International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 11 November 2024
Page No: 2593 - 2600
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0357

Impact of Socio-Economic Factors on The Transportation Mode Preferences of Work Trips in Medium-Sized Cities of Developing Countries

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Abstract

The rise in single-occupant automobiles has worsened traffic congestion and transportation emissions. Promoting public transportation is increasingly popular among commuters to improve transportation network efficiency. Patna, one of the world's fastest-growing metropolises, faces a widening gap between public and private transportation usage. This study, based on a revealed preference survey of 400 randomly selected respondents, examines key variables influencing public transportation choices in Patna, Bihar. To address the imbalance, a shift from private vehicles to environmentally friendly travel modes is necessary. The study explored the impact of socioeconomic factors on employees' mode choice using a self-administered quantitative questionnaire to gather travel behavior data. Descriptive-analytic tests in SPSS showed a preference for private transportation, with no significant positive influence of socioeconomic characteristics on public transit ridership. These findings provide valuable insights for stakeholders in planning and developing sustainable transportation strategies in Patna, and they can inform policymaking and future studies on mode choice models, including park-and-ride systems.

Keywords: *Mode choice; Revealed Preference Survey; Socio-Economic; Patna*

1. Introduction

The rapid urbanization and economic development occurring globally have resulted in a surge in the number of people living in cities. This population growth and rising prosperity have led to a significant increase in the demand for personal vehicle transportation. As a result, energy usage and greenhouse gas emissions have risen dramatically. The transportation industry accounted for over 14% of the world's greenhouse gas (GHG) emissions in 2015, consuming 31,310 TWh of energy. Forecasts suggest that the industry's need for this energy will rise by 260% by the year 2050 (Santos, G. 2017; Khalili, S. et al., 2019). As the vehicle's engine burns more fossil fuel to meet the increased energy demand, it will release higher quantities of harmful gases and carbon dioxide into the atmosphere. This surge in emissions has a detrimental impact on the global climate. Additionally, it contributes to sea level rise, temperature increases worldwide, and the eventual phenomena of global warming (Witchayaphong, P et al., 2020). (Sinha, S. et al., 2017) Emphasize the necessity of improving public transit in Patna, with paying particular attention to the city's bus services. For low-income residents in Patna, India, public and non-motorized transportation (NMT) is essential to sustainable and affordable mobility. (Kim, J. 2019) Highlights that adequate infrastructure and planning are required to enable NMT, which can serve as a feeder for public transportation. (Sinha, S. et al., 2017) Emphasizes the need to enhance public transportation service quality, especially regarding information, frequency, and timeliness, to draw in more passengers. (Rahul, T. and Verma 2018) Highlights the sustainability benefits of NMT infrastructure, such as cycling lanes and separated walkways, which can give low-income people another form of transportation. The necessity for a thorough comprehension of the components and advantages of NMT is further highlighted by (Mansoor, U. et al., 2022) particularly in the context of developing countries like India. The cost of traffic congestion in Patna is projected to increase

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significantly over the decade. This is a widespread problem in many cities, costing the US $29 billion annually (Kim, J. 2019). Traffic jams are not the only issue; Paris subway congestion also has a financial impact (Kalwar, S. et al., 2021). A modeling method has been implemented in Bhubaneswar to forecast congestion indices and offer remedies (Samal, S. and Das, A. 2020). One of the most important aspects of urban transportation planning is the mode choice behavior of commuters, especially for work trips. Understanding the factors influencing commuter's mode choice decisions is crucial for designing successful transportation policies and strategies, as the complexity of urban surroundings increases and the demand for efficient and sustainable transportation systems grows. The ultimate purpose of this study is to provide insights that can guide the construction of more sustainable and efficient transportation systems by examining the different elements that affect commuter's mode choice behavior when traveling for work. These studies demonstrate the need for practical solutions to the expanding issue of urban traffic congestion. The analysis of modal choice among working individuals is a key policy-focused element in forecasting and evaluating travel demand management strategies. Specifically, examining the modal distribution of commuters aims to offer insights into various policy interventions (Ahmad, N. 1995). Factors such as fare structures, fuel taxes, public transportation implementation, and road improvements influence mode choice. Analyzing mode choice is also beneficial for adopting sustainable transportation approaches. For example, in bus system planning, choice models can predict the number of users likely to utilize the system. The information helps optimize the use of available capacity and guides investments in system expansion (Mansoor, U. et al., 2022) This study aims to investigate how socio-economic factors impact travelers' choice of transportation mode and their likelihood to switch to public transportation when offered special incentives (Talpur, M. et al., 2014). The results of this study will be precious for informing policy decisions. Emphasis is placed on commuting trips due to their critical role in urban travel patterns and their consistent nature among urban residents. [1-5]

2. Problem Background

Most cities that have experienced the fastest growth rates over the past two decades are located in emerging nations. Patna is the capital and largest city of Bihar in India. With 2.35 million residents as of 2018, Patna was the 19th biggest city in India, according to the United Nations. With a population of more than 2.5 million and an urban agglomeration covering 250 square kilometers (97 sq. mi), the city is home to the 15th largest in the country (Patna (2024) Wikipedia). Bihar has the fastest growth rate, seeing an astonishing 52.61 % rise in population between 2001 and 2021 (Haywood, L. et al., 2015). With almost 129.21 million residents, Bihar is known as the fastest-growing area in the world (StatisticsTimes.com, Bihar-population). Since, the population of every decade Bihar state with a yearly growth rate of more than 2-3 %, as shown in Table 1. In recent times, Patna has witnessed a swift increase in both population and economic growth. As a result, there is now much more demand for transportation, which is placing undue strain on the system already in place (CORPORATION, P. M. R., and SOCIAL. n.d). The increasing number of private and public cars in the city has resulted in some transportation-related problems, including air and noise pollution, traffic congestion, and high accident rates (Prakash M. 2014). Developing sustainable transportation policies and strategies in Patna requires an understanding of the variables influencing preferences for different modes of transportation. Previous research has demonstrated that socioeconomic factors, including age, gender, employment, education level, and monthly income, may have significant impacts on people's travel habits (Li, J. et al., 2018; Saigal, T., 2022). For instance, research conducted in Shenyang, China, discovered a significant correlation between monthly income, gender, automobile ownership, and preferred modes of transportation (Li, J. et al., 2018). The majority of travellers in Patna are men (57%), with women making up the remaining 43% (Prakash M. 2014). Men travel by bicycle, two-wheeler, and four-wheeler more frequently than women do. Women also utilize walking and public transportation such as buses and minibuses. The gender disparity in travel habits emphasizes the need for non-motorized

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transport NMT infrastructure that is safer and better illuminated to protect commuters, particularly women (Prakash M. 2014). In addition, preferences for public transportation services vary between slum and non-slum dwellers. While non-slum dwellers choose higher fees for air-conditioned buses with higher frequency and shorter travel times, slum occupants prioritize the same cost of transportation but want air conditioning and more frequent travel (Prakash M. 2014). According to this, non-slum dwellers place a higher value on comfort when traveling. As a result of Patna's quick urbanization and economic expansion, the city's transportation demand and mode preferences have changed significantly. Developing inclusive and efficient transportation policies that meet the varied requirements of the city's people requires an understanding of how socioeconomic factors affect travel behavior. [5-10]

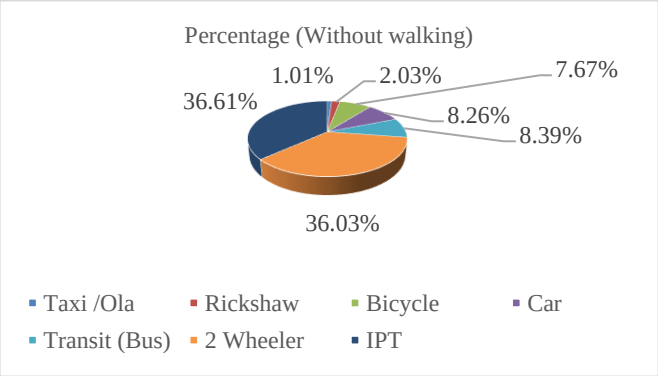

Figure 1 Mode Share (Ranjan, R. And Sinha, S, 2024)

Table 1 Bihar Population and Growth Rates (Statisticstimes.Com, Bihar-Population)

Year	Population	Growth rate (%)
1951	29,085,017	10.58
1961	34,840,968	19.79
1971	42,126,236	20.91
1981	52,302,665	24.16
1991	64,530,554	23.38
2001	82,998,509	28.62
2011	104,099,452	25.42

The primary objective of understanding the factors influencing the choice of modes of transport among commuters in Patna, a comprehensive survey on travel habits is crucial. The study aims to investigate the socio-economic and demographic characteristics of private and public transport users, which impact travel patterns and mode selection. To secure the necessary funding for the study, the researcher followed a decision-making process on the methodology. This investigation will help identify strategies to attract users of private transport to park-and-ride services, informing marketing and facility design initiatives (Brohi, S. et al., 2021; Brohi, S. et al., 2021b; Kalwar, S. et al., 2021). Table 1 shows Bihar population and growth rates (StatisticsTimes.com, Bihar-population) [11-15]

3. Execution and Method of Study

This study primarily focuses on employees or workers in Patna, specifically selecting respondents at random from work locations such as the city center, offices, and educational institutions within the research districts. To ensure the research is relevant, the scholar will exclusively target working individuals from the subject region. There are no age or self-sufficiency restrictions, as all respondents are employed and above the age of 18. Additionally, working individuals have the advantage of creating their journeys at specified times, which is crucial in metropolitan regions where traffic congestion is a significant issue. Furthermore, the qualification element is less important in their selection criterion, as most respondents are educated but have varying levels of education. The respondents were invited to participate voluntarily, and those who agreed received a self-administered questionnaire at their workplaces. A survey was conducted on employees in Patna to determine the specific variables that affect their choice of transportation mode and their willingness to shift from private modes to more sustainable transportation approaches. The survey collected information on passengers' actual trip selections, known as revealed preference, as well as their knowledge and opinions regarding hypothetical scenarios, referred to as stated preference. This data helps identify the factors influencing commuters' mode selection and their openness to adopting sustainable transportation options. The study

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analyzed the data from the expressed preferences to determine whether travellers were willing to adopt alternative sustainable transport methods. The research included 400 participants, determined using Krejcie and Morgan's well-known sample size calculation method (Krejcie, R. and Morgan, D. 1970)

$$n = \frac{x^2 Np\,(1-p)}{e^2(N-1)+x^2 p(1-p)}$$

Where, n = Sample size
N = Population size
e = sampling error
x^2 = Chi-square of degree of freedom 1 and confidence 95%
p = population proportion (0.5)

The study used a purposeful sampling strategy to reach the target demographic. This approach involves choosing individuals relevant to the specific area of interest, even if they aren't a perfect match for the study sample. Purposeful sampling is commonly used in fields focusing on a single topic, as it selects participants most relevant to the research. Transportation research can significantly benefit from the use of purposeful sampling. To ensure a sufficient response rate, the researcher typically selects respondents from the targeted population. The study employed a survey that utilized the Statistical Package for Social Sciences (SPSS) for data collection and analysis. SPSS is a widely used program for statistical analysis. [16]

4. Results and Discussion

This section analyses a survey. The survey questionnaire is divided into two parts: one for personal information and one for travel characteristics. The first part asks about sociodemographic data and actual travel choices (Revealed preference). The second part asks about trip features, including both actual and hypothetical travel choices (Stated preference). This section also discusses descriptive analysis of the survey data. The explanatory analysis uses the respondents' personal information and travel attributes. advantage of creating their journeys at specified times, which is crucial in metropolitan regions Employed participants were chosen from Patna city. The data was collected through physical (offline) questionnaires distributed at their workplaces.

4.1.Travel habits and sociodemographic characteristics of the respondents

This section describes the characteristics of the group chosen for the study. The data was collected from people in Patna City, including those in the city center, offices, and educational institutions. The goal was to gather data from 400 people, but the researcher actually approached 500 individuals. Of these, 426 people responded to the questionnaire, and 400 of these responses were randomly selected and analyzed.

4.2.Exploring Age- Related and Gender-Based Variations

In the Patna survey, the age distribution is divided into five distinct categories, as shown in Figure 2. The results indicate that 90% of the respondents are male, while 10% are female. Among the participants, 356 individuals fall within the age range of 15 to 45. Specifically, the age groups 15-25, 26-35, and 36-45 are represented by 124, 128, and 104 respondents, respectively. Additionally, 12 male respondents are from the 55+ age bracket, and 32 respondents, including 4 females, are between the ages of 46 and 55. The relationship between education level and vehicle ownership is significant, as illustrated in Fig. 3. The data reveals that 192 employees own a car, and in terms of education, 284 respondents hold a Master's degree, and 80 have a graduate in education qualification. [17]

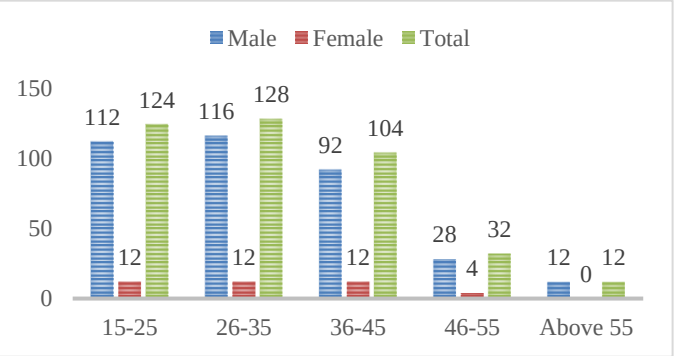

Figure 2 Age- Related and Gender-Based Variations

4.3.R Exploring the correlation between Education level and vehicle ownership

The analysis of the respondent data reveals notable trends in the relationship between vehicle ownership

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https://doi.org/10.47392/IRJAEH.2024.0357

and educational qualifications. Among the respondents, 11% own both a car and a motorcycle. Of the total participants, 32% hold a master's degree, while 12% are graduates. Specifically, 104 respondents own a motorcycle, of whom 56 have a master's degree, 36 are graduates, and 12 have a senior secondary education. The number of respondents who use only bicycles as their mode of transport is relatively low at 16, with 12 holding a master's degree and 4 being graduates. Additionally, 44 respondents do not own any mode of transport, with the majority possessing a master's degree. Overall, there are about 284 respondents with a master's degree, 80 graduates, 32 with senior secondary education, and only one with a secondary school education. The data indicates that most respondents with a master's degree or graduate qualification tend to own either a car or at least a motorcycle, while few rely on bicycles or have no mode of transport. This analysis suggests a significant correlation between educational qualifications and vehicle ownership. [18]

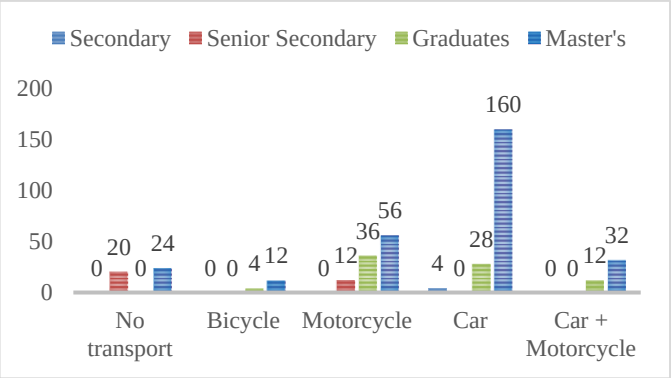

Figure 3 Correlation between education level and vehicle ownership

4.4.Exploring the correlations between Income and mode of travel

Respondents were categorized into five distinct monthly income brackets: less than 10,000, 10,000-20,000, 20,000-35,000, 35,000-50,000, and above 50,000. Correspondingly, five travel modes were identified: walking (other), bicycle, private car/two-wheelers, bus, and auto-rickshaw. According to figure 4, respondents across nearly all income levels predominantly choose private cars or two-wheelers for their commute from home to office. Additionally, Figure 4 indicates that as income levels rise, the preference for buses or alternative modes of transportation declines, while the inclination towards private cars or two-wheelers remains strong. [21-24]

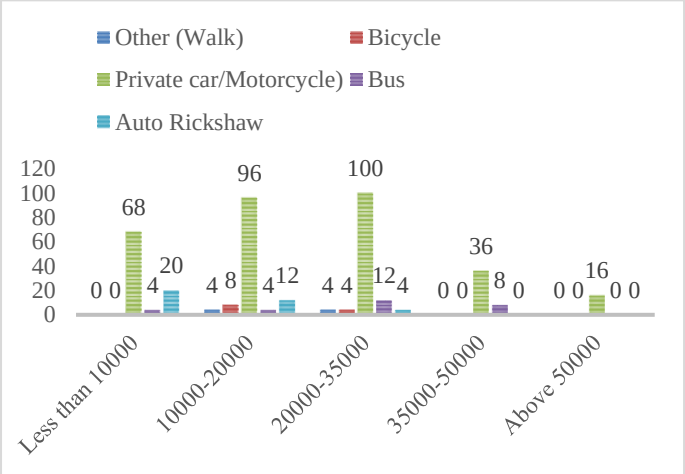

Figure 4 Correlations Between Modes of Travel by Income

4.5.Exploring the correlations between age, gender, and vehicle ownership

Correlations between different factors such as age, gender, and vehicle ownership. For instance, in Table 2, vehicle ownership is compared against the age and gender of respondents. It is noted that all female respondents own a car, except for one who owns both a car and a motorcycle. When comparing vehicle ownership and age, 124 respondents fall into the 15-25 age group, with most owning their mode of transportation except for twenty individuals. Similarly, 128 respondents are in the 26-35 age group; only twenty people have no transport ownership, and eight own a bicycle, while the rest have their own mode of transport. Among the 104 respondents in the 36-45 age group, most have car ownership, twelve have only a motorcycle, four have bicycle ownership, and four have no transport ownership. Thirty-two respondents belong to the 46-55 age group; four own a bicycle, four own a motorcycle, and the rest have car ownership. Finally, in the 55+ age group, twelve respondents were identified: four own a motorcycle, and eight have car ownership. 36 are graduates, and 12 have a senior secondary education Correspondingly, five travel modes were identified: walking (other), bicycle. [19]

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Table 2 Correlations Between Age, Gender, And Vehicle Ownership

Vehicle Ownership	Gender	Age of Respondent				
		15-25	26-35	36-45	46-55	Above 55
No transport	Male	20	20	4	0	0
Bicycle	Male	0	8	4	4	0
Motorcycle	Male	64	20	12	4	4
Car	Male	24	68	52	8	8
	Female	8	12	12	0	0
Car + Motorcycle	Male	4	0	20	12	0
	Female	4	0	0	4	0

4.6.Exploring the correlations between age, gender and travellers mode of travel

Consequently, Table 3 illustrates the correlations between the mode of travel from home to office and back, with respect to age group and gender. According to this analysis, females prefer their own mode of travel instead of using buses or auto-rickshaws. The analysis reveals that only eight people, all belonging to the 26-35 age group, walk to their office. Bicycles are rarely used, with just twelve people across different age groups using them. Motorcycles and private cars are the primary modes of travel, with 316 respondents using them for commuting to the office. Auto-rickshaws (para-transit) are used by very few respondents, only 28 in total. Bus (Public transport) is used by about 10 percent of the respondents, with thirty-six individuals, mostly from younger age groups. [20]

Table 3 Correlations Between Age, Gender and Travelers Mode of Travel

Travellers Mode of Travel	Gender	Age of Respondent				
		15-25	26-35	36-45	46-55	Above 55
Walk	Male	0	8	0	0	0
Bicycle	Male	0	4	4	4	0
Private car/ Motorcycles	Male	84	88	68	24	12
	Female	12	12	12	4	0
Auto Rickshaw	Male	4	8	16	0	0
Bus	Male	24	8	4	0	0

Conclusion

The majority of employees prefer to use their own means of transportation, with the majority having cars or motorcycles, according to the research's findings and conversations. Lower-class people have also been found to choose motorcycles over auto rickshaws (para-transit) and buses (public transportation). Owning a private vehicle and selecting private transportation for travel are positively impacted by education. In conclusion, several variables make using public transportation unfavourable. It is also apparent, nevertheless, that Patna lacks an effective and long-lasting public transit infrastructure. As a result, the majority of tourists like using their vehicles. Establishing a reliable and sustainable mass transit infrastructure is necessary to overcome the disparity between private and public transportation options. The government should first research travel patterns to identify the factors influencing people's mode preferences. Surveys on travel behavior will improve the quality of public transportation; this is a tried-and-true method of introducing a sustainable transportation system. It also goes into further detail on the variables that affect the application of demand management techniques for public transportation. These study findings serve as a basis for further studies on the

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https://doi.org/10.47392/IRJAEH.2024.0357

park-and-ride mode choice model and assist policymakers in their future planning and development of public transportation networks.

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