ASSESSING FOOTPATH SERVICE QUALITY IN DHAKA: A COMPARATIVE STUDY OF FOOTPATHS NEAR EXPRESSWAY RAMPS AND OTHER AREAS USING MCMC MODELING

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ABSTRACT

Pedestrian walkways are a vital part of the urban transportation infrastructure that offer safe, accessible and sustainable paths of travel for pedestrians. In big, rapidly expanding cities like Dhaka, Bangladesh, the condition of sidewalks and walking areas is very uneven. In some places it's decent, while in others it's poor. This inconsistency is mainly caused by three things: unplanned and haphazard city growth, a lack of proper maintenance, and the disruption caused by large construction projects—like building expressways. These differences affect the safety and walkability of the pedestrians. The objective of this paper is to evaluate the service quality of footpaths adjacent to the city expressway entrances and exits with respect to footpaths located in other urban areas, identify gaps, assess user feedback, discuss the proposals and recommend improvement measures. A questionnaire survey was conducted with the inclusion of 14 service quality attributes, which were obtained from the review of literature, focus group discussion, and expert opinion. These include general condition, access, width, surface quality (concrete pieces), safety/security provisions (e.g., bollards), cleanliness, lighting quantity and quality, presence of signs, including operational and warning signs, provision for women's security/safety if necessary due to cultural context, safety/security features included in the facility design and actual performance measured at night vs. during the day, vendor obstructions and effectiveness of drainage. It was conducted in targeted areas of Dhaka, including an area near the airport where construction for a highway has greatly disrupted pedestrians' ability to walk. Each parameter was rated using a 1–10 Likert scale in order to give an indication of the user perception and satisfaction. Analyses of collected data were performed in WinBUGS using Markov Chain Monte Carlo (MCMC) sampling methodology for robust parameter estimation accounting for uncertainty. The SelectKBest method (a specific scikit-learn function) was also used to select the most influential predictors of perceived footpath quality. The MCMC models performed well, with R^2 values of 0.7589 for expressway ramp-adjacent footpaths and 0.7464 for all other footpaths (good fit). Results indicated that expressway ramps had lower scores than controls in safety (4.63 vs 6.89), cleanliness (4.73 vs 5.93) and adequacy of lighting (4.48 vs 4.78), indicating a worse users' experiences in these areas. These results suggest a necessity of targeted interventions (such as better maintenance, illumination, drainage and safety provision) in construction-affected areas. The research shows that MCMC modelling is an effective approach in processing Likert-scale data and quantifying the uncertainties of perception-based assessments. This study in its entirety is valuable to contribute understanding of pedestrian infrastructure in developing urban areas, and also makes a good practice for those concerned with the intended goal towards safer, inclusive and walkable cities.

Keywords: *Pedestrian Infrastructure Quality, Urban Footpath Assessment, MCMC Modeling, Comparative Urban Study*

1. INTRODUCTION

By providing safe, comfortable and accessible pathways for pedestrians, footpaths are key contributors to urban movement in a city. Footpaths are an integral part of the transport network, and impact on pedestrian safety and mobility as well as city livability and walkability. In cities like Dhaka, Bangladesh which are densely populated and experiencing rapid urbanization, pedestrian infrastructure is under severe strain due to space limitation, unplanned growth and conflict with motorized traffic. Large-scale infrastructure projects such as the building of expressways have led to an inevitable increase in inequality among footpath quality and availability, raising safety issues capability of pedestrians, comfortability in walking and level of walkablity. Therefore, it is important to understand and assess the service quality of footpaths in these contexts to encourage sustainable urban mobility and enhance pedestrian walking environments.

Internationally, a lot of research has been conducted on design, state and performance of pedestrian infrastructure; however much of this research was carried out in developed nations. Early studies, such as the ones by Gellatly and co-workers (1986), studied footpath erosion and stressed that besides the water regime, surface conditions also have to be met to achieve durability. According to the Western Australian Planning Commission (2000), "design should be inclusive, providing for all users, including those people with disabilities and other disadvantaged sections of the community … to the extent practicable". Others have studied associations between pedestrian experiences and user characteristics as well as behavioral aspects.For example, Hamed (2001) concluded that gender and age are significant factors in assessing safety perception whereas Holland and Hill (2007)did find that two-way flowand high-density of pedestrians can decrease the overall LOS.

Studies have expanded from physical properties of footpaths to include perception and environment. Wang and Tian (2010) proved can be seen that geometry of the setting has an important effect of barriers on perceived service quality. Landis et al. (2001) and Petritsch et al. (2006) regression analysed traffic speed, lateral separation and vehicle mix as the critical factors in perceived LOS. Similarly, Muraleetharan et al. (2000) presented the idea of "Overall LOS," which includes multiple aspects that affect pedestrian satisfaction.

Subsequent research found that quantitative models alone do not entirely explain pedestrian perceptions. Aesthetic, safety, and comfort factors also started to be taken into account in a qualitative point of view. Jaskiewicz (2000) recognized nine qualitative variables such as street enclosure, path complexity and lighting as important CIMs for pedestrian satisfaction. Florez et al. (2014) took this further and developed the concept of Q-PLOS quality which formulated by accessibility, comfort, reliability and sociability. Likewise, Talavera-Garcia and Soria-Lara (2015) suggested Q-PLOS for use as a decision-making tool linking the quality of design to pedestrian requirements. Recent models (e.g., Bivina, Parida, 2019) employed Structural Equation Modeling (SEM), which can incorporate multifaceted relationships between factors such as cleanliness, lighting and street activity.

Types of pedestrian research in the worldwide civil engineering infrastructure and traffic flow-related progress on the subject in developing countries is scarce. There are few significant works in Bangladesh on pedestrian facilities. Zannat et al. (2019) introduced a method to evaluate perceived pedestrian level of service (PLOS) in the context of Chittagong by considering accessibility, safety, and attractiveness. Hasan et al. (2015) compared several PLOS models in Dhaka to find the most appropriate at subjective: and objective level. However, they primarily focused on pedestrian facilities in general with less attention to a context variation such as those around expressway ramps – prone to encroachments, accumulation of garbage and higher levels of danger due to high-speed vehicular activities.

This has created a deficit that requires an investigation focused on footpaths affected by large construction zones, as opposed to other urban portions. Alleviating the problem in places such as

Dhaka is critical, where rapid expansion of infrastructure exists alongside scant pedestrian planning. The objective of this paper is to fill this gap by analyzing, compared and quantitatively modeling footpath service quality in some urban settings. Through using the Markov Chain Monte Carlo (MCMC) modeling approach and SelectKBest feature selection method, this study delivers a rigorous data analytical framework to recognizing influential variables on footpath service quality. The results of this research are intended to inform urban planners and other decision makers on how better pedestrian infrastructure might be achieved, leading to safer, more intuitive, and sustainable walkable environments in rapidly developing cities.

2. METHODOLOGY

An extensive methodological approach is followed in this paper to assess and compare the service quality of footpaths in various urban settings, in particular near expressway ramps areas of Dhaka city. The methods combine the strengths of qualitative and quantitative approaches in an attempt to provide a full picture. A questionnaire survey, developed to measure user perceptions on important footpath service quality factors was used in collecting data. The data were analyzed by means of a multinomial regression model for detecting the relationships between those variables and their effects on perceived service quality. More solid and probabilistic insight about parameter estimation was implemented using the Markov chain Monte Carlo (MCMC) simulation. The MCMC algorithm is realised by using WinBUGS software, which entails the Bayesian paradigm, Gibbs sampling and Metropolis-Hastings method to draw samples from posterior distributions of the model parameters so that estimates of those are more precise and stable. Such an integrated method provides a comprehensive assessment of elements influencing pedestrian satisfaction and the potential of improving footpath infrastructure in targeted areas can be identified.

2.1 Questionnaire Form Design

A structured questionnaire was developed on Microsoft Office Online for data collection regarding the pedestrians' perception of footpath service quality. The questionnaire was designed using previous research, focus group discussions and held consultations with experts to cover all appropriate factors. A pilot study was performed to verify and modify the questionnaire in response to participant feedback.

The second version comprised developed in two sections: the first collected general and demographic data, while the second included user's perception on 14 factors related with service quality (i.e. safety, cleanliness, width and type adequacy of lighting), which were considered as key factors. Scores were measured using a 10-point Likert scale, from Very Poor to Perfect. The survey was made available online through Microsoft Forms, and 357 valid responses were obtained. The established sample size and variables were sufficient for performing a valid MCMC estimation in later phases.

2.2 Multinomial Regression

Multinomial regression was used to model the association of a dependent variable on overall service quality (the perceived value or preference) of footpaths and selected independent variables indicating concern with users' perceptions including safety, cleanliness, width and adequate lighting. This statistical technique was selected in particular as it takes better account of categorical and ordinal data, such as the Likert scale responses applied to survey data, enabling probability predictions across more than two categories of outcome rather than just one binary outcome.

In this research work, the multinomial regression model was used as a base to obtain the parameters estimate of selected variables and further Bayesian inference via MCMC simulation. In the model, the log-odds of each level of footpath service quality was modeled as a linear function of predictor variables.

MCMC was introduced in this study because of the relatively small number of observations in the available dataset that comprises 357 survey responses. This could potentially be inadequate for consideration by usual estimation techniques. But MCMC has the ability to perform robust parameter estimation based on the creation of posterior distributions regardless of the sample size or other assumptions.

The general form of the multinomial logistic regression model can be expressed as:

$$log\ (P(Y=j)/P(Y=base))=\beta_0 j+\beta_1 jX_1+\beta_2 jX_2+...+\beta_k jX_k \quad (1)$$

where $P(Y = j)$ represents the probability of the dependent variable belonging to category j, $P(Y = base)$ denotes the probability of the reference category, $\beta_0 j$ is the intercept term, and $\beta_1 j, \beta_2 j, ..., \beta_k j$ are the coefficients corresponding to the independent variables $X_1, X_2, ..., X_k$.
The probability of each category j can be derived as:

$$P(Y=j)=exp(\beta_0 j+\beta_1 jX_1+\beta_2 jX_2+...+\beta_k jX_k)/\Sigma_m exp(\beta_0 m + \beta_1 mX_1 + \beta_2 mX_2 + ... + \beta_k mX_k) \quad (2)$$

This model makes it possible to estimate how changes in the independent variables influence the probability of a specific footpath quality rating. Utilizing the multinomial regression coefficients obtained from equation (1) as priors in the Bayesian analysis within the MCMC framework for greater stability, and interpretability on model outcomes.

2.3 MCMC Simulation

WinBUGS Markov Chain Monte Carlo (MCMC) modeling uses Bayesian statistics to infer the parameters of complex probabilistic models. WinBUGS (Windows Bayesian Inference Using Gibbs Sampling) is dedicated software for conducting MCMC simulations and allowing Bayesian inference by assuming approximate posterior distributions of the parameters of a model..

2.3.1 Bayesian Inference

Bayesian inference is a theoretical framework for obtaining estimates of model parameters in a probabilistic way, incorporating prior information and observed data. It is grounded in Bayes' theorem, which adjusts the probability of a hypothesis as evidence accumulates. In this paper we present a Bayesian approach to estimating the parameters of the generalised logit model, which takes uncertainties in data into account and reduces judgemental errors made when assessing footpath service quality. The model parameters (β) were assumed to be normally distributed as most values of the parameters are thought to cluster around a middle value with some variation across individuals. This supposition enhances the realistic and stable estimation of parameters like safety, cleanliness and lighting adequacy.

Bayes' theorem can be expressed as:

$$P\ (\theta \mid D) = [P\ (D \mid \theta) \times P(\theta)]\ /\ P(D) \quad (3)$$

Here, $P(\theta \mid D)$ is the posterior probability distribution of parameters θ given data D; $P(D \mid \theta)$ is the likelihood function (the probability of observing the data given some parameters θ), $P(\theta)$ is a prior distribution on this parameter space and P(D) is the marginal likelihood or evidence. $P(\theta \mid D)$ encompasses prior information and IDA evidence, gives a fair account of parameter behavior.

The posterior estimate in this paper was obtained through Markov Chain Monte Carlo (MCMC) sampling, which samples from the posterior distribution of interest iteratively to approximate complex modeling when closed-form computation is not available.

2.3.2 Gibbs Sampling

Gibbs sampling, a special case of MCMC, was used to iteratively estimate model parameters by taking samples one at a time conditionally on the rest. It is a technique to reduce the complexity of multidimensional sampling by transforming into n consecutive one-dimensional conditional densities. This method leads to a sequence of parameter estimates that converges in the limit to the joint posterior. In this research, posterior estimates have been calculated for each footpath service quality-related variable, including safety, cleanliness and lighting adequacy by using Gibbs sampling. Sampling repeats until the chains converge, and this occurs when the posterior distribution is well-approximated. This guarantees consistent parameter estimation even in high dimension data settings.

2.3.3 The Metropolis-Hastings algorithm

Metropolis et al. (1953) first developed the Metropolis algorithm, bringing science into the era of Markov-chain-implemented simulation. The original proposal was later generalized by Hastings (1970) into what is commonly referred to as the Metropolis-Hastings algorithm. The latter is widely regarded as the canonical form of any MCMC scheme. Generalization: Green (1995) extended the Metropolis-Hastings algorithm to reversible jump Metropolis-Hustings algorithms in order to sample from parameter spaces with varying dimensions. The Metropolis-Hastings algorithm is given by the following iteration;

1. Set initials values $\gamma^{(0)}$

2. For $t = 1, \ldots\ldots\ldots, T$, repeat the following steps

- **a.** Set $\beta = \beta^{(t-1)}$
- **b.** Generate new candidate parameter values from a proposal distribution $q(\beta \rightarrow \beta') = q(\beta|\beta')$.
- **c.** Calculate

  $$\alpha = min\left(1, \frac{f(\beta')q(\gamma\beta|\beta')}{f(\beta)q(\beta|\beta')}\right)$$
- **d.** Update $\beta^{(t)} = \beta'$with probability ρ and $\beta^{(t)} = \beta = \beta^{(t-1)}$ with probability $(1 - \rho)$

The Metropolis–Hastings procedure will always, eventually work even for an arbitrarily bad proposal distribution q (buggered) itch a convergence to the equilibrium distribution. However, in practice proposal selection does matter and bad choices will slow convergence to the equilibrium distribution substantially.

3. DATA COLLECTION

To appraise the functionality of footpaths in different locations in Dhaka, a systematic and comprehensive data collection method was used in this study. The chosen places were Farmgate, Shahbagh, Mirpur, Banani and Airport area – all with different types of pedestrians even the expressway ramps in Banani and near the airport. A custom-made questionnaire was developed and distributed via Microsoft Forms, offering possibilities of online input or onsite face to face interviews with pedestrians in the survey sites. Interviews spanned a period of two months, (approximately, December 2023 and January 2024) to capture a wide range of user perspectives and experiences.

The distribution of sex was male 53.22% and female 46.78% in the surveyed subjects. This almost equal gender distribution will make the survey results not biased toward one gender and reasonably representative for both genders to understand the footpath service quality and user experiences more comprehensively.

Reasons for footpath utilization in Dhaka exposed a wide spectrum; and the survey findings of this study are illustrative. More than half of the people surveyed visited markets and bazaars for shopping, which proved to be most frequent reason (more than 30%). Educational and office traffic came in close second at about 14% each, underlining the relevance of footpaths for day-to-day requirements. Crucially, almost 10% use the footpaths to facilitate movement away from traffic congestion thus pointing to their function for city navigation.

4. ANALYSIS AND RESULTS

In this chapter a detailed development of the factors that contribute to the condition and usability of footpaths is presented which utilizes cutting-edge statistical modeling and selection techniques. To detect the most important factors influencing footpath conditions, we used jamming the k-best selection with 10 high-ranking features. A correlation matrix was developed to shed light on the interrelationships of the different covariates, allowing better understanding of how factors interact and depend on each other.

4.1 Comparison Using Average Value

To compare pedestrian facilities in regular urban areas (Farmgate, Mirpur and Shahbag) with the expressway ramp area (Airport and Banani), an analysis focuses on average values of each variable. These averages present a fair level of detail about how users perceive quality, safety and general usability of footpaths in the two environments.

Table 1: Average value comparison

Variable	Footpaths in regular urban areas	Footpaths near expressway ramps
Overall Condition	6.21	3.97
Ease of Access	7.27	5.32
Width	6.68	4.36
Smoothness Quality	5.83	3.81
Safety	8.55	5.63
Security	6.89	4.63
Cleanliness	5.93	4.73
Lighting Adequacy	4.78	4.48
Lighting Quality	4.81	4.74
Presence of Signs	4.48	4.15
Availability of Safety Features	5.14	3.74
Safety Features Effectiveness	5.22	4.29
Vendor Obstruction	7.57	6.34
Drainage Effectiveness	6.23	5.11

Comparison between the mean values of the analysed variables shows that in typical urban areas, sidewalks perform better than those along expressway exit ramps. Regular footpaths also received better condition, access score and a wider (wider than 120 cm) and smoother surface (more evenness), less reports of safety concern, and users finding the path to be cleaner. Similarly, off-ramps near highway ramps have significantly lower scores than in other highway ramps, particularly for safety (5.63 vs. 8.55) and smoothness (3.81 vs. 5.83) possibly as a result of ongoing construction activities and encroachments. Despite having persistent underperformance regarding lighting and signage in both locales, the continued disparity across most of the criteria underscores the urgency to make targeted infrastructure improvements in expressway-adjacent areas for pedestrian safety and access.

4.2 Top 10 Best Features Selection

The 10 best features of modelling both footpaths are calculated using SelectKBest method. It is a filter method that selects the K best features based on a statistical score (like chi-square, ANOVA F-value, mutual information, etc.).

Table 2: Feature Importance Score of Footpath Quality near expressway ramps using ANOVA

Rank	Feature	Score
1	Safety	75.55
2	Security	75.55
3	Smoothness Quality	69.08
4	Cleanliness	53.08
5	Width	34.81
6	Availability of Safety Features	15.95
7	Safety Features Effectiveness	15.69
8	Ease of Access	15.32
9	Presence of Signs	13.99
10	Lighting Adequacy	12.41

The feature importance of ANOVA analysis demonstrates that safety and security are the highest-ranking impact factors on footpath service quality at expressway access ramps, followed by surface smoothness and cleanliness. These results suggest that, importantly for pedestrians, safety, security and cleanliness of walking environments are prioritized by users.

Table 3: Feature Importance Score of Footpath Quality in regular urban areas using ANOVA

Rank	Feature	Score
1	Safety	87.21
2	Ease of Access	69.94
3	Security	50.57
4	Drainage Effectiveness	47.22
5	Vendor Obstruction	46.88
6	Smoothness Quality	45.92
7	Cleanliness	40.82
8	Width	29.89
9	Safety Features Effectiveness	15.44
10	Presence of Signs	11.06

The regular urban footpaths ANOVA-based feature importance analysis shows that the safety of the service is of greatest importance, followed by accessibility and security. Drainage efficiency, obstruction by manufacturers and surface is used extensively in determining users thought.

4.3 Determination of Significant Covariates

Figure 1 illustrates the correlation heatmap displaying the relationships among the covariates in case of footpaths in regular urban areas.

	Overall Condition	Ease of Access	Width	Smoothness Quality	Safety	Security	Cleanliness	Lighting Adequacy	Lighting Quality	Presence of Signs	Avail. of Safety Features	Safety Features Effect.	Vendor Obstruction	Drainage Effectiveness
Overall Condition	1													
Ease of Access	0.749	1												
Width	0.569	0.564	1											
Smoothness Quality	0.687	0.671	0.587	1										
Safety	0.770	0.857	0.693	0.733	1									
Security	0.698	0.703	0.575	0.646	0.848	1								
Cleanliness	0.642	0.499	0.401	0.748	0.580	0.560	1							
Lighting Adequacy	0.335	0.148	0.082	-0.027	0.183	0.166	0.080	1						
Lighting Quality	0.302	0.149	0.049	0.004	0.183	0.199	0.110	0.936	1					
Presence of Signs	0.387	0.239	0.262	0.100	0.304	0.232	0.135	0.754	0.743	1				
Avail.of Safety Features	0.346	0.248	0.204	0.422	0.326	0.099	0.282	0.372	0.396	0.512	1			
Safety Features Effect.	0.398	0.257	0.134	0.452	0.335	0.137	0.425	0.359	0.380	0.430	0.895	1		
Vendor Obstruction	0.651	0.739	0.551	0.578	0.828	0.751	0.469	0.168	0.175	0.237	0.139	0.157	1	
Drainage Effectiveness	0.631	0.500	0.287	0.438	0.547	0.466	0.437	0.592	0.613	0.590	0.590	0.636	0.451	1

Figure 1: Correlation Heatmap among Covariates (footpaths in regular urban areas)

"Overall Condition" of footpaths exhibits a similar strong positive relation with "Ease of Access" (0.749), "Smoothness Quality" (0.687), "Safety" (0.770) and "Security" (0.698). This suggests these are important factors affecting the overall perception of condition.

Figure 2 illustrates the correlation heatmap displaying the relationships among the covariates in case of footpaths near expressway ramps.

	Overall Condition	Ease of Access	Width	Smoothness Quality	Safety	Security	Cleanliness	Lighting Adequacy	Lighting Quality	Presence of Signs	Avail.of Safety Features	Safety Features Effect.	Vendor Obstruction	Drainage Effectiveness
Overall Condition	1													
Ease of Access	0.326	1												
Width	0.637	0.171	1											
Smoothness Quality	0.799	0.691	0.638	1										
Safety	0.808	0.060	0.722	0.708	1									
Security	0.808	0.060	0.722	0.708	1	1								
Cleanliness	0.626	0.741	0.222	0.828	0.514	0.514	1							
Lighting Adequacy	0.174	0.762	0.234	0.464	-0.055	-0.055	0.454	1						
Lighting Quality	0.075	0.691	0.115	0.358	-0.153	-0.153	0.372	0.944	1					
Presence of Signs	-0.045	0.700	0.114	0.268	-0.332	-0.332	0.314	0.731	0.684	1				
Avail.of Safety Features	0.161	0.909	0.112	0.541	-0.097	-0.097	0.612	0.812	0.734	0.807	1			
Safety Features Effect.	0.160	0.695	-0.381	0.413	-0.072	-0.072	0.729	0.384	0.383	0.304	0.612	1		
Vendor Obstruction	0.244	0.943	0.083	0.636	-0.059	-0.059	0.688	0.778	0.723	0.761	0.930	0.718	1	
Drainage Effectiveness	0.319	0.814	0.076	0.606	-0.033	-0.033	0.649	0.602	0.563	0.591	0.730	0.722	0.851	1

Figure 2: Correlation Heatmap among Covariates (footpaths near expressway ramps)

The "Overall Condition" of the footpaths sub index has a high positive correlation with "Smoothness Quality" (0.799), "Safety" (0.808) and "Security" (0.808), this means, therefore influence in great extent to the perception of footpath´s conditions in general.

5. MODELING

It may be insightful to test the validity of an MCMC model over r-squared (coefficient of determination) that measures how well predicted model values fit the observed values. R-squared: A measure of how much variability is explained by your model in the dependent variable. A high value of this statistic indicates that the MCMC model is an appropriate fit to the data in order to explain the variation associate with the dependent variable using variables included in model. It indicates that the model's predictions are in good agreement with the observed values, so it can be used for inference and to make predictions.

For simplicity, the SQ variable notations are as follows: Beta1 = Ease of Access, Beta2 = Width, Beta3 = Smoothness Quality, Beta4 = Safety, Beta5 = Security, Beta6 = Cleanliness, Beta7 = Lighting Adequacy, Beta8 = Lighting Quality, Beta9 = Presence of Signs, Beta10 = Availability of Safety Features, Beta11 = Safety Features Effectiveness, Beta12 = Vendor Obstruction, Beta13 = Drainage Effectiveness, and Rsqr represents the R-squared value.

Table 4: Output Statistics after modeling of footpaths in regular urban areas using MCMC

Node	Mean	SD	MC Error	2.5%	97.5%
Rsqr	0.7464	0.0058	0.00001	0.7329	0.7554
Beta0	-1.113	0.3433	0.0007	-1.788	-0.443
Beta1	0.303	0.0642	0.0001	0.174	0.4291
Beta10	-0.0667	0.0629	0.0001	-0.1905	0.0561
Beta11	0.0501	0.0661	0.0001	-0.0789	0.1779
Beta12	0.0126	0.0694	0.0001	-0.1234	0.149
Beta13	0.18	0.0594	0.0001	0.0629	0.2968
Beta2	0.092	0.0537	0.0001	-0.0135	0.1974
Beta3	0.1531	0.0763	0.0001	0.0035	0.3028
Beta4	-0.032	0.0955	0.0002	-0.2205	0.1534
Beta5	0.1338	0.0672	0.0001	0.0018	0.2657
Beta6	0.1989	0.0584	0.0001	0.0843	0.3135
Beta7	0.3758	0.0904	0.0001	0.1983	0.5533
Beta8	-0.3245	0.0971	0.0002	0.5152	-0.1347
Beta9	0.0952	0.0736	0.0001	-0.0489	0.2396

The model has a relatively high R-squared value of 0.7464 which means that the predictors can explain around 74.64% of the variation in footpath quality. Major predictors with a positive coefficient are Beta1 (mean = 0.303), Beta7(mean = 0.3758),Beta13 (mean = 0.18) and Beta6 (mean = 0.1989) which mean strong impacts on quality footpath.

Table 5: Output Statistics after modeling of footpaths near expressway ramps using MCMC

Node	Mean	SD	MC Error	2.5%	97.5%
Rsqr	0.7589	0.0117	0.00002	0.7311	0.7764
Beta0	-3.994	18.43	0.0419	40.16	32.2
Beta1	0.0744	0.2158	0.0005	-0.3494	0.5
Beta10	-0.0906	0.1511	0.0003	-0.388	0.2054
Beta11	-0.1104	0.1892	0.0004	-0.4817	0.2627
Beta12	-0.1901	0.294	0.0006	-0.7681	0.3867
Beta13	0.3645	0.1324	0.0002	0.1031	0.6241
Beta2	-0.319	0.1946	0.0004	-0.7004	0.0627
Beta3	0.3728	0.3178	0.0006	-0.2503	0.9958
Beta4	-1.03	18.28	0.0413	-36.84	34.81

Beta5	2.866	18.33	0.0414	-33.07	38.79
Beta6	-0.2516	0.2035	0.0004	-0.6505	0.1477
Beta7	0.1255	0.122	0.0002	-.113	0.3652
Beta8	-0.0871	0.1139	0.0002	-0.3092	0.1347
Beta9	0.305	0.1859	0.0004	-0.0599	0.6692

The R-squared value of 0.7589 (2.5% confidence interval=0.7311 to 0.7764) suggests that around 75.89% variance in footpath service quality is explained by the model, so we conclude the fit of the model was good. The small MC Error for all predictors demonstrate that the estimates are stable and reliable.

6. CONCLUSIONS

This study contributes a comprehensive evaluation of footpath service quality in Dhaka, comparing between near-expressway-ramp and urban-network footpaths. Using a structured questionnaire and using advanced statistical techniques like multinomial regression and Markov Chain Monte Carlo (MCMC) modeling, the study delivers a strong data driven understanding of factors that affect pedestrian experience and infrastructure performance.

The results show that there is a significant difference between these two types of footpaths. Pedestrian paths in non-urban areas rather than at regular city level received better comparisons and scoring in most dimensions, such as safety, fitness for appropriate use or accessibilities. This reduction is directly related to prolonged construction, lack of care and low pedestrian-oriented environment in locations dominated by vehicular constructions. Amongst 14 variables checked considering as indicators, safety, security, surface smoothness and cleanliness turned as prime factors for pedestrian's satisfaction. These results were also corroborated by the SelectKBest analysis, which ranked safety as risk factors of highest, followed in regular urban areas by drainage efficiency and accessibility, when considering both types of sidewalks.

R^2 values for the MCMC model were high: expressway-adjacent footpath $R^2 = 0.7589$; regular footpath $R^2 = 0.7464$ implying that the model was a good fit and reliable. These results confirm the capability of Bayesian-based modeling on perception-driven, ordinal data that naturally possesses uncertainty. Bayesian inference, Gibbs sampling and the Metropolis-Hastings algorithm were used in a combination form for parameter estimation with robustness and convergence which increased the accuracy of results.

In summary, the research highlights an imminent requirement for optimised policy and engineering measures to develop pedestrian infrastructure especially in areas affected by construction. In order to revitalize and maintain the walkable nature of these areas, it is necessary to maintain them regularly, provide good lighting conditions, sufficient underground drainage system for storm water runoff and improved safety features. Furthermore, future planning decisions for Dhaka must be pro-pedestrian, meaning big projects such as expressways should not compromise pedestrian mobility and safety.

This study can be added to the increasing body of work on pedestrian infrastructure assessment in developing countries and it reveals that by combining advanced modeling with user perception data, useful output for sustainable urban transport planning may be obtained.

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