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Perception of the important characteristics and conditions of bike lanes and cycle lanes in a medium-sized Brazilian city, according to cyclists

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SUMMARY

Although the rates of supporters of active mobility, especially cyclists, are considered low for most countries in Latin America, the benefits are great to the city and health of users. Understanding the profile of users of this mode of transport, their perceptions and possible difficulties is necessary to propose improvements with the competent public bodies. The aim of this study was to consult cyclists from a city in the interior of Brazil through the application of questionnaires and to assess their perception of the characteristics of the roads, the environment, the journey, the route, the journey traffic, the route, and the cyclist behavior during the COVID-19 pandemic. By means of the statistical treatment, it was possible to measure the most relevant characteristics for this group, in addition to verifying that the number of vehicles was a determining factor in the perception of traffic, since there is an unreasonable dispute for space in traffic in which the bicycle is often invisible and it seen as an obstacle to the flow of motor vehicles on the roads. Based on the conclusions of the study, investments in infrastructure and urban equipment that improve the interconnection of bike lands and cycle lanes are proposed. Awareness campaigns can also encourage a greater number of users to choose the bicycle as the main means of transport.
KEYWORDS: cycling; active mobility; bike lane

1. INTRODUCTION

Cities that promote and encourage cycling as a means of transport contribute to the improvement of the health of the population, such as reducing chronic diseases, lower rates of overweight and obesity, improving mental health, in addition to contributing to reducing air pollution and congestion, surpassing the individual level, and reaching the social level (Florindo, et al., 2018), (Pettigrew, et al., 2020).

The great challenge for public managers in most countries is to increase citizens' interest in cycling as a means of transport. As an example in Latin America, the rate of adherents reaches only 10%, being more expressive in the young population (Florindo, et al, 2018). In Chile, the rate of adhesion to the bicycle was 7%, with the majority being men, young people (from 18 to 24 years old) and people of low economic status. The climate was also reported as a determining factor, with hot summers and mild winters being preferable (Farias, 2019).

Kerr et al. (2019) analyzed the neighborhood environmental attributes associated with walking and cycling as a means of transportation for adults in 17 cities in 12 different countries, including Latin America and Europe. The results of cycling for transport were significantly related to the combination of land use – access, street connectivity, infrastructure, aesthetics, safety, and perceived distance to destinations.

Studies from high-income countries show that social and built environments and associated policies are relevant to strengthening the use of bicycles for transport purposes. In these places, they observe essential factors to increase the use of this modality of transport, such as: (1) safety of the environment for cycling, (2) integration of the bicycle with other forms of transport, (3) availability of bicycle racks, and (4) interventions based on education and on the mass media (Pucher, et al., 2010; Fraser, et al., 2011).

Similar research was developed by Kooshari et al. (2019), where they studied the importance of the built environment in choosing the bicycle as a means of transport in an Australian city. In this study, they concluded that adults living in high-density neighborhoods with nearby destinations and well-connected streets were likely to use the bicycle as a means of transport. In medium-density neighborhoods, on the other hand, the proximity to destinations and street connectivity may not be enough to make bicycle use prevail.

2 OBJECTIVES

To understand the profile of the cyclist in a medium-sized city in the interior of Brazil, which has cycle lanes and bike lanes, and to identify the important characteristics for choosing a bicycle as a means of transport. The research was developed during the period of restriction of movement characteristic of the pandemic caused by COVID-19. Thus, it was sought to identify whether users felt motivated to expand the use of bicycles beyond leisure as a means of transport, avoiding buses and crowded terminals and/or with great agglomeration during peak hours.

3 METHOD

3.1 Area characterization

The study was applied in the city of Uberlândia, located in the western portion of the state of Minas Gerais (Figure 1), in the mesoregion of Triângulo Mineiro/Alto Paranaíba. According to IBGE data (2020), it has 699,097 inhabitants and 4,115.206 km² of land area. It is considered the logistics capital for its privileged location, and it has an easy access to five federal highways for the Southeast, Midwest, and North regions. The estimate for 2050 is that the population will reach 1.2 million inhabitants if the growth model is maintained (CEPES/UFU, 2018).

Figure 1 – Location of Uberlândia – MG
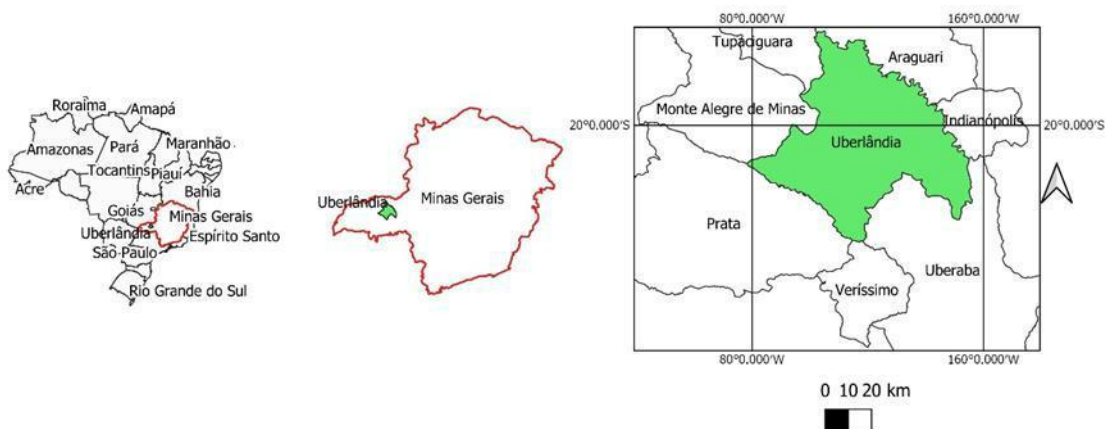
Source: The authors, 2021

The *Plano de Mobilidade Urbana* (PMU) – freely translated to *Urban Mobility Plan* –of Uberlândia (2010) prioritizes non-motorized modes and public transport within public policies. Figure 2 shows the map of bike lanes (red) and cycle lanes (blue) in Uberlândia – MG State, prepared by Barroso (2018). The municipality has an extension of 95 km of bike lanes and cycle lanes.

Figure 2 - Map of Uberlândia's bike lanes and cycle lanes (blue - cycle lanes and red - bike lanes)
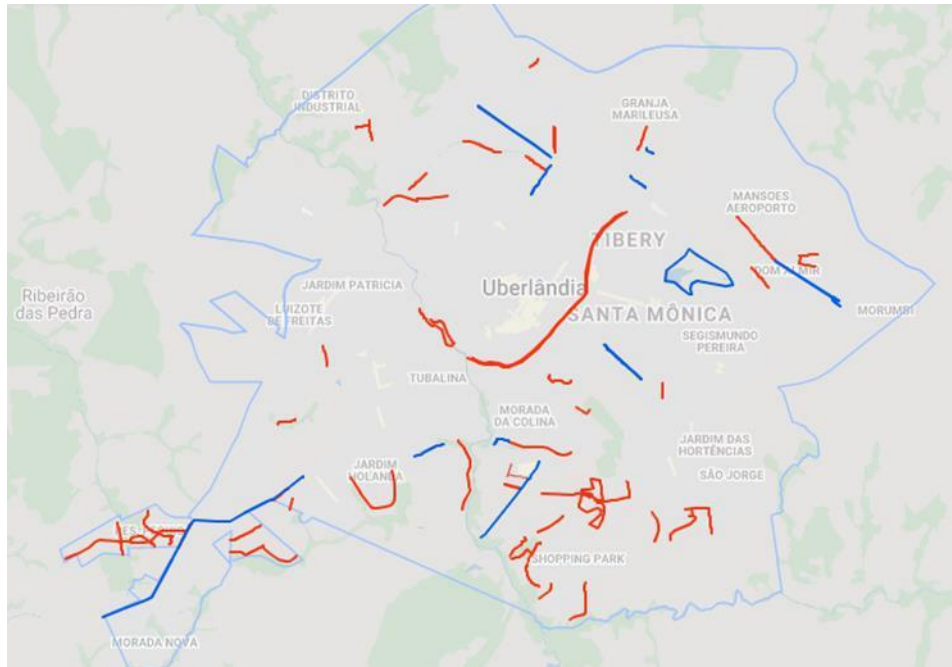
Source: Barroso, 2018

According to figure 2, it can be observed that the bike lanes and cycle lanes are well distributed across the city's network, but the connectivity is a derogatory factor when addressing active and integrated mobility in the city. Data from the PMU (2010) show that the profile of cyclists is 94% male, the age group with the highest incidence of cyclists is from 0 to 20 years (36.7%), followed by from 21 to 30 years (34.2 %). As for the profession, students and Office Boys are the ones who most use the bicycle as a means of transport. Such data reflect on the factors that interfere with urban mobility, according to Brasil (2013): income, age, and educational level. There is a direct relationship between per capita income and the number of trips produced.

The *Associação Brasileira de Fabricantes de Motocicletas, Ciclomotores e Bicicletas Bicicletas* – freely translated to *Brazilian Association of Manufacturers of Motorcycles, Mopeds and Bicycles* – (Rosenberg Associados, 2015) points out that in Brazil there are about 60 million bicycles, and most of their use is for leisure purposes (middle and upper classes) and means of transport (low-income class). The use of bicycles as a means of transport has several advantages: low investment in acquisition

and maintenance, energy efficiency, speed, and flexibility for short journeys - up to 5 km (Brasil, 2007). Disadvantages cited include limited maximum distance travelled, vulnerability to adverse environmental conditions and accidents. As for the urban characteristics that encourage the use of bicycles in the city, the lowest level of noise in traffic can be highlighted.

Assunção (2012) investigated the indicators of sustainable urban mobility in Uberlândia/MG, through the Sustainable Urban Mobility Index (IMUS). The value found for the IMUS was 0.717 on a scale from 0 to 1, indicating that the city has been concerned with public policies aimed at urban mobility. The author emphasizes that the domain of non-motorized modes contributed the least to urban mobility in the city studied, given the lack of bicycle racks in the bus terminals and the reduced lanes for the exclusive use of cyclists. Ferreira (2017) conducted an exploratory-descriptive study by means of documents provided by SETTRAN Uberlândia and he interviewed 109 cyclists to investigate the profile of the uberlandense cyclist. Most of them were female (52.3%).

A similar study was carried out by Alves (2015), through the analysis of the Travel Generating Poles (PGVs), which showed that the infrastructure of urban mobility did not satisfactorily and safely meet the needs of walking, cycling, and public transport. A survey on origin and destination of trips, carried out by the Faculty of Civil Engineering of the Federal University of Uberlândia/MG in 2002, revealed that displacements by foot occur in 27.2% of cases and by bicycle, around 4 .6%. Non-motorized modes are used by low-income people living in the urban periphery (Asunción, 2012).

The information obtained by Luz (2016) through the Cyclists Association of Uberlândia corroborates to the estimate presented that approximately 5% of Uberlandense citizens use the bicycle as a means of transport, similar to the result found by Florindo et al. (2018) in São Paulo/SP, 5.1%. This percentage is below that of European cities such as the Netherlands, where 90% of the population uses bicycles as the main means of transport and Denmark, with about 70% of the population using bicycles daily (E-moving urban mobility, 2020). Considering South America, countries like Chile have 7% of users who use bicycles as their main means of transport (Farias, 2019). Bogotá is an example where only 13% of the population owns a car and, in Brazil, the reference is the city of Curitiba/PR where there is a strong presence of an activist community that encourages the use of bicycles as a means of transport.

3.2 Applied Methodology

The study was based on the original questionnaire proposed by Segadilha (2014) to assess the importance of factors for choosing the lanes where the cyclist will ride, according to the assessment of their perception in the following aspects: (1) lane width, (2) one-way street, (3) type of pavement, (4) state of pavement conservation, (5) slope of the road, (6) parking allowed on the right side of the road, (7) volume of vehicles, (8) number of trucks , (9) number of buses, (10) speed of vehicles, (11) afforestation, (12) personal security, (13) number of intersections with a mandatory stop (STOP), (14) number of intersections with traffic lights, (15) duration of trip, (16) street lighting, (17)

total number of intersections, (18) need to go through roundabouts. For each factor, the respondent should rate importance on a 5-point scale, with "very important" coded at 5 points and "not important" coded at 1 point. In this questionnaire, the profile of the cyclist was also evaluated, including 5 multiple-choice questions: age, gender, frequency of use of the bicycle, reason for traveling by bicycle and if they usually plan their route.

For the research, the questionnaire was adapted to be published in electronic format and factors relevant to the current scenario were added. It consists of 28 factors, described in 7 attributes. The responses were coded on a 5-point Likert scale, with higher values indicating better quality of conditions for cyclists, see Figure 3.

Figure 3 – Degree of ordering of the Likert scale

Source: The authors (2021).

The attributes that are characterized in the study will be described below, related to each factor relevant to the attribute:

(1)   Cyclist Characteristics: 4 cyclist profile factors were evaluated from multiple-choice questions: gender, reason for using a bicycle, frequency of bicycle use and age of cyclists.

(2)   Characteristics of the road: 6 factors related to the infrastructure of cycling being, lane width, direction of the lane, type of pavement, condition of the pavement, slope of the lane and, if parking is allowed on the right side of the lane.

(3)   Traffic characteristics: 4 factors related to the traffic of the cycle routes being, volume of vehicles circulating together, number of trucks, number of buses, speed of vehicles.

(4)   Characteristics of the environment: 2 factors were evaluated being the existence of afforestation on site and the cyclist's personal safety (possibility of assaults, assaults).

(5)   Characteristics of the route as a whole: 6 factors were evaluated being number of intersections with a mandatory stop (STOP), number of intersections with traffic lights, street lighting, total number of intersections, the need to pass at roundabouts, existence of support/ support such as workshops, calibration station, bicycle racks on the stretches of the route.

(6)   Characteristics of the trip: 2 factors were evaluated being the length of the trip and the total time of the trip.

Finally, a new feature was added due to the reality marked by the COVID-19 Pandemic:

In this questionnaire, the ordinal classification was adopted for all factors, with values varying between (1) and (5). Saelens and Sallins et al. (2002) recommend that the final estimate of respondents' perception of a particular aspect (attributes) be considered the average of the values assigned to each of the items that make up the assessment aspect (factors) (see equation 1). However, there are contradictions about the suitability of using parametric statistics (mean and standard deviation) to analyze items evaluated using ordinal scales (Boone and Boone, 2012) and (Norman, 2010). In this research, although aware of this contradiction, the procedure proposed by Saelens and Sallins et al. (2002) also used by Jacob (2018) in Brazil.

To obtain the score for each attribute / characteristic, equation (1) was used: $X = (x_1 + x_2 + x_n) / n$

Where: (1)

X: average of each characteristic/attribute
x: average of each factor
n: number of items of each characteristic/attribute

In comparing the results, the application of the t and F statistical test was used to analyze the differences between the averages of the characteristics by regions.

In this study, an online form was applied, available in Google forms format for cyclists residing in the city of Uberlândia (MG). The form was made available online and it disseminated via a link from Whatsapp® and Facebook® groups of instant messaging applications with characteristics of bicycle sports practices and news/variety of the cities in question.

4 RESULTS

The pilot survey was applied between the 7th and 20th of November 2020, and it covered 30 respondents from the municipality. A margin of error of 5% was adopted for the total population surveyed, with a confidence interval of 95%.

4.1 Characteristics of evaluated cyclists

Figure 4 shows the profile of respondents and their respective percentages. The evaluation of the cyclist's characteristics was based on categorical analysis and frequency distribution. In both cities, most respondents are male, and the predominant age group is between 31 and 50 years old. The predominance is also for the same activity, although there was a small percentage for the use of commuting for work and studies. Respondents use the bicycle for their purposes at a frequency of 2 to 3 times a week.

Figure 4 – Characteristics of cyclists
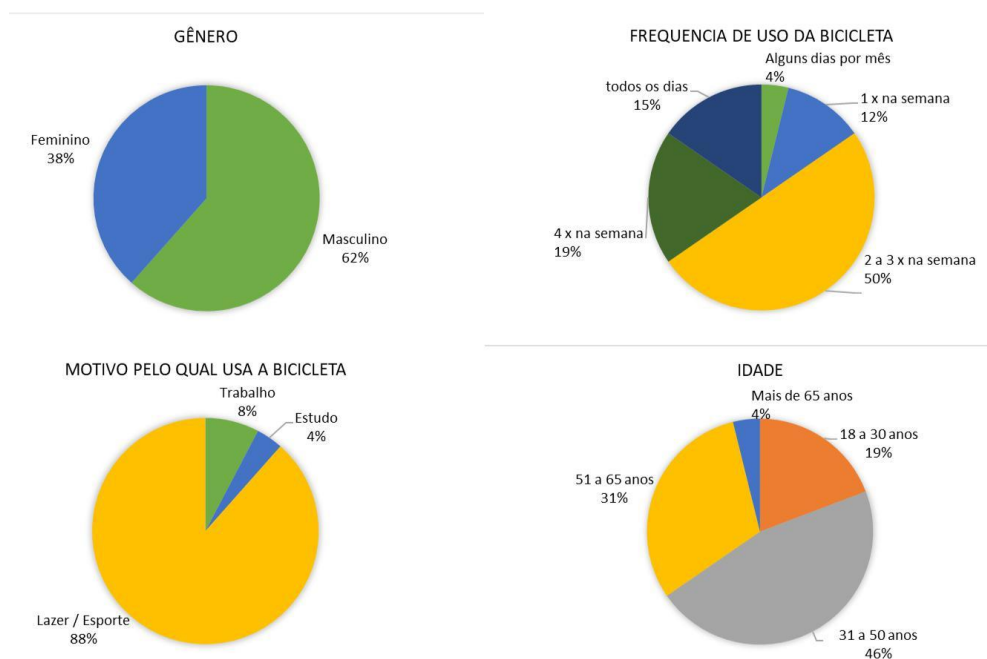
Source: Source: The authors (2020).

4.2 Perception of the characteristics of the routes that cyclists will ride

Tables 1 to 6 show cyclists' perception of the characteristics of the lanes (cycle lanes and bike lanes) they will ride, showing the mean, variance, standard deviation.

Table 1 - Perception of the characteristics of the lane

Characteristic	Average	variance	Standard deviation
width of the track	4.50	1.16	1.07
One-way street	3.73	2.00	1.41
Type of pavement	4.23	1.36	1.17
State of conservation of the pavement	4.37	1.21	1.10
Slope of the road	3.53	1.22	1.11
Parking allowed on the right side of the lane	3.80	1.20	1.10
CHARACTERISTIC OF THE LANE	4.03	0.59	0.77

Source: The authors.

For the perception of the characteristic of the lane, the response options were coded in an ordinal scale, ranging between 1 and 5, in which higher values imply better conditions of cycling infrastructure (Table 1).

Table 2 – Perception of traffic characteristics

Characteristic	Average	variance	Standard deviation
Volume of vehicles circulating	4.20	1.16	0.96
Number of trucks	4.30	2.00	0.92
Number of buses	4.37	1.36	0.85
Vehicle speed	4.63	1.21	0.49
CHARACTERISTIC TRAFFIC	4.38	0.06	0.24

Source: The authors.

The responses on the perception of traffic characteristics were coded on a 5-point Likert scale, in which higher values indicate better conditions for circulation of bicycles (Table 2).

Table 3 - Perception of the characteristics of the environment

Characteristic	Average	variance	Standard deviation
Afforestation	4.53	0.40	0.63
Personal security (possibility of assaults, assaults)	4.97	0.03	0.18
ENVIRONMENTAL CHARACTERISTICS	4.75	0.01	0.12

Source: The authors.

In the perception of the characteristic of the environment, the response options were coded on an ordinal scale, ranging between 1 and 5, in which higher values imply a more pleasant and safer environment for cycling (Table 3).

Table 4 - Perception of the characteristics of the route as a whole

Characteristic	Average	variance	Standard deviation
Number of intersections with a mandatory stop (STOP)	4.13	1.71	1.31
Number of intersections with a traffic light	4.03	1.34	1.16
road lighting	4.73	0.34	0.58
Total number of intersections	3.97	0.93	0.96
Need to pass roundabouts	3.63	1.00	1.00
Existence of support/support such as workshops, calibration station, bicycle racks on the stretches of the lane	3.93	1.10	1.05

CHARACTERISTIC OF THE ROUTE AS A WHOLE	4.07	0.50	0.71

Source: The authors.

In the perception of the characteristics of the route as a whole, the options of answer were coded on an ordinal scale, ranging from 1 to 5, in which higher values imply better conditions for circulation and support for bicycles (Table 4).

Table 5 – Perception of trip characteristics

Characteristic	Average	variance	Standard deviation
length of trip	3.67	1.47	1.21
Total trip time	3.83	1.24	1.02
CHARACTERISTIC OF THE TRIP	3.75	0.12	0.35

Source: The authors.

In the perception of the characteristic of the trip, the response options were coded in an ordinal scale, ranging between 1 and 5, in which higher values imply better conditions of length and travel time (Table 5).

Table 6 – Perception of cyclist characteristics in the COVID-19 pandemic

Characteristic	Average	variance	Standard deviation
Cycling in the COVID-19 Pandemic	4.20	0.86	0.92
Use of mask and hygiene for cycling in the COVID-19 Pandemic	3.63	1.69	1.30
Reason for using a bicycle COVID-19 Pandemic	2.77	0.39	0.63
Frequency of bicycle use in the COVID-19 Pandemic	3.17	1.52	1.23
CHARACTERISTIC OF CYCLISTS IN THE COVID-19 PANDEMIC	3.44	0.19	0.43

In the perception of cyclist characteristics in the COVID-19 pandemic, the response options were coded on an ordinal scale, ranging from 1 to 5, in which higher values imply that cyclists are using the bicycle more during the pandemic (Table 6).

Table 7 shows a summary of the averages by characteristics. Note that in the perception of cyclists, factors are important for the routes they will ride. In general, it is observed that the characteristics of the trip (the length of the bike lane/cycle lane and the total time of the trip) and the characteristics of the cyclist in the COVID-19 pandemic are indifferent in the perception of the respondents. The coefficient of variation provides the variation of the data obtained in relation to the mean. The smaller its value, the more

homogeneous the data it will be. It is observed that in all characteristics the percentage variation coefficient is below 25%, which implies that sample data is homogeneous.

Table 7 - Average by characteristic

Characteristic	Average	variance	Standard deviation	Coef. of variation percentage
Characteristics of the road	4,028	0.592	0.769	19.100%
Characteristic of the traffic Characteristic of	4,375	0.058	0.242	5.524%
the environment Characteristic of the route	4,750	0.015	0.122	2.565%
as a whole Characteristic of the journey	4,072	0.499	0.707	17.354%
	3,750	0.120	0.347	9.246%
Cyclist characteristics in the covid-19 pandemic	3,442	0.189	0.435	12.633%

Source: The authors.

5 DISCUSSION

According to the analysis of the data collected, it was evident that the profile of users is mostly male within the age group of 31 to 50 years old, and they use the bicycle for leisure/ sports frequently 2 to 3 times a week - consistent with the profile of Brazilian cyclists, (TRANSPORTE ATIVO, 2018). The age factor, predominantly young people aged from 18 to 25 years, is a determining factor for choosing the bicycle as a means of transport, confirmed by Campos et al. (2017) and Nogueira et al. (2019) through questionnaires applied to participants on the campuses of the Federal University of Minas Gerais and University of Brasília, respectively. As for gender, lower female adherence can be explained by the feeling of insecurity present on the lanes (PUCHER et al., 2010).

Kerr et al. (2019) suggest that cycling mentoring programs are effective in increasing cycling as long as it serves other community goals. People tend to ride their bikes to nearby destinations since they have material and social support. Among the improvements that would increase the frequency of bicycle use, there are: more and quality of infrastructure, traffic safety and education, signaling and public safety (RICIERI et al. 2017).

The characteristics of the traffic and the route occupy a prominent place: such finding may be related to the amount of UDIA's vehicle fleet, the second largest in the state (DENATRAN,2019), which has a direct impact on the flow, on vehicle traffic and on the dispute for shared space between cars and bicycles. Another fact is that the cyclists surveyed also use the bicycle as transport to work and to their studies, and they seek efficiency and safety in this means of transport.

Magalhães et al. (2018) divided the study of the determining factors for choosing a bicycle on roads with infrastructure and without adequate infrastructure for bicycles: in

the first case, the presence of bicycle racks, temperature in the region and number of accidents is important; in the second, the number of intersections, proximity to appropriate cycling routes and number of lanes. The authors reached the following conclusions: the presence of parking on the lane and a greater number of lanes negatively affect the number of bicycles on the lanes, hindering the flow of bicycles. Besides, the temperature between 25°C and 35°C was identified as ideal for cycling, and the fear of accidents is also a determining factor (MAGALHÃES et al. 2018).

A more significant factor considered in evaluating the characteristics of the route as a whole was the number of intersections with traffic lights. The average in this item was lower for UDIA, and the municipality has 332 traffic lights distributed in a road network of approximately 3000 km (UBERLÂNDIA, 2019). Some characteristics of the lane can help cyclist safety, such as colored markings for bicycles and indented cycle lane, that is, closing the cycle lane before crossing a few meters to improve the cyclist's visibility (Osmann, Laharmann, 2017; Hurwitz et al., 2015). When there are traffic conflicts, the presence of dotted markings and colored bicycle markings reduce the occurrence of traffic conflicts (Hurwitz et. al., 2015).

The characteristic of the trip (length and total time of the trip) is a factor that makes no difference to the cyclist when riding, according to the perception of respondents in the study presented. From another perspective, the perception of the distance covered is related to the environment in which they pedal (Shafizadeh and Neimeier, 1997). It implies that cyclists make longer trips in places that have cycling infrastructure. The UDIA cycle network is 95 km long, divided into 66 bike lanes and 22 cycle lanes. Heinen (2011) states that for trips up to 15 km away, the perception of cyclists influences the choice of the route, which contradicts the results presented in the work. Although there are physical differences in the length of cycle lanes between the two cities, the data presented showed that there were no significant differences between the means.

The influence to ride during the Covid-19 Pandemic is indifferent to the cyclist. Although there were expectations that it could generate an increase in active journeys, the study showed that even during the pandemic period, there was no increase in the frequency of bicycle use, and, besides, the reason that cyclists pedal is for leisure and sports.

6 FINAL CONSIDERATIONS

Active mobility (walking and cycling) in cities is an increasingly effective trend for improving the health of citizens, appropriating public space, in addition to offering other co-benefits such as reducing motor vehicle congestion and pollution in urban areas.
An orderly work between community and administration can yield good results and return on investment expressed in improved quality of life and user satisfaction. Among the improvements that would increase the frequency of bicycle use

are: greater quantity and quality of infrastructure, traffic safety and education, signaling and public safety.

Despite the limitations of this work, it was possible to understand in general the factors that have an impact on the choice of bicycles for recreational activities or as a mode of transport: the characteristics of the road and traffic characteristics played a prominent role among those surveyed. As for the use of bicycles during the pandemic period, there was no evidence of an increase in users in the period according to the survey.

It is noteworthy that the perception of the cyclist permeates their subjective view and may not be consistent with reality from a technical point of view. Thus, it is expected that this study is a precursor of new assessment and audit research in the active mobility sector, especially bike lanes and cycle lanes.

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