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Perception of safety in Public Transport in Brazil

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Abstract

This current study examines the perception of safety on the public bus transit system in a large Brazilian metropolis. Using a web-based survey, the study reached a convenient sample of bus users of a local university who were victims and witnesses to crime in two different types of local bus transit environments - the BRT MOVE - a modern bus system and its opposing counterpart - the conventional bus system. Research questions investigate whether or not riders' perception of safety is influenced by the presence of mechanisms of control and surveillance on buses. Using a linear regression model, this study hypothesizes that the perception of safety among victims and/or witnesses to crime varies according to exposure to risk in different bus transit systems. Limitations of the results were addressed and reliability and validity issues were reviewed. This study demonstrates the relevance of different types of risk factors on riders' perception of safety on buses, bus stops, and stations. This contributes to widening the range of public transit safety solutions in Brazil.

Keywords: crime on buses; perception of safety among college students; public transit crime, web-based survey; fear of crime

1. Introduction

The alarming and systematic increase of crime on buses in Brazil and other countries in Latin America, often announced by the media, operates as a catalyst for the feeling of fear and insecurity among millions of people who depends on the bus system as their main form of transportation (Paes-Machado & Viodres-Inoue, 2015; Natarajan et al., 2015). In Brazil, a survey conducted by the National Confederation of Public Transport in 2015 identified bus crimes as one of the greatest problems faced by the ridership, which represents approximately 25% of the country's entire population. Anxiety and uncertainty are constantly being generated among passengers, bus drivers, and conductors surprised by the unexpected, fast, and violent actions of offenders during their commute (Oliveira, Natarajan & Silva, 2019). Offenders are usually armed youths, working in pairs, looking for opportunities and immediate results, i.e.: stealing money, mobile phones, and other electronic devices (Oliveira et al., 2019).

While bus crime is not always reported to the police, it has been detrimental to bus drivers and conductors, according to a study carried out by the National Confederation of Public Transport in Brazil in 2016. Based on a sample of 1000 bus drivers in 169 Brazilian municipalities, this study showed that armed robbery and physical and verbal assaults were found to be the most common and highest number of crimes faced by bus drivers. In addition, it demonstrated that the fear of being a victim of crime is the second most common reason why bus drivers and conductors look to resign earlier than would be otherwise deemed usual. This has also contributed to compromising the access to mobility of the population in general and thusly demands a deeper analysis with the goal of gaining more control and prevention of the issue.

To paraphrase the 2017 National Public Transport Quality Survey, with 59 thousand participants from all Brazilian regions, the lack of safety in buses has surfaced as the most important issue for riders according to 32% of the people who were interviewed. Half of these respondents declared that they feel most unsafe inside the vehicles, while the other half designates bus stops to be the most unsafe and insecure locations (National Public Transport Quality Survey, 2017).

According to Delbosc and Currie (2011), the occurrence of public transport crime creates a "cycle of fear" among passengers: the fear is intensified by the decrease in the use of public transport, which in turn further weakens the informal control mechanisms of crowded vehicles. In their 2015 study of crime on buses in Brazil, Paes-Machado and Yvories indicate that the exposure of victims to violent and threatening action during bus travel might lead to devastating consequences for the mental health and behavioral habits of both the victims and witnesses. The coercive use of firearms and the use of terror via threats as well as psychological and verbal abuse leave victims of bus crimes feeling trapped and impotent (Paes-Machado & Viodres-Inoue, 2015; Jacobs, 2012, 2013).

The perception of fear and safety in the public bus environments and its consequences for urban mobility is undoubtedly a very important issue for security policies in public transport systems in Brazil. Some innovations to increase the comfort and safety of passengers as well as improve the efficiency of the bus transit is demonstrated by the implementation of the Bus Rapid Transit (BRT). The BRT system was created in 1974 by Jaime Lerner, an architect and mayor of the city of Curitiba, in the state of Porto Alegre, Brazil; it aimed to improve urban mobility and has been widespread in the country's largest metropolises, such as in Sao Paulo, Rio de Janeiro, Belo Horizonte, and Goiania.

Consisting of large and articulated collective vehicles, the BRT is considered more efficient, predictable, rapid, and comfortable than the conventional bus system, which is often perceived as slow, uncomfortable and chaotic. The BRT features new technologies such as CCTV video cameras inside buses and stations; advance payments; the redesign of bus stops like closed mini-stations with automatic doors and turnstiles for passage circulation; bus lanes segregated from car vehicles; and the increase of physical surveillance. All of these mechanisms seemed to increase not only the efficiency of the bus transit environment but also the perception of safety among bus workers, passengers, and the public in general. This is in line with the Routine Activities theory (Hollis & Felson, 2013) which assumes that increased capable guardianship at suitable targets (e.g., private security and CCTV cameras) and the implementation of controlling mechanisms or managers at specific places and/or risk facilities (e.g., bus station managers and staff, and alarm buttons on buses) have the potential to reduce and prevent crime. What constitutes a risky facility is defined by Eck and Clark (2016), as an environment with special functions with high risk of crime. This is exemplified by bus stops, due to their increased rates of crime compared to other environments in the bus system, such as on buses, as suggested by Ryan Gale, 2013, and Hart and Miethe, 2014. Risky facilities are also crime attractors as defined by Bowers, 2013, due to the concentration of opportunities available for criminal offending.

Based on empirical research, this current study brings a pioneering perspective on the perception of safety among victims and witnesses to crime on diferent types of bus system environments, controlled by conditions of objective and vicarious victimization. The study considers the complexities of the bus transit environments in a Brazilian metropolis, characterized by the coexistence of BRT MOVE - a modern bus system - and its opposing counterpart, the conventional bus system. It is aimed at answering two basic questions: (1) Does the perception of safety within bus systems vary among riders controlled by factors of socio-demographic background, locality of residence, exposure to risk (measured by frequency of ridership) as well as exposure to crime (victims and/or witnesses to crime)? (2) Does the perception of safety among riders vary according to the type of bus transit system? It hypothesizes that the perception of safety among victims and/or witnesses to crime varies according to exposure to risk in different bus transit systems. One's perception of safety would be reduced at bus environments (or risky facilities) characterized with greater vulnerability due to the lack of mechanisms of control and surveillance.

Using a web-based survey to reach a convenient sample of bus users - administrative staff, students, and faculty members of a local university - and applying a linear regression model, this study expands the knowledge on the relevance of the exposure to different types of risk factors and crime on the perception of safety on buses. This information might also contribute to widening the range of crime prevention policies and alternative solutions that embrace a more humanized view of public transit safety. One of the contributions of this study was to demonstrate that the exposure to the risk of victimization, measured by the frequency of travel use, varies in the two bus environments analyzed and is statistically significant in decreasing the sense of security of victims and/or witnesses of crime in the conventional bus system. On the contrary to the Municipal BRT MOVE system, the conventional bus system lacks the presence of capable mechanisms of surveillance to discourage potential offenders from committing crimes as suggested by the Routine Activity theory. We argue that this might be explained by the infrastructure, quality of maintenance, and design of bus stops - variables that should be explored in future research. The results suggest that the characteristics of the bus itself as well as bus stops are crucial factors in the perception of safety.

2. Literature Review

Transport crime (defined as crime related to buses, trains, rail stations, and bus stops) is a serious problem that causes fear and insecurity among millions of people who depend on public transport systems for everyday travel (Natarajan et al., 2015). In the megacities of Latin America, armed robberies, thefts, and sexual harassment, particularly against

women, in buses, trains, or subways (Yanes-Pagans et al., 2019) make up one of the greatest obstacles to safe, efficient, and high-quality public transport service. The growth of crime in public transport increases economic and operational costs for the city and public transport companies, generating a series of interdependent and relational losses, such as a general decrease in the quality of riders, an increased preference for private vehicles, and the consequent growth of traffic congestion (Newton, 2014). Studies point to many deficiencies that become hurdles to safety and prevention of crime in public transport, such as the absence or inefficiency of protective measures on vehicles, bus stops, and stations as well as the protection of employees and passengers (Yanez-Pagans et al., 2019). All these elements have drastic implications for the quality of urban mobility, which may be visible in the increased stress and anxiety among victims and public transport professionals, including increased absenteeism and chronic mental illnesses (Sousa et al., 2017); accordingly, public health in cities is compromised.

However, according to Rader (2017), the perception of fear is a great challenge for public security. Many factors are intertwined with the occurrence of the emotion, such as gender, age, race, social class, and so on (Rader, 2017). Fear influences social dynamics and urban mobility from the political and economic points of view (Hernandez & Titheridge, 2016; Soto, Orozco-Fontalvo & Useche, 2017). Investigating fear and the perception of safety among passengers seems to us to be essential for more humanized and efficient safety and prevention policies on the bus transit system.

While the risk of victimization and insecurity are chronic issues in public transport, particularly in Latin America and other developing regions where the bus system is the most common way of public transportation (Oliveira et al., 2019), very few studies dedicate themselves to understanding and explaining how this phenomenon affects urban mobility as well as what type of prevention measures could diminish the risk of crime among riders. Similar to rampant crime and violence, fear and the perception of safety also affect the behavior of users and transport workers alike, regardless of whether they themselves were victims. According to Van Leirop and El-Geinedy (2017), safety is an important aspect of service quality for transit users, which directly influences the amount of people that choose to use a public transportation modality.

According to Jackson (2011), the perception of fear is a subjective concept influenced by proximate causes of fear and feelings of vulnerability, and also by other factors, such as news broadcast by the media. Irvin-Erickson et al. (2020), for instance, have found that the stage of the journey, crowdedness, and signs of disorder - such as graffiti, trash, and indications of substance abuse - might interfere in public transit users' fear perception. However, it is important to highlight that there is no direct correlation between increased crime and increased fear and perception of insecurity. According to Hummelsheim et al. (2011), anxiety may be high even when crime rates are low.

Therefore, fear of crime and perception of safety are not distributed equally in the population, developing specific temporal and geographic patterns. It varies according to the social-demographic and economic conditions of individuals, including gender, age, race, ethnicity, education, place of residence, and prior experiences of victimization (Grohe et al, 2012). Thus, women tend to feel more fear and insecurity than men, despite their lower risk behavior (Ceccato, 2017; Soto, Orozco-Fontalvo & Useche, 2017), and elderly people tend to feel more afraid and vulnerable than young people, despite their lower risk of being victims of violence and crime (Ceccato & Bamzar, 2016).

According to Badiora, Ojewale and Okunola (2015), the physical characteristics of the environment and the location of bus stops and stations may be also crucial factors to increase fear and insecurity among users. Fear of crime is similarly influenced by specific times of the day, being greater at night than during the day (Sreetheran & Van Den Bosch, 2014). Additionally, riders' perceptions of safety are related to the quality of the public transport, including attributes such as functionality, environmental features, surrounding locations where bus crimes occur, and fear of violence from other people (Oliveira et al., 2019).

Furthermore, the reliance on a chaotic bus environment characterized by a lack of guardianship and informal and formal control mechanisms affects users' exposure to crime. Risk of victimization is also influenced by individuals' routine activities which explain, as demonstrated by Bunch, Clay-Warner and Lei (2012), the higher risk of victimization among some specific groups than others (Bunch, Clay-Warner & Lei, 2012). This might also explain riders' adoption of some precautionary measures to reduce risk of victimization and fear of crime. This might include changing urban mobility routines, such as reducing ridership frequency while choosing different bus routes over others, or preference for the use of private car vehicles over the use of public transportation.

In Brazil, while the growth of crime in public transport has been the object of research, there is still a dearth of studies focused on the perception of safety among drivers and users in the complex bus transit systems characterized by both the modernization of the bus system since the 1990s and the continued existence of a chaotic bus transit environment. More research is needed in this area to understand the variations on crime as well as the perception of safety related to different types of bus systems, in addition to the safety of the bus system as a whole. Strategies to reduce violence and increase

safety on buses is one of the greatest challenges faced by government authorities, policy makers, the police, and bus companies in Brazil.

3. Bus Public System in Belo Horizonte

The city of Belo Horizonte, capital of the state of Minas Gerais, has one of the highest standards of living in Brazil. However, it faces various challenges when it comes to ensuring the quality of living for over 2.5 million inhabitants as demonstrated by the Brazilian Institute of Geography and Statistics (IBGE), 2017. According to the City Human Development Index, an indicator published in the Human Development Atlas (2020), the city ranks in 18th place among 5.566 municipalities. It is a very privileged position compared to metropolises such as São Paulo (23) or Rio de Janeiro (28). The numbers for the Metropolitan Area of Belo Horizonte (RMBH for short), which integrates 23 municipalities and has a total population of 5.76 million people (IBGE, 2017), are somewhat less flattering. According to the urban welfare index (IBGE, 2017), it ranks 7th among the 16 Brazilian metropolitan areas and 25th among Brazilian municipalities (Ribeiro, 2013).

As for mobility dynamics, Belo Horizonte is a very special case. In Brazil, it is recognized as one of the most advanced cities in terms of its urban mobility projects. In the 1990s, the city was one of the pioneers in the creation of participatory planning projects, which resulted in the conception of the 1996 Urban Master Plan - Law 7165, 1996 (Fontoura, 2014). 1992 saw the creation of Transport Company Transit in Belo Horizonte (Empresa de Transporte e Tansito de Belo Horizonte, BHTANS). In 1995, the city also pioneered the creation of a permanent urban mobility information system (Fontoura, 2014). By 2011, Belo Horizonte was the first city in Brazil to have an urban mobility plan, and two strategies were prepared for the public organ that manages transport planning: the first plan for use until 2020, and the second until 2030. The city also made important investments to implement a transport system based on the Bus Rapid Transit (BRT) system, named MOVE. The system was launched in 2014, the year of the Confederations Cup and the FIFA World Cup, and won the city a Sustainable Transport Award from the Transport and Development Institute (ITDP).

Despite these initiatives to promote public transport, the Transport Company and Transit in Belo Horizonte (BHTRANS) indicates that mobility in Belo Horizonte is marked by a significantly low use of buses and the highest growth in the use of private automobiles in the country (BHTRANS, 2014). According to data from the Origin and Destination Survey carried out in 2012 (SEGEM, 2013), 6.3 million journeys were taken in the city, most of them by car (32.6%) and on foot (34.8%). Public bus transport accounted for 28% of all journeys, and the subway system, only 1.3% (BHTRANS, 2016). The metropolitan area (RMBH) has similar results. These numbers expose a significant deficiency in the use of buses (BHTRANS, 2014).

The decreasing use of public transport constitutes a strong trend in Brazilian metropolitan regions but is even more visible in the metropolitan region of Belo Horizonte, where public transport used to account for 60% of all trips in 2002. Despite the progressive loss of importance given to the demand for public transport, the bus system continues to supply most journeys in the city. The system offered to users is composed of a variety of vehicles and infrastructures with very unequal quality, accessibility, and safety conditions. There are two large transport systems: the conventional bus system and the MOVE BRT system.

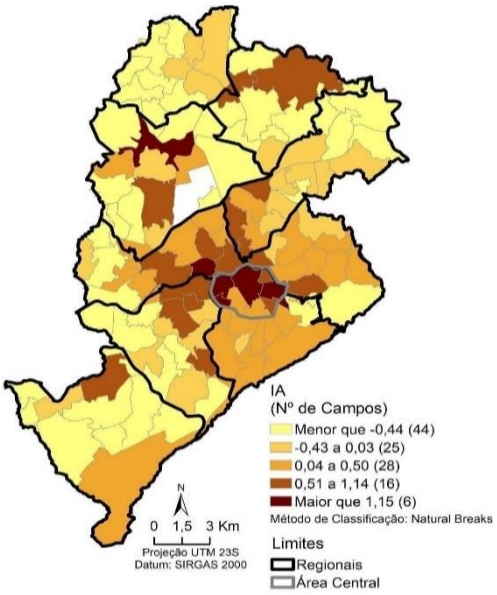
3.1 The Conventional Bus System

The conventional bus system is composed of 2,421 buses (currently, as of 2017) that connect neighborhoods in different parts of the city, and particularly, the city center. According to Belo Horizonte Municipal Government (PBH), these buses circulate on streets and stop for passengers to go in or out at specific bus stops with shelters or signage (PBH, 2020). The supplementary system is composed of buses that connect neighborhoods without crossing the city center, with over 312 microbuses operating 27 lines. The “vilas e favelas” service is composed of 12 lines that serve the city’s deprived neighborhoods, employing smaller buses. Some lines are equipped with panic and sexual harassment buttons, installed by the City Hall in 2018 in order to control the incidence of violence, particularly against women (Observatório do Milênio, 2020). These buttons are connected to Belo Horizonte’s Integrated Operations Center (COP-BH), which manages all of the city’s security cameras.

Conventional bus stops include various types of infrastructure with different levels of quality. On one hand, they can feature the most modern shelters, installed in the busiest areas, with night lighting, electronic display panels with information about routes, and spaces reserved for people with disabilities. On the other hand, there are shelters equipped only with stools for people with disabilities and “info points” – signs placed on poles along city streets.

According to Hasz (2017), the distribution of bus stops and bus lines in the various areas of the city is “very equitable, with a higher concentration in the Center-South zone, covered with a larger number of bus stops due to being the main destination of most passengers” (Hasz, 2017).

As a whole, the coverage of the public transport system is measured by the potential Accessibility Index (AI) of the population. For Belo Horizonte, this index was estimated by Miranda (2018), as the combination of the following numbers: 1) Bus Stop Density Ratio, the ratio between the number of bus stops and the population of each Field; 2) Frequency Ratio, the frequency of the bus lines that pass by each bus stop in a certain Field; and 3) Line Ratio, the number of bus lines that serve each bus stop in a certain Field. Figure 1, created by Miranda (2018), shows once again the unequal coverage of the city's transport system, especially precarious in peri-urban areas, close to the towns that form the metropolitan area, and highly concentrated in the city center and surroundings.



Lessa (2019)

Figure 1. Accessibility Index Map of the Bus Transit System in Belo Horizonte

3.2 The BRT System: MOVE

The execution of the MOVE BRT system started in 2012, due to the city being selected to host matches for the FIFA World Cup. MOVE opened its first line in 2014. The system carries 372,303 passengers every day in the two exclusive corridors currently in operation, with an extension of 39 km (GLOBAL BRT DATA, 2021). MOVE uses the trunk-and-feeder system, which had already been installed as part of the Belo Horizonte Public Transport Restructuring Plan (BHBUS), in operation since 1997; exclusive bus corridors had already been built within the main corridors that connect the city center to the north of the city (BHTRANS, 2013). Thus, the system connects the hyper center to expanding areas of the urban grid, as seen in Figure 2 in the Appendix.

MOVE is composed of two main corridors, on Antônio Carlos Avenue (14.7 km long) and Cristiano Machado Avenue (7.1 km long), the main axels of the system. In these corridors are exclusive lanes and embarking stations. The stations are divided between transfer and integration stations. Transfer stations (24 in the Antônio Carlos corridor and 9 in the Cristiano Machado corridor) are smaller and are used for either transferring between MOVE lines or for access to surrounding areas (see Figure 3).

Integration stations (see Figure 3), on the other hand, are much larger structures that serve MOVE trunk lines and the feeding lines that connect these stations to nearby neighborhoods. The stations are Pampulha, Venda Nova, Vilarinho, and São Gabriel. Vilarinho and São Gabriel also include subway stations and terminals for the metropolitan MOVE system. Of the four integration stations, only Pampulha Station was built as part of the BRT system. The others already operated as part of the BHBUS-trunk-and-feeder system and were adapted when they underwent renovation.

The Antônio Carlos and Cristiano Machado corridors are articulated via a junction on Paraná and Santos Dumont Avenues, in the hyper center. This junction saw the installation of six stations, four for municipal use and two for metropolitan use. Besides exclusive corridors, the system also includes a series of exclusive and preferential lanes for lines that leave segregated lanes and serve other regions.

The MOVE BRT bus system covers not only the city of Belo Horizonte but also its metropolitan area with Metropolitan MOVE, which includes the towns of Santa Luzia, Vespasiano, and Ribeirão das Neves. According to Hasz (2017), the main difference between the conventional system and MOVE is the management of waiting areas, which is more structured in the case of the latter. MOVE bus stations (including Transfer stations and Integration stations) charge customers and control their entry before embarking. These systems are watched by cameras and private security agents hired by the local government. Buses are equipped with GPS as well as panic and harassment alert buttons to control operations and surveil all vehicles in operation. The system is monitored directly by BHTRANS, the Military Police, the Municipal Guard, and the Fire Department via the Integrated Operations Center (COP-BH). Table 1 in the Appendix shows the main differences between the two bus transport systems operating in Belo Horizonte.

4. Methodology

This study involves a cross-sectional web-based survey design to investigate and capture the perception of safety on public buses among the academic community and staff of the Federal University of the State of Minas Gerais (UFMG), located in Belo Horizonte, the sixth largest Brazilian city. Web-based surveys, which involve delivering a questionnaire via a hyperlink embedded in the email list, are widely used by researchers and administrators to survey college students due to easy accessibility to this population (Park, K., Park, N., Heo, W. & Gustafson, K., 2019). Web-based surveys provide advantages related to cost reduction per questionnaire, speed of responses, the ability to expand the audience, and facilitating the process of tabulating and analyzing replies. In addition, this method offers greater flexibility to individuals, who may reply at a preferred time and location, as well as access to tools that eliminate issues that may lead to losses, such as a lack of replies that would be detrimental to the survey (Raju & Harinarayana, 2016). Despite advantages for data collection, storage, and analysis, web-based surveys have low rates of responses and selective participation in comparison to other methods (Wengrzik et al., 2016; Heiervang, E. & Goodman, R. 2011).

Target population and sampling technique: The target population consists of a total of 51,189 members of the UFMG. Out of this total, 64% includes undergraduate students (33,056); 21% are graduate students (10,716); 6.2% includes faculty members (3,202), and 8% are administrative staff (4,214) (UFMG.br., 2021). The UFMG community was an interesting population to study because the main campus is distant from the city center and yet must be accessible to the entire community, hence the necessity of public transport. The location of the campus also benefits the participants of the study due to the proximity to one of the main Municipal and Metropolitan MOVE BRT corridors: the Antônio Carlos corridors, often used by those who took part in the survey. Additionally, members of the university community are registered users of the university's online services. Therefore, a non-probabilistic convenience sampling was used based on the UFMG's official email list, which is often used to promote events and official communication to students, faculty members, and administrative staff. Everyone in the target population received a personal invitation through an official email. This also contributed to increasing trust in the serious nature of the survey. The email message contained information about the professors responsible for the survey so that participants could easily reach out to them if looking for more information. It also highlighted the confidentiality of the data. A survey was conducted throughout the month of August, 2017 and received 1,537 responses. The majority of the respondents was comprised of students: 70% were undergraduate students and about 18% were graduate students. This might be explained by the high proportion of students compared with the proportion of staff and faculty members as well as the familiarity and ease of access to technological tools by the Millennials' student generation compared with the older generation. Another explanation might be found in the high demand for public transportation among students as compared to the population of faculty and staff.

Data collection instrument: A multiple-choice web-based survey carried out on Google Forms was used to collect information from members of the UFMG community regarding transport users' perceptions of fear, insecurity, and exposure to crime, as well as demographic variables. A web-based survey is considered effective for this research purpose since it facilitates the wide dissemination of the survey among the target population. Before accessing the survey, participants were informed about the study objectives and requirements and were asked to provide informed consent accepting the data sharing and privacy policy. To finish the survey, participants connected directly to Google Forms via the link provided in the email. All the surveys were then downloaded as .txt files and manipulated using software SPSS, version 19, with the maximum guarantee of anonymity inherent in the web-survey format (which does not allow for the tracing of sensitive personal data in any way). For this reason, this study is exempt from requesting the approval of the ethics committee.

In order to overcome the challenge regarding nonresponse, which is common on web-based surveys, the survey and the importance of participation was announced on the UFMG Facebook two weeks before the survey was launched and throughout the month of August, 2017 when the survey was sent via the university email list.

Validity and Reliability Issues: Although the target population consists of members of the UFMG community who share a common characteristic of being internet literate and have the ability to understand the requirements to participate in a

web-based survey, some validity issues were likely to occur. Participants might not open the survey email because often in boxes tend to be full and not all messages are read. Additionally, even if all members of the UFMG community read the official email including the survey link, there would also be the possibility of the survey not being scrolled through to the end (Heiervang & Goodman, 2011). According to Heiervang and Goodman (2011), reliability issues would also be an issue due to the lack of a trainer interviewer on web-based surveys. To avoid these issues, detailed instructions about the questionnaire and its purposes and requirements were inserted on the survey along with researchers' contact information. Participants could reach out to researchers in case of any difficulty regarding question comprehension or technical issues regarding how to access and complete the web-based survey. In order to reduce reliability issues, a pre-test questionnaire was sent to a small group of students. This allowed researchers to identify errors and improve the questionnaire (Heiervang & Goodman, 2011).

Data statistical analysis: A cross-sectional database was used with a quantitative and inferential approach, focusing on linear regression analysis (OLS). The measure of safety perception in the city's bus system was analyzed from the different environments that make up the bus system: 1) inside the buses; 2) at bus stations; and 3) at bus stops. Additionally, considered were differences related to the type of bus system: 1) conventional; 2) MOVE BRT Municipal; and 3) BRT MOVE Metropolitan. Using a Likert scale to measure the perception of safety in the public bus transport system, respondents were asked about safety concerning the following: 1) inside conventional buses; 2) inside the municipal BRT MOVE buses; 3) inside the metropolitan BRT MOVE buses; 4) at conventional bus stops; 5) at the Municipal Integration Stations; 6) at the Metropolitan BRT MOVE transfer stations; and 7) the Municipal BRT MOVE transfer stations. To measure the link between fear and insecurity among public transport users and the dimensions of exposure to crime, social-demographic variables, and frequency of use of public transport, we used descriptive data analysis to understand the composition of the replies in the database, followed by linear regressions to explore the impact of each dimension on the final variables.

The question used to measure fear and insecurity among users was divided into the different locations of the public transport system, considering the essential differences between the perceptions of fear and insecurity on the buses and at the stations, as well as the differences between the municipal and metropolitan MOVE systems. Thus, with the question "On a scale of 1 to 5, with 1= very unsafe; 2 = not very safe; 3 = neutral; 4 = safe; 5 = very safe, how do you feel about the safety in buses?"

To operationalize the dependent variable of perception of safety in the different types and environments of the public transport system, the answers were combined and the scales added to compose the final measure of perception of safety based on the subdivision of spaces in the system. Figure 3 shows the histograms of the perceived security variable. In this graph it is possible to observe the distribution of the response variable for each of the types and environments related to the public mobility system evaluated in this article. To measure the model, we produced different response variables from the various spaces in the system. To operationalize the variable, we added up the variables of interest, as described in Table 2 in the Appendix.

Furthermore, we worked on the construction and operationalization of the independent variables of the inferential regression model. The description of each of these independent variables follows:

1) **Social-demographic Variables:** Gender as well as age measure differences among riders regarding their experience of fear and perception of safety. Both variables are considered crucial for the implementation of more specific and inclusive safety measures on public transit systems.

2) **Place of Residence**: The users' places of residence may affect the public transport structure and safety available to them, as well as how long they might use the system, since areas distant from city centers usually mean longer waits and crowded vehicles.

3) Frequency of Use of the System: The variations in the frequency of use of the system affects the knowledge of important elements that mediate the feelings of fear and insecurity, as well as increasing the probability of exposure to criminal incidents.

4) **Exposure to Crime**: This variable measure whether users have been exposed to criminal incidents, either as victims, witnesses, or both.

The operationalization of these variables is described in Table 3 in the Appendix.

In order to test the differences in terms of sociodemographic variables, exposure to crime, and the frequency of use in relation to the perception of safety, we performed a regression analysis that compares the type of system and manager - variables that have been shown to be key factors from the perspective of respondents. A linear regression model was divided into 5 parts:

1) Regression analysis with the perception of safety as a dependent variable for all locations in the bus transit system.
2) Comparison of perception of safety between inside the bus *versus* bus stations as well as *versus* bus stops.
3) Comparison of perception of safety between BRT MOVE (inside the bus and bus transfer stations) and Conventional Bus System (inside the bus and bus stops).
4) Comparison of perception of safety between the Municipal BRT MOVE System (inside the bus) and the Metropolitan BRT MOVE System (inside the bus).
5) Comparison of perception safety between the Municipal BRT MOVE System (Transfer Bus Stations) and the Metropolitan BRT MOVE (Transfer Bus Stations).

We present the general model for the perception of security regarding all responses and the different subdivisions here according to the type of bus system (conventional versus BRT MOVE) and spatiality (limited to the city of Belo Horizonte and the its metropolitan network). Model adjustments can be verified by the results of the adjusted regression coefficient. In Table 5, we identify the estimates, standard errors, and test statistic values used to determine the significance of the estimates of the proposed model.

5. Results and Analysis

Most of the respondents of the survey are female (63.9%), between 15 and 39 (89.1%), and reside in Belo Horizonte (86.3) (see Table 4 in the Appendix). In addition to being relevant sociodemographic variables, gender and age are important variables for the purposes of understanding patterns of mobility and crime perception (Ceccato, 2017). In turn, the participants' places of residence reveal differences in the public transit system available in the area, since transport systems in towns in the metropolitan area of Belo Horizonte present significant differences in terms of structure, frequency of use, and the relative distance to travel to the UFMG campus, the common focus of all survey respondents.

Over half of the respondents use public transport more than four times a week (and 24% use public transport every day). As for exposure to crime in public transport, including bus stops, stations, and buses, 49.6% of respondents declared they had been victims and/or witnesses of criminal incidents.

The survey results show significant differences in mobility patterns and the perception of safety in terms of sociodemographic variables and the respondent's home region, as most studies have shown (Ceccato, 2017; Ceccato and Bamzar, 2016; Grohe et al., 2012). However, a more in-depth analysis allows us to identify an important weight of the type of mobility system (from the bus system environment) that is used to differentiate the perceptions of crime incidence. This weight is associated with the type of infrastructure offered by public transport systems. As previously noted, in Belo Horizonte, public bus transport services are quite different in terms of quality, coverage, organization, and surveillance - all factors that can open onto opportunities for the generation of criminal events.

Altogether, Belo Horizonte's public bus transport systems are considered quite unsafe by most respondents (see Table 4). At least more than 50% rate buses and stations as "very unsafe" or "unsafe" spaces. However, it is necessary to point out important variations in relation to the type of mobility system used. In this study we assess the perception of safety not only in the vehicles, but also in the different waiting infrastructures that are part of the service offer.

In aggregate, we observe that the conventional bus system, consisting of buses that circulate on most of the city's streets and feature open bus stop shelters, is perceived more negatively by the interviewees. Furthermore, vehicles in this system were considered more dangerous as compared to the other systems, as 24.2% classified them as "very unsafe" and 50% as "unsafe." In addition, the physical structure of the bus stops, characterized by the lack of physical protection and surveillance, was considered "very insecure" by 67.4% of respondents (Table 4).

In contrast, the BRT MOVE system was rated better than the conventional one. However, we found differences between the system operated by the municipal BRT MOVE, operated by the Municipality of Belo Horizonte, and by the metropolitan BRT MOVE, operated by the State Government. Thus, the stations of the Municipal system were better evaluated, while metropolitan stations and buses were perceived in a more negative way.

These differences in perceptions of safety may be associated with the spatial and management arrangements of different urban mobility systems. The BRT MOVE system stations are more protected and closed, in addition to having specialized security guards and cameras as well as a Municipal Control Center that permanently monitors, guards, and manages these places and allows the deployment of police operations in a more efficient manner.

The conventional bus system, despite offering greater geographic coverage, is a system more dependent on the contextual conditions of where the infrastructures are located. Bus stops are more open spaces, more connected to the surrounding urban public spaces, and without institutionalized security systems. In this way, they can be spaces with greater variability in relation to the expansion of criminal opportunities.

In order to test the differences in terms of sociodemographic variables, exposure to crime, and the frequency of use in relation to the perception of safety, we performed a regression analysis that compares the type of system and manager - variables that have been shown to be key factors from the perspective of respondents. A linear regression model was divided into 5 parts:

1) Regression analysis with the perception of safety as a dependent variable for all locations in the bus transit system.

2) Comparison of perception of safety between inside the bus *versus* bus stations as well as *versus* bus stops.

3) Comparison of perception of safety between BRT MOVE (inside the bus and bus transfer stations) and Conventional Bus System (inside the bus and bus stops).

4) Comparison of perception of safety between the Municipal BRT MOVE System (inside the bus) and the Metropolitan BRT MOVE System (inside the bus).

5) Comparison of perception safety between the Municipal BRT MOVE System (Transfer Bus Stations) and the Metropolitan BRT MOVE (Transfer Bus Stations).

We present the general model for the perception of security regarding all responses and the different subdivisions here according to the type of bus system (conventional versus BRT MOVE) and spatiality (limited to the capital Belo Horizonte and the metropolitan network). Model adjustments can be verified by the results of the adjusted regression coefficient. In Table 5, we identify the estimates, standard errors, and test statistic values used to determine the significance of the estimates of the proposed model.

The results of the linear regression model in Table 5 (in the Appendix) showed that for all models, it appears that the variable of gender indicative of the female gender specifically has a negative association with the perception of safety, indicating that women have a lower perception of safety in public transport by bus. In the case where it was significant, the age variable presents an association similar to the previous one – that is, older people tend to have a lower perception of safety in the public transport system, regardless of type or spatiality. On the other hand, residents living in the city of Belo Horizonte have a greater perception of safety in public transport when compared to residents and users of other municipalities in its metropolitan region. Controlled for all other variables, the fact that the respondent was a victim of crime or witness to crime considerably reduces the perception of safety in bus public transport, so that this variable was shown to be statistically significant for all implemented models. Finally, the risk of exposure variable, operationalized here through the frequency of respondents' usage of the public bus transport system, was negatively associated with the perception of safety and statistically significant at the level of 5% for model 1 and model 2. In model 1, exposure to risk is negatively associated with the perception of safety inside buses; while considering both types analyzed (Conventional and BRT MOVE), this result is probably influenced by the perception related to conventional buses, partially confirmed by the result of model 2.

Additionally, the coefficient related to risk of exposure in model 1 is relatively more significant as pertains to the perception of safety at bus stops, which is certainly an effect resulting from the level of vulnerability and risk of crime by which these places (bus stops) are characterized. These bus stops, as explained and exemplified in the article, are places without any protection for the user, usually located inside the lanes of vehicles and where the passenger is very exposed with high chances of becoming a victim of crime.

The results of the coefficients found in model 2 for the risk exposure variable confirm the expectation that BRT MOVE (both in the case of stations and buses) is a system whose technology offers greater security (surveillance) for users. When compared to the conventional system, the perception of safety is not presented as a function of exposure to risk in the case of users of the BRT MOVE system, whereas the passengers' frequency of use in the conventional transport system is negatively associated with the perception of security in this system, and is statistically significant at the 5% level.

6. Limitations and Future Research

This study is a cross-sectional analysis of the perception of safety of riders and doesn't allow generalization about changes in the perception of safety on buses in an extended period of time. This might vary over time due to external factors such as the increase of urban violence portrayed in the media as well as changes in the geographical and temporal patterns of bus riders.

Another limitation of this study is the low number of responses from the target population. This can be explained by the overall tendency of email avoidance and school email avoidance of students (Ha et al., 2018), which impairs this study as the institutional email was used as the main divulgation strategy of the questionnaire. Smartphones, social media, and text messages are more important media for college students than emails (Ha et al., 2018). The present research has also used Facebook to publicize its form; yet it could have benefited from promoting the questionnaire via other networks

such as Instagram and Twitter, as these platforms are more popular among younger college students (Shane-Simpson et al., 2018). This could have accordingly broadened the opportunities of answering the form, especially among undergraduate students.

Additionally, by adopting only two indicators of risk of victimization - exposure to crime and frequency of the use of the bus system - this study cannot determine whether there are other intervening variables, such as the adoption of protective measures by respondents (victims and/or crime witnesses) that may have influenced their perception of safety in the MOVE BRT system and the conventional bus system. Lastly, the study lacks an in-depth analysis of how and why environmental factors of the immediate neighborhood and surroundings of both bus transit systems in the study - the conventional and the MOVE BRT system - might have influenced the perception of safety. These may include a detailed description of the design of bus stops, bus stations, and integrated bus stations, as well as of the physical and social features of the path walked by users towards these locations. Previous studies have shown that insecurity among riders is influenced by physical characteristics of the public transit environment, particularly by women and the elderly (Grohe et al., 2012). This might include the existence of enclosed stations that reduce the visibility of the outside and other surroundings, including poor lighting and desolate surrounding places as well as nearby areas featuring alleys and hiding places (Haans & De Kort, 2012).

Future research might include not only environmental variables that might influence riders' perception of safety, but also the narratives of passengers regarding the quality and safety of their travels. Qualitative data would enrich the understanding and explanations of the reasons why the perception of fear and insecurity vary across both bus systems in this study as well as across the socio-demographics of riders such as gender, age, social class, and race. An exploration of the perception of safety related to victims and witnesses of other crimes such as sexual harassment or pickpocketing would also improve the understanding on how riders' fear of crime and insecurity influence their bus mode preferences and preventive measures at different times and locations. As fear of crime can be detached from reality, official crime statistics could also be used to measure against the results found through the questionnaire.

7. Conclusion

In sum, this current study answered the main research questions by demonstrating that the perception of safety among bus riders varies according to individuals' sociodemographic background, locality of residency, frequency of ridership as well as exposure to crime (as victims and/or witnesses to crime). Age and gender variables present a negative association – that is, older people and women tend to have a lower perception of safety in the public transport system, regardless of type or spatiality. On the other hand, residents living in the capital have a greater perception of safety in public transport when compared to residents and users of other municipalities in the metropolitan region of Belo Horizonte. Controlled for all other variables, the fact that the respondent was a victim of or witness to crime considerably reduces the perception of safety in bus public transport, so that this variable was shown to be statistically significant for all implemented models. Finally, there is the risk of exposure variable, operationalized here through the frequency of respondents' usage of public transport.

Although in general respondents consider the bus system unsafe, the perception of safety among riders is influenced by the presence or absence of mechanisms of control in different types of bus vehicles and bus waiting infrastructures, particularly among the conventional buses and the MOVE. The former are considered unsafe and dangerous in comparison with the latter. This might be explained by the availability of different types of mechanisms of control provided by the MOVE bus system.

One of the contributions of this study was to demonstrate that the exposure to the risk of victimization, measured by the frequency of travel use, varies in the two bus environments analyzed and is statistically significant in decreasing the sense of security of victims and/or witnesses of crime in the conventional bus system. On the contrary to the Municipal BRT MOVE system, the conventional bus system lacks the presence of capable mechanisms of surveillance to discourage potential offenders from committing crimes as suggested by the Routine Activity theory. We argue that this might be explained by the infrastructure, quality of maintenance, and design of bus stops - variables that should be explored in future research. The results suggest that the characteristics of the bus itself as well as bus stops are crucial factors in the perception of safety.

Specific prevention policies should be implemented in order to improve the perception of safety on the conventional bus system. These measures should prioritize the design of safer infrastructures that favor the increase of guardianship over riders as well as surveillance through the use of technology, private security, and place managers - for instance, the use of alert buttons by drivers to send customized signals to bus companies and police departments in case of crime incidents on buses. Also available are customized LED alert message signs simultaneously shown on exterior message boards on buses - in front and rear. This situational crime prevention technique might help to increase the risks of offenders being captured by strengthening formal surveillance as well as assist natural surveillance on buses.

CCTV cameras on buses and safety APP for users are some examples of other types of situational crime prevention resources that might have an impact on reducing feelings of insecurity and fear. More research is needed on the perception of safety across riders and the complexity of the various types of public bus mobility systems including location as well as implementation throughout the broader context of urban spaces. Other angles to consider that would contribute to more efficient and inclusive measures to improve safety on public transit systems include: how and why mechanisms of safety are present or absent of inside buses, stations, and bus stops; the interdependent relationship between the perception of safety and the immediate surrounding environment along the bus journey; and the efficiency of place managers and guardianship in different bus system environments.

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