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ORIGINAL

Exploring user perceptions at public transport stops in a SEM approach to Accessibility and Safety

Explorando las percepciones de los usuarios en las paradas de transporte público desde un enfoque SEM para la accesibilidad y la seguridad

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ABSTRACT

Bus stops in consolidated urban areas of the Global South often feature minimal infrastructure, compromising accessibility and safety. This study explored user perceptions of accessibility and safety at public transport stops in Quito, Ecuador, addressing gaps in subjective assessment methodologies. Using immersive audiovisual stimuli (360° videos and spatial audio), 16 real-world bus stop scenarios were replicated. A sample of 529 bus users including university students/staff personal evaluated six perceptual indicators of accessibility and safety indicators via digital surveys on tablets with noise-cancelling headphones. Structural Equation Modelling analysed relationships between latent constructs and sociodemographic and residential location variables. The results revealed that accessibility negatively influenced safety perceptions. Strong loadings for *internal security* and *theft protection*. *Easy access* outweighed *stop size* for accessibility perception. Users in living in south of Quito reported higher safety, while northern residents perceived lower safety. Group travel increased safety perceptions, and higher user volumes improved accessibility. The inverse accessibility-safety relationship highlights design trade-offs in high-density areas. Location-based heterogeneity (e.g., south Quito's higher safety) underscores contextual influences. Immersive methods effectively captured perceptual complexity, but future research should expand to representative samples and integrate additional latent variables. Policy interventions require modular infrastructure adaptable to urban density gradients.

Keywords: Perceived Safety; Accessibility; Structural Equation Modelling; Bus Stops; Immersive Stimuli; Urban Transport.

RESUMEN

Las paradas de autobús en las zonas urbanas consolidadas del Sur Global suelen contar con una infraestructura mínima, lo que compromete la accesibilidad y la seguridad. Este estudio exploró las percepciones de los usuarios sobre la accesibilidad y la seguridad en las paradas de transporte público de Quito (Ecuador), abordando las lagunas existentes en las metodologías de evaluación subjetiva. Mediante estímulos audiovisuales inmersivos (vídeos de 360° y audio espacial), se replicaron 16 escenarios reales de paradas de autobús. Una muestra de 529 usuarios de autobús, entre los que se encontraban estudiantes y personal universitario, evaluó seis indicadores perceptivos de accesibilidad y seguridad mediante encuestas digitales en tabletas con auriculares con cancelación de ruido. El modelo de ecuaciones estructurales analizó las relaciones entre los constructos latentes y las variables sociodemográficas y de ubicación residencial. Los resultados revelaron que la accesibilidad influía negativamente en la percepción de la seguridad. Fuertes cargas para la *seguridad interna* y la *protección contra robos*. La *facilidad de acceso* superó al *tamaño de la parada* en la percepción de la accesibilidad. Los usuarios que viven en el sur de Quito informaron de una mayor seguridad

, mientras que los residentes del norte percibieron una menor seguridad. Los viajes en grupo aumentaban la percepción de seguridad, y un mayor volumen de usuarios mejoraba la accesibilidad. La relación inversa entre accesibilidad y seguridad pone de relieve las compensaciones de diseño en las zonas de alta densidad. La heterogeneidad basada en la ubicación (por ejemplo, la mayor seguridad del sur de Quito) subraya las influencias contextuales. Los métodos inmersivos captaron eficazmente la complejidad perceptiva, pero las investigaciones futuras deberían ampliarse a muestras representativas e integrar variables latentes adicionales. Las intervenciones políticas requieren una infraestructura modular adaptable a los gradientes de densidad urbana.

Palabras clave: Seguridad Percibida; Accesibilidad; Modelización de Ecuaciones Estructurales; Paradas de Autobús; Estímulos Inmersivos; Transporte Urbano.

INTRODUCTION

Bus stops are designated locations that facilitate the embarkation and disembarkation of passengers from the transportation network. The accessibility of these facilities constitutes a pivotal component of effective service provision. The extant literature demonstrates that bus stop design is informed by criteria that align with different levels of service for users and their suitability for the environment. However, in consolidated urban areas, due to the limited availability of space, bus stops are often equipped with only minimal infrastructure, consisting of a sign indicating their location and service timetables.

Investment in and adaptation of transport stop infrastructure does not represent a priority for transport operators, as it is not a specific factor in measuring service performance (kilometres-vehicle). However, it is imperative for users to measure quantitative and qualitative factors in order to evaluate aspects of service provision. It is evident from the extant literature that the analysis of customer concerns at transport stops is of paramount importance in order to ascertain the level of service performance (kilometres-passengers), particularly with regard to accessibility and safety indicators.[1]

In urban areas of the Global South, transport infrastructure is often situated in areas characterised by significant informal commercial activity, which can pose challenges to accessibility. Another salient issue for users is safety, which is predicated on the poor condition of the infrastructure and its location, which renders access difficult. The measurement of subjective factors facilitates a more nuanced interpretation of users' priorities with regard to the transport system.

There is considerable interest in the literature regarding the association between users' subjective perceptions and the need to explore their link with the various elements that influence the quality of transport services. Specifically, the relationships between indicators of accessibility, safety and services at stops have been studied in conjunction with the quantitative aspects of infrastructure.[2] Accessibility represents the primary factor experienced by users upon their initial engagement with the transport system. This can be evaluated as a reaction to the appeal of its infrastructure and environment. The extant literature makes reference to the indicators that are utilised for the purpose of its evaluation. Such indicators include the effort made by users to reach a stop location. The second factor that influences passengers' perceptions when they are waiting at stops is safety. It is important to note that there is a potential risk to passengers' safety whilst using the infrastructure to enter the transport system.

The present study explores the relationships between two latent variables measured subjectively by transport users in terms of accessibility and safety. To this end, a series of scenarios were devised, encompassing transport service locations exhibiting a range of characteristics. These scenarios were then meticulously selected to align with diverse attribute configurations. The audiovisual stimuli were reproduced using immersive devices (360º video and immersive sound) and then administered to a sample of users. A digitally assisted survey format was utilised, with measurements of the perceptual indicators and information on their sociodemographic characteristics and residential location being collected. Finally, a structural equation model was estimated to understand the behaviour of the latent variables as a function of sociodemographic data and the characteristics of the location of the dwellings.

The following structure has been adopted for the remainder of the document. The subsequent section delineates the existing literature regarding to subjective measurement factors in bus stop location. The third section delineates the methodological process proposed for the collection of information. The fourth section presents the results obtained during the verification of the proposed evaluation method using structural equation models, and the most significant results are discussed. Finally, the conclusions and future research areas are discussed.

Literature review

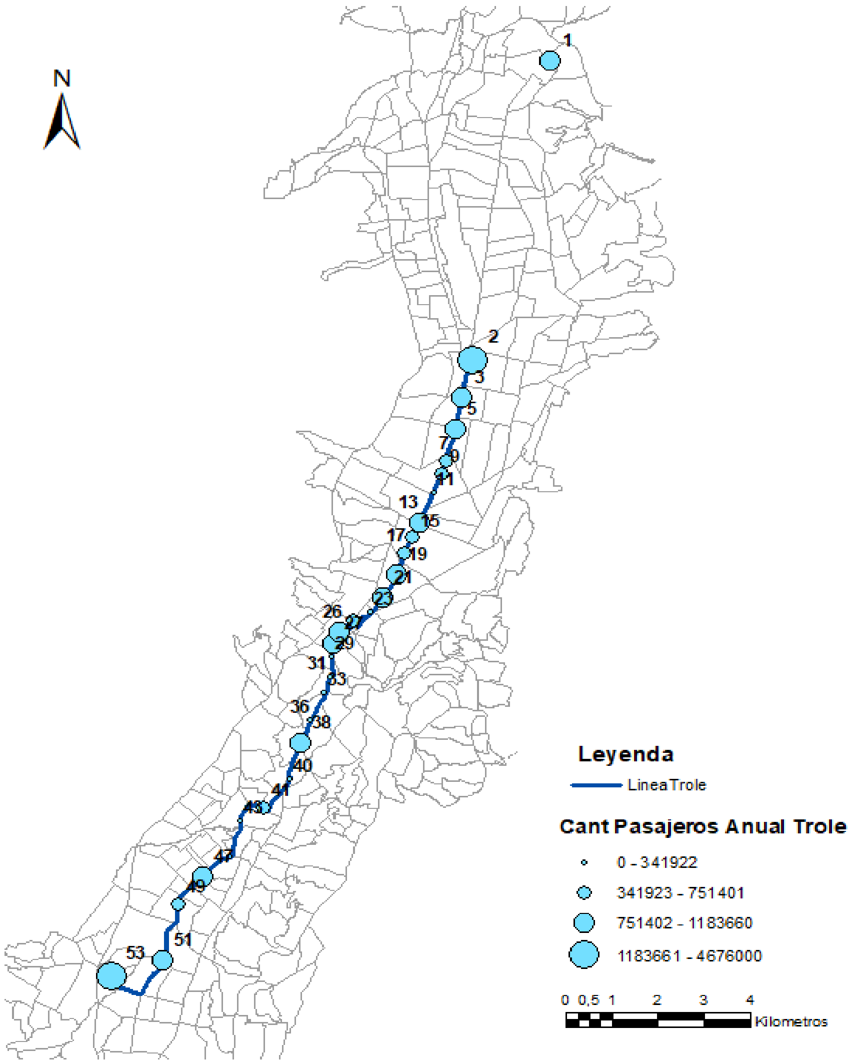
The study reveals that perceptions at public transport stops integrate multiple dimensions such as safety, accessibility, services and others, which are crucial for perceived quality. Users assess risks such as crime, accidents or unsafe conditions while waiting/transferring, affecting their willingness to use the system.[2] The quality of service (real-time information, cleanliness, availability of seats) reduces perceptions of insecurity, especially among vulnerable groups (women, older adults). For example, poorly lit stops or insufficient information generate anxiety, limiting mobility. Perceived accessibility decreases when these attributes fail, even in cities with high transport supply. The findings highlight that investments in comfort and information are as critical as frequency in promoting equitable use.

The concept of accessibility is broadened by the incorporation of qualitative factors, such as easily displacement and characteristics relatives to accessibility, in addition to the traditional concept of walking distance. Hansen[3] defines it as the 'intensity of possibility of interaction', while Lynch[4] adds dimensions of diversity, equity and control over space. Engwicht[5] and Grava[6] posit that accessibility is contingent on ease of access to opportunities, emphasising that hostile or unsafe environments act as a deterrent to progress. Recent studies[7,8] have modelled accessibility using mixed indicators (safety, comfort), yet these studies have underestimated the role of the immediate environment. The concept of inequality in design emerges when there is an absence of consideration for diverse needs (e.g., older adults who can tolerate walking but not waiting while standing without seats), thereby leading to exacerbation of exclusion.

The perception of safety at bus stops depends on contextual and demographic attributes. Studies confirm that women, young people and older adults perceive greater risk, adjusting routes or avoiding night-time travel.[9,10] Factors such as insufficient lighting, vandalism or lack of staff increase feelings of vulnerability, reducing the use of public transport.[11] In the study by Friman et al.[12] comfort (availability of seats, cleanliness) and reliable information during incidents were key predictors of safety mediating 23 % of the impact on accessibility. Cities with low standards in these attributes (e.g. Stockholm) showed lower levels of perceived safety.

METHOD

Study settings



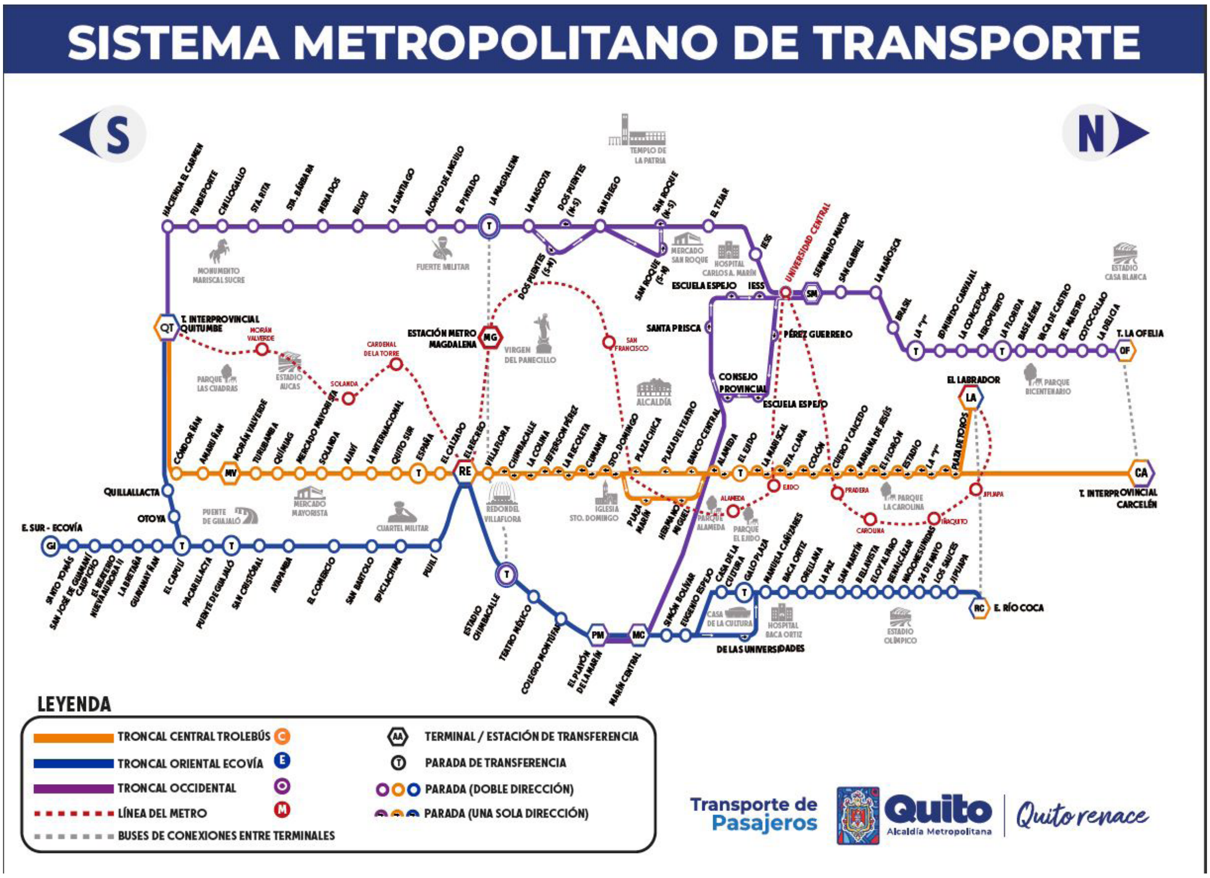


Figure 1. Bus stop scenarios[13]

The present study concentrated on the Metropolitan District of Quito, Ecuador, which is divided into 32 administrative divisions (districts) and covers approximately 305 km^2. According to the most recent census, conducted in 2022, the population of Quito is approximately 2,2 million. The study of transport stop preferences is carried out by identifying specific stops on the Trolebus system route, which extends for a total of 18,5 kilometres, starting from the station located north of Labrador and terminating at the Quitumbe Terminal in the southern region of Quito. The Trolebus system comprises a primary line, designated C1, which encompasses the initial 21 stops from the starting point in Labrador to the Recreo station[13], as illustrated in figure 1 the second line, designated C6, encompasses a total of 15 stops, originating from the El Recreo station and terminating at the Quitumbe Terminal. The selection of this Trolebus route facilitates the exploration of the diversity and intricacy of the transport infrastructure.

Participants

A total of 529 university students and staff in Quito who use bus services were selected to participate in this study, with data collected between November 2023 and June 2023 (table 1).

Table 1. Sociodemographic characteristics

Age	Total (%)	Level of Education	Total (%)	Impairment Problems	Hearing (%)	Visual (%)
26-35	289 (55)	Undergraduate	238 (45)	Eyeglasses	Non apply	105 (20)
36-45	132 (25)	Bachelor	67 (13)	Unknown	11 (2)	22 (4)
46-55	108 (20)	University	224 (42)	None	518 (98)	326 (76)
Note: the values correspond to the sample number, and the value in brackets corresponds to the calculated percentage						

Factor and attribute selection

The objective of this study was to assess multisensorial factors in various residential environments. The following factors were specifically assessed in order to explore users' perceptions of bus stop characteristics: (i) accessibility and (ii) safety. The statements associated with each perceptual indicator were derived from an extensive literature review, as illustrated in table 2. The measurement of the indicators was conducted utilising a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The applied survey incorporated

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a questionnaire designed to elicit data pertaining to socio-demographic characteristics and geographical location.

Table 2. Factors, indicators and variables

Variable/Factor	Question/Indicator	Scale
Socio-demographics (household head)		
	Age	Categorical
	Gender	Binary
	Level of education	Categorical
	Age	Categorical
	Occupation	Categorical
	Family income	Categorical
Residential location characteristics		
	District of residence	Categorical
Accessibility		
	I1. Senior citizens and people with disabilities can easily displacement and enter this stop (easily displacement)	5-point Likert
	I2. There are traffic lights and crosswalks in the vicinity of this stop to easily access. (easily access)	5-point Likert
	I3. The size of the bus stop is adequate with spacious areas for walking and waiting. (size)	5-point Likert
Safety		
	I4. The location of the stop is safe from theft. (theft-free)	5-point Likert
	I5. I feel safe inside this bus stop waiting for the transport units to arrive. (internal security)	5-point Likert
	I6. This stop is safe from traffic accidents. (traffic accidents)	5-point Likert

Accessibility perception

The perception of accessibility is influenced by the design's capacity to integrate multiple functions (e.g. rest and information) using universal design criteria. Corazza(14) demonstrates that an accessible system must meet diverse physical and cognitive requirements and not require adaptation by the user. However, in consolidated urban areas, the scarcity of space has a restrictive effect on optimal implementation, resulting in 'relatively optimal' solutions. Research by Grava(6) and Karlsson(15) indicates that inadequate furniture, lack of shelters or real-time information can reduce the perception of safety and comfort, especially in adverse weather conditions or at night. Research in this area, as evidenced by the works of Banister(16) and Cervero(17), has confirmed that these qualitative factors, in conjunction with urban connectivity(16), play a pivotal role in transport sustainability. Poorly perceived stops have been shown to negatively impact modal choice.

Safety perception

Perceived safety in bus stop location is linked to the ability to perform associated activities (e.g. buying tickets, resting) under various conditions (e.g. weather, time), affecting the decision to use the service. Corazza(14) redefines safety as the ability of the system to be used by all, shifting the burden of adaptation from the user to the design. This suggests that physical and cognitive barriers in design may lead to exclusion.

Attributes selection

A total of 14 real-life bus stop locations were selected from the trolleybus route. The methodology employed in the selection of these locations is delineated in figure 2. As illustrated in table 1, the study has identified a number of variables for consideration. The size of each stop is represented by its surface area, measured in square metres. The number of users was defined based on the count of users present at the stop. A meticulous enumeration was conducted to ascertain the quantity of entry and exit doors present at each designated station, inclusive of the doors leading to the transport units. In conclusion, the distance to emergency services is equivalent to the linear distance measured from each transport stop to the nearest police station.

Table 3. Quantitative Variables

Attribute	Units	Levels
Bus Stop size (Size)	Square meters	Low [<100], Moderate [100-200], High [>200]
Number of users (*users*)	Pedestrians	Low [<25], Moderate [25-35], High [>35]
Doors number (*door*)	Number	Low [<4], Moderate [4-8], High [>8]
Distance to Emergency services (*DES*)	meters	Low [<1000], Moderate [1000-1600], High [>1600]

Bus stop location

The methodology of the present study involved the recording of audiovisual extracts at bus stops in various Quito districts. These extracts were then measured and collected in each location. Thereafter, two research group members selected sixteen locations with the objective of ensuring consistency with the experiment, as described in figure 2.

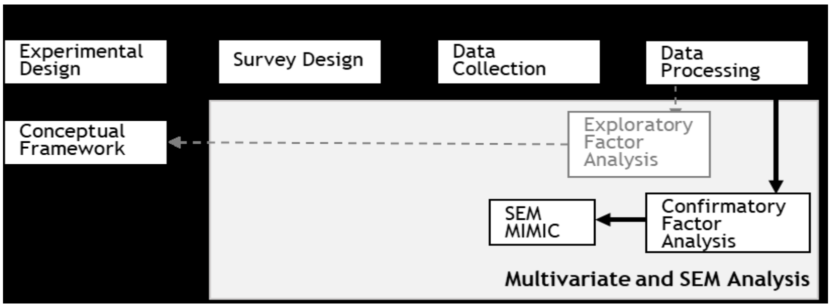

Figure 2. Flow chart for identifying bus stop locations

Once the location had been identified, one-minute auditory samples were recorded in situ using a portable 4-channel cardioid Ambisonic 3D TA-1 microphone. In order to complement the sound recordings, visual stimuli were also obtained using a spherical panoramic camera. The duration of all audio-visual sequences was set to 60 seconds. Sixteen real-life bus stop locations were recorded for a duration of sixty seconds. Each recording was processed as a 360-format video in combination with spatial audio formats, as described by Hong[18] and recently applied to recreate artificially audio-visual stimuli conditions.[19] The scenarios depicted in figure 3 were meticulously recorded to emulate the authentic conditions prevalent in diverse residential contexts, subsequently reproducing them for the purpose of experimental investigation. It is important to note that all scenarios were captured during daylight hours and in conditions that were free from rain between 10:00 a.m. and 5:00 p.m. The immersive audio-visual excerpts were uploaded to the YouTube platform.

Experimental setup and exposure conditions

The survey had a digital format and comprised three sections:

1. Socio-demographic and location information.
2. As shown in table 4, perceptual indicators were measured using a 5-point Likert scale (1= strongly disagree to 5= strongly agree). In this section, the 16 bus stop locations were grouped into four scenarios of bus stop.
3. The application survey was intended to help respondents from during the experiment administration. Each participant was instructed to use a 13-inch digital tablet screen and noise-cancelling headphones, as shown in figure 4. SPL was measured as part of the experimental setup. The experimental application took between 25-30 min to complete for each respondent, including viewing time. The present approach offers the advantage of portability for conducting the survey. Furthermore, the cost of the former is lower than the investment required for the use of a laboratory, as indicated by the respondents' schedules.

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In addition, the utilisation of a head-mounted virtual reality device had been planned. However, the implementation process was complex, and the internet connection required for its operation was not always available on-site. Accordingly, a tablet equipped with mobile data and internet capabilities was selected for the administration of the survey. The ecological validity of visual devices has been the subject of previous evaluation,[20] as well as the application of digital survey formats in a range of fields of knowledge.[19,20]

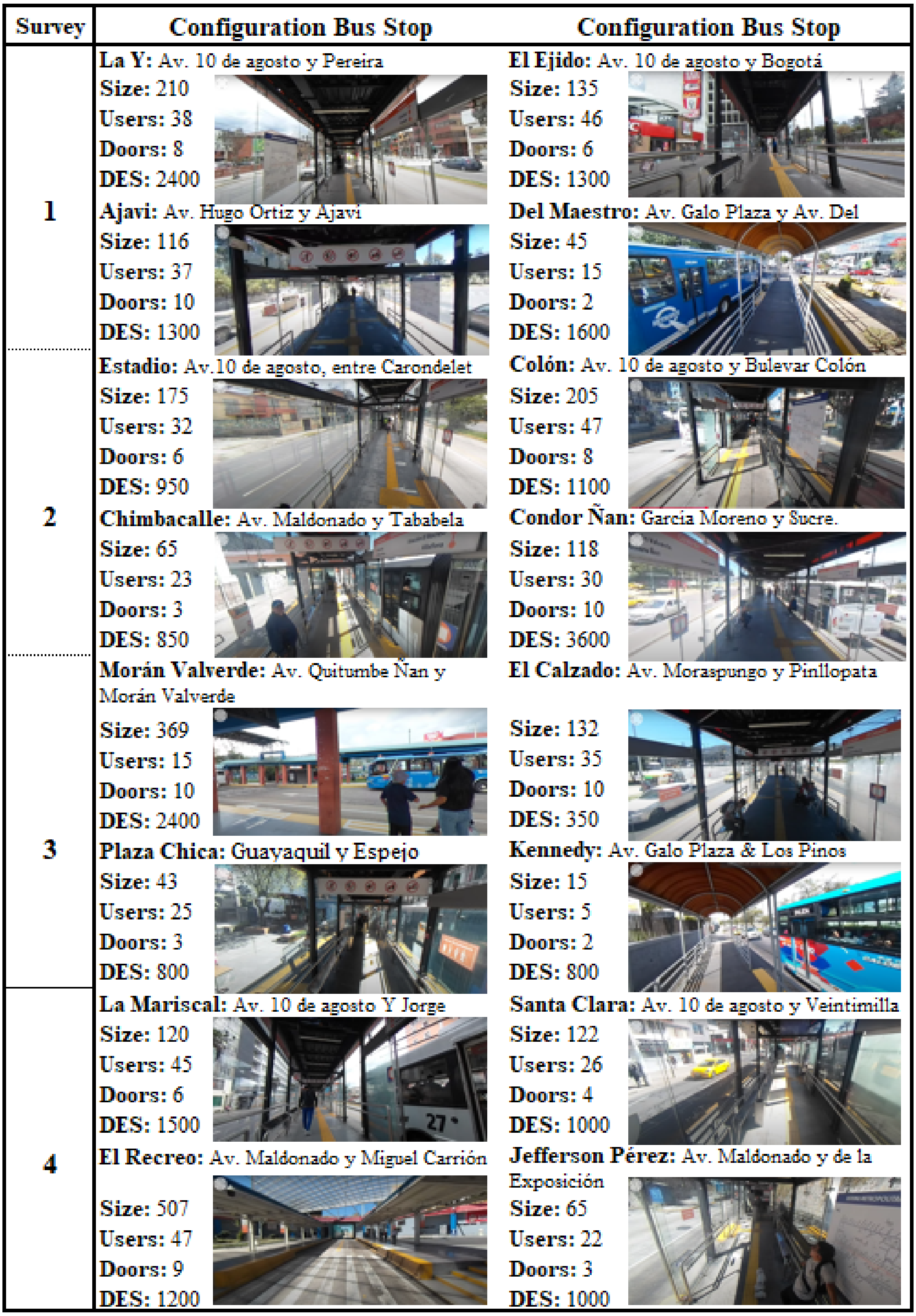

Figure 3. Bus stop scenarios

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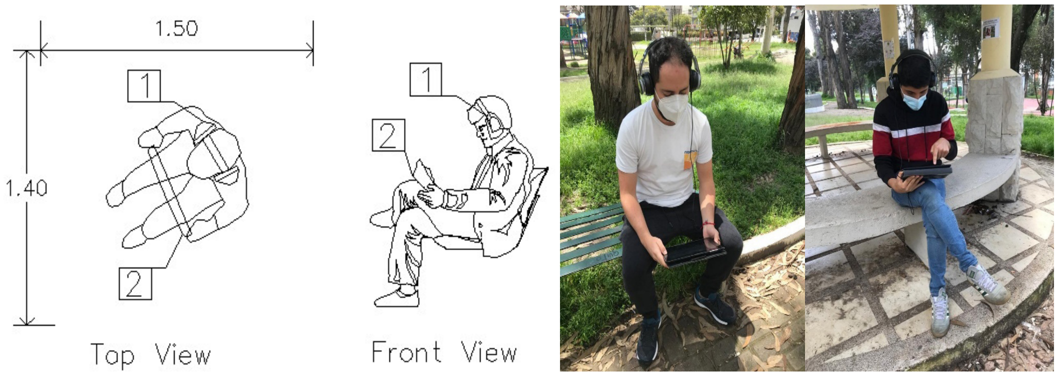

Figure 4. Experimental proceeding, equipment and portable structure. (1) headphones, (2) tablet

RESULTS AND DISCUSSION

In this section, the information collected from 529 participants is analysed. The results obtained are presented in four sections. Firstly, a descriptive statistical analysis of the collected data of the selected indicators was conducted.[21] Subsequently, an exploratory factor analysis (EFA) was conducted to extract the primary latent constructs from a set of measured indicators, with no a priori structure assumed. Following the identification of the structure between indicators and latent variables, a second step based on confirmatory factor analysis (CFA) was applied. The CFA is utilised for the purpose of evaluating the reliability and validity of measurement scales for both observed and latent variables.[22] Subsequently, an advanced SEM-MIMIC model was formulated in order to validate the hypotheses by estimating the loadings of the regressors' coefficients on the structural model. The collected data were processed and analysed using the Lavaan library[23] in R-Studio.

Data Analysis

Figure 5 summarises the responses to the perceptual indicators described in table 2. The averages for (I1), easily access (I2), size (I3) and sensitivity (I4), related to Accessibility. The mean values for the Safety indicators, such as Theft-free(I4), internal security (I5) and traffic accidents (I6).

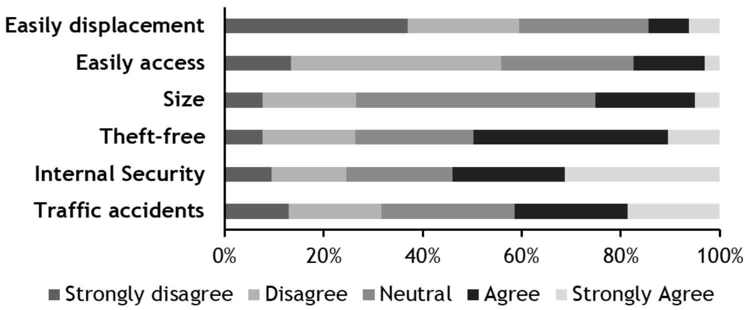

Figure 6. Analysis of perceived indicators

Exploratory Factor Analysis (EFA)

Table 4. Results Exploratory Factor Analysis

Indicators	MSA	Factor Loading	Variance explained (%)
Factor 1: Accessibility			37,1
I1. Easily displacement	0,59	0,7	
I2. Easily access	0,58	0,8	
I3. Size	0,7	0,41	
Factor 2: Safety			45,2
I4. Theft-free	0,56	0,71	
I5. Internal Security	0,55	0,85	
I6. Traffic accidents	0,77	0,44	

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The EFA was conducted with the objective of extracting the principal factors for each latent variable. A varimax rotation was utilised in order to analyse the principal components and thereby define the orthogonal factors. The sample adequacy criteria were used to verify results, in particular the Kaiser-Meyer-Olkin (KMO=0,62) index[24] and the Measure of Sampling Adequacy (MSA) for each indicator. Values above 0,4 were considered acceptable. As demonstrated in table 4, a total of two factors were identified that met the criterion of an eigenvalue greater than one. These factors accounted for 82,3 % of the total variance, with loadings ranging from 0,41 to 0,85. Factor 1 represented accessibility of bus stop and explained 37,1 % of the variances.

Confirmatory Factor Analysis (CFA)

The confirmatory factor analysis was performed in order to examine the reliability and validity of the latent variables (table 5). A Cronbach-alpha coefficient with a minimum value of 0,6 is generally accepted as indicative of good reliability.[25] However, Hair et al.[26] proposed an alternative approach, suggesting an examination of convergent validity according to three reliability criteria: construct reliability (CR), average variance extracted (AVE), and standardised factor loadings.

Table 5. Results Confirmatory Factor Analysis

Latent Variable	Cronbach's Alpha	Std. Factor Loading	CR	AVE	MSV	ASV
Accesibility	0,65		0,68	0,65	0,63	0,43
I1. Easily displacement		0,59				
I2. Easily access		0,79				
I3. Size		0,4				
Safety	0,6		0,94	0,84	0,3	0,18
I4. Theft-free		0,72				
I5. Internal Security		0,84				
I6. Traffic accidents		0,45				

The observed variables demonstrated reasonably good convergent validity, with values exceeding 0,5, thus confirming satisfactory convergent validity (Std.factor.loading ≥ 0,5, AVE ≥ 0,6, CR ≥ 0,6). The constructs also demonstrate adequate validity and sufficient reliability, consistent with the recommended values in the extant literature (MSV < AVE, ASV < AVE).[27]

Conceptual of a structural equation model

Although there are studies examining associations between latent variables in bus stops, we have not found prior theory-driven considerations to jointly explore the relationships between accessibility and Safety. Latent constructs, such as accessibility, have been traditionally analysed jointly with person-related attributes (i.e., socio-demographic information) and noise-annoyance.

Moreover, there is evidence in the literature to suggest that the socio-demographic variables influence both accessibility and safety and that this influence may change with bus stop and commercial activity in surroundings. The effects of measured variables and accessibility in different urban contexts have also been demonstrated. However, only a limited discussion is available concerning the influence on Safety factor, especially in a Latin American context. Within the framework of this paper, following relationships found in previous studies and former results, a conceptual SEM was tested concerning the three hypotheses depicted in figure 7 for a bus stop framework context:

HA: the Accessibility and infrastructure influences Safety perception of users on the bus stop.

HB1: the socio-demographic characteristics of citizens influence Accessibility and Safety.

HB2: the dwelling location of users influences Accessibility and Safety.

The conceptual model presented in figure 7 incorporates the socio-demographic and geographical variables as regressors, in addition to the latent variables. The values of the fit measures for the conceptual model are presented in table 6. The socio-demographic variables were categorised as follows: gender ("female" or "male"), age ("young" or "adult" or "elderly"), education degree ("elementary" or "high-school" or "university"), employment status ("unskilled" or "qualified" or "specialised"). The location variables were defined as residential location, with the categories of "south-Quito", "north-Quito", and "centre-Quito". It is imperative to note that all variables are accompanied by a reference category, which is delineated in quotation marks above. For instance, "South-Quito" is designated as the reference category for residential locations within the city. This approach is undertaken to account for the heterogeneity that exists across householders'

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perceptions. The respondent's socio-demographic and residential location characteristics were associated with both latent constructs as explanatory variables. Besides, on the specification of Accessibility and Safety all measured variables were also included (i.e., size of bus stop, numbers of users, door numbers and distance to emergency services).

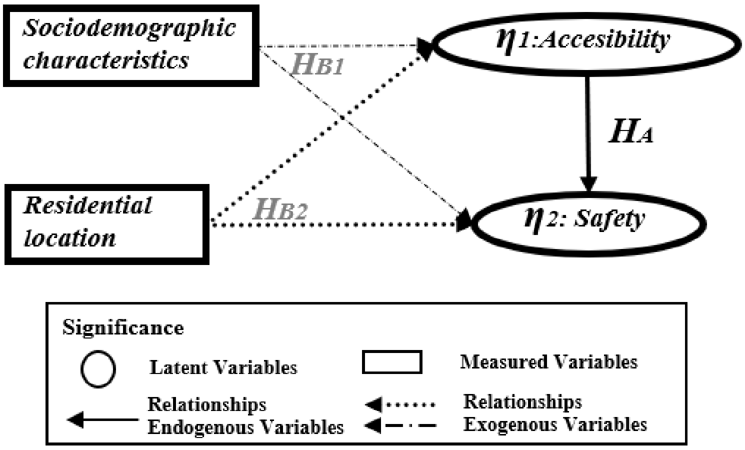

Figure 7. Conceptual Structure SEM

Modified structural equation model

Table 6. Fit measures of the tested models and recommended values (N=529)

Model Fit Index	X_{SB}^2/df	CFI	TLI	RMSEA	SRMR
Conceptual model values	4,4	0,997	0,999	0,025	0,018
Modified model values	4,2	0,997	0,999	0,027	0,018
Recommended values	< 5,0	>0,90	>0,90	< 0,08	< 0,05

Table 7. Results modified SEM (N=529)

Measurement	Estimate	S.E.	*p*-value	Std. estimate
ACCESSIBILITY				
I1. Easily displacement	0,845	0,037	< 0,001	0,708
I2. Easily access	0,85	0,034	< 0,001	0,858
I3. Size	0,316	0,023	< 0,001	0,335
SAFETY				
I4. Theft-free	0,652	0,034	< 0,001	0,59
I5. Internal Security	1,023	0,047	< 0,001	0,782
I6. Traffic accidents	0,509	0,034	< 0,001	0,399
Regressions	Accessibility		Safety	
"Using transport alone"				
Using transport with one more person	0,036		0,043	
"Low frequency using transport service"				
High frequency using transport service	-0,053*		-	
Size of bus stop	-0,06*		-	
Number of users	0,082**		-	
Specialised work				
"Centre-Quito"				
North-Quito	0,053		-0,037	
South-Quito	0,058*		0,08**	
Note: *p* < 0,10, *p < 0,05, **p < 0,01, ***p < 0,001.				

The approach to identifying the optimal path model is as follows: first, the prerequisite logic adequacy of regressors in the model is checked, and then, to define the path, those regressors that are statistically significant are specified. The process of modification is halted once the goodness-of-fit indices exceed the recommended values from the preceding model, as illustrated in Table 6 Fit measures of the tested models and recommended values (N=529) table 6.

Table 6 shows the variables selected of the modified structure model estimated with 22 parameters. These results indicate a good-level-of-fit for assessing the modified structural model, according to the recommended criteria described in the literature. The regression paths loadings of the models were estimated using the Maximum Likelihood method.

Figure 8 shows the estimated parameters of the modified SEM-MIMIC model, such as standard error (S.E.), p-value, and standardised estimate. In terms of the hypothesis HA, the standardized path loadings (HA=-0,04, p-value <0,1) suggests at the 90 % confidence level that sound accessibility negatively influences safety on bus stop locations.

In terms of the analysis of relationships between both variables, the hypothesis H_{B1} was analysed considering the estimates of the total effect of socio-economic variables on accessibility and safety. With regard to H_{B2} the hypothesis was tested regarding the effect of the residential location of the dwelling of participants and the relationships between all perceptions accessibility and safety.

The initial analysis of the H_{B1} hypothesis revealed a positive and significant relationship between socio-economic variables and the latent construct of accessibility. For instance, individuals utilising the transportation system with multiple passengers tend to experience greater accessibility in comparison to those who travel alone (0,036, p-value < 0,1). Conversely, accessibility exhibited a negative correlation with high-frequency utilisation of the transportation system, with a statistically significant result of (-0,053 p-value <0,05. In accordance with the logic, an increase in the accessibility of users is observed in circumstances where a greater number of individuals are able to access the bus stop (0,082, p-value <0,01). This phenomenon is represented by the number of users waiting within the bus stop. Finally, it was found that accessibility decreased in proportion to the size of the stop, particularly in the case of smaller stops (-0,06, p-value <0,05). The second analysis was proposed between socio-economic variables and safety perception. The effect was estimated using the following methodology. Firstly, the effect given by people using the transport system with more than one person (0,043, p-value <0,1) was estimated. It was found that these people felt safer than those who are alone when using bus stops.

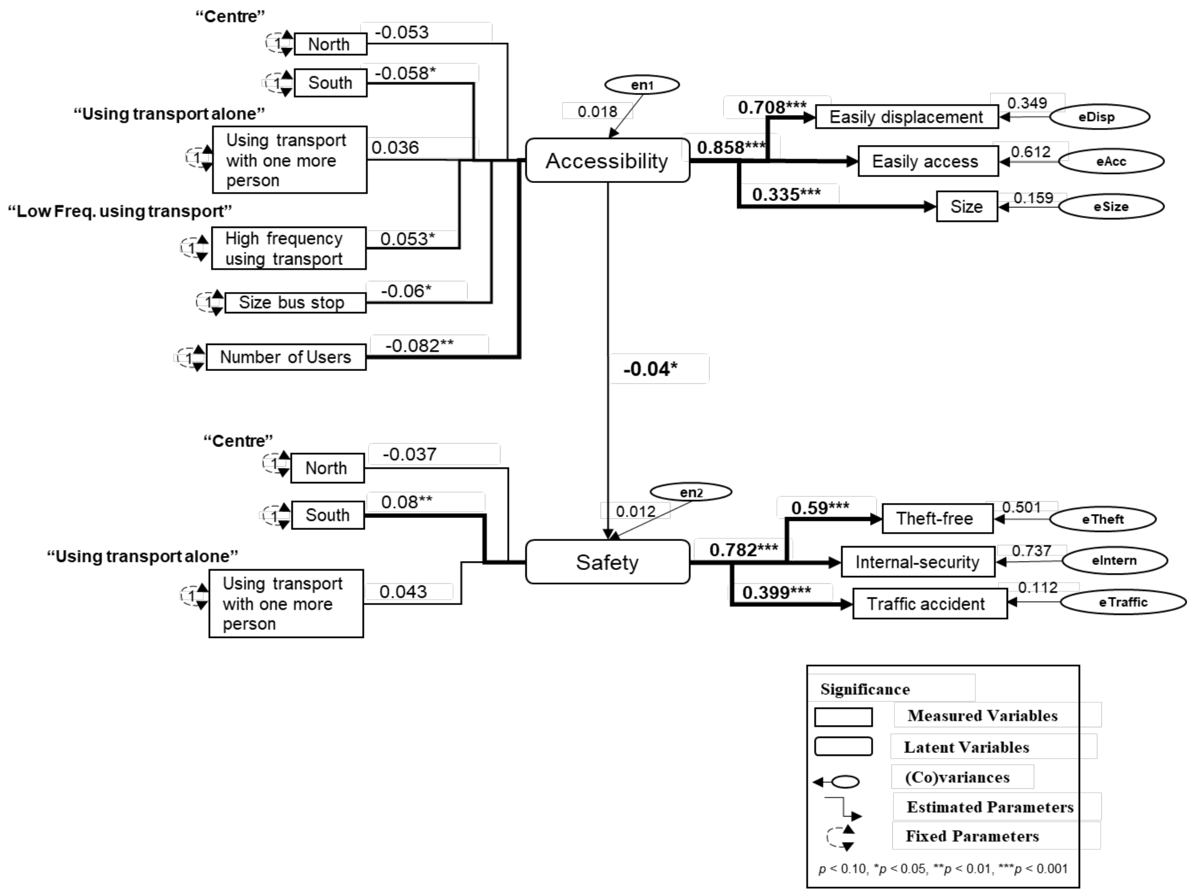

Figure 8. Modified Structure SEM

Therefore, considering the non-zero estimates of the effects of socio-economic characteristics on the latent construct of accessibility and safety, we cannot reject hypothesis H_{B1} at the 95 % confidence level. The results of the analysis demonstrated a significant heterogeneity effect among users located in the Quito main districts (north, centre, and south). This finding was based on an examination of the correlation between the dwelling location of public transport users and both latent constructs. It is noteworthy that users residing in the North (0,053, p-value 0,1) and South (0,058, p-value <0,05) of Quito exhibited higher ratings of accessibility compared to those inhabiting the central district of the city. Furthermore, participants residing in North-Quito (0,053, p-value <0,1) reported perceiving lower levels of safety at bus stops in comparison to those residing in the central and southern regions of the city (0,08, p-value <0,01). Consequently, these households living in North and South of the city rated heterogeneity in perceptions of accessibility and safety. The total effects calculated above suggest that the perceptual dimensions vary according to the place of residence of the users, which allows accepting hypothesis H_{B2} at the 95 % confidence level.

CONCLUSIONS

This research integrates an innovative survey technique that is contextualized under the observation of bus stop quantitative and qualitative characteristics. A total of fourteen scenarios were selected for analysis, with the selection process informed by an experimental conceived to configure a set of accessibility and safety attributes at varying levels. The experiment was conducted on 529 users under conditions employing immersive sound-visual devices. This approach provides participants with the necessary flexibility to evaluate variables in street conditions with a satisfactory level of detail.

The present study draws upon the SEM-MIMIC model structure to demonstrate the influences between accessibility and safety of bus stop locations in a Latin American context. The measurement and validation of a set of indicators was conducted for each latent construct, in accordance with the underlying theory about perceptions that has been described in the literature. Moreover, the analysis and estimation of the effect demonstrated the association between the latent constructs and explanatory variables in the context of bus stops.

The initial hypothesis concerning the relationship between accessibility and safety was found to be negative. In terms of the analysis, the estimation of the effect demonstrates a correlation between accessibility and safety perception across the majority of sociodemographic characteristics. The perception of accessibility and safety varies among users, with their dwelling location serving as the primary explanatory variable. These findings complement the understanding of the complex relationships described in the literature between the latent constructions.

Future research should consider a larger sample and hopefully one that is representative of the population under analysis. Our sample, due to the limited funds available to carry out the study could be biased due to its snowball sampling characteristics. On a more methodological side, a future study could include an output alternative Finally, a new stud y could include other latent variables that may influence the bus stop location decision and might interact with accessibility and safety perceptions.

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