Public transportation and fear of crime at BRT Systems: Approaching to the case of Barranquilla (Colombia) through integrated choice and latent variable models

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Public transportation and fear of crime at BRT Systems: Approaching to the case of Barranquilla (Colombia) through integrated choice and latent variable models

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A R T I C L E I N F O

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A B S T R A C T

Security perception and Fear of Crime (FoC) in urban scenarios have the potential to affect travel behavior, changing people's travel choices and patterns. In this sense, the feeling of being "safe" or "at-risk" in public transportation not only depends on observable factors like illumination, travel companionship or transport crowding, but also on unobservable individual-specific latent attributes, among which fear of crime constitutes a major issue to consider in transport security policy-making. This study aimed to describe the relationships among sociodemographic features, travel situations, system-design features, and the Fear of Crime at three different locations (buses, bus stops, and stations) of the BRT system of Barranquilla (Colombia). Using an image-based survey applied in Barranquilla, data was collected from a full-sample of 500 adult users (64% females and 36% males) of the system. It was estimated a hybrid choice model to include location-based fear of crime in public transportation perception of risk, along with attributes related to (e.g.) surveillance, crowding, time of the day, and companionship. The relation between fear of crime and perception of security in public transportation is negative and highly significant. FoC inside the bus has the highest negative effect on the utility, followed by bus stops and BRT Stations, for which it remains non-significant. Gender (being a female user) was the strongest FoC predictor. Moreover, it was found that the higher is the user's income, the lower is the fear of crime reported for each one of these three types of location. Overall, the inclusion of the fear of crime perception in the estimation of the hybrid choice model enhances the model fit. Also, the user-related findings of this study at different locations provide a better understanding of the decision-making process and the predictors of fear of crime in BRT systems.

1. Introduction

Fear of Crime (FoC), apart from being widely accepted as a phenomenon (Tandogan & Ilhan, 2016), can be understood as an emotional response of stress, anxiety, or dread to crime or situations associated with crime, as a consequence of perceived risk (Ferraro, 1995). Especially in developing countries, security perception and Fear of Crime in public spaces -that are usually negatively

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correlated- have both the potential to affect key travelers' behavior, such as modal choices, travel schedules, or even the decision to travel itself (Alonso et al., 2020; Orozco-Fontalvo et al., 2019; Allen et al., 2018; Mellgren et al., 2018). Among other factors, the literature highlights that this perception seems to be influenced by both individuals' socio-economic profile and previous experiences in transport, rather than objective real risks present in the urban and/or transportation environments (Jackson & Stafford, 2009; Prieto-Curiel & Bishop, 2018).

Recent studies point that Fear of Crime limits life opportunities of people and their participation in key environments such as school, work and public life, as it enhances behavioral changes that are sometimes incompatible with performing certain daily life tasks, especially among people who do not have access to a private vehicle and remain dependent on public transport (Ceccato & Loukaitou-Sideris, 2021; Alonso et al., 2020). In other words, risk-related attitudes and perceptions of users might have an important impact on the decision-making process, if approached from behavioral-economical and psychological perspectives, and FoC seems to play a key role in this regard (Tversky & Kahneman, 1992).

Furthermore, and considering facts such as that female users are the ones typically reporting being more fearful than their male counterparts in transport-related environments (Loukaitou-Sideris, 2016), some of these studies have also closely linked the fear of crime with the fear of sexual harassment, and their subsequent feelings of anxiety and vulnerability (Ceccato & Loukaitou-Sideris, 2021; Davidson et al., 2016; Loukaitou-Sideris & Fink, 2009; Macmillan et al., 2000). This highly gendered state-of-affairs in terms of fear, potential violence and actual victimization rates in transit environments –that are influenced by a variety of factors– has lead some authors to argue that womens' FoC is, markedly (although not exclusively), a "fear of sexual victimization", as the fear of sexual assault heavily influences the FoC (Henson & Reyns, 2015; Fyhri & Backer-Grøndahl, 2012; May et al., 2010; Ferraro, 1996).

However, the relationships among harassment, fear of sexual assault, and overall FoC have not been widely studied from an integrative approach (Gardner et al., 2017). Hence, new empirical evidence -whose findings might substantially vary in function of contextual issues- seem to be needed in order to develop adequate policies and measures to improve transportation security and user welfare. Concretely, this study addressed the case of the Bus Rapid Transit (BRT) system of Barranquilla (Colombia).

1.1. *Objective and hypothesis of the study*

The core aim of this research was to assess the relationships among sociodemographic features, travel situations, system-design features, and the Fear of Crime (FoC) at three different locations: buses, bus stops, and stations of the BRT system of Barranquilla (Colombia). In this regard, it was hypothesized that demographic features of BRT users such as gender and income-level and their travel patterns may influence the levels of security perceived in the three BRT-system scenarios addressed.

The main contributions by this research are to provide context-based empirical evidence to bridge the gap related to FoC and perception of security in public transportation, as well as to contribute with a novel approach in the context of FoC in public transportation, using a hybrid choice model as a modeling framework to study this relationship.

This paper is structured as follows: Chapter 1 (Background); Chapter 2 "Methods" provides information about the survey and collected data; Chapter 3 "Model Framework" shows the structure of the estimated model; Chapter 4 "Results and Discussion" provides the results and interpretation of the estimated model. Finally, Chapter 5 "Conclusions" summarizes the most significant findings of the study.

1.2. *Background (Literature review)*

As previously introduced, Fear of Crime and all its related perceptions can negatively impact travel behavior of transportation users, as well as their health and well-being outcomes (Ceccato & Loukaitou-Sideris, 2021; Lorenc et al., 2014). For instance, a recent study performed in Sweden (one of the countries with lower crime rates, worldwide) found that FoC experienced by male subjects was associated to critical rates of psychological distress and poor health outcomes, even though the impact of FoC was considerably negative for both men and women (Macassa et al., 2018). Nonetheless, and as they represent the most vulnerable users in a gender-based perspective, women are, in most cases, the main focus in terms of behavioral, health and welfare-related affectations enhanced by this threatful perception (Tandogan & Ilhan, 2016).

Also, and even though most of the literature emphasizes FoC with a negative connotation, Jackson & Gray (2010) studied what they called the *Fear of Crime's positive aspects*, introducing the concept of "functional fear". Under such denomination, fear is considered as a *"motivating force that encourages vigilance and stimulates precautionary activity"*, which plays a pragmatically useful role in the self-preservation of an individual's welfare (Chadee et al., 2019). However, 75% of the respondents of Jackson & Grey's study were classified as "dysfunctional-fearful" individuals, suggesting that the negative effects of fear of crime are considerably greater than the positive outcomes (most of them related to self-care habits and permanent vigilance patterns), impairing quality of life among individuals reporting higher degrees of FoC. In other words, this is a situation in which the costs clearly exceed the benefits, making studies and evidence-based interventions something needed to improve people's security and welfare.

In the specific field of public transport dynamics, the accumulated evidence supports the idea that Fear of Crime is enhanced by frequently noticeable issues at transport facilities (e.g., bus/train stations) and vehicles, in both developing and industrialized countries. Some of these issues are: poor environmental maintenance, lack of lighting at nighttime, absence of controlling authorities, and the occasional occurrence of security incidents that contribute to generate a negative stereotype on public transport, even in the case of users who have never suffered any previous victimization in this context (Alonso et al., 2020; BTPA, 2008). Furthermore, and apart from victimizations potentially experienced by users in the past, gender remains the most relevant demographic factor influencing perceptions related to personal safety and security in the transportation environment (Fyhri & Backer-Grøndahl, 2012; Currie, Delbosc & Makhoud, 2010; Yavuz & Welch, 2010).

1.3. How gendered is fear of crime in public transportation?

Although the extent to which a person feels safe in a particular context is, indeed, considerably linked to the structural and social problems surrounding it, some studies have shown that the demographic and psychosocial factors of individuals might explain key differences among them. For instance, and compared to men, women are (*i*) the ones reporting the most Fear of Crime at public transport, and (*ii*) in most contexts, more prone to suffer certain types of victimization experiences, such as non-violent thefts, psychological violence and sexual harassment (Prieto-Curiel & Bishop, 2017; BTPA, 2008).

In this regard, Fear of Crime has been proved to have key gender differences, with women reporting two or three times more FoC than men, when it is measured as a quantitative variable (Noon et al., 2019; Stark & Meschik, 2018; Macmillan et al., 2000; Ferraro, 1996 & 1995). The reasons thereof can be attributed to womeńs higher perceived vulnerability to sexual harassment and attributes such as the absence of surveillance staff or poor lighting during late service hours (Orozco-Fontalvo et al., 2019; Yavuz & Welch, 2010), even though men have statistically a greater likelihood to become victims.

This is known as the "Fear of Crime gender paradox" (Lauritsen & Heimer, 2008). In other words, while self-reports of fear tend to show greater values among women, males are those actually suffering the higher rates of victimizations in different environments. However, and far from downplaying the crimes suffered by women, it is worth remarking how their victimization experiences have particular features worsening their consequences on victims' integrity and welfare. Firstly, women suffer a greater amount of violence in particular contexts, in which they result more vulnerable than men, as the domestic, labor and transit environments (Gale et al., 2019; Ansara & Hindin, 2010; Loukaitou-Sideris & Fink, 2009; Morris & Gelsthorpe, 1991); secondly, it is common to find that women who are victimized at these environments tend not to report these crimes (frequently avoiding to feel revictimized by authorities), thus enhancing gender-based underreporting bias (Quinones, 2020; Scott, 2003; Johnson, 1996); and thirdly, it is worth highlighting the sexual nature of crimes frequently experienced by women in both transit and other environments, while men are rarely victims of sexual assaults in these scenarios, nor feel considerably afraid of it (Warr, 1984). All these issues, along with many others that remain to be empirically documented in countries such as Colombia, may not only help to explain key FoC differences, but also how much does it actually impact their travel behavior.

Stark & Meschik (2018) state that if women's fear has a strong influence on travel behavior, personal security perception should always be considered in public spaces design just as traditional variables such as cost or waiting time. Different locations in public places may also imply different degrees of security/risk perception; for example, bus stops are perceived more dangerous than the bus itself, albeit more crimes are committed while on the bus. Across studies, environmental variables found to influence the security perception in public transportation are (e.g.) crowding, lighting, and time of the day (Orozco-Fontalvo et al., 2019; Cozens & Sun, 2019; Cozens et al., 2003).

Also, Fear of Crime seems to be closely linked to differential behavioral outcomes between genders. Fyhri & Backer-Grøndahl (2012) found that females were more likely than males to perform behavioral adaptations in regard to their usual transport modes, especially in terms of avoiding traveling at certain times (principally by night), changes to routes that often take longer and even avoiding travelling altogether, as a response to Fear of Crime-related perceptions in the transit environment.

Similarly, a more recent study performed in the Dominican Republic found that women, whose degree of security perceived at public transport systems is significantly lower, frequently tend to modify their travel schedules, transportation means (for instance, shifting from buses to taxis at nighttime) and, especially if they have suffered crime-related victimization - or an attempt of it, frequently intend to change their travel routes, and/or to avoid traveling alone (Alonso et al., 2020).

1.4. Measuring FoC: Key considerations and shortcomings in the literature

Measuring FoC has been widely studied by researchers. The main methods for gathering information found in the literature are: official institution surveys (Gallup, 2019; Spicer & Song, 2017; Chataway & Hart, 2016; Yavuz & Welch, 2010), interviews and focus groups (Kash, 2019; Whitley & Prince, 2005; Tulloch, 2003) and authorś designed surveys (Noon, Beaudry, Schier, et al., 2019; Orozco-Fontalvo et al., 2019; Stark & Meschik, 2018). Analysis techniques found in the literature include mapping and spatial analyses (Yates & Ceccato, 2020; Spicer & Song, 2017; Sousa et al., 2017), statistical tests (Noon et al., 2019; Stark & Meschik, 2018), cluster analysis (Tulloch, 2003), confirmatory factor analysis (Chataway & Hart, 2016), regression models (Yavuz & Welch, 2010), and logistic regressions (Ceccato, Langefors & Näsman, 2021; Kash, 2019; Orozco-Fontalvo et al., 2019). However, to the best of our knowledge, we found no evidence of techniques that assess FoC impact in public places security perception.

Another factor that should be considered is the nature and characteristics of public transport systems. For this study, it was addressed the case of BRT systems that, in the light of having been recently developed, *i.e.*. during the last two decades in most cities where they currently operate, offer too scarce evidence regarding user's Fear of Crime and victimization. Although Bus Rapid Transit (BRT) systems offer several advantages over traditional public transportation systems (such as a higher integration among different modes, routes, and greater levels of surveillance all across the system), several shortcomings have been identified in the case of Colombian BRT systems.

For instance, recent studies have problematized several shortcomings and hazardous factors that are still present in these environments, such as the high amount of stressors that affect both drivers and passengers (Calvo & Ferrer, 2018; Useche, Gómez & Cendales, 2017), the saturation of the system at peak-hours (Sarmiento et al., 2020) and the considerably frequent occurrence of security incidents, such as pickpockets, violent theft attempts and women's harassment (Orozco-Fontalvo et al., 2019; Calvo & Ferrer, 2018). In this regard, the accumulated evidence suggests that, especially in emerging countries, security-related issues (highly influenced by economic gaps and social disparities) may impact both the security perceptions and travel preferences and behaviors among BRT system's users (Kepaptsoglou et al., 2020; Calvo & Ferrer, 2018; Hirsch et al., 2018).

2. Methods

2.1. Context of the study: The case of Barranquilla

This study was conducted in the city of Barranquilla, the most populated city in the Colombian Caribbean region, with 1,120,103 inhabitants and 346,988 housing units (DANE, 2018). The city has had an important development in the last few years, attracting both foreign and national investors, despite having a security index of 0.58 on a 0–1 scale composed of indicators such as security perception, murder rates, number of police officers, and percentage of people affected by crime. Also, the city has been ranked 5th out of the six main cities of the country, regarding security index (being the city at the 1st place the most secure, and 6th the most insecure; Cabello et al., 2017).

Regarding the perception of security in public transportation "*Barranquilla: How are we going?*" (BQCV, 2017) conducted a survey including questions on security perception in public places, and results were filtered by income levels[1]. Most high-income inhabitants feel secure in different public places, including public transportation. Meanwhile, 40% of medium-income and 55% of low-income inhabitants feel insecure in public transportation.

The foregoing shows that public transportation is perceived as insecure, the public transportation in the city is composed of traditional buses and the BRT system (where this study is focused) which launched in 2010 and has approximately 14 km of dedicated bus lanes in two corridors and almost 200 km in mixed traffic. The two trunk corridors have 18 BRT stations altogether and there are over 600 bus stops in the feeder routes. The system moves around 150,000 passengers per day with a fleet of 284 buses (Transmetro, 2020). Fig. 1 shows the BRT network and bus stops, geographically the most insecure areas of the city are located in the southern region and given that a great portion of the BRT network operates in this region the fear of being a victim of a crime is latent.

2.2. Study sample and sociodemographic profile of respondents

For this cross-sectional study, we analyzed the data collected from a full sample of $n = 500$ users of the BRT system of Barranquilla (Colombia), through a face-to-face survey applied to 320 female and 180 male users of the BRT system during the period between May to June 2018. The survey collected information about socioeconomic characteristics, perceptions about fear of crime, and a stated preferences section.

Table 1 summarizes respondents' socioeconomic characteristics, in comparison to the last available population census (BQCV, 2019). Regarding gender, we had a participation of 64% females and 36%, males (although respondents could specify non-binary gender options, none of them did so, reason by which this category was deleted for analytic pruposes). Also, it is worth remarking that these shares do not accurately represent population-based percentages, since the objective of this study was to represent, rather, the public transport users profile, for which case there is no study that specifically details these percentages.

In addition, and based on the aforementioned considerations on FoC and victimization at transit environments, we gathered a considerably greater number of female participants, constituting 6.4 out of each 10 study participants. This was due to two reasons: firstly, it is known that both their victimization records and insecurity perceptions (*i.e.*, objective and subjective data) are considerably more prevalent –and in a higher degree– than those corresponding to men, constituting the main victims of on-street sexual harassment (Yavuz & Welch, 2010; Coppola & Silvestri, 2020; UN Women, 2017). Having more "positive" cases having suffered these events allows going a little deeper into the analysis of the problem, having a greater variability to put into the model; and secondly, as a result of their greater willingness to partake in the study, if compared to male subjects, as frequently observed in applied social research (for a summary, please refer to Mindell et al., 2015).

In terms of age, respondents were selected only if they were over 18 years old, which is the legal age. In the sample, we have a majority of young adults from 18 to 35 years old (69%), in line with the population (>18 years) percentages (60%). Respondents over 36 years old represent 31%, as opposed to 40% of the population.

Neighborhood socioeconomic status is used as a proxy for income (Cantillo-Garcia et al., 2019). The socioeconomic status is an area-based classification system used in Colombia in order to divide the households into six levels (from lower to higher), primarily used by public-utility companies for billing purposes.

Therefore, respondents are divided into low (1–2), mid (3–4), and high (5–6) strata areas. In the sample, 55%, 42%, and 3% live in low, medium, and high strata zones, respectively. This is consistent with the population percentages, having only an underrepresentation of high strata respondents, which can be explained by the higher use of private transport among high-income people for commuting (BQCV, 2017). Regarding occupation, most respondents are employed (41%), followed by students (31%) and self-employed (14%). Also, the schooling levels are approximately split between high school graduates, technicians, and college

[1] In the BCVQ (2017) survey, participants responded to the question "*¿se siente seguro o inseguro en el transporte público? (original question in Spanish)*", or "*do you feel secure or insecure in public transportation? (English Translation)*" (dichotomic scale), being characterized according to their income level to analyze the answers provided. For the present study, we used Likert [1–5] scale-based items, in order to increase the sensitiveness of the analyses. For more information, please refer to section 2.3 of this paper.

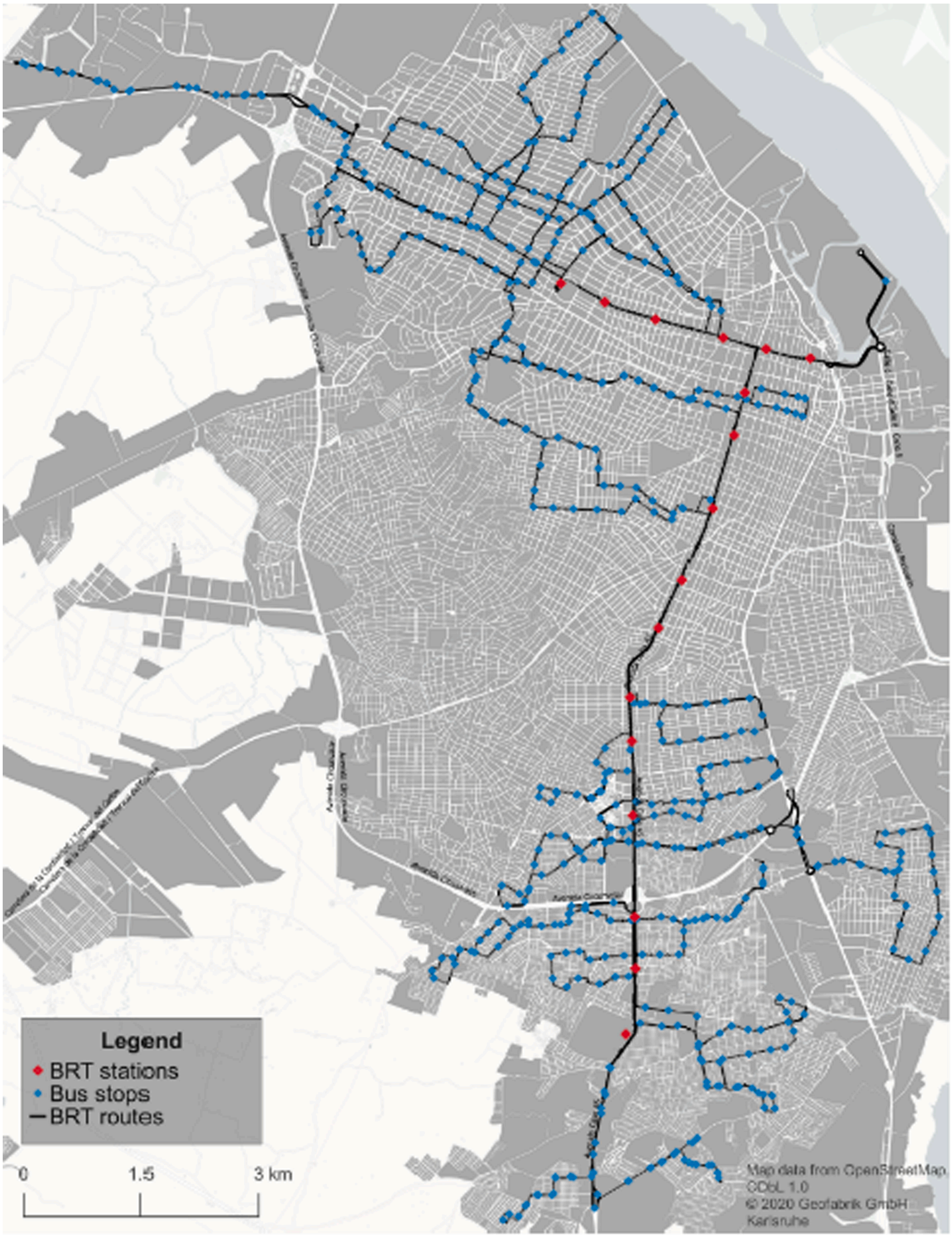

Fig. 1. BRT Network of Barranquilla (Colombia).

graduates. See Table 1 for more details.

Our behavioral hypothesis is that the feeling of being safe or at risk in the public transportation context does not only depend on observable factors like illumination, companionship, or crowding, but also on unobservable individual-specific latent attributes like Fear of Crime (FoC). In this sense, and as initially hypothesized, there is a negative relationship between FoC and security perception. An individual with higher FoC might have more crime awareness and, consequently, penalize more the effect of security issues in the global perception of a transportation system.

Table 1
Sociodemographic profile of respondents.

Socioeconomic Features		Frequency	% of Sample	% of Population[2]
Gender	Female	320	64%	51%
	Male	180	36%	49%
Age	18 to 25	197	39%	22%
	26 to 35	144	30%	38%
	36 to 50	112	22%	35%
	50+	47	9%	5%
Neighborhood socioeconomic status	1 – 2 (lower)	272	55%	51%
	3 – 4 (mid)	212	42%	43%
	5 – 6 (higher)	16	3%	6%
Schooling level	Elementary School	5	1%	16%
	High School	150	30%	24%
	Technician	160	32%	41%
	Graduate	175	35%	18%
	Postgraduate	10	2%	1%
Occupation	Employee	205	41%	47 %[3]
	Student	155	31%	18%
	Self-employed	70	14%	19%
	Unemployed	30	6%	5.4%
	Other	30	6%	4.2%
	Retired	10	2%	3.6%

[3]Source: Barranquilla Encuesta de Percepción Ciudadana 2019 (BQCV, 2019): https://barranquillacomovamos.org/informe/barranquilla-encuesta-de-percepcion-ciudadana-2019/

2.3. Stated preferences experiment

In the part of the survey aimed at assessing participants' stated preferences, hypothetical-choice situations were generated for three specific locations: inside the bus, at bus stops (street environment), and inside main BRT stations. A fractional factorial design was made for each location using N-gene® (Choice Metrics, 2012), obtaining nine blocks with four choice situations each. The attributes used in the experimental design were those found as significant in the literature of security perception and harassment in public transportation, like time of the day (Davidson et al., 2016), surveillance (Allen et al., 2018; Ceccato et al., 2020; Yavuz & Welch, 2010); isolation (Gardner et al., 2017; Davidson et al., 2016; Gekoski et al., 2015; Hirsch & Thompson, 2011); crowding (Gekoski et al., 2015; Hirsch & Thompson, 2011) and lightning (Gekoski et al., 2015). Full design attributes and levels are specified in Table 2.

An image-based experiment was used to easily evaluate all variables considered in the design (Noon, Beaudry, & Knowles, 2019; Orozco-Fontalvo et al., 2019; Hensher & Mulley, 2015). In each choice situation, respondents were questioned whether they feel safe or not by looking at the image shown to them. For some variables, a small text was added for context. Also, drawings were used to overemphasize the design attributes of time of the day and surveillance. This was necessary because, on the pilot survey (applied to 85 people, a month before the final instrument) respondents were sometimes not aware of the attribute of interest when photo-realistic representations were presented, especially for the case of surveillance cameras and police.

Table 2
Attributes and specific scenarios (levels) included in the survey

Attribute	Levels
Time of the day	Day Night
Artificial lighting	Good lightning No lightning
Crowding level	Empty Few passengers Crowded Overcrowded (Bus only)
Companionship	Alone With a woman With a man
Surveillance	None Surveillance camera Police/security staff

In this section, respondents were faced with 8 different hypothetical choice situations[2]. Each respondent was asked about two design blocks, one belonging to the "inside the bus" experimental design and the other to the "bus stop or main BRT station" design experiment depending on which of these locations was more familiar for the respondent. Then, a total of 4,000 (500 respondents) valid pseudo-observations were collected, with 2000 observations (500 respondents) for inside the bus choice situations and 1000 observations (250 respondents) for bus stops and BRT stations. In other words, each respondent faced the bus scenarios (applied to all of them), plus whether (*i*) station scenarios or (*ii*) bus stops scenarios, depending on which infrastructure they typically used to access the system. An example of each one of the scenarios is shown in Figs. 2 and 3, which were accompanied by the question "*Would you feel safe in this scenario?*", the respondent provided a binary *yes/no* answer, these results are presented in Table 3.

In the next section of the survey, respondents were asked to rate in a 1 to 5 Likert scale, ranging from "Low Risk"/"Strongly disagree" to "High risk"/"Strongly agree", with "medium risk" as an intermediate value for mean-scored responses, about their perception of the risk associated with the use of public transportation, considering situations like using the service at nighttime, travel with low illumination, the risk of being robbed or sexually harassed. These indicators were asked for three places: inside the bus, bus stops, and main BRT stations, for a total of 12 perception indicators.

Table 4 shows the variables used in the choice models, dividing them into three groups: socioeconomic characteristics, latent variables, and design attributes. Except for the latent variables, which by construction are continuous variables, the socioeconomic characteristics and design attributes were introduced in the model as "dummy" (values of *success*) variables.

Indicators for the three locations studied (bus, bus stop, and stations) were computed. Table 5 shows the responses for each indicator. In general, respondents seem to feel more insecure at the bus stops, followed by BRT stations and inside the bus. The greatest fear seems to be getting robbed at bus stops, which were the most street-open scenarios. On the other hand, being robbed in the BRT stations presented the lowest FoC reported by participants. However, when it comes to being at risk of suffering sexual harassment, inside-bus locations had a greater percentage of perceived FoC than at bus stops and BRT stations.

In Table 4, reliability measures of the indicators and goodness of fit of the factor analysis can be found. Although not very high, Cronbach's Alpha (α) coefficients were acceptable, suggesting that the indicators included in the latent variable model are reliable and internally consistent. Besides, CFI and TLI show a good model fit for the confirmatory factor analysis conducted on the data, which allows us to include the fear of crime in the hybrid choice model.

In addition, respondents were asked for BRT weekly use and previous experiences with sexual harassment. This makes sense if there is considered that recent studies have shown hw previous victimization experiences (especially those related to sexual crimes) might trigger behavioral changes related to avoidance and precautionary patterns at public transport (Ceccato, Langefors & Näsman, 2021; Alonso et al., 2020). As it can be seen in Table 6, more than half the sample are frequent users (3 + days per week). Also, 44,5% of the female respondents have been victims of some kind of sexual harassment, versus a 26% victimization for male respondents, which includes practices such as leering, whistling, kissing, touching, brushing, and sexual gestures, among others (Australian Human Rights Commission, 2008). It can be observed that *Inside the Bus* is the place where most of the SH happens, as expected, and fewer cases at *Bus Stops* and *BRT Stations*.

3. Model framework

In this research, discrete choice models based on random utility theory were used (Ortuzar & Willumsen, 2011). According to this approach, individuals act rationally, and they choose the alternative that maximizes their utility or satisfaction. Given that the modeler can't know with certainty all the attributes that generate the personal utility for each respondent, only a systematic utility can be modeled, which takes the form of a linear-in-parameters equation and an error term (McFadden, 2001), as in (1) and (2):

$$U_{ni} \geq U_{nj} \forall j \neq i \tag{1}$$

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{2}$$

Traditionally, in discrete choice models, the systematic utility is specified as a linear-in-parameter function of observed attributes, with parameters representing the marginal utility of each attribute. However, as a growing body of evidence reflects, unobservable or latent factors within the traditional framework could explain better the decision-making process in various contexts (Ben-Akiva et al., 2002; Bolduc et al., 2008; Soto et al., 2018). The inclusion of unobservable factors into the choice can be done by integrating a latent variable model into the discrete choice framework and the latent variables in the utility function, as in (3) where Asc_i is the alternative-specific constant and θ and β are parameters to be estimated, the X_q vector corresponds to the design attributes and η_q are the individual-specific latent variables.

$$U_{iq} = Asc_i + \sum_k \theta_{ki} X_{kiq} + \sum_l \beta_{li} \eta_{liq} + \varepsilon_{iq} \tag{3}$$

Assuming ε_{iq} distributes independent and identically distributed Gumbel, it leads to the family of logit models. Our model also included a panel effect to consider correlation among responses of each individual in one location. Given that the survey was physically applied in 3 different locations, the variable "location" constituted a *grouping factor* with three possible excluding values: bus, stations

[2] Obtained after a fractional factorial design, which using Table 3 attributes and levels generated nine blocks with four scenarios each. Each respondent answered two four-choice scenarios.

Fig. 2. SP Choice Situation Examples: *Accompanied by a male (daylight)*.

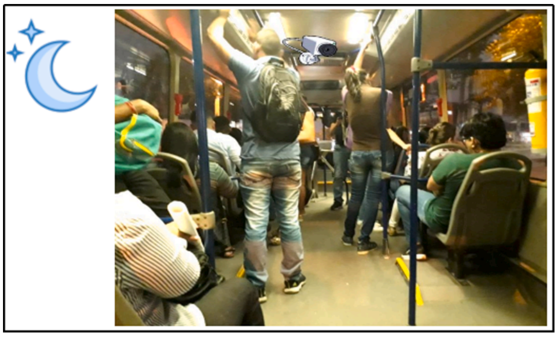

Fig. 3. SP Choice Situation Examples: *Traveling alone (good lighting)*.

Table 3
Answers registered for each hypothetical scenario

Would you feel safe in this scenario?				
Location	**Yes**	**%**	**No**	**%**
Bus	1049	52%	951	48%
Bus stop	606	61%	394	39%
Station	554	55%	446	45%

and bus stops, not possible scenarios with potentially endogenous outcomes. Therefore, the panel effect was specified among observations of the same location within individuals, not across all different locations, to avoid those unobserved effects among locations.

The latent variable model has two parts: the structural equation model, which are the equations that reflect how the latent variables are explained by socioeconomic characteristics; and the measurement model, which expresses the relation between latent variables and indicators. The structural equations were estimated as a function of socioeconomic characteristics and an error term with mean zero and variance normalized to 1, for identifiability reasons.

$$\eta_{liq} = \sum_r \alpha_{lri} S_{riq} + \upsilon_{liq} \tag{4}$$

Where η_{lq} is the latent variable l for respondent q, α_{lr} are the coefficients to be estimated, S_{rq} is the socioeconomic variable r for respondent q and υ_{lq} is the error term.

For the measurement equations, an ordinal logit framework through categorical indicators was used. In this case, when the continuous latent variable lies within some thresholds, it will assume a certain value through a censorship mechanism. If there are m indicators, then m-1 thresholds must be estimated and the first and last ones must be fixed to -∞ and +∞, respectively, for identifiability.

$$C_{piq} = \{1 if (-\infty) < C^*_{piq} \leq \tau_{p1} 2 if \tau_{p1} < C^*_{piq} \leq \tau_{p2} \cdots m if \tau_{p(m-1)} < C^*_{piq} \leq \infty \tag{5}$$

$$C^*_{piq} = \sum_l \gamma_{lpi} \eta_{liq} + \zeta_{piq} \tag{6}$$

Where η_{lq} is the latent variable l for respondent q, C_{pq} is the response of individual q to the indicator p. γ_{lp} and thresholds τ_{pm} are

Table 4
Description of variables included in the integrated choice model

Sphere	Variable	Type	Description
Socioeconomic features	Victim SH	Dummy	1: Previous victim of sexual harassment (Any kind) 0: Other
	Graduate	Dummy	1: Graduate or Postgraduate 0: Other
	Student	Dummy	1: Student 0: Other
	Gender	Dummy	1: Female 0: Male
	Frequent BRT use	Dummy	1: Uses BRT>3 times per week 0: Other
	Age 18–25	Dummy	1: If the respondent is between 18 and 25 years old 0: Other
	Age 26–35	Dummy	1: If the respondent is between 26 and 35 years old 0: Other
	Age 36–50	Dummy	1: If the respondent is between 36 and 50 years old 0: Other
	Medium income	Dummy	1: If the neighborhood socioeconomic status is 3 or 4. 0: Other
	High income	Dummy	1: If the neighborhood socioeconomic status is 5 or 6. 0: Other
Latent variables	FoC – Bus	Continuous	Not observable
	FoC – Bus stops	Continuous	Not observable
	FoC – Stations	Continuous	Not observable
Design attributes	No Illumination	Dummy	1: Space does not have artificial illumination 0: Other
	Travel at night	Dummy	1: The travel is made at nighttime 0: Other
	Empty	Dummy	1: There are no people with the respondent 0: Other
	Overcrowded bus	Dummy	1: The bus is overcrowded 0: Other
	Traveling alone	Dummy	1: The respondent travels without companionship 0: Other
	Police presence	Dummy	1: There is a policeman nearby 0: Other
	Surveillance camera	Dummy	1: There is a surveillance camera 0: Other

Table 5
Response distribution for the three different scenarios.

Location	Indicator	Values					Mean
		1	2	3	4	5	
Inside the Bus	I1 Risk of being robbed	3.6%	14.6%	31.0%	27.6%	23.2%	3.522
($\alpha = 0.66$)	I2 Risk of being sexually harassed	1.6%	12.0%	25.8%	33.8%	26.8%	3.722
	I3 Risk for travelling with low illumination	1.6%	6.8%	26.0%	43.6%	22.0%	3.776
	I4 Risk for using the service at night	1.4%	7.2%	34.8%	42.2%	14.4%	3.61
Bus Stops	I5 Risk of being robbed	0.2%	1.4%	10.6%	33.2%	54.6%	4.406
($\alpha = 0.64$)	I6 Risk of being sexually harassed	5.0%	25.2%	30.2%	28.4%	11.2%	3.156
	I7 Risk for travelling with low illumination	0.6%	1.4%	7.8%	41.8%	48.4%	4.36
	I8 Risk for using the service at night	0.2%	1.0%	11.0%	38.2%	49.6%	4.36
BRT Station	I9 Risk of being robbed	5.0%	20.4%	37.2%	30.2%	7.2%	3.142
($\alpha = 0.71$)	I10 Risk of being sexually harassed	8.0%	29.0%	33.6%	22.6%	6.8%	2.912
	I11 Risk for travelling with low illumination	1.2%	6.4%	25.2%	37.2%	30.0%	3.884
	I12 Risk for using the service at night	2.4%	9.6%	33.2%	41.6%	13.2%	3.536
Observations				500			
CFI (>0.9)				0.951			
TLI (>0.9)				0.925			

Table 6
Prevalence of Sexual Harassment Victimization.

Sexual Harassment	Male	Female
Frequent BRT use	58.6%	53.1%
Victim of sexual harassment	26%	44.5%
Inside the Bus	3.9%	13.7%
At Bus Stops	20.4%	27%
At BRT Stations	3.3%	11%

parameters to be estimated and ζ_{pq} is the error term. Under the assumption that the error term (ζ) follows a logistic distribution, the probability of observing C_{piq} within a discrete indicator or category m, can be written as (7).

$$P\{C_{piq}\in k|\eta_q\} = \frac{1}{1+e^{-\left(\tau_{pk}-\sum_l \gamma_{lpi}\eta_{liq}\right)}} - \frac{1}{1+e^{-\left(\tau_{p(k-1)}-\sum_l \gamma_{lpi}\eta_{liq}\right)}} \tag{7}$$

Then, the joint probability of observing choice and the indicators is estimated as the product of the probabilities of the choice component and the latent variable model. Where $P(.)$ is the choice probability, $f(.)$ is the density function of the measurement equation and $g(.)$ is the density function of structural equations (8):

$$\underline{P}(y_{iqt},\ C_q|X_{qt},S_q,\theta,\beta,\tau,\gamma,\alpha,\Sigma_\varepsilon,\Sigma_\zeta,\Sigma_\upsilon) = \int_n P(y_{iqt}|X_{qt},\eta_q,\theta,\beta,\Sigma_\varepsilon) f(C_q|\eta_q,\gamma,\tau,\Sigma_\zeta) g(\eta_q|S_q,\alpha,\Sigma_\upsilon) d_{\eta_q} \tag{8}$$

Fig. 4 graphically shows the final structure of the selected hybrid choice model. Variables in rectangles are observed, like socio-economic characteristics, design attributes, or responses. Latent constructs like latent variables and utility are unobserved and represented with ovals. For simplicity of the graph, it only shows four indicators, even though each indicator was asked for each location separately.

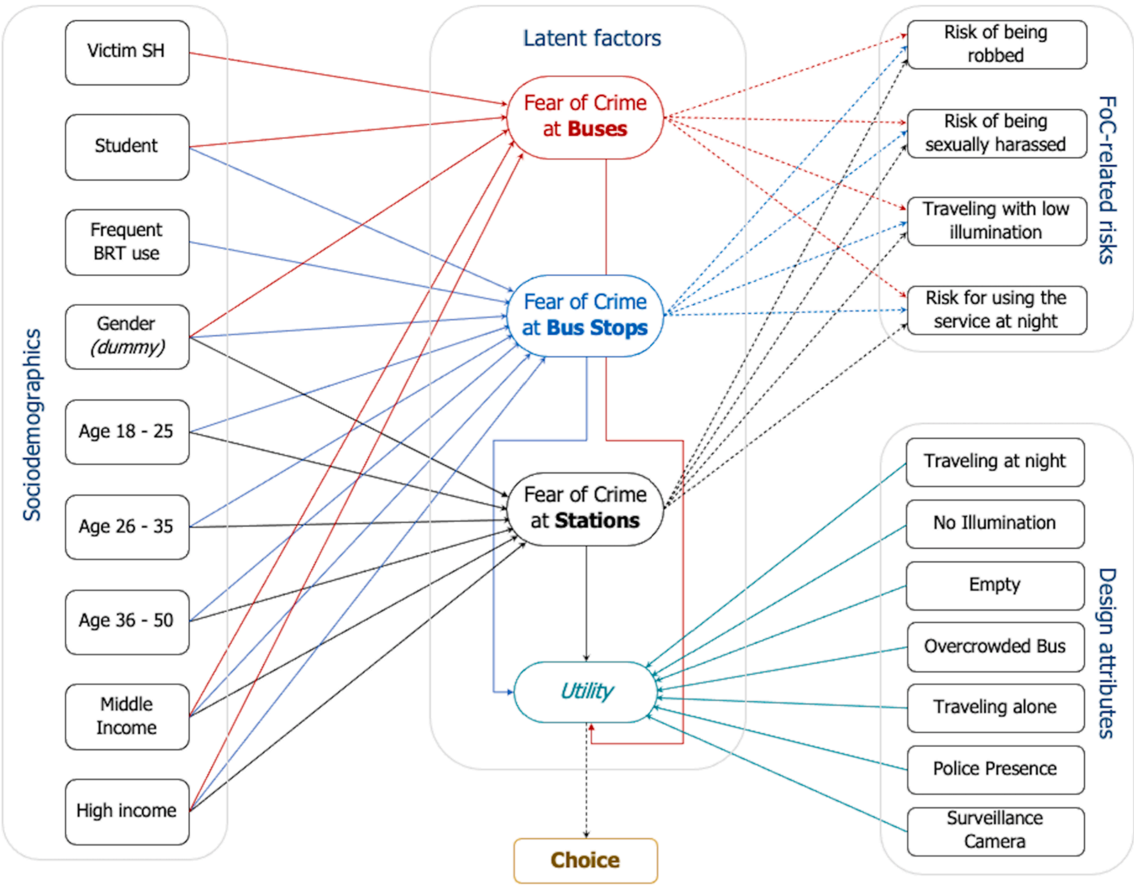

Fig. 4. Structure of the Hybrid Discrete Choice Model.

4. Results and Discussion

Results are summarized in Tables 6 to 8. Table 6 corresponds to the structural equation model; Table 7 shows the measurement model and Table 8 shows the choice models. A mixed logit with panel effect was estimated along with the hybrid choice model for comparison. All models were estimated by simulated maximum likelihood, using Modified Latin Hypercube Sampling (MLHS) draws (Hess et al., 2006) on the software Ox, version 7.1 (Doornik, 2015).

4.1. The structural equation model

Table 7 shows the results of the structural equations for each latent variable in the hybrid choice model. It can be observed that the strongest predictor of FoC is gender, given the largest coefficient on every latent variable, as found by Henson & Reys (2015). The significant model outcomes suggest that, as male subjects statistically report higher victimization rates than females, and these results could be thus interpreted in a first glance as in line with the so-called "gender-paradox", there can be several factors to consider prior to endorse this hypothesis. Firstly, and given that women commonly experience higher physical and psychological harassment, we could count on a great extent of "hidden violence" episodes, that are rarely reported, and sometimes even underestimated as victimization incidents by the victims themselves (Quinones, 2020; Loukaitou-Sideris & Fink, 2009; Franklin, Franklin, & Fearn, 2008). Secondly, recent studies have found that women's fear for sexual assault could make them more prone to be afraid of all forms of crime (Ozascilar, 2013; Rader, 2017). Said in other words, it might be expectable that the actual victimization rates of women (if non-registered violence was accounted), their fear of crime levels would, indeed, match with their likelihood to suffer a crime, hence contributing to debunk the "gender-paradox" hypothesis (Lane, et al., 2014). Also, and contrary to results found by Ferrero (1995), previously sexual harassment-victimized participants have a higher FoC and this happens *inside the bus,* where indeed most of these events tend to occur (Orozco-Fontalvo et al., 2019).

In terms of age, there is a higher fear of crime in the 26 to 35 range, followed by the 18 to 25 range in bus stops. A lower fear of crime by the younger transit riders could be because most respondents in this age segment are students, which tend to have lower fear of crime. Besides, older people tend to see themselves as more vulnerable when traveling (Tulloch, 2000), hence a higher fear of crime.

Regarding participants' income, we found an inverse association with their Fear of Crime, the higher the income, the lower was the FoC reported on every location. This could sound odd at first, but it has been found that FoC is higher in low-income or socially economic deprived areas (Loukaitou-Sideris, 2014; Yavuz & Welch, 2010). This is explained as resulting from higher crime rates and the fact that users from low-income zones are captive users of public transportation (Gardner et al., 2017; Loukaitou-Sideris, 2014).

Also, high-income users tend to use the system in more secure zones. Besides, these users do not go to the most insecure bus stops and their trips are not from/to insecure zones, also, some studies suggest that high-income people are more able to overcome crime situations most rapidly such as theft (Vauclair & Bratanova, 2016; Schulz et. al., 2012); hence, their FoC could be lower, while its impact on low-income people makes them feel vulnerable.

4.2. The measurement model

Even though the results of the measurement equations are not directly used for evaluating the hybrid choice model, it is important to examine it to verify the overall suitability of the results and to verify whether latent variables are significantly explaining indicators. As it is presented in Table 8, all the estimated parameters were positive, a fact that is consistent with the expected signs, as to higher FoC the perception of risk for every indicator should be higher too. Besides, the threshold parameters are also significant, which means that the ordered model proposed herein adequately represents the responses captured through the indicators.

4.3. The choice model

The results from the two choice models are shown in Table 9. Regarding model fit, it should be noticed that by including the latent variables in the model we achieve a better fit of the model in terms of log-likelihood and a slight increase in First Preference Recovery

Table 7
Structural Equation Model, showing sociodemographic variables (left column) and latent factors.

Sociodemographic variables	FoC – Bus		FoC - Bus stops		FoC - BRT Stations	
	Coeff.	T-test	Coeff.	T-test	Coeff.	T-test
Victim SH	0.586***	5.629				
Student	−0.222**	−2.401	−0.319***	−3.208	−0.188**	−2.000
Frequent BRT use			0.168	1.840		
Gender (Female Dummy)	1.084***	10.750	1.125***	9.858	0.786***	8.798
Age 18 – 25			0.335*	1.965	0.305**	2.012
Age 26 – 35			0.456**	2.578	0.468***	2.965
Age 36 – 50			0.121	0.700	0.379**	2.420
Medium Income	−0.328**	−3.713	−0.078	−0.838	−0.242**	−2.826
High Income	−0.466	−1.792	−0.480	−1.731	−0.333	−1.291

Notes for the table: *significant at $p < 0.05$ level; **significant at $p < 0.01$ level; ***significant at $p < 0.001$ level.

Table 8
Latent variables, indicators, estimates, and thresholds appended in the significant model.

Latent Variable	Indicator		Coefficient	Thresholds			
				1	2	3	4
Fear of crime - Bus	**I1**	Coefficient	1.07	−3.37	−1.31	0.60	2.22
		t-test	11.03	−12.99	−6.58	3.13	10.46
	I2	Coefficient	1.04	−4.14	−1.69	0.06	1.94
		t-test	10.62	−13.61	−8.72	0.30	8.25
	I3	Coefficient	0.93	−4.12	−2.31	−0.26	2.13
		t-test	10.37	−13.55	−11.60	−1.53	11.40
	I5	Coefficient	1.20	−4.46	−2.36	0.38	3.15
		t-test	10.25	−12.36	−9.64	1.80	12.69
Fear of crime - Bus Stop	**I6**	Coefficient	0.90	−5.89	−3.78	−1.51	0.62
		t-test	8.70	−8.10	−12.62	−8.11	3.41
	I7	Coefficient	0.94	−2.58	−0.20	1.40	3.39
		t-test	9.92	−11.67	−0.98	6.01	11.84
	I8	Coefficient	1.00	−4.79	−3.54	−1.78	1.00
		t-test	8.48	−10.64	−12.22	−8.68	5.18
	I10	Coefficient	1.21	−6.00	−4.16	−1.48	1.15
		t-test	8.72	−7.99	−11.09	−6.29	5.08
Fear of crime - Station	**I11**	Coefficient	1.45	−2.99	−0.58	1.72	4.42
		t-test	11.40	−10.41	−2.44	6.89	14.17
	I12	Coefficient	1.37	−2.33	0.16	2.17	4.39
		t-test	11.68	−9.61	0.69	7.85	12.95
	I13	Coefficient	1.12	−4.37	−2.37	−0.20	1.83
		t-test	10.96	−12.64	−10.91	−1.08	8.97
	I15	Coefficient	1.28	−3.80	−1.78	0.63	3.34
		t-test	11.38	−12.57	−7.83	2.90	12.76

(FPR). This means that shared predictions are very similar between models, which was expected due to the simple nature of the choice, a binary one. However, FoC is significant in the perception of security in public transportation and its inclusion in the utility improves the understanding of the decision-making process, as the resulting model is richer in behavioral insights than its mixed logit counterpart.

As the choice was binary – yes/no answer to a "*Do you feel safe/secure?*" question- the model was estimated using utility as a representation of security. Hence, a higher utility means a higher perception of security in transit environments. As expected, the directionality of association of the latent variables was negative. This means that, with a higher FoC, the perception of security tends to be lower, as observed in several studies addressing the topic (e.g., Lusk et al., 2019; Prieto-Curiel & Bishop, 2018; Lorenc et al., 2013; Hirsh & Thompson, 2011). In fact, the FoC perception *inside the bus* has the highest negative effect on the utility, followed by *bus stops*. In the case of *BRT Stations*, the latent variable turned out to be non-significant, as gender alone on the utility outweighs the effect of the FoC latent variable.

To address the different impacts of the context into our model specification, due to different sample dimensions according to the context -larger for *inside the bus* in comparison to *bus stops* and *BRT Stations*-, we used specific coefficients per context and scale factors. Using the scale for inside the bus as a reference fixed equal to 1, the scale factor for the other locations were lower than one, which gave us a hint of a higher variance, as expected for the lower sample size. However, the robust *t*-test outcome was below 1 for both cases, so we decided to exclude them from the final model and to keep only the specific coefficients per context, which performed well.

Regarding the design attributes, crowding *inside the bus* has the highest negative coefficient, probably related to the fact that most sexual harassment and pickpocket are inside the bus in crowding conditions (Hirsch et al., 2016; Orozco-Fontalvo et al., 2019). Also, traveling at night has an important negative effect on the perception of security, as expected by the literature review. The lack of illumination also has a negative impact on the utility, as it has been found to influence the perception of security among public transport users in the country (Oviedo-Trespalacios & Scott-Parker, 2017). Also, traveling alone and isolated places have also shown to be significant negative factors in the utility function, as highlighted in previous studies carried out in Latin American countries (Alonso et al., 2020; Orozco-Fontalvo et al., 2019; Sousa et al., 2017).

The factors with a positive impact on the utility are related to surveillance by cameras or by policemen (or security staff). In fact, the police presence has a higher positive impact than the presence of security cameras, as cameras are seen to be helpful to record but not to prevent the crime.

Regarding the comparison among locations, we can see that traveling at night and an empty location is related to a higher perception of insecurity on bus stops in comparison with inside the bus or BRT stations. This is expected due to the nature of the location, as is perceived as more insecure for the respondents (Orozco-Fontalvo et al., 2019). The lack of illumination also has a high negative impact on the security perception, and is higher on BRT stations and Bus stops, as buses could have street illumination when traveling. It is interesting to notice that on buses, there is a higher perception of insecurity on the two ends of the number of people inside, as being alone and being on an overcrowded bus have negative values. In these cases, probably the fear itself is not the same, as crowding is related to pickpocketing and an empty location could be related to other crimes and sexual assault, as similarly seen in the case of a previous study partfoemed in Brazil by means of a spatial analysis (Sousa et al., 2017). Finally, and as for it refers to the

Table 9
Discrete Choice Models: summary of parameters and results.

Variable	Location	ML[1]		HCM[2]	
		Coefficient	*t*-test	Coefficient	*t*-test
	Bus	1.660***	7.041	1.611***	6.551
	Bus Stop	1.132***	5.446	1.218***	5.319
	BRT Station	0.427**	2.142	0.402*	1.973
Night Time	Bus	−1.455***	−8.253	−1.481***	−8.135
	Bus Stop	−1.719***	−10.981	−1.726***	−10.791
	BRT Station	−1.484***	−9.201	−1.442***	−8.966
No Illumination	Bus	−0.931***	−5.845	−0.873***	−5.595
	Bus Stop	−0.941	−0.941	−0.931***	−5.783
	BRT Station	−1.083***	−6.536	−1.062***	−6.491
Empty	Bus	−0.472**	−2.621	−0.492**	−2.674
	Bus Stop	−0.765***	−4.834	−0.766***	−4.809
	BRT Station	−0.483***	−3.053	−0.479***	−3.077
Crowding	Bus	−3.557***	−14.948	−3.638***	−14.542
Traveling Alone	Bus	−0.977***	−6.630	−1.000***	−6.638
	Bus Stop	−0.610***	−3.821	−0.607***	−3.789
	BRT Station	−0.719***	−4.480	−0.700***	−4.418
Surveillance Camera	Bus	1.165***	7.147	1.194***	7.136
	Bus Stop	1.263***	7.244	1.274***	7.183
	BRT Station	2.175***	10.937	2.100***	10.391
Police Presence	Bus	2.899***	13.678	2.954***	13.462
	Bus Stop	3.252***	14.602	3.264***	13.994
	BRT Station	3.302***	14.949	3.197***	13.994
Gender	Bus	−0.650***	−4.041		
	Bus Stop	−0.536***	−3.069		
	BRT Station	−0.793***	−4.581	−0.918**	−2.628
Fear Of Crime	Bus			−0.566***	−4.548
	Bus Stop			−0.457***	−3.336
	BRT Station			−0.184	−0.490
Panel Effect	SIGMA	−0.625***	−6.516	0.436**	2.773
Parameters		26		27	
Observations		3992		3992	
MLHS Draws		500		500	
LL Hybrid Choice Model				−16290.3	
LL Discrete Choice Model		−1893.87		−1890.18	
FPR		78.43%		78.56%	

Notes for the table: [1]ML = Mixed logit;
[2]HCM = Hybrid Choice Model.

surveillance-related variables, it is interesting to notice that police or surveillance bodies' presence is reassuring in all locations almost to the same degree. However, when it comes to the presence of surveillance cameras, the coefficient is much higher on BRT stations in comparison with the other two locations addressed in the study.

4.4. Implications for policy

To evaluate the effect of socioeconomic characteristics on the choice, we estimated the probabilities of the chosen alternatives by sample enumeration. Fig. 5, there are shown the estimated probabilities of feeling unsafe by socioeconomic characteristics in a grouped boxplot. As previously analyzed, the greatest increase among socioeconomic characteristics belongs to gender, as women feel significantly more unsafe than men in public transportation. Also, it can be observed that low-income respondents have the highest unsafe percentage among income bands, with high income having the lowest. Also, young, and middle-aged respondents have a higher percentage of feeling unsafe than older people.

According to both previous studies and this research case, gender has shown to be the greatest predictor of fear of crime in transportation settings (Derksen, 2012; Sutton & Farrall, 2005). In Fig. 6, we performed a series of simulations using the socioeconomic variables, following a similar exercise done by Hess et al. (2018). In each row of the figure, representing one socioeconomic variable, we simulate the probabilities if all respondents had such characteristics.

For instance, we calculate the probabilities if all respondents were women or if all were men. Then, we compare the probabilities with the base probabilities estimated with the HCM and calculate its deviation. A negative value implies a decrease in the security

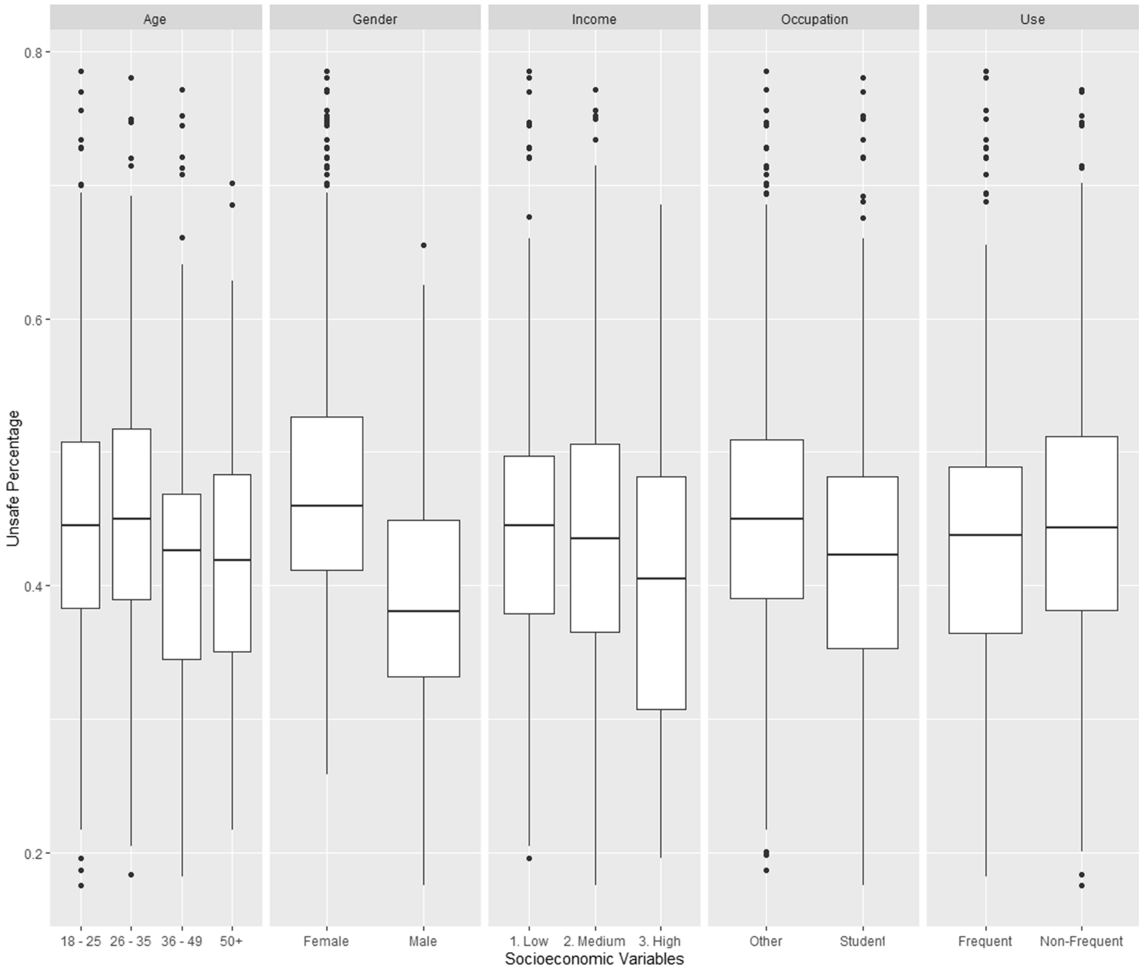

Fig. 5. Probability of feeling unsafe at the BRT system.

perception and a positive value indicates an increase in the security perception.

It can be seen that the variable that has the highest impact is gender, as there are the higher decreases in terms of security perception if respondents are female, and the highest increase takes place when respondents are male. Also, a variable with a high negative impact is being a victim of sexual harassment inside the buses. The higher positive impacts are related to a higher income and people over 50 years old. These two variables are also linked to lower use of BRT daily, as higher-income users are not captive transit users and older people tend to travel less frequently.

To encourage public transportation use and lower the fear of crime perception among users (especially women) would require the implementation of hard (punitive) and soft measures (campaigns). A first set of strategies that can be derived from the estimated models involve tightening surveillance measures, with CCTV cameras and police enforcement.

Despite police presence and surveillance remains more desirable for respondents, CCTV cameras could be used for legal matters and crime enforcement. However, there is a need to encourage apprehension and punishment with these tools, to reassure users' confidence and to lower fear of crime. Increasing police presence in BRT stations and installing CCTV cameras on bus stops and buses would improve security perception. Also, the results suggest that lighting improvement during nighttime is desirable, especially at bus stops and low-income neighborhoods, as endorsed by Cozens et al. (2003) and Squires (2003) in previous studies carried out in the United Kingdom. At the same time, *soft measures* regarding fear of crime-related perceptions should be developed to influence people's perception of insecurity.

As reasonable and complementary alternatives to strengthen other actions, crime apprehension campaigns (*i.e.*, those usually developed when crime rates increase) and Crime Perception Through Environmental Design (CPTED) measures have shown a certain effectiveness in low-income neighborhoods and school environments, especially among users unable to easily choose alternative transport means (Lusk et al., 2019; Vagi et al., 2018), as it was the case of most of our study participants, even though the essential sample-related differences derived from our very specific context of study.

Precisely in this regard, a recent systematic review highlights how Fear of Crime could be better understood through place-based approaches (Solymosi, Buil-Gil, Vozmediano & Guedes, 2020); in other words, situational factors must be considered both for

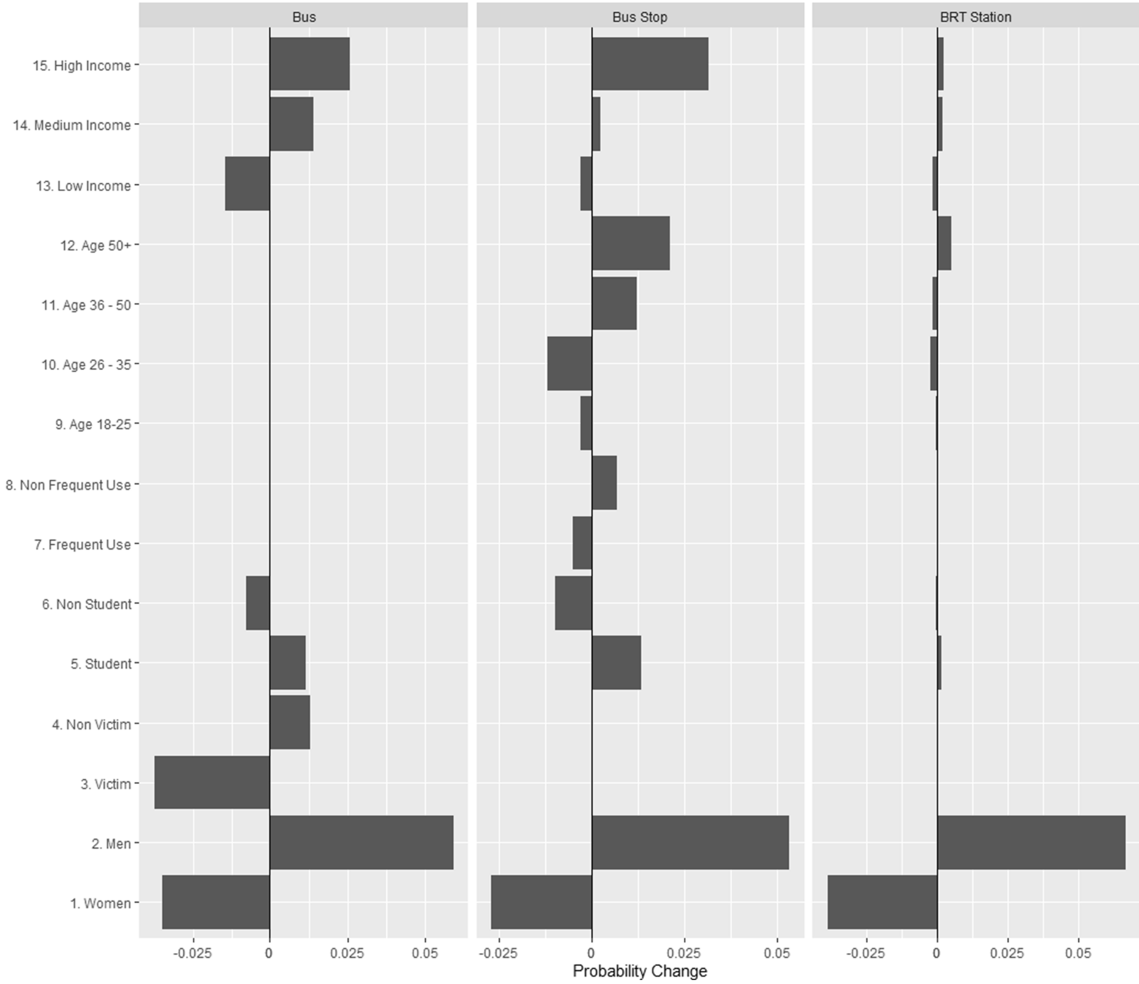

Fig. 6. Socioeconomic variables-based simulation results.

understanding users' perceptions in transit environments, but also to develop more effective problem-solving approaches and measures (Solymosi, Bowers & Fujiyama, 2015; Wiebe et al., 2013; Newton, Johnson & Bowers, 2004), in consideration of the opportunities and potentialities given by systematic interventions that are constantly re-evaluated and improved over time (Cozens & Sun, 2019). Of course, it is worth mentioning that an important percentage of campaigns should be targeted at women (the most affected gender-based group), in order to not only increase security perceptions and reduce fear of crime, but also to enhance the necessary objective conditions they need for safely using public transportation.

4.5. Limitations of the study

Although the data sources and sample size were considerably extensive, covering different sociodemographic profiles of BRT users and travel patterns, and all essential statistical parameters were accurately and positively tested during the data analysis phase, some key technical limitations potentially affecting the results of this study should be acknowledged. Firstly, the data used in this study corresponds to a considerably large number of observations and pseudo-observations that, although representing the case of BRT systems in Barranquilla (Colombia), remains short to be extrapolated to other systems, cities, or cases (whose conditions may substantially vary), so that the outcomes of the study should be carefully interpreted, preventing us from making generalizations without firstly considering the specific conditions and dynamics of the context addressed. Even though, it is worth remarking that the outcomes of this study keep several similarities (including measures of association, their directionality/significance and gender-based differences), that provides a good support on the validity of the results and model presented.

Regarding the modelling framework, we acknowledge that the endogenous variable it's more a perception than a choice itself, and we are not explaining a hypothesized behavioral choice (that indeed does not guarantee the behavior declared, neither), but the feeling potentially triggering it, at best. However, perceptions such as safety/security (Coppola & Silvestri, 2020) and transit service quality (dell'Olio et al., 2010) have been modeled through discrete choice models.

Another issue is that our survey enquired about security as a perception; this measure -although psychometrically reliable- remains subjective, and should not be equalized to objectively assessed security that could be, rather, estimated through fixed indicators we did not address in the study. Despite this, FoC has been measured as a yes/no question on previous cases (Prieto-Curiel & Bishop, 2017; INEGI, 2018). Besides, if we consider that the survey addressed a set of topics embodied in the current social discussions and directly affecting the BRT user's daily experience, several social concerns related to factors such as poverty, inequalities and insecurity may emerge, as observed in previous studies addressing topics perceived as sensitive by the population, such as crime, fear of crime and victimization (Derksen, 2012; Sutton & Farrall, 2005). In other words, these studies suggest that sensitive topics could be stigmatized, and therefore affect study outputs, even though technical remedies put in the research procedure (e.g. anonymity and strictly scientific use of the data) were clearly guaranteed to the study participants.

5. Conclusions

In this research, we estimated a hybrid choice model to study the perception of security in public transportation in different locations of the BRT system in Barranquilla, Colombia. Results show that the inclusion of the FoC in the estimated models could be a more appropriate representation of the behaviors when security is assessed in the public transportation context.

The estimated models suggest that FoC has a negative influence on the perception of security. The greater decrease in utility perception occurs inside the bus, followed by bus stops and is non-significant in BRT Stations, outweighed by gender. At the same time, the strongest predictor for FoC has clearly been gender. A frequent public transportation user has a higher FoC in the bus stops, and a victim of sexual harassment has higher FoC inside the bus, where most events of harassment occur.

Regarding the relationship between income and FoC, the higher the income, the lower the FoC. This could be associated with safer neighborhoods and fewer captive users of the public transportation system. Traveling at night or without illumination, being alone and crowding are attributes with high disutility. Meanwhile, surveillance cameras and police presence are desired attributes, with police presence having a higher positive effect than surveillance cameras, as the latter are seen as helpful to record but not to prevent the crime. Based on the foregoing, transportation systems should provide security features such as CCTV cameras (and letting people know they are being recorded) and security staff presence in both bus tops and inside the vehicles. Also, providing good lighting and removing blind spots through environment design in bus stops and stations could decrease FoC. These actions should be prioritized in low-income zones and given that the main FoC factor for women is sexual harassment risk, this issue should be addressed specifically by strengthening legislation against sex offenders which has been proved to be the main barrier. (Orozco-Fontalvo et al., 2019; Lorenc et al., 2013).

Further research should evaluate the influence of FoC on mode choice at different times of the day and by gender, to consider this experience and to be able to make better public transportation policies mostly in the cities, especially for captive users or people at lower income levels.

CRediT authorship contribution statement

Jose Soto: Conceptualization, Formal analysis, Writing – original draft, Methodology, Software, Writing – review & editing. **Mauricio Orozco-Fontalvo:** Conceptualization, Formal analysis, Writing – original draft, Methodology, Data curation, Writing – review & editing. **Sergio Useche:** Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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