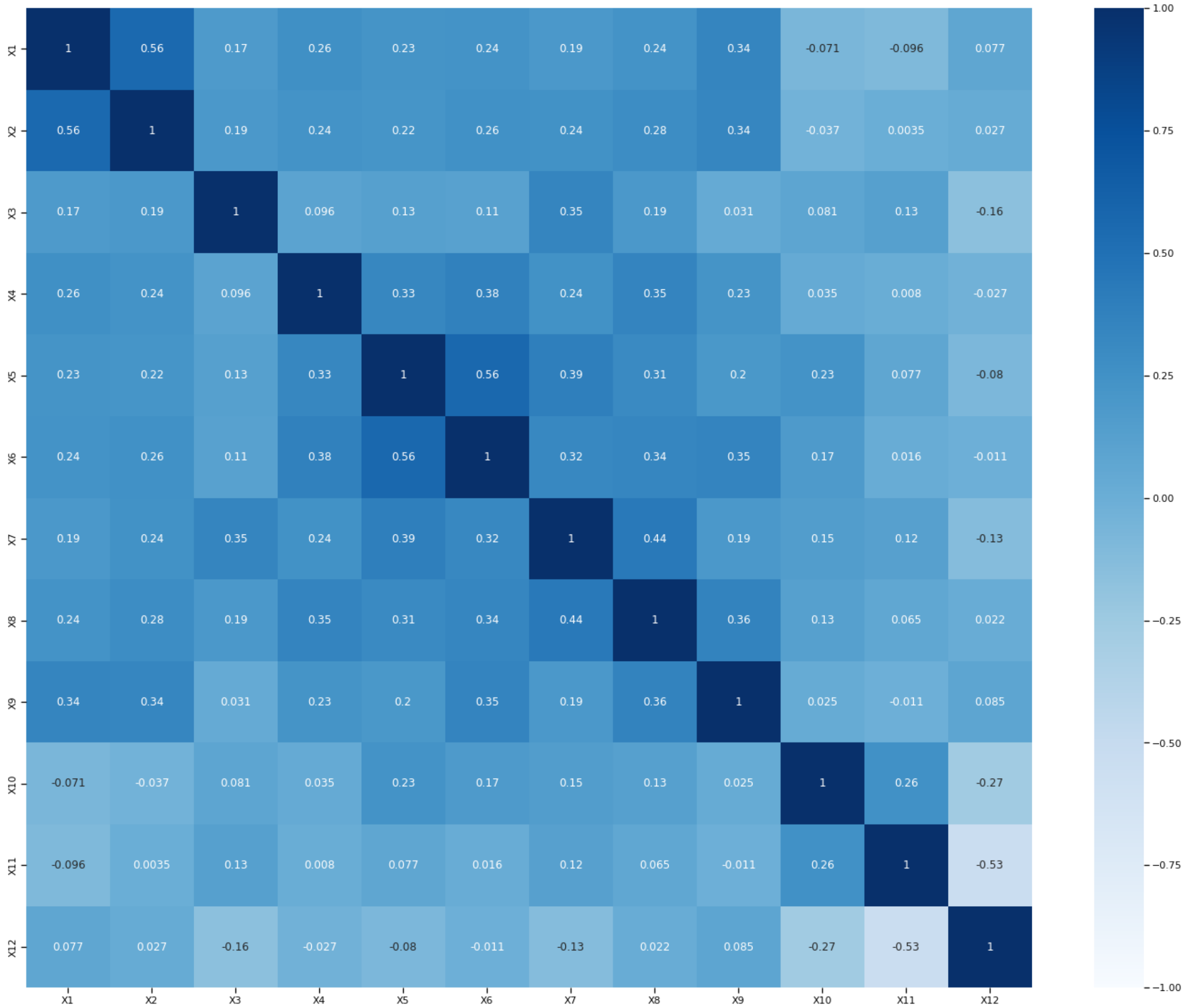

Figure 2: Correlation Matrix for the Independent Variables

Spearman's correlation test was performed between the independent variables where an absolute correlation coefficient >0.7 among two or more predictors indicates the presence of multicollinearity (Sakib et al., 2023). It can be seen from Figure 2 that none of the values of the correlation coefficient is above 0.7, meaning there is no multicollinearity between the twelve independent variables indicating that these attributes are distinct and independent of each other. Hence, it would be possible to examine the individual explanation of all the independent variables on the dependent variable by statistical modeling.

3.2 Model Development

This section illustrates the estimation of models to examine the effect of twelve bicycling experience attributes on OBE. Model estimation was performed utilizing both OLR and BOLR at a 95% confidence interval. The dependent variables are based on the participant's perception of OBE from E "very dissatisfied" to A as "very satisfied"

Maximum likelihood techniques utilized to perform the OLR model. It can be observed from Table 3 that Bicycle Lanes Availability (X1), Bicycle Parking Facility (X2), Bicycle Repair-shop Availability (X3), Road Surface Condition (X5), Safety at Intersection Crossing (X8), Journey Comfort (X10), and Air Quality (X12) has significant (p value < 0.05) impact on OBE. The estimated coefficient has a positive impact on OBE, this indicates that bicycle lanes availability, bicycle parking facility, bicycle repair-shop availability, road surface condition, safety at intersection crossing, journey comfort, and air quality in bicycling are associated with higher OBE.

Table 3: Observed Results from OLR and BOLR Model

	Ordered Logistic Regression (OLR)		**Bayesian Ordered Logistic Regression (BOLR)**			
Threshold	**Estimated Coefficient**	**P value**	**2.50%**	**Mean**	**97.50%**	**MCSE**
Cut 1	3.161	0.000	2.926	3.242	3.533	0.016
Cut 2	4.725	0.000	4.665	4.786	4.905	0.009
Cut 3	7.509	0.000	7.418	7.575	7.735	0.011
Cut 4	9.053	0.000	8.902	9.149	9.383	0.021
Independent Variable						
X1	0.348	0.016	0.181	0.377*	0.564	0.012
X2	0.358	0.005	0.110	0.346*	0.605	0.018
X3	0.304	0.000	0.138	0.323*	0.470	0.006
X4	0.118	0.214	-0.068	0.174	0.304	0.016
X5	0.187	0.044	0.025	0.184*	0.399	0.007
X6	-0.131	0.288	-0.371	-0.109	0.110	0.014
X7	0.084	0.392	-0.108	0.071	0.276	0.005
X8	0.284	0.048	0.084	0.276*	0.484	0.014
X9	0.150	0.163	-0.060	0.169	0.360	0.012
X10	0.845	0.000	0.765	0.832*	1.124	0.013
X11	-0.052	0.586	-0.237	-0.037	0.134	0.007
X12	0.224	0.006	0.063	0.213*	0.383	0.008
Goodness of Fit	**OLR**		**BOLR**			
	-2 Log likelihood	609.869	- Log marginal-likelihood		710.322	
	AIC	1251.738	DIC		1241.823	
	BIC	1319.799				
	Pseudo R Square	0.351	Acceptance rate		0.226	

Note: X1: Bicycle Lanes Availability, X2: Bicycle Parking Facility, X3: Bicycle Repair-shop Availability, X4: Traffic Congestion Condition, X5: Road Surface Condition, X6: Street Drainage Facilities, X7: Lighting Facilities, X8: Safety at Intersection Crossing, X9: Security for Bicycle Theft, X10: Journey Comfort, X11: Weather Condition, X12: Air Quality & '' value in BOLR is statistically significant at a 95% credible interval.*

In BOLR model analysis was conducted using the Metropolis-Hastings algorithm, the mean value as shown in Table 3 is the transpose of the weight matrix multiplied by the predictor matrix which got from a 95% credible interval and Monte Carlo Standard Error (MCSE) is an estimate of the inaccuracy of Monte Carlo data. It is essentially a standard deviation around the posterior mean of the data. The mean and credible interval value sample parameters are constructed based on the posterior distribution. If the path value (95% credible interval value) is included zero then the variable is considered statistically not significant (Wakefield, 2013). Table 3 represents that the mean value estimated by

BOLR is almost similar to OLR in all significant variables. One possible reason for the similarity is the noninformative uniform prior distribution used by the BOLR model. Another reason might be due to the data characteristics. The posterior probabilistic mean of significant variable X1: Bicycle Lanes Availability is 0.377 (37.7%), X2: Bicycle Parking Facility is 0.346 (34.6%), X3: Bicycle Repair-shop Availability is 0.323 (32.3%), X5: Road Surface Condition is 0.184 (18.4%), X8: Safety at Intersection Crossing is 0.276 (27.6%), X10: Journey Comfort is 0.832 (83.2%), and X12: Air Quality is 0.213 (21.3%). This result indicates that journey comfort has a high impact and road surface condition has a comparatively low impact on OBE among significant variables (Figure 3).

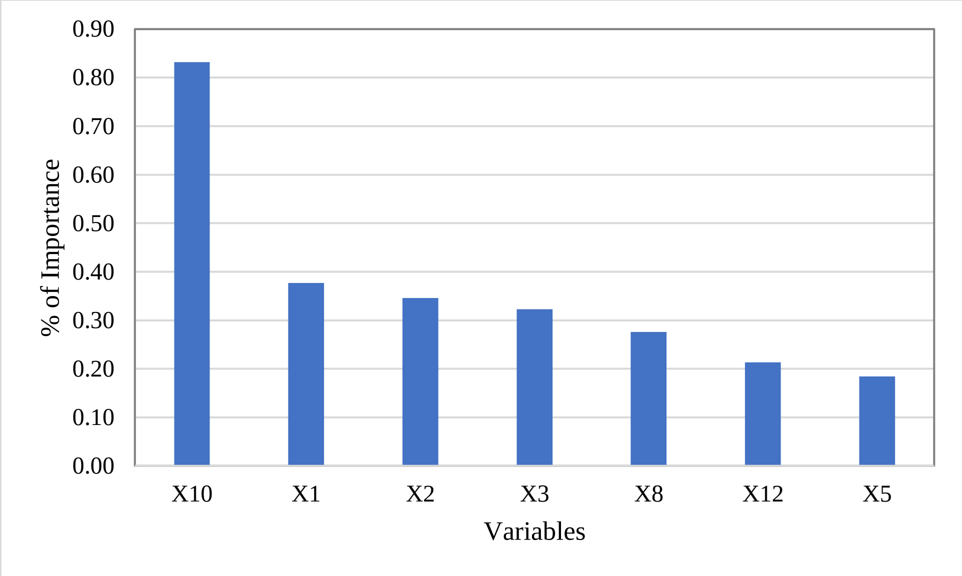

Figure 3: Ranking of Bicycling Experience Variables based on BOLR (X10: Journey Comfort, X1: Bicycle Lanes Availability, X2: Bicycle Parking Facility, X3: Bicycle Repair-shop Availability, X8: Safety at Intersection Crossing, X12: Air Quality, X5: Road Surface Condition)

3.3 Goodness of Fit

The suitability is assessed and confirmed using the following goodness of fit indicators for OLR: -2 log Likelihood (609.869), McFadden Pseudo R Square (0.351) standard value range is 0.2-0.4 (Hu et al., 2006). The R square value indicates reliability of the model, where a greater R square value signifies a good correlation between the data (McFadden, 1973). For BOLR, the suitability is assessed and confirmed using - log marginal-likelihood (710.322), DIC (Deviance Information Criterion) is 1241.823 which is the AIC (1251.738) of OLR (Wakefield, 2013). The efficiency of Markov Chain Monte Carlo (MCMC) has been confirmed using the acceptance rate of the chain which is 0.226 (acceptance rate around 0.234 is acceptable) (Sherlock & Roberts, 2009). Based on the model fitness results BOLR performs better than OLR.

3.4 Marginal Effects of OLR Model

Table 4 illustrates the marginal effect of the significant independent variables on the OBE of bicycling using OLR. Marginal effects denote how the OBE for Bicycling changes when a specific independent variable change while others are assumed to be held constant. A positive marginal effect indicates that an increase in the marginal of overall gap (1-5) increases the probability of OBE to be higher and the negative marginal effect decreases the same magnitude of probability (Ujjwal & Bandyopadhyaya, 2023). For example, marginal effect is 0.024% for OBE B with respect to bicycle lanes availability that a 1% increase in bicycle lanes availability will increase the probability of OBE being categorized as OBE B by 0.024.

Table 4: Marginal Effects of OLR Model

Bicycling Experience Attributes	**OBE E**	**OBE D**	**OBE C**	**OBE B**	**OBE A**
X1: Bicycle Lanes Availability	-0.017*	-0.018*	-0.026*	0.024*	0.037*
X2: Bicycle Parking Facility	-0.018**	-0.019**	-0.026**	0.021**	0.033**
X3: Bicycle Repair-shop Availability	-0.015***	-0.016***	-0.022***	0.011***	0.04***
X5: Road Surface Condition	-0.009*	-0.010*	-0.014*	0.013*	0.020*
X8: Safety at Intersection Crossing	-0.014**	-0.015**	-0.021**	0.020**	0.030**
X10: Journey Comfort	-0.047***	-0.050***	-0.069***	0.065***	0.101***
X12: Air Quality	-0.011**	-0.012**	-0.016**	0.015**	0.024**

*Note: OBE A=Very Satisfied (5), OBE B=Satisfied (4), OBE C=Neutral (3), OBE D= Dissatisfied (2), OBE E=Very Dissatisfied (1), *** $p<0.001$, ** $p<0.01$, * $p<0.05$*

4 CONCLUSION

This study provides valuable insights into the factors that shape the bicycling experience in developing countries, with a specific focus on Bangladesh. Bicycling emerges as a sustainable and eco-friendly transportation alternative in the face of rapid urbanization and environmental challenges. The research identifies twelve key variables, ranging from bicycle lanes availability to air quality, and assesses their impact on the overall bicycling experience (OBE) using a 5-point Likert scale. The findings underscore the critical nature of implementing policy measures, strategic urban planning, and government interventions to promote cycling as a feasible means of transportation; doing so would contribute to the sustainability of urban mobility, public health, and the environment. The study revealed that OBE is significantly influenced by seven out of the twelve factors.

The factors considered include bicycle lanes, parking facilities, repair shops, road quality, intersection safety, riding comfort, and air pollution. The average comfort score for riding was highest. In contrast, bicycle lane availability and theft protection scored lowest. This indicates dissatisfaction in these areas among cyclists. Therefore, it's important to apply these findings practically. Policymakers and transport authorities should focus on improving bicycle lane infrastructure, ensuring their accessibility and safety. To better the cycling experience, secure parking and better road surfaces are needed. Also, safety at intersections and accessible bicycle repair services are vital for a cyclist-friendly environment. Addressing air pollution benefits not only cyclists but also the broader community, improving overall urban health. Promoting cycling can be done through public awareness, cycling incentives, and community involvement in planning. Regular monitoring and feedback are key to meeting cyclists' needs. Applying these insights can make cycling a more attractive and practical transport option in Bangladesh, aiding sustainable urban development and environmental conservation.

REFERENCES

Aras, R. L., Ouellette, N. T., & Jain, R. K. (2023). A barrier too far: Understanding the role of intersection crossing distance on bicycle rider behavior in Chicago. *Environment and Planning B: Urban Analytics and City Science*, *50*(8), 2118–2132. https://doi.org/10.1177/23998083221147922

Bouranta, N., Chitiris, L., & Paravantis, J. (2009). The relationship between internal and external service quality. *International Journal of Contemporary Hospitality Management*, *21*(3), 275–293. https://doi.org/10.1108/09596110910948297

Brait, D. C. P., Alves, K. T., & Silva, O. H. da. (2023). Evaluation of the cycling infrastructure in a small town: A case study in Guaíra, São Paulo: Avaliação da infraestrutura cicloviária de uma cidade de pequeno porte: estudo de caso em Guaíra, São Paulo. *Concilium*, *23*(7), Article 7. https://doi.org/10.53660/CLM-1194-23E20A

Griswold, J. B., Yu, M., Filingeri, V., Grembek, O., & Walker, J. L. (2018). A behavioral modeling approach to bicycle level of service. *Transportation Research Part A: Policy and Practice*, *116*, 166–177.

Hu, B., Shao, J., & Palta, M. (2006). Pseudo-R 2 in logistic regression model. *Statistica Sinica*, 847–860.

Jensen, S. U. (2007). Pedestrian and Bicyclist Level of Service on Roadway Segments. *Transportation Research Record: Journal of the Transportation Research Board*, *2031*(1), 43–51. https://doi.org/10.3141/2031-06

Kang, K., & Lee, K. (2012). Development of a bicycle level of service model from the user's perspective. *KSCE Journal of Civil Engineering*, *16*(6), 1032–1039. https://doi.org/10.1007/s12205-012-1146-z

Landis, B. W., Vattikuti, V. R., & Brannick, M. T. (1997). Real-Time Human Perceptions: Toward a Bicycle Level of Service. *Transportation Research Record: Journal of the Transportation Research Board*, *1578*(1), 119–126. https://doi.org/10.3141/1578-15

Lowry, M. B., Callister, D., Gresham, M., & Moore, B. (2012). Assessment of Communitywide Bikeability with Bicycle Level of Service. *Transportation Research Record: Journal of the Transportation Research Board*, *2314*(1), 41–48. https://doi.org/10.3141/2314-06

Majumdar, B. B., & Mitra, S. (2015). Identification of factors influencing bicycling in small sized cities: A case study of Kharagpur, India. *Case Studies on Transport Policy*, *3*(3), 331–346.

McFadden, D. (1973). *Conditional logit analysis of qualitative choice behavior*. https://eml.berkeley.edu/reprints/mcfadden/zarembka.pdf

Monga, M., Sadhukhan, S., & Pitale, A. M. (2023). Measuring Users' Perceived Importance Towards Factors Affecting Their Willingness to Use Bicycle: Patna as a Case Study. In A. Agarwal, S. Velmurugan, & A. K. Maurya (Eds.), *Recent Trends in Transportation Infrastructure, Volume 2* (pp. 397–409). Springer Nature. https://doi.org/10.1007/978-981-99-2556-8_30

Pandit, D., & Sharma, D. (2022). *Bicycling Infrastructure Design for Indian Cities and Emerging Economies*. Springer Nature. https://doi.org/10.1007/978-981-19-2203-9

Pritchard, R., Frøyen, Y., & Snizek, B. (2019). Bicycle level of service for route choice—A GIS evaluation of four existing indicators with empirical data. *ISPRS International Journal of Geo-Information*, *8*(5), 214.

Sakib, N., Paul, T., Ahmed, M. T., Islam, M., & Wang, L. (2023, January 11). *Assessment of the Pedestrian Walkway Level of Service for Sustainable Development*. Transportation Research Board (TRB) 102nd Annual Meeting, Washington, D.C., USA.

Sakib, N., Paul, T., Ahmed, Md. T., Momin, K. A., & Barua, S. (2024). Investigating factors influencing pedestrian crosswalk usage behavior in Dhaka city using supervised machine learning techniques. *Multimodal Transportation*, *3*(1), 100108. https://doi.org/10.1016/j.multra.2023.100108

Saleh, S., Tithi, A. S., Sakib, N., Paul, T., Anwari, N., & Amin, S. (2023). Theory of Planned Behavior to Understand Commuter's Perception towards Mass Rapid Transit in Dhaka City, Bangladesh. *Sustainability*, *15*(14), 11270.

Sherlock, C., & Roberts, G. (2009). *Optimal scaling of the random walk Metropolis on elliptically symmetric unimodal targets*. https://projecteuclid.org/journals/bernoulli/volume-15/issue-

3/Optimal-scaling-of-the-random-walk-Metropolis-on-elliptically-symmetric/10.3150/08-BEJ176.short

Silva, L., Calazans, M., Vasconcelos, L., Barcellos, R., Trevisan, D., & Viterbo, J. (2023). Smart Cities in Focus: A Bicycle Transport Applications Analysis. *2023 26th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, 855–860. https://doi.org/10.1109/CSCWD57460.2023.10152820

Ujjwal, J., & Bandyopadhyaya, R. (2023). Development of comprehensive service quality assessment framework for sidewalks considering desired and actual conditions. *Transportation Letters*, *15*(3), 227–241. https://doi.org/10.1080/19427867.2022.2047439

Ursachi, G., Horodnic, I. A., & Zait, A. (2015). How Reliable are Measurement Scales? External Factors with Indirect Influence on Reliability Estimators. *Procedia Economics and Finance*, *20*, 679–686. https://doi.org/10.1016/S2212-5671(15)00123-9

Wakefield, J. (2013). *Bayesian and Frequentist Regression Methods*. Springer New York. https://doi.org/10.1007/978-1-4419-0925-1

Zhang, Y., Brussel, M., van den Bosch, F., Grigolon, A., & Van Maarseveen, M. (2016). A GIS based Bicycle Level of Service route model. *Proceedings of the 13th International Conference on Design & Decision Support Systems in Architecture and Urban Planning, Eindhoven, The Netherlands*, 27–28. https://www.researchgate.net/profile/Anna-Beatriz-Grigolon/publication/304891563_A_GIS_BASED_BICYCLE_LEVEL_OF_SERVICE_ROUTE_MODEL/links/577cb4d708aece6c20fe0ea7/A-GIS-BASED-BICYCLE-LEVEL-OF-SERVICE-ROUTE-MODEL.pdf

Zhivkov, P., & Simidchiev, A. (2022). Development of Software Tool for Optimization and Evaluation of Cycling Routes by Characterizing Cyclist Exposure to Air Pollution. *Annals of Computer Science and Information Systems*, *32*, 105–112. https://annals-csis.org/proceedings/2022/drp/230.html