Service Quality of Addis Ababa Light Rail Transit: Passengers' Views and Perspectives

Adane Obsie¹ · Mintesnot Woldeamanuel² · Berhanu Woldetensae³

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Abstract Understanding the service quality of public transportation based on users' perception is an important input for local governments and transit service providers in their planning efforts to improve system performance. Using the Addis Ababa Light Rail Transit (AALRT) as a case, this study aims to examine service users' views and perspectives by using 18 quality attributes. Factor analysis and ordered logit model were employed for this study. Factor analysis with principal components was used to extract the most important factors of satisfaction from the 18 attributes. The results showed that safety and security, ticketing system, travel information, crowdedness, frequency, cleanliness, and comfort are the most important factors influencing user satisfaction. The level of importance of these factors varies depending on different socioeconomic and travel characteristics of AALRT users. Riders who use the light rail at afternoon peak hours, have high household income and short travel duration, and use

LRT for shopping purposes have a negative perception regarding the crowdedness, frequency, ticketing, and information system of the AALRT. Passengers with longer travel distance, those who use the AALRT frequently, and full- or part-time workers and students have a positive perception towards several attributes of the system.

Keywords Satisfaction · Service quality · Light rail transit · Perceptions · Public transportation · Factor analysis · Ordered logit model

1 Introduction

The service quality of light rail transit can be understood through performance measurement based on riders' experience [1]. The quality of the public transit service and customer satisfaction are directly related. The relationship is measured through riders' views and perspectives and their emotional judgments of the service, which can be explained through liking and disliking, or agreeing and disagreeing with attributes of the service [2–4].

To better understand the satisfaction levels of riders based on their experience, it is important to relate their perception with their usage frequency and socioeconomic characteristics. Frequent users, occasional users, and nonusers have different levels of satisfaction. Likewise, satisfaction can be segmented based on gender, age group, income, marital status, education level, travel purpose, car availability (mode choice), and job type of passengers [1]. These classifications can help to understand satisfaction based on the sociodemographic characteristics of riders and to devise policies and programs that meet the needs of the existing and potential riders. This then contributes to an

✉ Mintesnot Woldeamanuel
mintesnot.woldeamanuel@csun.edu

Adane Obsie
adaneo@wollegauniversity.edu.et; adanebifa@gmail.com

Berhanu Woldetensae
berhanu.woldetensae@eiabc.edu.et

¹ Institute of Technology, Wollega University,
P.O. Box 395, Nekemte, Ethiopia

² Department of Urban Studies and Planning, California State
University, Northridge, 18111 Nordhoff Street, Northridge,
CA 91330, USA

³ Ethiopian Institute of Architecture, Building Construction
and City Development (EiABC), Addis Ababa University,
P.O. Box 518, Addis Ababa, Ethiopia

effective and healthy public transit service delivery, therefore attracting more riders to the system [5].

For cities such as Addis Ababa, who launched light rail transit (LRT) service recently, exploring the perception of riders based on their experience is important to improve the quality of the service. For a long time, Addis Ababa's public transport system mainly consisted of buses and shared minibus taxis [6]. The overall transportation system has been characterized by congestion and pollution, a high rate of accidents, a weak traffic management system, and an outdated fleet [7, 8]. The majority of public transportation users are of low- and middle-income groups. In response to these transportation challenges, the city administration launched its first LRT system in 2015. The LRT is serving the city and meeting the high demand of public transportation.

However, little is known about the performance of the service from the riders' point of view. There is an gap in the understanding of which of the service attributes are more dissatisfying or satisfying for passengers. This study uses the Addis Ababa Light Rail Transit (AALRT) as a case study and explore riders' views, perspectives, and satisfaction with the quality attributes of the service. The research also aims to determine the effect of sociodemographic factors and the travel characteristics of riders on their satisfaction by calibrating models where overall satisfaction is considered a dependent variable. The results of the study contribute to filling the literature gap as well as improving the current service quality and providing insight for the future expansion of LRT.

The remainder of this manuscript is organized as follows. The next section presents a literature review, while Sect. 3 focuses on data and methodology with a brief description of the AALRT, sampling techniques, and methods of data collection and analysis. Sections 4 and 5 focus on the analysis and discussion of results, respectively, and Sect. 6 presents the conclusions, recommendations, and areas for future investigation.

2 Literature Review

Service quality in mass transits can be evaluated in two ways: objectively, by service operators based on efficiency and effectiveness of the service, and also subjectively, based on passengers' perception and expectation. The latter can be done using customer satisfaction surveys. Satisfaction is an experience-based construct determined by market expectations and performance perceptions in any given period. It is also measured or compared with past satisfaction from period to period [9, 10] through users' response to the service. This makes customer satisfaction a key intermediary objective in service operations as an

evaluation of performance for the public transportation service to be successful [11, 12]. The main aim of understanding service quality in public transport is to assist policymakers and service providers to increase the attractiveness of the service and to improve its use [3].

Satisfaction with service quality is always related to the expectations of customers. Consequently, if the service delivered is conforming to the customer's expectations, then a service provider is considered to be delivering quality service and contributing to a positive perception [13, 14]. So, in a sense, satisfaction can be measured by surveying customers' perception towards the service provided [15, 16]. Since the passengers are the users of the system, they can evaluate whether the service meets their expectations or not [17, 18].

Studies have indicated that different factors are directly and indirectly related to the service quality of public transit and users' level of satisfaction. Ponrahono et al. [19] studied bus users in Peninsular Malaysia by using 1130 surveys of on-board passengers in the age range of 15–55 years, with a convenient sampling method. They found that travel time, waiting time, occupancy, regularity of service, reliability, comfort, cleanliness, and crew behavior affect the satisfaction of the riders. Geetika and Nandan [16] studied the Indian railway platform by using survey methods with convenience sampling of 700 passengers. They analyzed 16 variables related to the service quality of the railway to measure customer perception by using a five-point Likert scale. Their study indicated that the availability and quality of refreshments, effectiveness of information systems, behavior of railway staff, basic amenities provided on platforms, and safety and security were the main determinants of passenger satisfaction. Vanniarajan and Stephen [20] also identified the railway service quality factors. They indicated reliability, assurance, tangibles, empathy, and responsiveness as the main factors that affect users' perception towards the service. Their study goes on to state that attributes such as the availability of transit service, service monitoring, travel time, safety and security, maintenance, and construction affect the riders' satisfaction level. In addition, Eboli and Mazzulla [21] discussed bus service quality and indicated that the availability of shelter and benches at bus stops, cleanliness, overcrowding, information system, safety, personnel security, helpfulness of personnel, and physical condition of bus stops were the main factors determining satisfaction level of passenger with public transit.

Another study on Malaysia LRT by Peng et al. [22] found that passengers were generally satisfied with the facility, comfort, information delivery, and prices of the service provision, while efficiency, staff service, and safety proved to be dissatisfying factors of the LRT. Also, a study by Irfan et al. [23] examined passengers' perspective

towards rail transport by including eight service quality attributes such as empathy, assurance, tangibles, timeliness, responsiveness, information system, food, safety, and security to measure the passengers' satisfaction. The study identified the main determinants that influence commuters' satisfaction with the service as responsiveness, safety, information, and timeliness (punctuality). In the same way, riders' satisfaction was found to be dependent on employee's interest in solving the problems of passengers and their tendency towards helping them. Attributes related to the waiting area, escalator, the quality and quantity of seats in the train, comfort, and convenience of parking are also factors that affect satisfaction [24].

In addition, Khalid et al. [25] used punctuality, ticketing systems, delays, frequency of train, safety elements, and convenience to study passengers' perception towards the rail services based on users' personal experiences and direct interaction with the system. Furthermore, Zhen et al. [26] studied perception of high-speed rail (HSR) passengers along the Shanghai–Nanjing corridor by surveying 4237 passengers, using a regression analysis method. Their study shows that HSR should maintain the performance of high operating speed and frequent service, high level of positive staff attitudes, convenience of ticket purchase, ease of access trips, and carriage cleanliness to make users happy and satisfied. However, toilet sanitation, seat comfort, power outlets, and cell phone signal had substandard performance and were found to be prioritized for additional improvement.

Studies have shown customer satisfaction to be influenced by socio-demographic and economic variables such as age, income, gender, perceived quality, and value of the service [27]. Likewise, Haustein et al. [28] explored the relationship between age and perception towards public transport service. Their results show that people above the age of 65 years said that safety from crime was “very important” to them. Shorter waiting time was “very important” for users below the age of 30 years, demonstrating that, for young people, saving time is a satisfying factor. The study concluded that older people have more time than younger people, and their concern is convenience and safety. In general, seat availability, lower travel fare, travel time conditions, shorter distance to light rail or bus stops, and shorter waiting time are the key attributes customers expect from the public transport service [29].

Service quality matters not only to passengers but also to operators and politicians, because identification of passenger perceptions towards the service quality is directly translated into a higher number of riders and overall success of the transit system [30, 31]. Therefore, identifying the passengers' perception towards public transport is very important as people use public transportation services only

when the system is perceived to be safe and running efficiently [32].

There is limited research on the Addis Ababa Light Rail Transit (AALRT), in particular relating to passengers' perception and satisfaction. The only known study on satisfaction towards Addis Ababa LRT is the one by Woldemmanuel and Woldetensae [33], which was conducted by using 205 sample respondents and only considered 14 service variables. According to the results, passengers were satisfied with affordability and cleanliness but less satisfied with crowding, safety, and security of the service.

Based on the literature reviewed above, this study considered 18 service quality variables and 1020 samples with a motivation of filling the gaps related to the literature and understanding the service quality of the AALRT. The Addis Ababa Light Rail Transit was the first urban rail transit system in Ethiopia, therefore, the findings of this study will assist local transportation planners in their endeavor of improving the existing service and also for similar future projects in other cities of the country.

3 Data and Methods

3.1 Background of Addis Ababa Light Rail Transit

This case study is based on the Addis Ababa Light Rail Transit (AALRT) system, which started its operation in 2015. Prior to the opening of the AALRT, the city was challenged by poor transportation infrastructure which was characterized by emissions, accidents, and congestion [7, 8]. The LRT project has two lines known as east–west (E–W line) and north–south (N–S line). The system has a total of 39 stations with 5 common stations overlapping at the two lines (Fig. 1). These communal stations are found in the city center and characterized by larger numbers of passengers when compared with other stations [34]. Both lines have nearly the same distance and equal numbers of stations. The E–W corridor covers a 17.5-km distance and has 22 stations, including the 5 communal stations. The line connects residential areas of the eastern part of Addis Ababa to the center, while the N–S corridor covers a 16.9-km distance and 22 stations also including the 5 communal stations. This line connects the residential and industrial areas at the south to the commercial areas of the city center [7, 8].

Even though the AALRT started with 41 trains on both lines, now it serves the public using 17 train vehicles on both lines (North–South line has 9 train vehicles with a 15-min average waiting time, while the E–W line has 8 train vehicles with a 12-min average waiting time [35]). The construction of the LRT included the physical layout

Fig. 1 Map of Addis Ababa LRT system and 14 selected stations from both lines (*Source: Reorganized and edited by authors based on data from AALRT*)

of grade, elevated, and underground level, with 29 stations on the surface, 9 above, and 1 underground.

3.2 Data and Sampling

The survey method was adopted for this study to gather information on the perception of passengers on the service quality of the Addis Ababa Light Rail Transit (AALRT). Accordingly, a survey questionnaire, including the socioeconomic and travel characteristics of the passengers, their level of LRT use, and their satisfaction level, was used to collect data. To measure passengers' perception of

the service quality attributes, a five-point Likert scale measurement was used (i.e., very dissatisfied = 0, dissatisfied = 1, neutral = 2, satisfied = 3, and very satisfied = 4).

The sample population of this study consisted of riders of the Addis Ababa Light Rail Transit (AALRT). Sample size selection was carried out in three steps. The first step was calculating the sample size from the total population of LRT users. The minimum sample size for a population greater than 100,000 at 95% confidence interval, with a 0.5 (50%) degree of variability and $\pm 5\%$ precision by using the Cochran formula, is 384. Data from the AALRT office

indicated the average amount of passengers per day as 105,760. This number varies from month to month, but it is always greater than 100,000 per day. Depending on this figure, we decided to conduct a survey of more than 1000 passengers (more than 384 for the convenience of getting more responses per station). Random sampling was used to survey more than 1000 passengers waiting for the train at each systematically selected station.

The second step was to identify stations where the survey should take place. From the 39 stations, 14 (36% of total stations) were selected (Fig. 1). The selection process followed systematic techniques (i.e., systematic intervals of 2, 3, 2, 3, 2) to choose 14 stations from both lines, including all types of stations (i.e., at grade, overhead, and underground stations). The stations also represent all densities and land uses along the corridors. Accordingly, seven stations from east–west and seven stations from north–south lines were selected (Fig. 1).

The third step was deciding on the proportion of sample size for the lines and at each selected station. We proportionally distributed the 1000+ samples into 575 for the north–south (N–S) line (distributed for the seven selected stations on the line) and 446 for the east–west (E–W) line (also distributed to the seven selected stations on the line) based on the total average percentages of passenger numbers per day.

Three important considerations that can normalize the survey data were made during the data collection process at each of the 14 stations selected. The first was to subjectively group passengers in terms of their age to include all the age groups proportionally in the survey; the second consideration was gender proportions within the age group; and the third was conducting the survey during peak and off-peak hours (50% at each time period).

3.3 Characteristics of Respondents

The survey yielded 1021 responses, with 931 respondents answering all of the questions. Of the 1021 respondents, 38.1% were female and 61.9% male. Overall, 45.8% were 21–30 years old, followed by 21.3% being 31–40 years old. Of the respondents, 40.1% were married, while 55.7% said they were single. In terms of family size, four was the most frequent answer at 21.9%, while family size of three, five, and six were recorded at 16%, 18.2%, and 13.6%, respectively, with an average family size of 4.8. Most of the surveyed riders attained a degree or completed secondary school. Also, the majority of the respondents had full-time employment status (55.7%), followed by student status. In addition, most of the riders had a household income of less than 6000 Ethiopian Birr (ETB) (about USD \$180) per month. More than half of the respondents (58%) used the LRT very often, 58.7% used the LRT

during working days (weekdays), and 28.9% used the LRT during both weekend and weekdays. Of all respondents, 32% had a travel distance of 5–10 km, with an average distance of 11.1 km (Table 1).

More than half of the riders said the LRT was their main mode of travel to work (56.1%), followed by shared minibus taxi (29.6%). A high percentage of the riders used the LRT for most of their trip purposes. However, taxi was the most-used mode for all trip purposes except for work. Walking and private cars were used mostly for shopping purposes, at 43% and 38%, respectively.

3.4 Analysis Methods: Factor Analysis and Ordered Logit Model

Factor analysis was adopted to screen out the 18 variables of service quality of the AALRT. The 18 service parameters were minimized to the most important ones by using principal component analysis (PCA) with the Varimax rotation method and Kaiser normalization at an eigenvalue greater than one.

Then, based on the “most important” variables that resulted from the factor analysis, we examined the relationships between the socioeconomic characteristics of users and their satisfaction level using the ordered logit model. The multinomial logit or probit model is not effective for the ordinal nature of the dependent variable (satisfaction), but the ordered logit model is able to treat variables with a ranking order [36]. Passengers’ perceptions were modeled based on the ranked responses of a survey with important satisfaction variables screened out by factor analysis. The rating was based on a five-point Likert scale, i.e., from very satisfied to very dissatisfied. Accordingly, the threshold values of satisfaction ordered items according to these ranks, which can be best analyzed using the ordered logit model. The thresholds in Table 3 are used to differentiate the adjacent levels of the response variable (the dependent variables used to measure the latent variable). In general, thresholds are not used in the interpretation of the results as they are the cut points closely related to the dependent variable, produced by the statistical package SPSS.

4 Analysis of Results

4.1 Results of Satisfaction Data

To understand passengers’ perception towards the service provided by the AALRT, 18 quality attributes were included in the survey questionnaire using the five-point Likert scale measurement. The survey results showed that most of the respondents (more than 56.7%) were satisfied

Table 1 Socioeconomic and travel characteristics of survey respondents

Variable	Category	%	Variable	Category	%
Age (years) (<i>N</i> = 1021)	Below 15 years old	1.1	Travel distance (km) (<i>N</i> = 952)	1–5 km	26.2
	15–20	15.1		5.1–10 km	32
	21–30	45.8		10.1–15 km	22.5
	31–40	21.3		15.1–20 km	13.1
	41–50	8.4		20.1–30 km	5.0
	51–60	4.7		More than 30 km	1.2
	61+	3.2			
Marital status (<i>N</i> = 1021)	Single	55.7	Rider's level of LRT use (<i>N</i> = 1021)	Always	28.1
	Married	40.1		Very often	30.1
	Divorced	3.1		Sometimes	41.5
	Widowed	0.6		Never	0.3
	Other	0.5			
Family size (<i>N</i> = 931)	1–2 family members	14.3	Main mode to work (<i>N</i> = 974)	Private car	4.9
	3–4 family members	37.8		Train	56.1
	5–6 family members	31.7		Bus	5.4
	7–8 family members	11.6		Minibus taxi	29.6
	9–10 family members	2.5		Walk	2.4
	More than 10	2.1		Other	1.6
Level of education (<i>N</i> = 1020)	Illiterate	0.9	Main mode to school (<i>N</i> = 784)	Private car	3.6
	Elementary (1–8)	7.0		Train	36
	Secondary school (9–10)	14.6		Bus	10.7
	Preparatory school (11–12)	14.7		Minibus taxi	40.6
	Technical and Vocational Education and Training (TVET)	8.4		Walk	6.3
	College diploma	16.9		Other	2.9
	Bachelor's degree	30.6			
Occupation (<i>N</i> = 1021)	Master's degree and PhD	7.0	Main mode for visiting relatives (<i>N</i> = 960)	Private car	5.3
	Student	19.5		Train	34.7
	Full-time employment	55.7		Bus	9.2
	Part-time employment	1.0		Minibus taxi	47.3
	Unemployed	7.8		Walk	2.5
	Homemaker (housewife)	3.1		Other	1.0
	Retired	1.4			
Household income (<i>N</i> = 1021)	Other	2.5	LRT use time in the week (<i>N</i> = 1021)	Weekdays	58.8
				Weekend	12.4
	Less than 2000 ETB*	23.0		Both	28.8
	2001–4000 ETB	30.5			
	4001–6000 ETB	12.5	Departure time (<i>N</i> = 1021)	6:00 AM–9:00 AM	55.9
	6001–8000 ETB	12.8		9:00 AM–12:00 PM	26
	8001–10,000 ETB	12.0		12:00 PM–2:00 PM	5.3
	More than 10,000 ETB	9.1		2:00 PM–4:00 PM	4.7
				4:00 PM–7:00 PM	3.7
				7:00 PM–10:00 PM	1.7
				Do not use LRT	2.7

*ETB = Ethiopian Birr (Ethiopian currency where USD \$1 = 30 ETB)

or very satisfied with service quality attributes such as price, station cleanliness, train interior cleanliness, and sense of safety at the station. However, service quality parameters such as crowdedness in the train and at the station, passengers' behaviors, travel information, and waiting time were considerably dissatisfying attributes (Fig. 2).

4.2 Factor Analysis Results

Factor analysis was used to reduce the 18 service quality variables into smaller numbers of important factors and to identify influencing variables that affect the satisfaction of riders of the AALRT. The identified influencing variables/factors were then related to the socioeconomic variables to understand satisfaction based on riders' characteristics. Accordingly, all of the 18 service attributes were run for factor analysis by using principal component analysis with the Varimax rotation method and the Kaiser normalization at an eigenvalue greater than one. The analysis results yielded four factors that influenced the overall perceptions of riders (Table 2).

Factor 1 comprises attributes related to safety, passengers' behaviors, and stairs at the stations. The variables loaded on to this factor are related to safety issues. Hence, factor 1 can be interpreted and named as the perception related to *safety and security* (Table 2). Factor 1 has four variables, which are more important to users than other factors with a variance of 32.12%. In other words, 32.12% of the variation in satisfaction is due to the four variables

under factor 1. Factor 1 variables are considered the most influential in relation to other factors because of the large eigenvalue of 5.781. Sense of safety in the train is “very important” and an influencing variable with a loading score of 0.786, followed by the sense of safety at stations with a loading score of 0.771, passengers' behaviors with a loading score of 0.608, and the convenience of stations' stairs with a loading score of 0.555. These four variables are the most important variables that influence satisfaction of users of the AALRT service.

The second factor, labeled as *ticketing and information system* is also important in influencing satisfaction with an eigenvalue of 1.491 and an 8.3% variance of influence. It is not as important as the first factor. It is composed of four variables such as ticketing system, which was importantly loaded with higher loading score than other variables such as boarding and alighting, price, and travel information.

The third factor is related to crowding and service frequency, consisting of crowdedness at stations, crowdedness in the train, stations seats, shelter availability, and waiting time (frequency of the trains). Hence, this factor is labeled as *crowdedness and frequency*, which is the third important factor with a variance of 7.3% (Table 2). The fourth factor is related to *cleanliness and comfort*, with a loading score of variables between 0.75 and 0.60. These variables are station cleanliness, train interior cleanliness, and train seat comfort. The 6.36% variance shows that the *cleanliness and comfort* variables are the least important in influencing satisfaction.

Fig. 2 Satisfaction towards AALRT service quality attributes

Table 2 Factor analysis results of 18 service quality attributes

Factor (component)	Loaded variables	Factor loading	Eigenvalue of factor	Percent of variance
Factor 1: safety and security	Sense of safety in the train	0.786	5.781	32.12%
	Sense of safety at the station	0.771		
	Passengers' behavior	0.608		
	Station stairs	0.555		
Factor 2: ticketing system and information	Ticketing	0.745	1.491	8.28%
	Boarding and alighting	0.714		
	Price	0.663		
	Travel information	0.568		
Factor 3: crowdedness and frequency	Station crowdedness	0.732	1.313	7.30%
	Crowdedness in the train	0.669		
	Station seat and shelter	0.586		
	Waiting time	0.551		
Factor 4: cleanliness and comfort	Train interior cleanliness	0.753	1.145	6.36%
	Station cleanliness	0.730		
	Train seat comfort	0.606		
	Speed**			
	Ticket checkers' behavior**			
	Station elevators**			

$N = 1002$

**Variables not included in any of the identified factors due to eigenvalue < 1

4.3 Ordered Logit Model Result

The ordered logit model is based on the four satisfaction factors identified by the factor reduction process explained above. Values of variables under each factor are averaged out to be considered as dependent variables, and 13 predictors, i.e., independent/explanatory variables, were used for the analysis. Log likelihood is distributed using a chi-square test to analyze parallel line assumption. The results show that all four dependent variables except one have log likelihood differences above the chi-square cutoff values for the given degrees of freedom and significance level (Table 3).

The interpretations of the results were based on the t -value at 24 degree of freedom to determine the variable's statistical significance level. Since the t -value for a 24 degree of freedom with a significance level of $p < 0.05$ is 1.711, all the variables with the t -value ≥ 1.711 are considered statistically significant (Table 3). To observe variables with marginal significance, a t -value of 1.318 is considered for the 90% confidence level.

Accordingly, the results indicated that satisfaction towards important attributes of the AALRT varies depending on the socioeconomic characteristics and travel behaviors of passengers. The model results show that age, gender, marital status, household income, occupation, travel distance, travel duration, main mode (to work, school,

and go shopping), frequency of using the LRT, and LRT use time to home were the statistically significant variables with a t -value greater than the accepted value (≥ 1.711) at a 95% confidence interval ($p < 0.05$) and (≥ 1.318) at 90% confidence interval ($p < 0.1$) for different satisfaction perception variables.

Age is statistically significant for the *safety and security* of the LRT at a 95% confidence interval. As indicated by the negative beta coefficient, likelihood of a negative perception about *the safety and security* of the AALRT increases with the increase in age, signifying that older passengers are more likely to be dissatisfied with the service.

Male passengers perceive that the *ticketing and information* system is not convenient and that the train is less clean and comfortable. Also, single and married passengers think that the AALRT is less safe and secure for them. Single passengers are concerned with *safety and security* related factors of the AALRT more than married passengers as indicated by the high beta coefficient.

The occupation of the passengers was also a statistically important explanatory variable with a t -value greater than the accepted value for full- and part-time employees, unemployed, and homemaker riders. Full- and part-time workers and unemployed riders complained less about the *crowdedness and frequency* related factors of the AALRT. However, their concern was *safety and security*. The

Table 3 Ordered logit model results

	Safety and security		Ticketing and information system		Crowdedness and frequency		Cleanliness and comfort	
	β	<i>t</i> -Value	β	<i>t</i> -Value	β	<i>t</i> -Value	β	<i>t</i> -Value
<i>Threshold</i>								
[Yi = 0]	−4.802	14.382	−3.649	8.429	−3.655	8.349	−5.394	17.530
[Yi = 1]	−3.252	6.694	−1.961	2.487	−1.315	1.095	−3.710	8.594
[Yi = 2]	−1.576	1.581	−0.241	0.038	0.390	0.096	−1.909	2.300
[Yi = 3]	0.349	0.078	1.664	1.790	2.506	3.907	0.009	0.000
<i>Independent variable</i>								
Age	−0.140	2.953**	0.034	0.174	−0.042	0.257	−0.023	0.081
Level of education	−0.034	0.645	−0.042	0.975	−0.036	0.698	−0.041	0.930
Family size	−0.014	0.240	0.008	0.076	0.014	0.229	0.018	0.380
Household income	0.039	2.778**	0.023	0.978	−0.071	8.819**	−0.004	0.025
Distance	0.005	0.169	0.009	0.679	0.020	3.167**	−0.002	0.025
Frequency of using LRT	0.144	2.085**	0.164	2.696**	0.038	0.147	0.204	4.13**
LRT use time to home	0.033	0.395	−0.091	3.025**	−0.119	5.092**	−0.070	1.77**
LRT use time from home	−0.018	0.113	0.020	0.136	0.038	0.491	−0.046	0.696
Travel duration	−0.002	0.181	−0.007	2.861**	−0.008	3.885**	−0.008	3.62**
Mode to work: LRT	−0.096	1.593*	−0.114	2.223**	0.028	0.129	0.067	0.771
Mode to school: LRT	0.130	3.295**	0.063	0.765	−0.044	0.365	−0.154	4.55**
Mode to market: LRT	−0.004	0.002	−0.045	0.274	−0.203	5.557**	−0.073	0.714
Mode to go shopping: LRT	0.026	0.154	0.050	0.546	0.000	0.000	0.097	2.04**
[Gender = male]	0.058	0.129	−0.290	3.231**	−0.089	0.300	−0.271	2.78**
[Gender = female]	—	—	—	—	—	—	—	—
[Marital status = single]	−1.658	3.099**	0.682	0.542	0.322	0.119	−0.358	0.144
[Marital status = married]	−1.463	2.388**	0.428	0.211	0.261	0.077	−0.259	0.075
[Marital status = divorced]	−0.730	0.499	0.683	0.450	0.529	0.265	1.096	1.105
[Marital status = widowed]	20.22	0.000	0.382	0.056	0.199	0.015	1.489	0.767
[Marital status = other]	—	—	—	—	—	—	—	—
[Occupation = student]	−0.241	0.200	−0.571	1.114	0.706	1.637*	−0.376	0.478
[Occupation = full time employment]	−0.625	1.530*	−0.513	1.025	0.820	2.500**	−0.171	0.114
[Occupation = part-time employment]	−0.930	2.884**	−0.337	0.378	1.175	4.406**	−0.159	0.083
[Occupation = unemployed]	−0.740	1.627*	−0.160	0.075	0.910	2.363**	−0.160	0.075
[Occupation = homemaker]	0.226	0.099	−0.992	1.894**	0.767	1.104	−1.007	1.93**
[Occupation = retired]	0.493	0.349	−0.485	0.349	1.032	1.541*	−0.965	1.362*
[Occupation = other]	—	—	—	—	—	—	—	—
<i>Model fitting</i>								
−2 Log likelihood (null; final)	(1811.64; 1772.98)		(1767.97; 1744.48)		(1721.02; 1675.74)		(1705.36; 1662.88)	
Chi square	38.662		23.491***		45.275		42.479	
<i>df</i>	24		24		24		24	
Significance	0.030		0.491		0.005		0.011	

*Statistically significant at 90% confidence interval

**Statistically significant at 95% confidence interval

***Less than chi-square cutoff value

negative beta coefficient showed that they were concerned about the safety and security of the AALRT, whereas for homemakers, the *ticketing and information system* and the *cleanliness and comfort* related factors of the AALRT were not satisfying and negatively perceived.

Household income of the riders is one of the statistically significant explanatory variables for *safety and security* and *crowdedness and frequency*. The results indicated that, as the income of the riders' household increased, a negative perception for *crowdedness and frequency* was more likely, as well as a positive view of the *safety and security* of the AALRT.

Travel distance and travel duration of the riders were also statistically significant. Riders traveling longer distances had a positive perception of the *crowdedness and frequency* of the service, indicating that, as the travel distance increased, they were less likely to complain about the *crowdedness and frequency*. However, riders with a shorter travel duration (time) thought that the AALRT was not safe or secure, more crowded, and less frequent.

Usage frequency of the LRT was a statistically significant explanatory variable for *safety and security* and *ticketing and information system*. As the usage frequency of the LRT increased, a positive perception was more likely, as indicated by the positive beta coefficient attached to the variable.

LRT use time (peak or off-peak) was also a statistically significant variable for *ticketing and information system*, *crowdedness and frequency*, and *cleanliness and comfort*. As indicated by the negative beta attached to the variables, riders who used the LRT during peak afternoon hours had a negative perception toward all the three factors.

Mode to (work, school, and go shopping) was also a statistically significant variable. Riders who used the LRT to go to work thought that the *ticketing and information system* was not satisfying. Riders who used the LRT as their main mode to school perceived the AALRT as safe and secure but negatively perceived the *cleanliness and comfort* of the system. Riders who used the LRT to go shopping thought that the *crowdedness and frequency* of the AALRT was an issue when using the service for shopping purposes.

5 Discussion of the Results

The results of this study suggest that, in aggregate, price, station, train interior cleanliness, and sense of safety at stations are the service quality attributes that AALRT users are satisfied with. However, note that some of these variables are listed in the lower end of the factor analysis, which shows that their effect in shifting riders' perception is low because respondents are already satisfied with these

attributes. These findings are in good agreement with those of the study by Eboli et al. [37], who revealed that comfort and cleanliness are crucial concerns for transit passengers. Comfort might relate to the physical aspects of the vehicles as well as the ambient states at transit stations and inside the train.

Crowdedness in the train and at the station, passengers' behavior, travel information, and waiting time were dissatisfying attributes of the AALRT affecting riders' overall perception of the service. Long wait time of the AALRT along with high demand during peak-hours lead to more crowdedness. Crowdedness and inappropriate behavior of passengers created more concerns for safety and security, and resulted in fear of using the light rail system. Likewise, Marteach et al. [32] identified that negative perceptions over safety can increase passenger tensions because of crowding, worsening on-time performance and therefore acting as a barrier to using public transportation. If wait time was decreased, then the crowdedness might be decreased, and safety and security increased; For instance, Fan et al. [38] indicated that waiting is often perceived negatively and is a significant obstacle to mode shifts to transit. Longer wait times will make passengers experience more crowdedness. This has an influence on perceptions of safety in public transportation, resulting in a fear of crime. Crime, if occurring even once, makes passengers feel more fearful to use the transit service [39–41].

Safety and security, along with *ticketing and information system*, *crowdedness and frequency*, and *cleanliness and comfort*, were important variables influencing the satisfaction of users. Safety was the main influencing factor related to sense of security in the train and at stations along with passengers' behaviors and convenience of station stairs in the elevated stations. These findings are in line with the study by Karlsson and Larsson [42] and Holmberg and Hydén [43], who named them as keywords of public transport service quality indicators from users' points of view. These are also consistent with the findings of Marinov et al. [44]. The study revealed that satisfaction factors such as cleanliness of trains and stations, ticketing service, information provision, safety and security, price, and journey time affect overall satisfaction with light rail transit. Moreover, Susilo et al. [45] indicated in their study of Jakarta, Bandung, and Jogjakart Cities (Indonesia) that riders take all of the quality attributes into consideration, but safety and security, comfort and cleanliness, frequency, and a convenient ticketing system are the most important ones.

Riders' socioeconomic characteristics and travel behavior influenced their perception towards the service quality of the AALRT. Accordingly, the elderly, single and married people, full- and part-time employees, unemployed people, and those who do not use the LRT to go to work

have a negative perception towards the safety and security of the AALRT. With an increase in the age of riders, a negative perception towards the AALRT is more likely, which is in line with the findings of Haustein et al. [28] stating that safety from crime was “very important” for people above 65 years. Wong et al. [46] stated that elderly people were dissatisfied with the condition of stops, stations, and seat availability. In the same manner, elevated stations, stairs, and crowdedness at stations and on trains became a safety and security concern for elderly riders. Elderly people are regarded as having limited transport choices, and they are very dependent on public transport, hence there should be public transport policy measures for improving elderly mobility [29].

High-income households, frequent users, and riders who use the LRT to go to school have a positive perception towards the safety and security of the AALRT. Frequent users of the AALRT are happy with the safety and security and the ticketing and information system, implying that riders who have more experience of using the LRT have a more positive perception of the indicated attributes. Also, riders with longer travel distances have a positive attitude towards the crowdedness and frequency of the AALRT. This implies that the LRT has a good safety record, as indicated through descriptive, factored, and ordered model results. However, crowdedness and frequency generally prompted a negative reaction. If the crowdedness and long wait time of the service continues in the current state, it will change the positive image of the safety and security system, as literature has indicated; For instance, Khalid et al. [25] found in their study in Kuala Lumpur that overcrowded coaches contribute to increased wait time and lead to further delays that could induce inconvenience and affect safety and security. In their study, Marteache et al. [32] also discussed that, if there were rider tensions due to crowding or worsening on-time performance, a negative perception over safety could be developed and act as a barrier to using public transportation.

In our study, riders with a shorter travel time (duration) and riders who use the LRT at peak afternoon hours are more likely to have a negative perception towards the ticketing and information system, crowdedness, frequency, and the cleanliness and comfort of the AALRT. Crowdedness and unavailability of seats contributed to a negative perception, which was consistent with the study of Karlsson and Larsson [42], which stated that trip time is perceived to be longer and considered negative when there are no seats or when the passengers have to stand during the journey. In addition, travel time (duration) is a factor that influences mode choice. The findings of this study in relation to peak-hour users are in line with the findings of Khalid et al. [25]. This study found that it was usual for commuters to experience disrupted services as, during peak

hours, the number of passengers builds up to the extent that the train carriages are highly packed. This automatically discouraged people from using public transportation, unless the frequency of the services was increased.

Riders who used the LRT to go to work perceived the ticketing and information system as unsatisfactory, while riders who used the LRT to go to shopping facilities think that the crowdedness and frequency of the LRT was inconvenient. The ticketing system and information is one of the more dissatisfying factors in transit ridership, as Ibrahim et al. [47] discussed in their study of Kuala Lumpur. It was said that ticket counters, the process of purchasing tickets, and punctuality required high-priority improvement action by the commuter rail management. In general, negative perceptions towards public transportation may lead to users looking for other modes of transport through changing personal attitudes, resulting in a challenge to move to a sustainable public transportation system [48, 49].

6 Conclusions and Recommendations

The main focus of this study is to evaluate passengers' perception and attitudes towards the Addis Ababa Light Rail Transit system. The results indicate that some service quality variables such as station crowdedness, waiting time, passenger behavior, crowdedness in the trains, and travel information were perceived as dissatisfying service attributes. Therefore, the city's transport authority needs to improve the service to reduce waiting time by increasing the frequency, adding higher numbers of trains, and separating boarding and alighting doors.

The factor analysis results showed that safety and security as well as the ticketing and information system were important influencing factors on the overall satisfaction of the passengers. The satisfaction level towards those attributes is different depending on socioeconomic characteristics, travel patterns, and behaviors of the riders. The study also highlighted that the AALRT is not tailored for all purposes, as crowdedness and train frequency are challenging for LRT riders who wish to go to shopping facilities. Though the LRT has enormous potential to connect the main business centers of Addis Ababa to residential areas in all four directions, those using the service for shopping purposes have no favorable view of the service. In the same manner, in terms of age and income, the study indicated that the system was not safe for elderly riders, while the crowdedness and frequency were discouraging high-income riders from using the service.

The AALRT service should consider all passengers' characteristics. So, to increase service quality and address the issues riders face, the LRT service providers should

improve safety and security of the service by improving waiting time, minimizing crowdedness, and improving the overall ticketing and information system. The ticketing issue can be resolved by providing ticketing booths at stations on both sides. This study provides useful insights on important factors affecting LRT users' views and perspectives. The results can serve as positive input for the enhancement of the current system and the future development of the light rail transit.

Future research may investigate why frequent users are satisfied with the service but infrequent users are not. Are there other external factors, or is it only a matter of experience and expectation? These are the issues and questions that need investigating for a better understanding of the service.

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