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*Original Article*

# Determinants of Walking as a Mode of Transportation: A Case Study of Howrah

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***Abstract*** *- This study investigates the factors influencing the choice to walk for work trips in Howrah, a densely populated city characterized by narrow streets and by-lanes. A sample of 250 residents from 25 wards were surveyed to analyze socio-demographic and trip-specific variables, including age, education, house rent, and trip length. The study addresses two main questions: whether residents prefer walking for work trips and the reasons behind this choice, such as budget, health, short distance, or a lack of preference. Logistic regression analysis revealed that age, education, house rent, and trip length significantly impact walking preferences. Wealthier individuals were found less likely to walk due to insufficient pedestrian infrastructure, while older individuals walked more for health and budget reasons. The study highlights the urgent need for better pedestrian infrastructure, including safer footpaths and pedestrian-friendly streets, especially for older residents. This research fills a critical gap in urban transportation studies by exploring walking behavior in the Indian context, offering valuable insights for planners aiming to improve urban mobility.*

***Keywords*** *- Pedestrian mobility, Resilient infrastructure, Sustainable development, Road safety, Traffic management.*

## 1. Introduction

Urbanization and transportation infrastructure are inherently interconnected, as rapid urban growth frequently strains existing transport systems. Howrah district in West Bengal, home to over 4.8 million people, experiences a high degree of urban concentration, particularly in the city of Howrah. This dense population contributes to significant demand for transportation networks and other urban services, highlighting the need for efficient and scalable infrastructure to support the district's growing urbanization. The district's socio-economic characteristics and population distribution play a pivotal role in shaping its urban and transportation development needs. Walking, as a mode of transportation, is often overlooked in transportation policy but plays a vital role in reducing traffic congestion, promoting physical health, and reducing environmental impact. In a city like Howrah, where economic diversity and infrastructure vary widely across its 60 wards, understanding what drives the decision to walk is key to designing effective transportation policies. However, data on walking behavior and its determinants are limited. This study aims to address the following research questions:

1. What factors influence the decision to walk for work-related trips in Howrah?
2. How do socio-economic and trip-specific variables such as age, education, house rent, and trip length affect walking preferences?
3. What are the implications of these findings for urban transportation policy and pedestrian infrastructure in Howrah?

This study aims to provide insights into improving Howrah's urban transportation policies and pedestrian infrastructure by identifying the key determinants of walking behavior. The next section provides a detailed literature on the available literature studying the walking needs for work trips.

## 2. Literature Review

### *2.1. Walking as a Mode Choice in Indian Cities*

Some limited studies underscored the importance of considering socio-economic disparities in transportation planning, particularly for non-motorized modes like walking and cycling.

Rahul et al. (2014) analyzed the role of Non-Motorized Transport (NMT) modes, focusing on walking and cycling trip distances in Bangalore. Using 2009 household travel data, they explored socio-demographic factors like gender, age, vehicle ownership, and trip location, finding significant differences in trip distances based on gender and vehicle ownership. Similarly, Rastogi et al. (2003) examined commuter travel behavior in Mumbai, analyzing access mode use, trip characteristics, and acceptable walking and bicycling distances.

Both studies highlight the influence of socioeconomic factors like occupation and income on walking and cycling behavior. However, Rahul et al. focused more on gender disparities, while Rastogi emphasized income and vehicle availability.

Manoj et al. (2015) explored non-workers' activity-travel behavior in Bangalore, finding that low-income individuals walked longer distances and made more social stops compared to wealthier groups. This focus on socio-economic differences in mobility is echoed in Srinivasan et al. (2004), who studied low-income residents in Chennai, finding that central locations encouraged more reliance on non-motorized modes, such as walking or cycling. Both studies emphasize the need for equitable land-use planning to ensure access to basic facilities for low-income groups. Rastogi et al. (2010) investigated commuters' willingness to shift to walking or bicycling for rail access in suburban Mumbai, revealing that lower- and middle-income commuters were more inclined to shift than wealthier ones. This contrasts with Manoj et al. (2015), who found that non-workers' travel behavior varied significantly with income in terms of trip length and frequency rather than a willingness to shift modes.

### *2.2. Determinants of Walking as a Mode of Transport*

Hatamzadeh et al. (2016) examined factors influencing walking for school trips in Rasht, Iran, developing behavioral models for different student age groups. They found that girls were less likely to walk than boys and household car ownership reduced walking across all groups, with other factors like time of day and travel distance varying by age. Winters et al. (2017) reviewed policies promoting walking and cycling, highlighting the need for safe infrastructure at multiple socio-ecological levels while calling for further research to assess policy effectiveness. Wigan (1995) emphasized walking's overlooked role in transportation planning, advocating for its integration into policy, especially for vulnerable groups. Ton et al. (2019) analyzed walking and cycling choices in the Netherlands, showing that cycling was infrastructure-dependent while walking was influenced by urban design. Duncan et al. (2016) linked higher Walk Scores to increased walking in Paris, underscoring the importance of walkable environments in promoting physical activity.

### *2.3. Inference from the Literature and Motivation*

It can be inferred that various socio-demographic, infrastructural, and environmental factors influence walking as a transportation mode across different age groups, income levels, and urban settings. While factors like gender, car ownership, and proximity to services are significant, policy-level interventions and urban design also play crucial roles in promoting walking and cycling. However, gaps in the literature include the need for more region-specific research on the effectiveness of policies promoting walking, especially in developing countries, and a deeper exploration of how different urban design elements interact to influence walking behavior across diverse socio-economic contexts.

Howrah is a densely populated city in West Bengal within the Kolkata metropolitan region, characterized by narrow lanes, major roads, and a strong reliance on walking as a primary mode of transportation. The city's infrastructure, especially its narrow lanes and congested streets, makes walking a practical and often necessary mode of travel for many residents, further underscoring the importance of understanding the factors influencing this choice. Given the clear influence of socio-demographic factors and urban infrastructure on walking behavior, along with the gaps in region-specific policy effectiveness, this study aims to explore the determinants of walking for work-related trips in the Howrah district, with the goal of informing urban planning efforts to promote sustainable and equitable transportation options**.**

## 3. Data Collection and Methodology

The methodology adopted in this paper is by preparing a comprehensive questionnaire and conducting the interview of people across the Howrah city. Data were collected from 250 residents across 25 of Howrah's 60 wards, ensuring a representative sample aligned with the population distribution. The respondents, aged between 17 and 82 years, came from diverse backgrounds, including students, working professionals, and retirees. The sample comprised 33 females and 217 males. Figure 1 presents some sample photos taken during the interview process.

**Fig. 1 Sample photographs taken during the interview process**

Data collection was conducted through structured, in-person interviews. Before the full survey, a pilot study was carried out to refine the questionnaire, which led to the inclusion of additional variables to capture a more comprehensive picture of travel preferences. This pre-survey ensured the final questionnaire was tailored to the specific needs of the study.

Administering the questionnaire in person allowed for greater clarity and minimized issues like respondent bias and social desirability bias. The participants agreed, in general, to

disclose their travel datasets to the public, provided their identity is not revealed. The in-person interview approach enhanced the reliability and validity of the data by reducing the potential for misinterpretation, which is critical in interview-based studies. The study focused on walking as the mode of travel, and the random sampling method was used to collect data in proportion to Howrah's population distribution. This method ensured that the findings represented the broader commuting trends in the urban population of Howrah.

The Independent Variables (IVs) in this study include socio-demographic factors such as age, gender, income, status of accommodation (house rented or owned) and education, alongside trip-specific attributes like trip length and vehicle ownership. These variables were selected for their potential to influence transportation mode choices. The Dependent Variables (DVs) include: (1) a binary question asking whether the respondent prefers walking as a primary mode of transport, and (2) a categorical question asking for the reason behind this preference, with four options—budget, health, short distance, or not preferring walking. The second DV, while categorical, can also be treated as ordinal depending on the analysis required. Table 1 provides a list of DV and IV and their details. Income was calculated by an indirect analysis. For the purpose of this analysis, we assume the following costs for different modes of transport: a bike costs ₹60,000, a car costs ₹4,00,000, a toto (electric rickshaw) costs ₹70,000, and a cycle cost ₹3,000. The interviewees were asked about the number of each of the above vehicle types owned by them. Based on these assumptions, we estimated the income, allowing us to compare each person's financial implications indirectly. Out of 250 people, 17 people, or about 6.8 % were walking trips.

## 4. Modelling and Interpretation

This section provides a detailed overview about the modeling and analysis of the collected data. Firstly, the influencing variables for each dependent variable are noted. Then, analysis is performed only using the significant dependent variables. Logistic regression is the most suitable method for this study as it effectively models binary outcomes, such as the decision to walk or not, and categorical variables, like trip length and socio-demographic factors, central to understanding walking behavior. Logistic regression was preferred because it offers a more interpretable approach for modeling binary choices and allows for clearer insights into the impact of socio-demographic factors on walking behavior.

**Table 1. Details of the variables calculated**

| Variable Name | DV /IV * | Pattern | Max Value | Min Value |
|---|---|---|---|---|
| Age (years) | IV | Continuous | 71 | 18 |
| Gender | IV | Binary | 1 | 0 |
| Education | IV | Categorical | PhD | Class 2 |
| Trip Length (km) | IV | Continuous | 22.5 | 0.1 |
| Income representation by Vehicle Ownership in INR | IV | Continuous | 436000 | 0 |
| Prefer Walking (Yes/No) | DV | Binary | 0 | 1 |
| Reason for Walking | DV | Ordinal | 1 | 4 |
| House rented/owned | IV | Binary | 1 | 0 |
| Households in the building | IV | Integer | 100 | 1 |

* DV = dependent variable, IV = independent variable.

### *4.1. Modeling the Factors and Choice to Walk or Not To*

The factors affecting the binary choice of whether to walk or not to walk can be calculated by means of logistic regression. This model can estimate how each IV (like age, gender, income, etc.) influences the choice to walk or not. All the IV and DV tables were added in statistical software to analyse p-values (which reveal if the IV affects the DV or not) and the coefficients (which provide the effect of the IV on the choice). The p-value and coefficient for each IV on the choice to walk are provided in Table 2.

**Table 2. Effect of various independent variables on the choice to walk or not**

| Variable | Coefficient | P-Value | Variable Name | DV/IV* | Pattern | Max Value | Min Value |
|---|---|---|---|---|---|---|---|
| Constant | 1.9164 | 0.0314 | Age (years) | IV | Continuous | 71 | 18 |
| Age | -0.001 | 0.9324 | Gender | IV | Binary | 1 | 0 |
| Education | -0.3046 | 0.0381 | Education | IV | Categorical | PhD | Class 2 |
| House rent | -0.6096 | 0.0427 | Trip Length (km) | IV | Continuous | 22.5 | 0.1 |
| Households in Family | 0.0129 | 0.4041 | Income representation by Vehicle Ownership in INR | IV | Continuous | 436000 | 0 |
| Gender | 0.1922 | 0.6322 | Prefer Walking (Yes/No) | DV | Binary | 0 | 1 |
| Assets | -7.35E-07 | 0.3941 | Reason for Walking | DV | Ordinal | 1 | 4 |
| Trip Length (km) | -0.0214 | 0.0127 | House rented/owned | IV | Binary | 1 | 0 |
| Width of Approach Road | 0.033 | 0.6639 | Households in the building | IV | Integer | 100 | 1 |

The p-values in Table 2 indicate that education (p = 0.0381), Trip length (p=0.0127) and house rent (p = 0.0427) are significant predictors of the choice to walk, as their values are below the 0.05 threshold. This suggests that these factors significantly influence the decision to walk or not. In contrast, other variables such as age, gender, household size, assets, and width of the approach road have p-values greater than 0.05, indicating that they do not have a statistically significant impact on the decision to walk. Counter-intuitively, people's vehicle ownership did not affect their decision to walk. The coefficients show that education (-0.3046) and house rent (-0.6096) have negative values, meaning that higher education levels and people living in their own houses rather than in rented houses reduce the likelihood of walking. The negative coefficient for trip length (-0.0214) suggests that longer trips may slightly decrease the probability of walking.
The general equation for the logistic regression model based on the provided results can be expressed as Equation (1).

$$\text{logit}\left(\text{P(Walk} = 1)\right) = \beta_0 + \beta_1 \times \text{Age} + \beta_2 \times \text{Education} + \beta_3 \times \text{House}_{\text{Rent}} + \beta_4 \times \text{Households} + \beta_5 \times \text{Gender} + \beta_6 \times \text{Assents} + \beta_7 \times \text{Trip length} + \beta_8 \times \text{Approach road width.} \quad (1)$$

Using the above equation and substituting the values from Table 2, one can estimate the log-likelihood of probability to walk based on the developed logit model and can estimate whether a person with a given demographics and social status will walk or not to their destination.

**Table 3. Effect of various independent variables on the choice to prefer walk**

| Variable | P-Value for Choice = Walk due to Low Budget | P-Value for Choice = Walk for Health Reasons | P-Value for Choice = Walk due to Shorter Trips |
|---|---|---|---|
| Constant | 0.03 | 0.03 | 0.57 |
| Age | 0.01 | 0.01 | 0.01 |
| Education | 0.9 | 0.76 | 0.02 |
| House rent | 0.66 | 0.37 | 0.19 |
| Households | 0.58 | 0.97 | 0.67 |
| Gender | 0.88 | 0.26 | 0.94 |
| Assets | 0.05 | 0.09 | 0.23 |
| Trip length (km) | 0.26 | 0.27 | 0.03 |
| Width of approach road | 0.84 | 0.6 | 0.25 |

### *4.2. Modelling the Factors Affecting the Reason for Walking*

The interviewees were asked the question, 'For what reason do you prefer walking?' Here, they provided the answers in four options, noted as serial numbers 1-4 as (1) Do not prefer to walk any time. (2) Their budget does not allow them to incur the cost of traveling by any vehicle daily, (3) Health reasons (They Walk to maintain their good health), and (4) Their trip length is of a short distance to prefer to walk. Their response is recorded as an ordinal response, as against the other independent variables, and Table 3 provides the coefficient of correlation for choices 2,3 and 4, as compared with the first choice, which is not to walk. Table 4 provides the coefficients of the respective choices with respect to the choice 'not prefer to walk'. It is to be noted that the choice of individuals (probability to choose a particular choice) can be predicted based on substituting the values in the general logistic regression equation (Equation 1).

**Table 4. Coefficient of the multinomial logistic regression for each choice with respect to the independent variables**

| Variable | Coefficient for Choice = Walk due to Low Budget | Coefficient for Choice = Walk for Health Reasons | Coefficient for Choice = Walk Due to Shorter Trips |
|---|---|---|---|
| Constant | 1.92 | 3.10E-03 | -3.20E-02 |
| Age | 0.0451 | 1.40E-02 | 1.93E-03 |
| Education | -0.3 | -0.4 | 1.5 |
| House Rent/owned | -0.61 | -0.4 | 2.00E-04 |
| Households in dwelling | 0.01 | 0.02 | -6.00E-02 |
| Gender | 0.19 | -5.10E-01 | 2.30E-02 |
| Assets | -7.35E-07 | 1.93E-04 | 5.70E-04 |
| Trip length (km) | -0.02 | -3.10E-02 | -2.30E-02 |
| Width of approach road | 0.03 | -1.00E-01 | 3.70E-02 |

The results can be interpreted in the following manner.

*4.2.1. Category 1: Budget Restrictions (Walk Due to Financial Constraints)*

- Age: A positive coefficient (0.0451, p=0.003) means older individuals are more likely to walk for budget reasons.
- Education, House status, Households in the dwelling, Gender, Trip length, and width of approach road: All these factors don't significantly affect whether someone walks due to budget restrictions.
- Assets: This is marginally significant (p=0.049), indicating some effect (those with fewer assets may walk due to budget constraints).

*4.2.2 Category 2: Health Reasons (Walk to Maintain Health)*

- Age: Positive coefficient (0.0415, p=0.008), indicating older individuals are more likely to walk for health.

- Gender, Assets, and House status: All have a Negative but insignificant effect on people's likelihood to walk for health.

*4.2.3. Category 3: Short Trip Distance (Walk Due to Short Trip Distances)*

- Age: Positive coefficient (1.93E-03, p=0.009), indicating older individuals are more likely to walk due to shorter trips.
- Education: Significant negative coefficient (-1.1228, p=0.018), showing that those with lower education levels are more likely to walk due to short trips.
- House status: Negative but insignificant (p=0.188), so renting or owning a house isn't a major factor.
- Trip length: Positive and obvious since people who have shorter trips actually feel the urge to walk since they realize it is a short trip.

## 5. Interpretation and Implication of Obtained Results

### *5.1. Interpretation of Results*

*5.1.1. Walking Preferences (Multinomial Logistic Regression)*

Age positively affects walking preferences for both health reasons and budget restrictions. Older individuals are more likely to prefer walking for these reasons, but its effect is stronger for health. Education negatively impacts walking preference, particularly for health reasons. More educated individuals seem less inclined to walk for health or other reasons. House Rent has a negative coefficient, suggesting that those who rent houses are less likely to walk. This could be linked to socio-economic factors or the need to travel longer distances. Trip Length has a modest impact: longer trips reduce the likelihood of walking, particularly for shorter trips (e.g., those who walk due to short distances). The width of Approach Road seems less significant in the multinomial model. However, its positive effect for short trip distances suggests that wider streets may encourage walking over shorter distances, although the overall impact is weak.

*5.1.2. Choice to Walk (Binary Logistic Regression)*

Education and House Rent both significantly reduce the likelihood of walking. Higher education often correlates with higher incomes, implying a greater ability to afford other modes of transport. Trip Length has a significant, albeit negative, effect, further indicating that people are less likely to walk when trips are longer. Interestingly, factors like Gender, Age, and Households in the family don't significantly affect the binary decision to walk.

### *5.2. Implications for Transportation Planners*

- Pedestrian Infrastructure: In dense cities like Howrah, where streets are narrow and heavily connected through by lanes, proper footpaths are critical. The negative association of education and house rent with walking indicates that more affluent individuals prefer other modes of transport, likely due to a lack of safe pedestrian infrastructure. Building continuous, well-maintained footpaths will encourage walking among all socio-economic groups, regardless of education level or housing situation.
- Pedestrian-Only Streets: The positive preference for walking among those citing health or budget reasons suggests an opportunity to create pedestrian-only streets in areas with high foot traffic. This will support health-conscious commuters and those who walk due to financial constraints. Streets dedicated to walking, free from vehicular congestion, will make walking a more attractive option.
- Short Trip Distances: For shorter trip distances, many individuals prefer walking. Designing local, interconnected networks of pedestrian-friendly routes through narrow lanes will facilitate walking. The width of approach roads should be optimized for pedestrian traffic in these cases, ensuring that key connections between residential and work areas are easily accessible on foot.
- Planning for older people: The data shows that older individuals are more likely to prefer walking for health and budget reasons. This suggests that pedestrian infrastructure, particularly in areas with higher concentrations of older residents, should prioritize accessibility, comfort, and safety. Providing well-maintained footpaths with seating areas, proper lighting, and easy access to public transport can encourage walking among older populations, improving their mobility and well-being.

## 6. Conclusion and Future Scope

This study on walking preferences in Howrah highlights the need for better pedestrian infrastructure, especially in densely populated areas with narrow streets. Interviews from pedestrians can be modelled into logit models, which provide some insights into people's behavior and factors affecting walking. Factors such as education, house rent, and trip length influence the choice to walk, with more affluent individuals less likely to do so. Improving footpaths and creating pedestrian-only streets will encourage walking for both health and budget-conscious commuters, making the city more pedestrian-friendly for all. This study uniquely contributes to understanding walking behavior in Howrah, a densely populated city, by examining how socio-demographic factors, such as age, education, and house rent, interact with urban infrastructure challenges. Unlike previous studies (e.g., Shi et al., 2014; Parmar et al., 2023), which focus on broader socio-economic disparities in walking, our research specifically addresses the role of inadequate pedestrian infrastructure in shaping walking preferences, providing valuable insights for region-specific urban transportation policies.

As a future scope, more cities similar to Howrah can be explored with similar interview studies to know walkers'

travel patterns. Future research could explore the specific design requirements for pedestrian infrastructure that meet the diverse needs of different age groups, especially older people and those from varying socio-economic backgrounds.

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