Comparative Assessment of Service Quality of IPT Modes in Urban India

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Abstract This paper carries out a comparative assessment of service quality of intermediate public transport (IPT) modes namely auto-rickshaws and e-rickshaws through users' perception. A questionnaire-based survey was carried out to collect users' data about the importance and satisfaction on a six-point Likert scale. A total number of 856 filled questionnaires were taken and analyzed using Importance-Performance Analysis (IPA). The analysis showed that the attributes of security, convenience for elderly and differently-abled people, and safety of female users, especially during night hours were assigned high importance but low satisfaction with both IPT modes. Further, it was also found that on-board illumination inside the vehicle at night for auto-rickshaw and safety concern for e-rickshaw was also rated with high importance but with low satisfaction. In order to increase the patronage of these IPT modes and improve their service quality, the above attributes were needed to be addressed on a priority basis. The attributes having a high satisfaction need to be maintained at least at the existing levels. The findings of the study shall be useful for policy makers and operators in planning and improvement of the transportation systems of mid-sized cities of developing countries.

Keywords Service Quality, Intermediate Public Transport (IPT) Modes, Auto-rickshaw, E-rickshaw, IPA

1. Introduction

Developing countries are characterized by rapid urbanization due to high internal growth rates and large scale rural-urban migration. The high density of population in these urban areas coupled with the lack of

proper urban infrastructure has resulted in numerous problems. Urban transportation also suffers from problems related to its quality and coverage [1]. Public transport, the most important element of urban transportation had by and large remained neglected in many cities of developing countries like India and was given some importance in planning only after the 1980s. Even at present, many cities lack well-organized, adequate, and good quality public transportation systems. People here, especially those belonging to economically weaker sections of the society, are captive to these inadequate, unreliable, and poor quality public transportation systems [2].

Patna, the largest and capital city of the province of Bihar has a population of more than 1.6 million as per the census of 2011 and its population continues to grow due to the concentration of all commercial, healthcare, and educational activities of the province [3]. In 2018, Patna along with its hinterland accommodating about 2.62 million people, mainly depends on intermediate public transport (IPT) modes along with the other private mode of transportation. There is an absence of good quality public transportation (PT) system in the city [4]. Paratransit or intermediate public transport (IPT) can be defined as an intermediate mode between privately owned vehicles and transit or public transport, which operate on a fixed route and schedule [5]. The IPT modes operate on both a shared ride and hired basis. Two popular types of IPT modes in operation in Patna and other cities of developing countries are auto-rickshaw and e-rickshaw. The auto-rickshaw is in operation in the city since the 1960s and powered by fossil fuel, gasoline/diesel/CNG whereas the e-rickshaw is a battery-operated vehicle. E-rickshaw has been introduced in the city as late as in the year 2014 [4]. Some of the major characteristics of both modes of transportation are given in (Table 1). In

developing countries like India, the IPT modes generally operate on fixed routes, but with flexible schedule [4]. This shall not be out of context to mention that an assessment of travel demand was made for future trips in the Comprehensive Mobility Plan (CMP) for the city and based on future trips a high capacity public transport system in the form of mass rapid transit (MRT) has been proposed along four major arterial roads in the city [4].

The IPT modes have less seating capacity (3-6 persons) as compared to bus services; however, they have the advantages of easy mobility, high accessibility, low operation, and maintenance cost [6]. Due to the lesser requirement of supporting infrastructure associated with it, these types of services can be started and closed down with more ease [7]. It also has the potential for employment generation for low skilled jobs as drivers of these vehicles in large numbers; therefore, it can help in ameliorating the socio-economic condition of people [8].

1.1. Study Area

The public transportation system of Patna mainly consists of buses (mini buses and privately owned yellow colour buses and recently introduced new midi buses on selected routes under Bihar State Road Transport Corporation (BSRTC)), auto-rickshaws and e-rickshaws, etc. [4]. The existing public transport system (mainly public transport buses) of Patna is not able to cater the total transport demand. The various factors such as overcrowding in buses, longer travel time, poor condition of the buses, poor frequency of bus service, the unreliability of bus service, lack of bus information at the bus stops, safety concerns especially for women (in yellow buses), lack of facilities meant for the elderly and differently-abled person and absence of amenities inside the vehicle or at the bus stops, etc. discourage the choice of the bus by the commuters [2].

Table 1. Specification difference between auto-rickshaw and e-rickshaw

Sr. No	Characteristics	Auto-rickshaw	E-rickshaw
01	Dimension	2635mm X 1300mm X 1710mm	2625mm X 855mm X 1740mm
02	Ground Clearance	200 mm	230 mm
03	Wheel Base	2000 mm	1910 mm
04	Fuel Used	Petrol/Diesel/LPG/CNG	Battery (Chargeable by electricity)
05	Transmission Mode	With gear and Clutch	Non-gear
06	Engine	Twin Spark, 4 Stroke DTSi	48 Volts brushless DC motor
07	Brake Type	Hydraulic expanding friction shoe type	Double rear drum type
08	Top speed	65 Kmph	25 Kmph
09	Mileage	35-40 Km/l	60-70 Km/ Charge (Charging Hour-9-10 hrs Charge Voltage- 220 V(50Hz))
10	Major manufacture company (in India)	Bajaj Auto, Piaggio, Mahindra, Atul Auto, TVS Auto, JS Auto, etc.	Mahindra, Mayuri Electric, Kinetic Green, Jezza motors, Skyride, Thukral Electric Bikes, etc.

Table 2. % Mode share of vehicles along major routes in Patna

Categories of Road	Traffic Flow	Direction of Flow	% Share						
			Auto-Rickshaw	E-Rickshaw	Two-Wheelers	Four-Wheelers	Buses	Cycle-Rickshaw	Cycle
Sub arterial	PJ-GM	NB	46.00%	1.50%	26.00%	13.00%	5.40%	4.00%	4.10%
Sub arterial	GM-PJ	SB	55.20%	0.80%	26.86%	8.91%	3.31%	2.74%	2.17%
Arterial	PJ-IT	WB	4.25%	1.16%	58.03%	26.11%	0.00%	5.03%	5.42%
Arterial	IT-PJ	EB	3.73%	0.83%	54.98%	31.12%	0.00%	4.98%	4.36%
Sub arterial	PJ-NR	NB	0.00%	0.00%	65.15%	17.27%	0.00%	6.67%	10.91%
Sub arterial	NR-PJ	WB	0.00%	0.00%	47.57%	22.00%	0.00%	7.12%	23.30%
Sub arterial	NR-GM	WB	0.00%	0.00%	51.01%	26.78%	0.00%	4.04%	18.18%
Sub arterial	GM-NR	SB	0.00%	0.28%	56.22%	19.61%	0.00%	3.36%	20.73%
Arterial	NR-IT	WB	0.00%	0.18%	59.96%	20.83%	0.00%	8.66%	4.06%
Arterial	IT-NR	EB	1.10%	0.11%	57.95%	27.60%	0.00%	8.28%	4.97%
Arterial	GM-IT	SB	0.00%	0.34%	62.85%	25.17%	1.04%	3.64%	6.94%
Arterial	IT-GM	EB	0.00%	0.18%	62.73%	29.52%	0.55%	1.47%	5.54%
Arterial	BR-HM	EB	17.05%	0.72%	44.33%	35.34%	0.88%	0.96%	0.72%
Arterial	BR-EC	EB	0.00%	2.44%	30.95%	19.05%	0.00%	23.81%	23.81%
Arterial	BR-RM	EB	8.04%	0.00%	59.82%	21.43%	0.00%	1.78%	8.93%
Sub arterial	EC-HM	NB	0.36%	1.02%	62.68%	28.86%	0.00%	0.80%	6.27%
Sub arterial	EC-RM	NB	0.00%	0.00%	43.89%	16.67%	0.00%	12.22%	26.67%
Arterial	EC-BR	NB	0.00%	0.00%	55.20%	26.52%	0.00%	7.89%	15.77%
Sub arterial	RM-EC	SB	0.00%	0.00%	77.88%	9.73%	0.00%	3.54%	8.85%
Arterial	RM-BR	SB	1.61%	0.00%	46.77%	38.71%	0.00%	0.81%	12.10%
Sub arterial	RM-HM	SB	6.83%	0.40%	61.04%	22.90%	0.00%	1.61%	7.23%
Sub Arterial	KM-GM	WB	18.38%	39.80%	24.71%	5.20%	0.00%	5.45%	6.46%
Sub Arterial	GM-PJ	SB	22.53%	2.58%	49.62%	13.16%	0.22%	5.04%	6.85%
Sub Arterial	PJ-GM	NB	30.16%	2.25%	48.60%	6.13%	0.14%	4.42%	8.30%
Sub Arterial	KM-PJ	SB	1.28%	2.77%	71.28%	8.30%	0.00%	8.72%	7.66%

(Source: Comprehensive Mobility Plan, Patna 2018)

Abbreviations: PJ-Patna Junction; GM-Gandhi Maidan; IT: Income Tax Golamber; NR-Nala Road; BR-Bailey Raod; HM- Hartali More; EC-Eco Park; RM- Radhe Krishna Mandir; KM- Khetan Market; EB- East Bound; WB; West Bound; NB; North Bound; SB; South Bound.

The contribution of auto-rickshaw and e-rickshaw that have been taken together is significant for the city and for a few roads; it even goes as high as fifty percent of the total traffic. Roads where auto-rickshaws and e-rickshaws are not in operation, the percentage mode share of personalized vehicle increases manifold and it goes even up to eighty percent. (Table 2) [4]. Lately, e-rickshaw has become very popular and is used as a preferred mode of transportation. This has led to a significant increase in its ridership. Thus, the poor quality of existing public transport in Patna city compels the commuters to opt for other alternatives for which they don't have any other choice than to opt for IPT modes namely auto-rickshaw and e-rickshaw. These IPT modes operate on common routes where they act as competing modes of travel. In order to discourage the use of private modes of transport in the city vehicle, the policy maker or the public transport authority should also think about the introduction of good quality public transport system in the city and also about the operation of IPT modes on new routes in the city where these modes are not in operation. The mode share of different mode of transportation is enclosed as (Table 3) [4].

Table 3. Modal Split (Primary Survey)

Mode of Journey	Percentage (Without Walk)
2 Wheeler	36.03%
Car	8.26%
Taxi/Ola	1.01%
Rickshaw	2.03%
Bicycle	7.67%
IPT	36.61%
Transit (Bus)	8.39%

Source: CMP Primary Survey 2018

Public transport mode share in the city is quite low, having a value of 8.39 percent, which is comprised of city buses only. The mode share of IPT is 36.61 percent, which is significantly higher than the total of the existing public transport in the city. The study aims to assess the service quality of IPT modes and to find out how the users rate various attributes of IPT modes namely auto-rickshaws and e-rickshaws. It also explores whether the users are satisfied with the different attributes of service (as listed in Table 4) and tries to identify the importance assigned to these attributes.

Table 4. List of IPT modes service quality attributes with their abbreviations

Code	Attributes	Description
A01	Comfort of ride in sitting (CRS)	It means the comfort level of seating while riding a vehicle.
A02	Driver's attitude (DRA)	It refers to the behaviour of the drivers towards the passenger.
A03	Cleanliness of vehicle (COV)	It refers to cleanliness of vehicle.
A04	Travel time(minutes/km) (TRT)	It refers the average travel time taken by vehicle per kilometer.
A05	On Board Safety (OBS)	It refers the degree of safety inside the vehicle.
A06	Security (SEC)	It refers degree of security while riding.
A07	Reliability (REL)	It refers to the timely response of the vehicle as per demand.
A08	Occupancy of vehicle (OOV)	It refers to the number of passenger riding the vehicle.
A09	Frequency of fleet (FOF)	It refers to the time gap between the successive availability of vehicles.
A10	Convenience for elderly and differently-abled people (CED)	It refers to the provision kept for elderly and differently abled people using the vehicle.
A11	Condition of the vehicle (CVE)	It refers to the physical condition of the vehicle.
A12	Safety of female users especially during night (SFN)	It refers to the safety of female passenger especially at night riding vehicle.
A13	On Board illumination at night (OBI)	It refers to the availability of lighting inside the vehicle during night.
A14	Fare related to travel (FRT)	It refers to average fare of vehicle per kilometer.
A15	Exposure to weather (ETW)	It refers to the exposure to the external weather for the passenger.
A16	Ease of carrying luggage (ECL)	It refers to the security of travellers and their belongings while travelling during nights.
A17	Presence of amenities (POA)	It refers to the availability of amenities in the vehicle.
A18	Noise Exposure(NOE)	It refers to the exposure to the external and internal noise produced the vehicle.
A19	Co-passenger behaviour (CPB)	It refers to the behaviour of co-passenger travelling in the vehicle.

(Source: Comprehensive Mobility Plan, Patna 2018)

Figure 1. IPT routes of operation in Patna, India

The literature review showed that only a few studies have been carried out in the past taking these two particular modes of IPT. Further, as no study related to the assessment of service quality of these modes has been reported in contemporary literature in mid-sized cities of developing countries, the authors were motivated to carry out evaluation work of service quality for these modes using customers' perception.

The city map of Patna showing different major routes of operation of IPT modes is given in (Fig. 1).

The typical pictures of IPT modes (auto-rickshaw and e-rickshaw) operating on various major roads of Patna reflecting various attributes of service quality of these modes are shown in (Fig. 2).

Figure 2(b). Improper seating facilities

Figure 2(a). Insufficient height causing discomfort

Figure 2(c). Crowding situation in morning peak hour

Figure 2(d). Crowding situation in evening peak hour

Figure 2(g). Inconvenient to differently-abled people

Figure 2(e). Safety lapse on Auto-rickshaw

Figure 2(h). Inconvenient to elderly people

Figure 2(f). Safety lapse on Auto-rickshaw

Figure 2(i). negligible leg space

Figure 2(j). Overloading of luggage

Figure 2. Typical Pics of IPT modes (Auto-rickshaw and E-rickshaw) in Patna, India

2. Literature Review

Auto-rickshaw and e-rickshaw operate in the competition after the recent introduction of e-rickshaw in Patna in 2014 [4]. The service quality is defined simply as the difference in expected service and perceived service by users [9]. Various research works had been carried out to assess the service quality of public transport modes across the globe. Comparative analysis of the basic features of the expected and perceived qualities of mass passenger public transport (MPPT) service was carried out in Belgrade and ranking of attributes was carried out in the period 2005-2007 [10]. Yaya, et al. [11] proposed a scale to measure the perceived service quality of bus service and also find out the demographic characteristics that affect the service quality of it. They also identified the difference between perceptions among different public transport users for the given attributes. A heterogeneous customer satisfaction index (HCSI) was introduced by Eboli and Mazzulla [12], which covered the heterogeneity of perceptions across the passengers. It is based on the fact that perception towards any particular question varies from person to person based on their socioeconomic characteristics. This index was used for assessing the service quality of public transport. Various researchers have been carried out to assess the service quality of different modes of transportation. They have used different methods for their evaluation. The service quality using the users' perception of bus transit service was analyzed by Sinha et al. [2]; Filipovic et al. [10]; Yaya et al. [11]; Eboli and Mazzulla [12]; Eboli and Mazzulla [13]; Felleson and Friman [14]; Eboli and Mazzulla [15]; Dell'Olio et al. [16]; Castillo and Benitez [17]; Deng et al. [18]; Castillo and Benitez [19]; Grujicic et al. [20]; Godavarthi et al. [21]; Ma et al. [22]; Guirao et al. [23];

Morton et al. [24]; Abedin et al. [25]; and many others.

Performance analysis had been carried out on satisfaction evaluation of public transport systems in Indonesia, China and Sweden respectively [26-28]. Majumdar and Jash [29] evaluated the service quality of e-rickshaw as an alternative mode of the public transportation system in the state of West Bengal, India and suggested the need for its proper regulation and management to enhance its economic and environmental benefits.

IPA method has also been applied in other fields such as the healthcare sector, the estimation of e-government, the hotel industry, tourism management, and construction management [30-35].

Nathanail [36] and Raoniar et al. [37] worked on a rail-based transportation system and suggested improvement measures to make it more sustainable. Hussain et al. [38] worked on UAE-based Airline Company to estimate the service quality and customer satisfaction of its users. The quality of interchange between metro and buses was the most important parameters affecting the ridership and patronage of the metro systems in China [39].

It was observed that improvements in certain attributes enhance the performance of a mode of transportation, which results in an increase in ridership and patronage of that mode [20, 37, 40].

Sinha et al. [2] had carried out a study to evaluate the service quality of recently introduced midi-buses operated under BSRTC in Patna, India through users' perception and using TOPSIS for analyzing the collected data. Users were found to be satisfied with the qualitative aspects like ticketing facility, seat comfort, condition of bus stops, condition of the bus, etc., On the other hand, they were dissatisfied with quantitative aspects like the frequency of bus service, buses on being time, and bus information at the bus stops. Eboli and Mazzulla [13] identified those attributes which were of primary importance to customer satisfaction with the bus transit system. The study gave a relationship between service quality of bus and the transit attributes, using structural equation modelling. This methodology was found to be helpful in finding the primary attributes which contributed towards the achievement of high level of service quality of public transport mode. Felleson and Friman [14] provided a comparison of the perceived service qualities of public transport among eight European countries with a user perception survey for given seventeen attributes of PT using factor analysis. Dell'Olio et al. [16] presented a methodology to measure the service quality desired by commuters of the public transport system in Spain. The perceptual quality of users is different from their desired quality and the gap between these two is known as the service quality of that particular public transport mode and it varies from person to person. This study of desired qualities provides crucial information to public transport

authorities; and therefore, it is a guiding input influencing the policy making. Castillo & Benitez [17, 19] developed a relationship between ratings given to the overall satisfaction of public transport modes and the rating given to individual attributes by the users of public transport. Morton et al. [24] had carried out a performance evaluation of the Scottish bus transit system on an 11 item opinion scale covering all the service qualities.

Nathanail [36] presented a framework with improved service quality which was helpful for railway operators to make it a sustainable mode of transport. Eboli and Mazulla [41] proposed a methodology to find out the transit passenger's point of view by rating and choice option using discrete choice models. Ona and Ona [42] provided a useful and comprehensive review of the key issues associated with the evaluation of service quality of the public transportation system as well as the reasons behind the different methodological approaches that have been used to address this issue. Ojo [43] presented a comprehensive literature review of the service quality of the public transport system carried out across the world from 2005 to 2015. Askari and Peiravian [44] presented a variety of models and methodologies usually used in the public transportation field. They also suggested various analysis methods, discussions, and comparisons between them to give an idea about the best approach that suited the specific work.

Keeping in mind the problems of the existing transportation system of Patna and the relevant literature reviews regarding the evaluation of service quality of public transportation system, the main objective of this paper is to carry out an assessment of service qualities of auto-rickshaw and e-rickshaw as an IPT mode and also to compare the service qualities of these modes.

There are various methods through which the importance and satisfaction level of users can be assessed. The factor analysis method had been used by Felleson and Friman [14]. IPA method was used by Grujicic et al. [20]; Putra et al. [26]; Miranda et al. [30]; Ho et al. [32]; Boley et al. [33]; Chang et al. [34]; Raoniar et al. [37]; Martilla and James [40]; Matzler et al. [45]; Deng et al. [46]; Yang et al. [47] and CSI method is used by Putra et al. [26]; Raoniar et al. [37]; Supranto [48] and many others. Despite the availability of several methods, the IPA method has been popularly used for the assessment of service in the field of transportation planning and therefore it has been adopted in the present study.

2.1. Importance-Performance Analysis

Importance performance analysis (IPA), also known as Quadrant analysis, was introduced by Martilla and James [40]. In the 1970s, IPA was applied in various industries due to the ease of identification of attributes that need improvement to enhance the service quality. An attractive feature of the importance-performance analysis is that the

results may be graphically displayed in an easily-interpreted two-dimensional grid [40]. The IPA had been used in the determination of attributes of service quality to identify the key attributes of service quality that require improvement [20]. IPA pointed out the areas where improvements can have the greatest impact on increasing the satisfaction level in the entire system [47]. The method makes it possible to identify the parameters that are the most important to the consumers, as well as those which have poor performance. The poorly performing parameters should be improved on a priority basis [45-46].

In IPA studies, commuters are asked to give their ratings of importance and satisfaction on a predefined Likert's scale. The responses from commuters are plotted on four quadrants of Cartesian diagram or IPA diagram also known as I-P mapping. An approach named "data-centered quadrants approach" has been widely used to locate the observed data at cross points. In this approach, two lines are drawn which form the four quadrants of the IPA diagram. The central values of these lines are obtained by dividing the total grades of the average level of satisfaction and importance per user of each attribute with the total number of attributes respectively. The best part of this analysis method is that the comparative assessment of the service quality of two or more systems is easy and convenient. The main disadvantage of the IPA method is that it only shows the dependence between two or more attributes based on their average value of the importance and satisfaction and it does not give any idea about the overall satisfaction level.

The S (satisfaction) and I (importance) value for each service quality attribute is calculated by the average grade given by users of Auto-rickshaw and E-rickshaw users.

The S and I value for each attribute was calculated by the following expressions:

$$S_i = \frac{\sum_{j=1}^n y_{ij}}{n} \quad (1)$$

$$I_i = \frac{\sum_{j=1}^n x_{ij}}{n} \quad (2)$$

Where: y -the grade of satisfaction; x -the grade of importance; i -ordinal number of service quality attributes (1,2,3.....19); j -ordinal number of auto-rickshaw and e-rickshaw user (1,2,3,4....., n); n -Total number of auto-rickshaw and e-rickshaw users.

The IPA diagram showing four quadrants is shown in (Fig. 3) including various terms which are described as follows:

Point (P): It is the middle point on the Y-axis (importance level), obtained by dividing the total grades of the average level of importance per user of each attribute by the total number of attributes.

Point (Q): It is the middle point on the X-axis (satisfaction level), obtained by dividing the total grades of the average level of satisfaction per user of each attribute by the total number of attributes.

Quadrant I: The attributes which fall into this quadrant show high importance and low satisfaction level assigned to it. Therefore, these are the attributes that need primary treatment for improvement to increase the ridership as well as the performance of the IPT mode.

Quadrant II: The attributes of this quadrant show the high importance and high satisfaction of the IPT mode. In order to have the larger patronage of the IPT mode, these attributes need to be maintained at the same level.

Quadrant III: In this quadrant, the attributes have low importance, but a high satisfaction level. Therefore, the IPT users are satisfied with these attributes even though they are less important for them.

Quadrant IV: The attributes of this quadrant have low importance and low satisfaction and therefore, are of not much importance to influence the choice of the IPT mode.

Figure 3. Cartesian Diagram or IPA Diagram

2.2. Data Collection

A questionnaire-based importance and satisfaction survey of the users of IPT modes were carried out along the various routes of operation in Patna. Data related to both importance and satisfaction were collected using the same questionnaire and from the same respondent. The importance survey gave the idea about the level of service

desired by commuters from these IPT modes, whereas the perceived level of service of commuters from these IPT modes was obtained from the satisfaction survey. The difference between these two levels of service, i.e. Importance and satisfaction indicated the service quality of that particular mode. The attributes included in the questionnaire were decided based on a literature review and also on expert opinion. A total of nineteen service quality attributes were identified for the assessment of service quality of IPT modes in Patna. The suitable attributes for carrying out these surveys are tabulated in (Table 4) with their description. The questionnaire designed for the purpose composed of two parts. In the first part, the commuters were asked about their socioeconomic characteristics like gender, age group, family income, educational qualification, occupation, vehicle ownership, etc., trip-related information like frequency of trip, trip purpose, trip origin, and destination, etc. In the second part of the questionnaire, commuters were asked to respond to the level of importance as well as the level of satisfaction on a six-point Likert scale for each of the nineteen attributes (Table 4). The users were also asked to respond to their overall level of satisfaction with auto-rickshaw and e-rickshaw on the same scale. In order to collect the data, interviews with commuters of IPT were carried out at various locations of the city. It also included a roadside interview and home-based surveys. A total of 950 commuters were interviewed, out of which 94 questionnaire forms were found to be incomplete and were therefore rejected. A total of 856 valid questionnaires were used for data analysis, out of which 573 responses were collected through road-side interviews and the balance 283 responses were collected through home-based surveys. The data collection was carried out during the period from May 2018 to December 2018. The user characteristics (socio-economic characteristics and trip-related information) obtained from collected survey data are presented in (Table 5).

Table 5. User Characteristics

Characteristics	Statistics
1. Gender	Male (57%), Female (43%)
2. Age Group	<10 years (4%), 10-25 years (43%), 25-40 years (34%), 40-60 years (14%), >60 years (5%)
3. Educational Qualification	Matriculate (11%), Intermediate (31%), Graduate (41%), Post Graduate (13%), Others (4%)
4. Occupation	Job (23%), Business (12%), Student (36%), Unemployed (19%), Others (10%)
5. Family Income (INR/m)	<10,000 (14%), 10,000-20,000 (28%), 20,000-35,000 (29%), 35,000-50,000 (20%), >50,000 (9%)
6. Vehicle Ownership	Two-Wheeler (44%), Four-Wheeler (16%), Bicycle (26%), None (14%)
7. Number of Trips (per week)	1-2 (31%), 3-5 (29%), 6-10 (21%), 10-20 (15%), >20 (4%)
8. Trip Purpose	Work (29%), Business (11%), Educational (36%), Recreational (10%), Others (14%)
9. Other modes used	Bus (33%), Cycle-rickshaw (17%), Own Vehicle (26%), Others (24%)

3. Results and Discussion

The attributes of auto-rickshaw and e-rickshaw which fall in different quadrants after IPA analysis are shown in Table 6 and Table 7 and also through scatter plots as shown in (Fig. 4) and (Fig. 5) respectively.

Table 6. Positions of attributes of Auto-rickshaw in IPA

Sr.no.	Attributes	Satisfaction	Importance	Quadrant			
		(X)	(Y)	I	II	III	IV
A01	Comfort of ride in sitting (CRS)	3.18	4.11			√	
A02	Driver's attitude (DRA)	3.27	3.35			√	
A03	Cleanliness of Vehicle (COV)	3.35	4.34		√		
A04	Travel time (in minutes) (TRT)	3.56	4.51		√		
A05	On Board Safety (OBS)	3.13	4.38		√		
A06	Security (SEC)	2.83	4.44	√			
A07	Reliability (REL)	3.03	4.17				√
A08	Occupancy of Vehicle (OOV)	3.32	4.07			√	
A09	Frequency of Fleet (FOF)	3.18	4.14			√	
A10	Convenience for elderly and differently-abled people (CED)	2.65	4.82	√			
A11	Condition of the Vehicle (CVE)	3.06	4.43	√			
A12	Safety of female users especially during night (SFN)	2.53	4.88	√			
A13	On Board Illumination at night (OBI)	2.55	4.27	√			
A14	Fare related to travel (FRT)	3.39	4.15			√	
A15	Exposure to weather (EWT)	3.35	4.14			√	
A16	Ease of carrying luggage (ECL)	3.34	4.12			√	
A17	Presence of amenities (POA)	2.44	3.92				√
A18	Noise Exposure (NOE)	2.96	4.10				√
A19	Co-passenger behaviour (CPB)	3.23	4.16			√	
	Average	3.07	4.24				

Table 7. Positions of Attributes of E-rickshaw in IPA

Sr.no.	Attributes	Satisfaction	Importance	Quadrant			
		(X)	(Y)	I	II	III	IV
A01	Comfort of ride in sitting (CRS)	3.56	4.41		√		
A02	Driver's attitude (DRA)	3.45	4.30			√	
A03	Cleanliness of vehicle (COV)	3.67	4.53		√		
A04	Travel time (in minutes) (TRT)	3.50	4.53		√		
A05	On Board Safety (OBS)	3.06	5.05	√			
A06	Security (SEC)	2.90	4.51	√			
A07	Reliability (REL)	3.11	4.17				√
A08	Occupancy of Vehicle (OOV)	3.39	4.21			√	
A09	Frequency of Fleet (FOF)	3.22	4.25			√	
A10	Convenience for elderly and differently-abled people (CED)	2.52	4.86	√			
A11	Condition of the Vehicle (CVE)	3.37	4.57		√		
A12	Safety of female users especially during night (SFN)	2.39	4.86	√			
A13	On Board Illumination at night (OBI)	2.46	4.21				√
A14	Fare related to travel (FRT)	3.11	4.24				√
A15	Exposure to weather (EWT)	2.93	4.08				√
A16	Ease of carrying luggage (ECL)	3.00	4.09				√
A17	Presence of amenities (POA)	2.55	3.99				√
A18	Noise Exposure (NOE)	3.61	4.13			√	
A19	Co-passenger behaviour (CPB)	3.39	4.14			√	
	Average	3.12	4.38

Figure 4. Cartesian Diagram IPA of Auto-rickshaw

Figure 5. Cartesian Diagram IPA of E-rickshaw

The IPA diagram of auto-rickshaw as given in (Fig. 4) clearly shows that security of passengers, convenience for the elderly and differently-abled people, and condition of the vehicle were the attributes which were given high importance but low satisfaction. Further, the safety of female users especially during night hours and on-board illumination at night were also given high importance but low satisfaction with auto-rickshaw. On the other hand, the IPA diagram of e-rickshaw as given in (Fig. 5) clearly shows the safety of the passenger, security of passenger, convenience for the elderly and differently-abled people, and safety of female users especially at night hours as attributes with high importance but low satisfaction.

It was found that cleanliness, lesser travel time and safety of passenger of auto-rickshaw encourages the commuters to use it, whereas comfort of ride in sitting, cleanliness, travel time and condition of the e-rickshaw encourages the commuters to use e-rickshaw as a preferred mode of transportation as users satisfaction for these attributes of IPT modes are high and is up to the expectation level.

The IPA diagram of auto-rickshaw as given in (Fig. 4) clearly shows that comfort of ride in sitting, driver's attitude, occupancy of the vehicle, and frequency of fleet were rated as of low importance and high satisfaction. Further, fare related to travel, exposure to weather, ease of carrying luggage, and co-passenger behaviour were also at the same level for both auto-rickshaw and e-rickshaw. On the other hand, the IPA diagram of e-rickshaw as given in (Fig. 5) clearly shows that driver's attitude, occupancy of vehicle and frequency of fleet possessed the same rating as low importance but perceiving as high satisfaction. In addition to these attributes of e-rickshaw, noise exposure and co-passenger behaviour were also assigned the same rating.

The attributes of auto-rickshaw having a low importance and low satisfaction as given in (Fig. 4) are reliability, presence of amenities, and noise exposure. The IPA diagram, of e-rickshaw as given in (Fig. 5) clearly shows that reliability, on board illumination at night, fare related to travel have low importance and low satisfaction. In addition to these attributes, the attributes like exposure to weather, ease of carrying luggage, and the presence of amenities have also the same level of importance and satisfaction

4. Conclusions and Recommendations

In view of the large patronage of IPT modes in the mode share of all types of trips in the city, the study was carried out for comparative assessment of their service quality. In order to achieve this objective, the importance and satisfaction survey to collect the perceived data of users and the collected data was analyzed with the help of IPA technique.

The results showed that the users of both types of IPT modes were not satisfied with the attributes like security, convenience for the elderly and differently-abled people, and safety for female trip makers, especially during the night, though these attributes were of high importance to the users of both types of IPT modes. Therefore, there is a need for primary treatment of the above attributes to enhance the service quality of the IPT modes.

The users assign high importance and are highly satisfied with the cleanliness and travel time for both the IPT modes. Further, users are highly satisfied but have assigned low importance to the attributes driver's attitude, occupancy of vehicle, frequency of fleet, and behavior of passenger. The results also show that the users of both IPT modes are not satisfied with the reliability and presence of amenities but have assigned low importance to these attributes.

Even though both the IPT modes share common perceptions about some of the attributes, there are certain other attributes for which users have rated both the modes differently. The users of e-rickshaw were satisfied with the condition of the vehicle while the auto-users were not satisfied with it, though both users assign high importance to this attribute. As e-rickshaw is battery operated and is almost noiseless, its users are satisfied with the noise exposure, whereas auto-rickshaw are fossil fuel operated and have two/four-stroke engines and therefore are noisier, people are not satisfied with the noise levels for auto-rickshaws. However, the users are satisfied with the fare structure and exposure to weather of autos as compared to that of an e-rickshaw where the users are not satisfied with these two attributes. The users, however, assign lesser importance to these two attributes. High importance is assigned to the comfort of the ride while sitting to e-rickshaw users, whereas the auto users assign low importance to it, however, both users are satisfied with it.

It can be concluded that even though the users of autos are more satisfied with the attributes like fare and exposure to weather condition, they assign lesser importance to such factors; However, the e-rickshaw users have a higher level of satisfaction for the attributes which are rated as important such as the condition of vehicle and noise exposure. Therefore, based on the survey, it can be concluded that the e-rickshaw users are more satisfied than the auto users and rate e-rickshaw as the better of the two operating IPT modes. Therefore, because of the better quality of service of e-rickshaw, its patronage is increasing as compared to an auto.

Even though e-rickshaws are less polluting, in order to attract its larger patronage, e-rickshaw should overcome the issues related to security, convenience for the elderly and differently-abled people, and safety of female users during the night. These concerns can be catered only with sincere policy interventions and administrative efforts. Further, there is also a need to rationalize the fare

structure of e - rickshaws and make it comparable to auto-rickshaw to attract more users. The e-rickshaw manufacturers, who have come up in large numbers, can be suggested to incorporate design changes so that the exposure to adverse weather conditions can be minimized.

Though the survey responses have given less importance to reliability, with the growing concern for reliability among the users, there is a need for policy interventions such as peak hour demand management, stop facility management, charging facility creation, enforcement of lane discipline, and monitoring, etc. which should be looked into and implemented. What is required is a concerted effort at all levels, including policy makers, police, operators, and users to overcome the above issues to provide a sustainable mode of transport and to improve the quality of life of people.

The recommendations of the study were forwarded to the team of National Institute of Technology Patna, India who carried out the work of preparation of Comprehensive Mobility Plan (CMP) [4] for the city, who have incorporated some of its recommendations in the Comprehensive Mobility Plan [4] for Patna which in its recommendations has suggested for the incorporation of elements of security and safety of female users during the night hours. The CMP [4] has further recommended the authority to issue permits to only those vehicles which suit the requirements of elderly and differently-abled people.

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