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Understanding the gap related to bicycle mobility in Medellin

The great disparity between the rate of bicycle use and
other means, based on the case of the National
University of Colombia at Medellin

Thesis submitted in the Partial Fulfillment for the Requirement of the
Degree of Master of Science in Integrated Urbanism and Sustainable Design

by

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Disclaimer

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07/24/2023

Luis Alberto Sanchez Munoz

Signature

Dedication

To the memory of Paco, my best friend and furry companion, who went to heaven during the last months of this research and to whom I said goodbye in the distance.

I hope you are running happily beside a bike, as you did with mine.

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Abstract

Motorized vehicle trips are attractive compared to other modes; current levels of car use do not allow sustainable levels of economy, social welfare, and environmental resilience that prioritize active mobility and public transport, according to Redman et al. (2013). Another kind of phenomenon that discourages the use of active and public modes comes from particular conditions (Cervero and Kockelman 1997; Heinen *et al.* 2010; de Sousa *et al.* 2014; Fernández-Heredia *et al.* 2016)

For most people, the above phenomenon triggers a migration of means based on speed, safety, comfort, and cost, known as a trade-off (Walker 2011). It has derived a significant gap between the bicycle use rate and other means, in this case for Medellín, according to the ciphers showed by Área Metropolitana del Valle de Aburrá (2018).

As a strategy to counteract the negative impacts of this phenomenon, this research is focused on people's preferences and the limitation or concern about the variables that impact the daily use of bicycle in regards to clarifying the profiles of the users and non-users of that means, to suggest specific interventions and contribute to the routinary use growth and the improvement of the current panorama, specially focused on the National University of Colombia at Medellín sample as a case of study of the city. This research follows a quantitative methodology with biological gender approach since the required conditions for bicycle use are different for female and male citizens.

The research includes a bibliographic review of the city context; a literature review of the variables that affect bicycle use in the global, continental, country, and city contexts; field exploration carried out with survey methodologies in the territory; analysis of the findings; conclusions based on the findings and the analysis of the theoretical frame

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1. Introduction

In human settlements around the planet, inadequate planning and industrialization of the automotive market have led to a substantial increase in motorized mobility, according to Kyte (2013). It implies increased greenhouse gases emission, congestion of the private and public mobility network, increased travel times for users, and a decrease in the use of the active modes of mobility, among others.

Many theories and concepts have been developed due to research and strategies that attempt to counteract the impacts generated by the growing acquisition and use of private mobility. One example can be seen in Anaya (2017).

The use of motorized mobility has significant impacts on settlements, according to Hans Koster (2022). The situation is similar worldwide, and the basic principles do not differ between countries; nevertheless, particular phenomena entail addressing different challenges to find appropriate solutions to the needs in each settlement, as shown by Mosquera (2016) and Walta (2018).

Thus, active mobility and public transport have suffered the impacts of a massive migration of users to motorized modes, especially in countries where these modes are not so strong, and the vehicle industry has taken advantage of this situation.

In the specific case of Medellín, the factors mentioned are essential. However, the characteristics of the city (built and natural environment) strongly impact some modes, such as the bicycle, and the modal choice is strongly influenced by these conditions.

Concerning the characteristics of the city of Medellín, the bicycle has had little participation in its modal distribution, as the following chapters show, and there is a massive gap in its use rate compared with other modes.

It is also known that many bicycle users have opted for this means because it is a low-cost transportation option (Alcaldía De Medellín 2014).

At the same time, for this city, the users have opted predominantly for motorized means due to the economic possibilities and, probably, it is also related to the idea of acquiring more status behind the vehicle ownership, as can be seen in Federal Ministry for Digital and Transport (2020) and Alcaldía de Medellín (2016).

The research explores the characteristics related to the choice of the bicycle as the preferred means of mobility and how bicycle could be a more attractive alternative, reducing the gap between this means of transportation and others by understanding and counteracting crucial negative trade-off factors in the particular conditions of Medellín. This research explores the variables that impact the choice, shows evidence, and suggests alternatives to counteract the impacts on bicycle mobility taking a case study as representative of the city.

2. Determinants of the study

- This study was developed for the population of the National University of Colombia at Medellín. Many of the findings can be applied to the complete city.
- the result of this study is based in a higher rate of users compared with the rate of use in the city, as seen in section 3.8.4.
- Based on the information showed in the section 3.8.5, the study also was developed with biological gender approach. In the section 4.3.1 Gender-oriented Approach, the fundamentals are illustrated according to (Fernández-Heredia *et al.* 2016), the high impact of differentiation is fundamental, and the principle of autonomy is needed to plan properly based on Alcaldía de Medellín *et al.* (2022). Gender impact hardly the dynamics and studies must analyze the phenomenon according to biological gender.

3. Chapter I – Context

This chapter illustrates the general spatial and social conditions on which this work was elaborated. From the country to the city where the representative case study was done. Focused on general factors that influence the dynamic of the bicycle in the city and country.

Thus, it is essential to point out that the city of Medellín is located in Colombia, which is a developing country with a percentage of poverty that in 2022 reached almost 40% of the population. Colombia has enormous inequity in settlements, evidenced in 52.2% of informal households, according to Portafolio (2022).

Colombia is the second most biodiverse country in the world concerning its environment, according to Minciencias (2016) and a culturally rich country. The strategic position makes it a unique point of convergence between the South and the center of America. Additionally, mainly due to the forced migration of communities, Colombia settlements could be defined as a biodiverse spotlight of cultural exchange (Mincultura 2022).

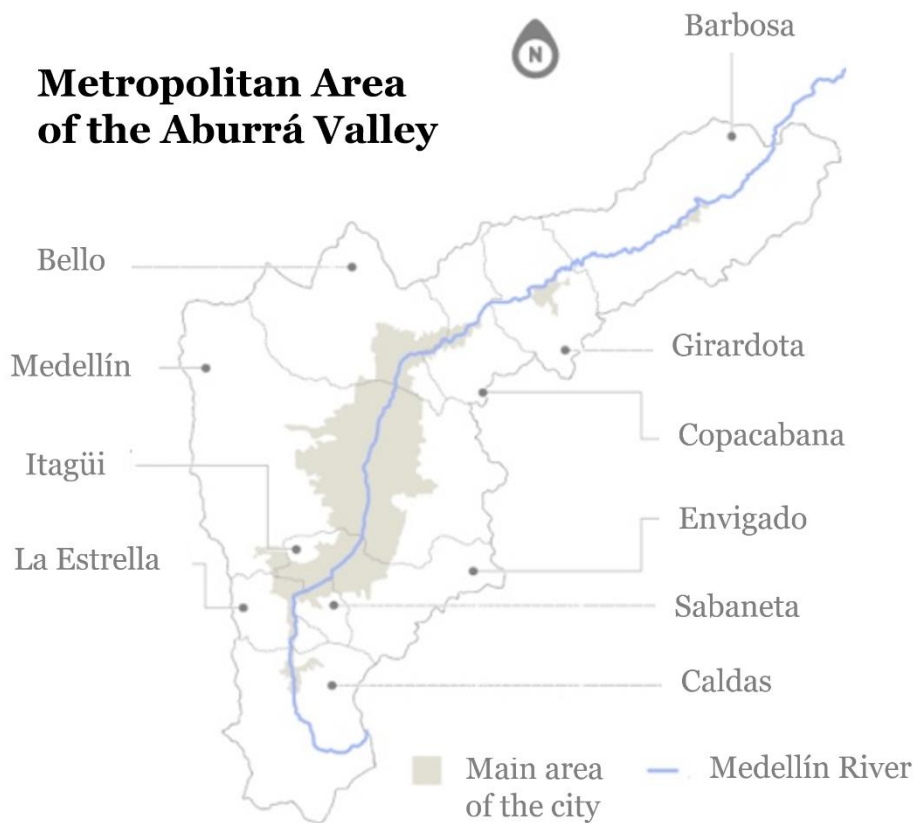
Medellín is the capital of the department of Antioquia and the second largest city in the country. According to 2018 census data from the National Administrative Department of Statistics - DANE, in that year, Medellín had a population of 2,427,129 inhabitants, 47% men and 53% women. (Medellin cómo vamos 2019).

The city is located in the "Aburrá" Valley, along with 10 other smaller municipalities that surround it. In total, it is the epicenter of 4.11 million inhabitants (Área Metropolitana del Valle de Aburrá 2022a), and it is divided into "Comunas" and "Corregimientos" which also are divided into neighborhoods. Medellín also is one of the most unequal cities in Colombia (Medellín cómo vamos 2020)

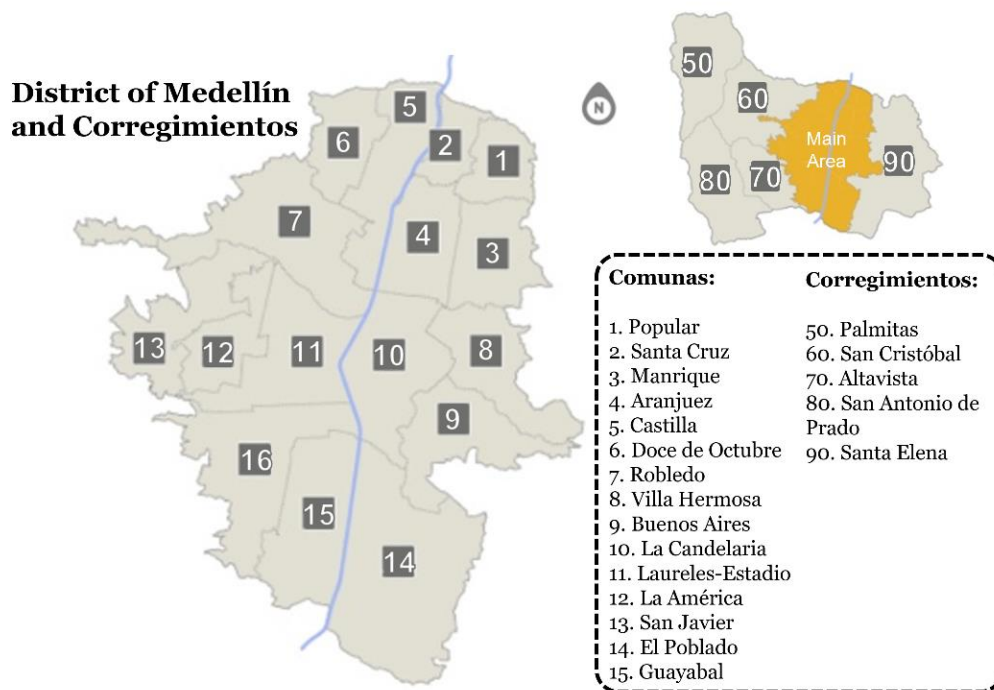
Medellín has a population density of 6546.3 inh per Km², distributed over 387 Km² (Secretaria Seccional de Salud y Protección Social de Antioquia 2022).

It means around seven inhabitants per square meter on average. Medellín is not one of the densest cities in the world, but the characteristics of the topography and the correlation with the population imply more concentration of inhabitants in the flattest places of the Aburrá Valley; this concentration can be seen in the next sections of this chapter.

The political distribution of the valley and the city can be seen in ((Fig. 1) and (Fig. 2).



(Fig. 1) Political distribution of the Aburrá Valley
Source: Author



(Fig. 2) Political distribution of the District of Medellín

Source: Author

Medellin is considered a model of social urbanism in the world, a benchmark for mobility in Colombia and Latin America, a global benchmark for innovation, and at the same time a city with great disparities in relation to the equity of its inhabitants.

The main characteristics of the environment in which this research is developed are mentioned next.

3.1. Climate and weather

Medellín is known as the city of eternal spring due to its unique and privileged climate. The temperature generally varies from 16 °C to 26 °C and rarely falls below 15 °C or rises to over 27 °C as can be seen in (Weather Spark 2023).

with the wet season (three months each three months approximately) has a 69% probability of rain in a day. The month with the most rain in Medellín is May, an average of 268 millimeters. The month with the least rain in Medellín is January, with an average of 112 millimeters. (Weather Spark 2023).

The length of the day in Medellín is approximately 12 hours all year round due to its location very close to the planet's equator. Also, solar radiation is constant, and the sun is always near the zenith (Weather Spark 2023).

Medellín and the center of Colombia have two marked rainy seasons, the first occurs during September, October, and November, and the second occurs during March, April, and May. These seasons are caused by the influence of the Intertropical Convergence Zone (ITCZ) over the country. Even so, these are not the only rainy seasons in the city, as it frequently rains with high intensity, due to its location and the influence of some global scale phenomena such as the one mentioned above, in addition to the El Niño phenomenon, the cold air coming from the south pole and the tropical waves from the east. Finally, it is worth mentioning that there is also an incidence of mesoscale phenomena such as the called "Chorro del Chocó" and its warm microclimate is derived from its location between mountains, among other factors as mentioned detailed in Poveda (2004).

3.2. Air quality

The city has a natural and built environment that have triggered a very harmful air quality problem for its citizens in recent years. According to Observatorio de Políticas Publicas del Concejo de Medellín et al. (2017) the air in Medellín "is harmful to sensitive groups and to the population in general".

Massive alerts about the harmfulness of the air at some specific moments and even the recommendation to citizens to avoid outdoor activities are indicators of this situation that seriously affects the city. 59% of the harmful material in the air was emitted by vehicles, and the rest is due to business activity based on Observatorio de Políticas Publicas del Concejo de Medellín et al. (2017).

3.3. Topography

The city is located in a mountain river valley (central axis of the city) within the abrupt topography of the Colombian mountain ranges. Not all areas of the city have an adequate topography for cycling uphill without too much physical effort, and the appropriate area for cycling in the city (areas with a slope less than or equal to 20%) is mainly located in the urban area near the river.

3.4. Urban land use

According to the land management plan (Alcaldía De Medellín 2014), the urban part of the city and along the Medellín river corridor, areas of economic activity, high-intensity use, and institutional use are concentrated. These areas have a large part of the different activities of citizens. Also, the residential areas have less commercial activities and mainly residential use. The map of Urban land uses can be seen in the appendices as "Usos Generales del Suelo Urbano" in the appendices of this document.

3.5. Planning Categories

The city has four levels of planning named river "Rio", hillside "Ladera", border "borde" and rural "rural"; These categories can be seen in the map "Modelo de ocupación" in the appendices of this document. Each of these categories is described below.

3.5.1. River category

They are Central public spaces located on the banks of the river and in the Metropolitan Center, within the "MEDRío" Strategic Intervention Area. (Alcaldía De Medellín 2014)

3.5.2. Hillside Category

They are public spaces associated with consolidated residential neighborhoods. (Alcaldía De Medellín 2014)

3.5.3. Border Category

Areas of peripheral public recreational use are located in the Urban-Rural border Strategic Intervention Area. (Alcaldía De Medellín 2014)

3.5.4. Rural Category

They are natural spaces intervened sustainably and built as places of recreation and meeting places destined for collective enjoyment, passive recreation, ecotourism, balance, environmental sustainability, and social development of the communities that use them. (Alcaldía De Medellín 2014)

3.6. The complete public mobility system

In the district of Medellín, there are:

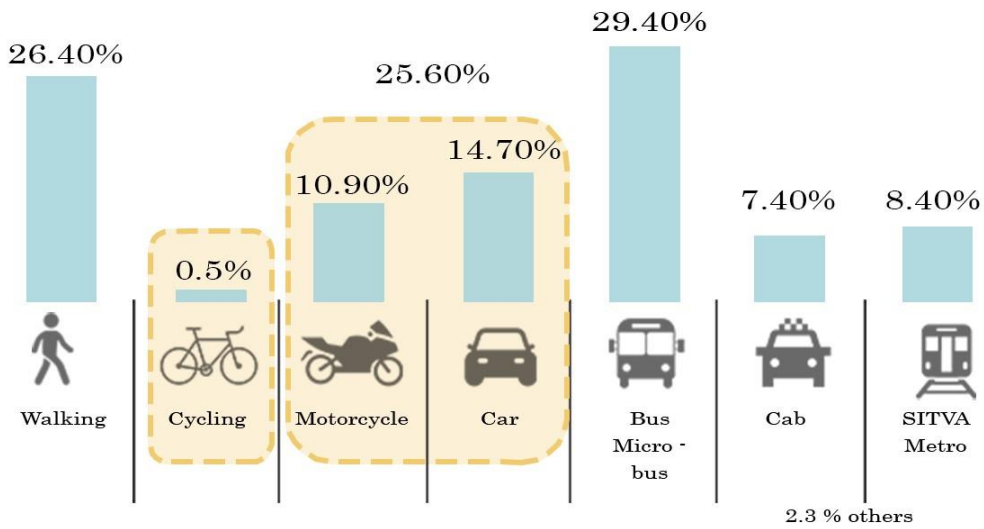
- 175 km of bike lanes, according to Alcaldía de Medellín (2023a) and Alcaldía de Medellín (2022). This information is available in the appendices as "Red de cicloinfraestructura".
- An integrated metropolitan public bicycle sharing system with 109 stations, 67 located in the city of Medellín (Área Metropolitana del Valle de Aburrá 2022a) available in the appendices as "Estaciones de EnCicla 2022"
- Around 210 public bicycle parking facilities (Alcaldia De Medellín 2018). Available in the appendices as "Red de cicloinfraestructura"
- Two train lines with a total length of 31.3 kilometers, 27 stations, and a fleet of 80 units. (Área Metropolitana del Valle de Aburrá 2022a)
- Three lines of articulated and standard buses with a total length of 27 km, 26 stations, a fleet of 31 articulated buses, and 57 standard buses. (Área Metropolitana del Valle de Aburrá 2022a)

- Five lines of cable cabs (including a tourist line), with a total length of 12.6 km, 15 stations, and a fleet of 362 cable cabs. (Área Metropolitana del Valle de Aburrá 2022a)
- One tram line with 4.3 km in length, nine stations, and a fleet of 12 units. (Área Metropolitana del Valle de Aburrá 2022a)
- Integrated and feeder bus routes of the system, with a fleet of 370 vehicles. (Área Metropolitana del Valle de Aburrá 2022a)
- 401 Non-integrated public transport bus routes based on Alcaldía de Medellín (2023b) and Alcaldía de Medellín (2022)

3.7. Modal split

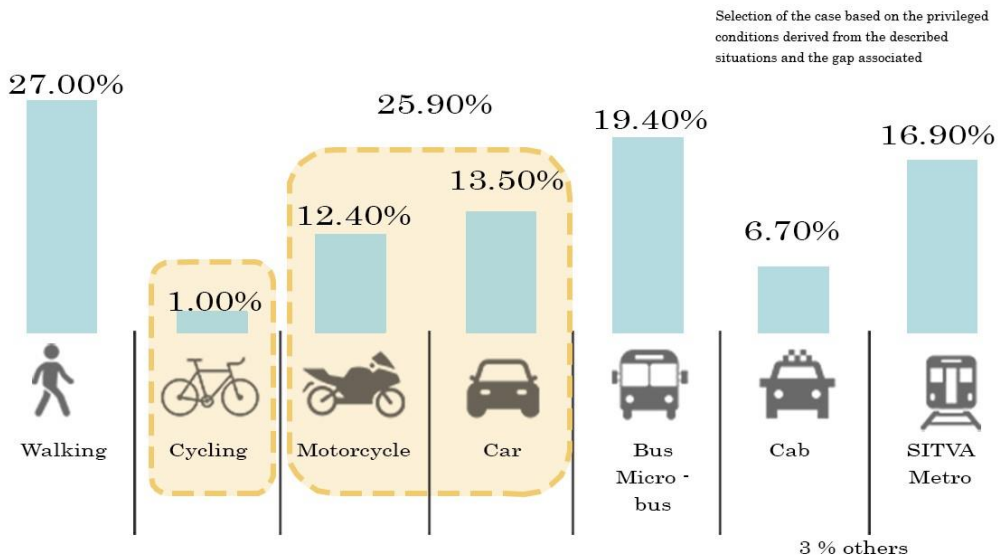
The metropolitan area has 6.13 million daily trips, of which 3.75 million or 61% are generated and attracted in the district. Likewise, the modal partition of these trips corresponds to 27% by feet, 9.4% by public transportation, 13.5% by car, 12.4% by motorcycle, 16.9% by metro, 6.7% by cab, 3% by other modes, 2% by BRT and approximately 1% by bicycle (Área Metropolitana del Valle de Aburrá 2018). as can be seen in (Fig. 4) and can be compared with the (Fig. 3) that represents the same information but from 2012.

The information from the most recent survey (2023), shown in (Fig. 5) was obtained during this research; however, it has yet to be officially published by the entity in charge. The figure shows how the gap has reduced because the bicycle use has increased and the trends of the use of cars and motorcycles have changed.



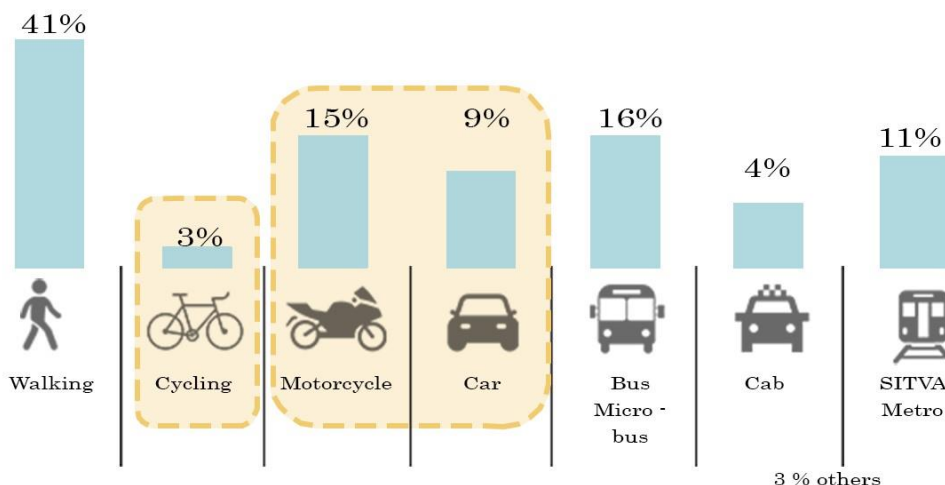
(Fig. 3) Modal Split 2012

Source: Author based on Área Metropolitana del Valle de Aburrá (2012)



(Fig. 4) Modal Split 2017

Source: Author based on Área Metropolitana del Valle de Aburrá (2018)



(Fig. 5) Modal Split 2023

Source: Author based on Area Metropolitana del Valle de Aburrá (not officially published)

3.8. The cyclable network

Next, a brief description of the main characteristics of the network for bicycles is presented.

3.8.1. Corridors

The city has several bicycle lanes, including segregated and painted corridors and lanes shared with other vehicles and pedestrians, as seen in the following table.

Typologies of available bike lanes in Medellín		
Shared Sidewalk	1.7	Km
Shared in pavement	15.4	Km
Shared in pavement and sidewalk	0.5	Km
Painted in pavement	0.4	Km
Segregated in sidewalk	45.7	Km
Provisionally segregated in pavement	48.8	Km
Undefined	0.2	Km
Non registered	62.4	Km
Total	175.0	Km

(Tab. 1) Typologies of available bike lanes in Medellín

Source: (Alcaldía de Medellín 2022a)

According to Alcaldía de Medellín (2022) these bike lanes are distributed as the Appendice “Red de cicloinfraestructura shows”, but it is not clear where are the 62.4 Km of non-registered bike lanes in this document.

3.8.2. The public bicycle parking places

According to Alcaldía de Medellín (2022), there are 200 public parking places with different capacities identified, as can be seen in “Red de cicloinfraestructura” in the appendices, however, this number has a fast variability due to the dynamics in the city.

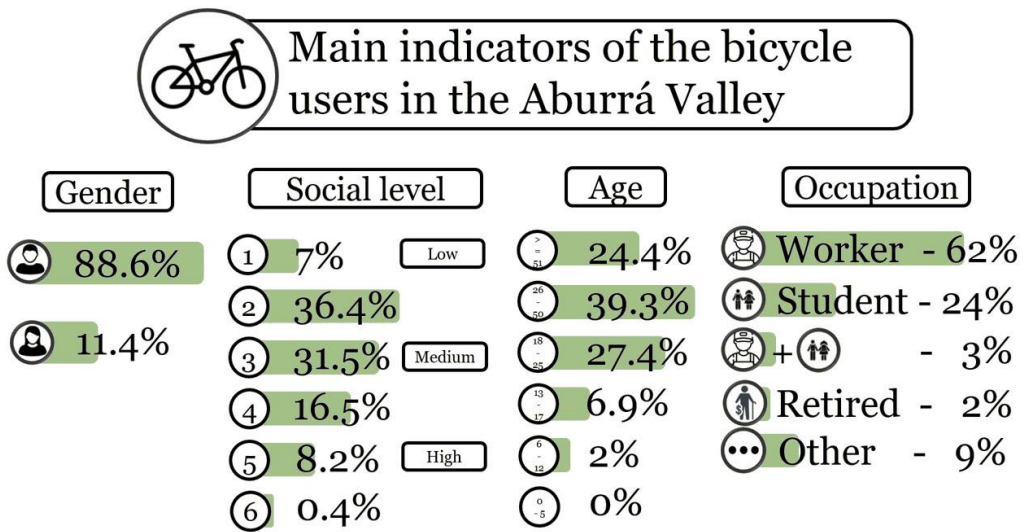
3.8.3. Public shared bicycle system

Based on the available information from open data found in Área Metropolitana del Valle de Aburrá (2022b), there are 67 stations. The available information does not show the characteristics of each station (automatic or manual). However, it can be seen that for January of 2023, more than 115.591 trips were made in the complete metropolitan area, mainly in Medellín, according to the appendice "Prestamos EnCicla".

3.8.4. The behavior of the bicycle users in the district

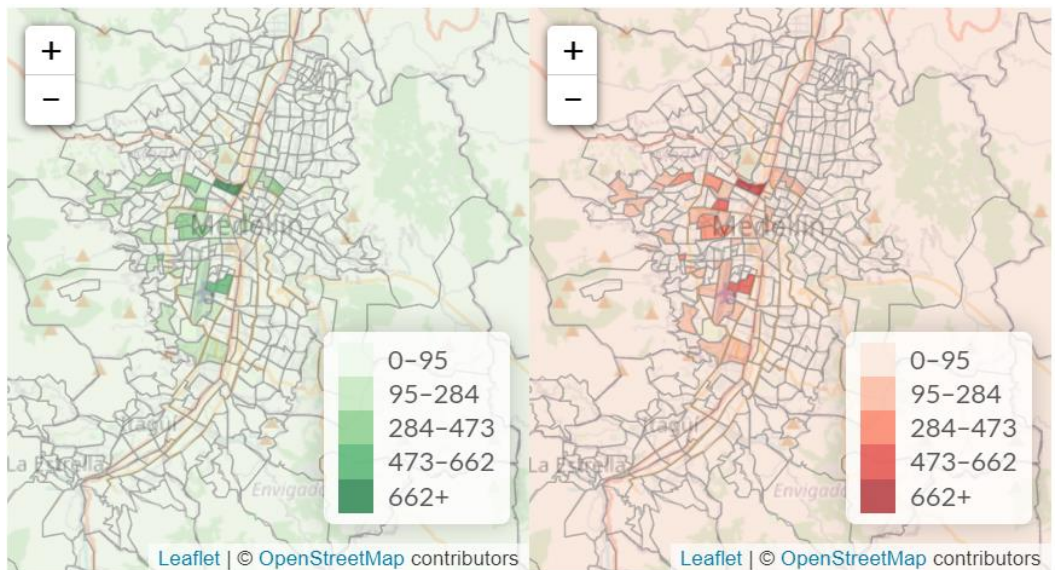
The Metropolitan Area has 61842 bicycle trips, equivalent to 1% of the total, and the district has 40476 trips, equivalent to 0.66% of the total; this means that the city does not have a strong demand for bicycle users and that most of the trips (origin and destination) are concentrated within the district.

Some of the Main indicators of the bicycle users in the Aburra Valley are shown in the following figure; it is essential to note that these indicators are for the entire Aburrá Valley and not only for the city of Medellín.



(Fig. 6) Main indicators of the bicycle users in the Aburrá valley
Source: autor based on Área Metropolitana del Valle de Aburrá (2018)

The five comunas with the district's highest bicycle modal use rate are; 11. Laureles - estadio (17.5%),; 10. La Candelaria (13,5%); 16. Belén (12,5%); 13. San Javier (9.0%) and, 15. Guayabal (8.3%). The following figure illustrates their location, the number of trips for the origin on the left and the destination on the right. The graphic units are trips per day.



(Fig. 7) Cyclists' behavior in Medellín
Source: (Área Metropolitana del Valle de Aburrá 2018)

3.8.5. Women and bicycle in Medellín

In Medellín, care trips predominate, and women walk often (it is unclear whether this is an obligation or a preference). It is also clear that they use bicycles less, although, in the public bicycle system, the percentage of women's use rises with respect to the use of the mode in general (Alcaldía de Medellín *et al.* 2022). This author also shows that the use rate of active mobility in Medellín is higher for women than men.

It can also be observed in Alcaldía de Medellín *et al.* (2022) that women have different commuting schedules, reaching peak times in the mid-morning during the week, with the most predominant reasons being care and work trips.

Regarding trip distance, women generally travel less than 3 km, and men travel more than 5 km, probably due to working conditions and access to mobility modes. It is unclear if this difference is equivalent to difficulties associated with barriers for women. (Alcaldía de Medellín *et al.* 2022).

The bicycle could be a vehicle for female students or workers (mainly informal or self-employed) but there is no information on many trip characteristics for their modal choice, it needs to be explored. The partitioning according to profession or role can be seen in Alcaldía de Medellín *et al.* (2022).

3.8.6. The bicycle and the road safety

In 2022, 244 people died in Medellín, of which 4 were cyclists, and 411 road incidents with injured cyclists occurred in the city, according to Alcaldía de Medellín (2022b).

In this way, the problem in Medellín can be cataloged as a public health problem that could highly influence users' preferences when using bicycles.

3.9. The bicycle a suitable vehicular alternative to reduce the gap between the rate of bicycle use and other means

The bicycle presents several advantages, from individual benefits such as health benefits and efficiency in dense urban environments to social benefits due to its efficient performance and reduced impacts on economic infrastructure. Furthermore, although it also has disadvantages due to the physical effort and the difficulty of carrying things, in addition to the vulnerability related to the climate, according to Heinen et al. (2010); It is an efficient mode of transportation on a human scale (concerning the distances it can travel) and with multiple applications in daily life.

According to (Cámara de Comercio de Bogotá (2009), the main reasons to choose the bicycle for the district of Bogotá are divided into Economic, Environmental, and health. These reasons could apply to Medellín based on the conditions analyzed by the author for this city in the Colombian context.

3.9.1. Economic reasons

According to Cámara de Comercio de Bogotá (2009), Among the suggested economic reasons why the use of bicycles should be encouraged for the majority of citizens are:

1. The cost of the infrastructure since it is much lower than that of motorized mobility. Additionally, the cost of this vehicle and its maintenance is much lower for the user and has no impact on the road surface.
2. The efficient use of space, since up to twenty bicycles can be parked in the space in which a car is parked, additionally a bicycle consumes less than 60% of the space required to circulate concerning a car.
3. The contribution to the reduction of congestion: it reduces travel times for citizens.
4. The contribution to reducing fuel consumption: bicycles save the world's consumption of 240 million gallons of gasoline per year.

3.9.2. Environmental reasons

According to Cámara de Comercio de Bogotá (2009), among the suggested environmental reasons, transport by bicycle is not a pollutant, and it does not produce noise pollution; it also contributes to energy savings: cycling saves 1.5 Kg of CO₂ emitted per day to the atmosphere for every 5 km, which makes it the best vehicular alternative against climate change. A 6.5 km round trip by bicycle frees the environment of 7 kg of pollutants emitted by other modes.

3.9.3. Health reasons

The World Health Organization published a report that places physical activity as one of the risk factors and modifiable causes of death, especially in industrialized countries. Regular physical activity by bicycle contributes to and reduces the risk of heart disease, diabetes, colon cancer, and hypertension. Physical activity helps older people to be functional and independent, as mentioned in Cámara de Comercio de Bogotá (2009).

Countless studies suggest physical activity as a potential risk reducer for developing obesity and osteoporosis, immune system diseases, stress, and anxiety. It is estimated that a person of 70 Kg can burn, in a 20 km trip, 410 calories. With only 10 minutes of cycling, there are already positive impacts on the body, and after 50 minutes, fat metabolism stimulates.

(Cámara de Comercio de Bogotá 2009)

3.10. Relevant conflicts for the country, identified in the National Strategy of Active Mobility by (Ministerio de Transporte de Colombia et al. (2022))

The National Government has developed a strategy that includes points related to how to incentivize bicycle use in Colombia and the barriers that the processes have. These conflicts must be considered and improved in the coming years to increase the presence of the bicycle as means of transport in the modal split of the country. The most related conflicts are going to be mentioned next.

3.10.1. Infrastructure conflicts

- Infrastructure design manuals that ignore urban dynamics and active mobility with a gender and differential approach.
- Decision makers' vision that privileges the use of private motorized vehicles over active mobility.
- Technical criteria ignore active mobility and the gender and differential approach, biasing the tools that justify infrastructure interventions.
- Low quality of infrastructure for active mobility with a gender and differential approach.
- Loss of health due to road incidents, where those who use active mobility are among the most vulnerable road actors on the roads.

3.10.2. Cultural transformation conflicts

- Sociocultural barriers based on imaginaries that delay the positioning of active mobility.
- Street behaviors associated with social and urban imaginaries.
- Conceptual and discursive differences on active mobility.
- Lack of investment in cultural processes related to active mobility.

- Lack of methodologies and scenarios for effective citizen participation.

3.10.3. Governance conflicts

- Asymmetry in capacities from active, gender and differential mobility instances.
- Lack of comparable information between territorial entities.
- Lack of scenarios and incentives for coordinating regulatory, financial, and public organization aspects.
- Lack of coordination between territorial entities and inter-municipal bodies to promote active mobility issues.
- Incoherence in the implementation of public policies on gender and active mobility. Active mobility.

3.10.4. Planning and land management conflicts

- Land Management Plans in the process of revision or expired do not stimulate active mobility with a gender and differential approach.
- Mobility Plans are weak instruments that affect the planning, development and continuity of active mobility projects with a gender and differential approach.
- The disarticulation and lack of correspondence of different planning instruments do not favor the continuity of active mobility projects with a gender and gender and differential approach in the cities.

4. Chapter II – Justification and theoretical framework

Traditional transportation research relies on utility maximization to explain mode choice, including the decision to use active mobility. Some research assumes that people choose according to utility maximization, which is directly related to cost and time, as seen in McNally (2000) . When this knowledge is extended to active modes, it has been recognized that there are other determinants of mode choice, and recent research reinforces that the role of individual attitudes, preferences, and interpersonal relationships has a major impact on modal choice, especially concerning active modes (Krizek *et al.* 2009).

Based on the information presented in the 3.7 section, Modal split, it is clear that there is a gap between the preference for the bicycle mode and other modes of transport in Medellín, especially with the direct motorized means. Thus, to analyze the situation, it is necessary to review the variables that impact the increase or reduction of this mode.

There is evidence related to the significant negative impacts of different factors that influence the bicycle as a means resulting in a critical gap shown in the rate of use, also related to the 3.9 section.

In the academic context, Fernández-Heredia *et al.* (2016) argues that it is necessary to know the factors that affect the free choice for cycling, and it is also necessary to identify, quantify and understand the impacts of these variables in order to understand the modal choice. This author also suggests two problems: the identification and the design of the strategy to introduce these factors in the appropriate operational standards.

In the same way, some authors have reviewed in detail the factors that negatively influence the dynamics related to cycling, such as de Sousa *et al.* (2014),

who evaluate the perception of a group of individuals regarding the obstacles that may hinder the use of bicycles to commute to work, Heinen et al. (2010) who review the literature on bicycle commuting to work to show essential points in the habits of users, Handy et al. (2014) who work on bicycle promotion from needs and challenges, , Handy et al. (2002) and Cervero et al. (2019) who explore the built environment, Cervero and Kockelman (1997) who explore concepts of density diversity and design in addition to the association between the network, commuting and the built and natural environment in Cervero et al. (2019). These authors are some of the most relevant references for the development of this theoretical framework, as they are the ones who have presented advances concerning the field of study, and this document discusses some of their postulates.

In the Latin American context, many instruments related to the field have been developed by private companies, such as "Ciclo-inclusión en America Latina y el Caribe" This instrument is a guide to impulse bicycle use (Interamerican Development Bank *et al.* 2015), "¡a todo pedal!" that is a guide to build "cycling cities" in Latin America and the Caribbean (Interamerican Development Bank and Gehl Studio 2016), "Aprender de los países vecinos" " this instrument is a compilation of experiences of Latin American cities in the promotion of bicycles as a mode of daily transport (Interamerican Development Bank *et al.* 2017) and "Mujeres y Ciclismo Urbano" an effort to promote gender-inclusive mobility policy in Latin America (Interamerican Development Bank 2017), among many others.

In some countries, in the public latin american context, such as Mexico, Ecuador, Brazil, Uruguay, Mexico, Panama, and Argentina, perception tools have been developed to understand the context of modal choice and the relationship with the bicycle. In 2011, in Mexico was developed the "Manual integral de movilidad ciclista para ciudades mexicanas" focusing on a public policy mobility program, mobility network, infrastructure, intermodality and education and promotion (Institute for Transportation and Development Policy 2011); The Ecuadorian Embassy in Netherlands developed "El uso masivo de la

bicicleta para el buen vivir", with the aim to develop strategic guidelines for the creation of public policies, and an economical and cultural structure to incent the massification of bicycle use as a clean mobility alternative in Ecuador (Embajada del Ecuador en los Países Bajos 2013); in Brazil, was developed the guide "Incluyendo A Bicicleta nos Planos" as part of the campaign "Bicicleta nos Planos" and it had as objective the orientation of the society and the decision makers to include the bicycle in the plans related to transport management and urban planning through the insertion of this modes in the Urban Mobility Planning Process (Bike Anjo *et al.* 2016); in 2016, the Metropolitan Area of Montevideo (Uruguay), conducted the mobility survey in order to establish an updated information tool for the mobility field for its inhabitants (Municipio de Santiago de Cali and Universidad del Valle 2019) and in 2018, a survey was conducted in several cities in Argentina to determine common elements of mobility aimed at tackle aspects of planning to be prioritized in that country based on the user's point of view, as mentioned by the same author, among many others.

In the Colombian context, it is noteworthy that the "Red Colombiana de Ciudades ¿Cómo Vamos?" has generated tools in different aspects, including the field of mobility, for the generation of impartial and comparable information among cities, including some of the main Colombian cities (Municipio de Santiago de Cali and Universidad del Valle 2019). Also, the National Strategy of Active Mobility by Ministerio de Transporte de Colombia *et al.* (2019) was developed to detect the main problems and factors that influence active mobility in general in the country and guide the next steps for improving active mobility as a general tool.

At the local level outside of the capital city of the country of Colombia, the city of Cali has developed initiatives beyond the mobility modal choice survey (Municipio de Santiago de Cali and Universidad del Valle (2019), in addition to the book "Infrastructure for active mobility and gender - a methodological guide" developed by Alcaldía de Medellín *et al.* (2022) To support the overall goal that no woman should suffer in any way while moving, converting mobility in the way of improving their living conditions and

guarantee their economic, physical and decision-making autonomy.

Apart from the instruments mentioned above in different cities of the country, it is essential to highlight the efforts made by the District of Bogotá to understand the factors that influence mobility behavior and incentive of bicycle mobility. Some of the instruments developed by this city are "Movilidad en Bicicleta en Bogotá" to move forward in the consolidation of the mobility system of the region (Cámara de Comercio de Bogotá 2009); The Spanish translation and correlation with the Colombian environment of the "Cycle-Inclusive Policy Development: A Handbook" named "Manual de Políticas Amables con la Bicicleta", which was developed to become a tool for the district of Bogotá and municipal authorities in the development of public policies that promote bicycles as a standard mode of transportation (Cámara de Comercio de Bogotá 2009); The book "El libro de la Bici" developed to impulse actions from citizens to promote the bicycle culture in the city of Bogotá (Alcaldía Mayor de Bogotá 2014); The report "Integración de transporte no motorizado y DOTS", which analyzes non-motorized transport and its integration with urban development, framed within the broader discussion of Development Oriented Sustainable Transport (DOTS) (Cámara de Comercio de Bogotá and Despacio 2014) and the report "Diagnóstico sensible al género sobre las dinámicas de movilidad en Bogotá y Cundinamarca", a gender-sensitive diagnosis of the dynamics of mobility between Bogotá and the municipalities of western Cundinamarca (Funza, Mosquera, Madrid, and Facatativá).

Finally, from different institutions and researchers in the country, there are considerable efforts to understand the problems beyond the technical aspect and correlate it with social aspects. Despacio (2014) provides data about the bicycle infrastructure in Bogotá as well as survey data on popular perceptions of bicycle use in English, Castillo et al. (2016) creates a diagnostic of the network in Bogotá from health point of view, Alvarez Orrego (2021) analyzes the perception of women in Medellín, regarding the use of different modes through quantitative and qualitative methods and, Mejía Jimenez (2023) who analyzed social capital from the theory of resources and capabilities for the Smart City.

Based on the literature mentioned above, some additional authors and taking as a starting point the efforts made by entities, governments, and researchers. This chapter justifies the concepts to generate a detailed analysis of the gap in bicycle mobility in Medellin.

As mentioned, two examples of cities from Colombia are Cali and Bogotá, and they have explored different variables to determine impacts in the mobility dynamic of those cities.

For example, the study conducted by Despacio (2014) in Bogotá presents factors related to the use or non-use of bicycles in the city. This study analyzed conditioning variables and their impacts on the use of the mode, and its results show us a clear application of the factors that condition the use of bicycles and their impacts in the capital of Colombia.

The following are the factors that people in Bogota consider adverse to bicycle use:

Adverse factor	Response %
Bein attacked	56%
Being hit	53%
Wather/rain	46%
Car behavior towars cyclists	42%
Pollution from motor vehicles	39%
Bikeway design and obstacles	37%
Finding a place to park bike	26%
sweat	17%
Cannot carry what I normally do	17%
Far from school/work	16%
Cannot leave bike anywhere (if I do not return on bike)	15%
Clothes get dirty (have to use athletic wear	14%
Cannot leave bike anywere (If I get tired, have an incident, etc.)	11%

(Tab. 2) Most Adverse factors related to bicycle use in Bogotá
Source: (Despacio 2014)

As a result, public and road safety are the negative factors that most condition bicycle use ("being attacked" refers to the possibility of being the victim of a

crime, for example, a mugging), followed by weather conditions and interaction with motorized mobility. Travel distance is not such a representative variable (Despacio 2014). This study also suggests that for the bicycle to reach a modal share of more than 10%, the expansion of the infrastructure network is essential, followed by implementing a public bicycle system and free bicycle parking at Transmilenio stations. The study highlights the improved integration of Bogotá's transport infrastructure around cycling.

The results showed for the city of Bogotá illustrate how to develop the analysis of the variables and what kind of factors could be important for other cities in a similar context. For the city of Cali, the results show how this kind of research can be applied to the field and used to generate planning instruments to transform the current situation.

4.1. The meaning of Gap and the definition related to bicycle mobility in Medellín

According to Walker (2011), in traditional transportation theories, travelers must make choices when making their journeys; This involves making trade-offs based on each mode's relevant attributes and weighing each attribute's value to their trip, choosing the alternative that provides the most utility according to their analysis at the end.

Also, as mentioned by Gärling and Axhausen (2003) the user choice scenario generally becomes a habit and generates statistical trends such as those observed in the 3.7 section, Modal split.

As it was seen in the introduction of this chapter, according to classical transportation theory, it should be assumed that users maximize utility and, observing the rates of use for the different modes in the city of Medellín, shown in 3.7 section, Modal split, a trade-off tendency in the users is generated derived in a significant gap between the bicycle use rate and the rest of the modes.

According to Oxford University Press (1989) , one of the oldest and most reliable language references, the meaning of gap is "a space where something is missing"

In Spanish, according to Real Academia de la lengua Española (2022), which is the institution in charge of the official definition of the language the "Gap" can be translated as "Brecha", this word comes from the word brèche, and this one also from breka 'roto' and the old German bréhhan (Real Academia de la lengua Española 2022b) and means "Diferencia o distancia entre situaciones, cosas o grupos de personas, especialmente por la falta de unión o cohesión" Literally translated in English as "Difference or distance between situations, things or groups of people, especially due to lack of union or cohesion".

Based on the available definitions, for this research, the concept of gap applied to the system of mobility, derived from the trade-off made by the user, leading individuals to have strong preference tendencies for some specific modes of mobility, is defined as **a representative distance between the preference of a mode of mobility created by the fracture related to factors that change the organic balance of mobility modes.**

For an adequate analysis of the situation, it is necessary to delimit the focus of the study concerning the variables and justify their choice according to their representativeness.

4.2. Factors that condition the use of bicycles

In the case of bicycles, innumerable variables can determine user preferences. According to Heinen et al. (2010) The determinants of bicycle use into five groups: a. Built environment, b. Natural environment, c. Socioeconomic variables, d. Psychological factors and, e. Cost of time, effort, and safety. Based on these five groups, the representative factors for Medellín will be developed below. This categorization was selected because it groups the different factors that can condition the use of bicycles, and within these factors, any condition can be mentioned.

Recently many authors have introduced user perception that condition the use of modes in models; through this, it is possible to quantify the impact of perception on modal choice. According to Fernández-Heredia et al. (2016), knowing these

variables and their indicators are very important to model the behavior of bicycle users.

Fernández-Heredia et al. (2016) group the factors influencing bicycle use into three main groups, a. environmental, b. facilities, c. subjective perceptions. In this work, we will use the grouping created by Heinen et al. (2010), because it covers the influencing factors in a more detailed way.

Recently, some researchers such as Fernández-Heredia et al. (2016) have defended the inclusion of qualitative information in choice models, especially for active modes, because they have a huge influence and it justifies better the modal choice. This approach has also been developed in the Structural Equation Model System (SEM), a model that works with latent variables.

"The individual, attitudinal, and environmental perception of each person largely condition the use of bicycles as a mode of transportation. While some perceive some barriers as modest, for others, these variables can be very significant and can condition the use of bicycles in their mobility routines" (de Sousa *et al.* 2014).

In a nutshell, the factors that condition the use of bicycles affect the trade-off between modes that generates marked preferences towards modes other than bicycles and generates the gap.

4.2.1. Psychological factors

It refers to characteristics related to habits and attitudes, individual and social behavior, among others. Some characteristics of importance to take into account for bicycles in this determinant that influence the modal choice and consequently the gap between the bicycle and other means, if they are representative enough, are:

a. Companies and institutions vision:

- Offering incentives to companies and institutions to get bicycles is evidence of a positive attitude towards cycling and can encourage bicycle use.(Heinen *et al.* 2010).

b. Social influences:

- Individual social circles may or may not encourage new bicycle users. Cultural norms of the wider community may also influence individual behavior. Seeing cycling as an everyday mode of transportation may motivate people to do so and vice versa.(Handy *et al.* 2014).
- Bicycling itself is a social activity; riders prefer to have the opportunity to ride side by side. This factor is vital for parents who drive their children to school or home from work accompanied. (Cámara de Comercio de Bogotá *et al.* 2010)

c. Car-oriented thinking:

- Attitudes towards cars are generally more favorable than attitudes towards cycling as a mode of transport. Negative perceptions of cars tend to encourage cycling.(Heinen *et al.* 2010)

d. Ecology and altruism:

- People with preferences for activities out of home, good access to goods and services, public transportation users, physically active people, and people in urban environments have more probability of using public and active mobility.(Heinen *et al.* 2010)

e. Habits:

- Experiencing other mobility alternatives can lead people to transform their habits; a person used to one mode may stay in that mode, so alternatives such as bicycles are not feasible (Heinen *et al.* 2010). However, it is said that the lack of alternatives in mobility is a huge obstacle; habits can also play an important role. (Gärling and Axhausen 2003)

- It can be said that by making something routine, people miss essential alternatives, and by forcing people with a strong inclination to use the car routinely to discuss the topic, a prolonged decrease in this habit is feasible. (Gärling and Axhausen 2003).
- It is imperative to notice that the perception of the benefits of cycling as a function of previous experience and permanence of use improves as regular cyclists become more aware and consistent. Early exposure to cycling in life also facilitates social insertion. (Fernández-Heredia *et al.* 2016).
- In the study conducted by Despacio (2014) we can see the main reasons why the citizens of Bogotá increased the use of bicycles; the main argument is related to the possibility of exercising during their trips, which is more related to physical activity than to exercise per se, it means that people use their physical capacities to be active exclusively; the second reason was the care of the environment for women and the reduction of travel time for men. Health benefits ranked third in this study.
- Consistent with the paragraph above, there are conditioning factors for non-users, such as road safety, weather, and travel characteristics, in that order of importance. Personal safety is less important For non-users based on Despacio (2014) results.

f. The no cycling argument and the reality:

- After the experience of using the bicycle, inexperienced people may feel that the experience is different from what they thought it would be concerning the factors for which it is promoted, such as health and enjoyment of the landscape, among others. On the other hand, concerning some factors that may be considered unfavorable such as road safety, the impact may need to be stronger in practice. Cyclists value their commute to work as more relaxing and exciting than pedestrians, car drivers, and public transport users.(Heinen *et al.* 2010)

According to the theory of planned behavior mentioned by Fernández-Heredia et al. (2016), completely subjective perceptions depend on factors that cannot be quantified. This author highlights their incidence in how people move and emphasizes that capturing perceptions and attitudes to create new models is fundamental to encouraging cycling as a mode of transportation. Fear of road incidents is a significant factor.

There is a clear need to go beyond observable factors to capture emotions, feelings, and perceptions. Discrete choice models establish two components, the first is the systematic one, which is replicable and analyzable, and the other is unknown; the latter is considered as part of the error and other factors; it will be necessary to study the incidence of these variables in the supposed error to determine its actual incidence. (Fernández-Heredia *et al.* 2016)

4.2.2. Built environment

The built environment includes urban form, infrastructure, and work facilities, which in this document will be considered as facilities in general. This factor is assumed to be very representative because it has a direct connection with the grey infrastructure, and it has been worked as one of the most important to incentivize bicycle use. However, it is unclear how it behaves in Medellín and if it represents the Gap between the bicycle and other means.

According to (Cervero *et al.* 2009), in the case of Bogotá, there are five components called "Ds" in the built environment, these are density, diversity, design, distance (to transit), and accessibility to the destination; these components would be the basis for the findings related to the built environment in the Colombian context due to the similarities with the capital city.

Some characteristics of importance to take into account for bicycles in this determinant are:

a. Distance:

- The bicycle is often more used in distances between 0.5 and 3.5 km, an increase in trip distance derives a lower share in mode choice for cycling. In the same way, the resistance to travel is likely to increase exponentially if the distance is very long due to the physical effort required. (Heinen *et al.* 2010).
- In Medellín, according to Ospina et al. (2020), living closer to a commercial district reduces long bicycle trips due to the proximity to goods and services. The land-use plan category called high-mixed areas is attractive even for people who commute long distances; cyclists are attracted to these destinations.
- The relatively low investment in cycling makes it attractive to low-income people. However, the use of bicycles in this group is lower in the case of Bogota since lower-income neighborhoods are located far from workplaces or main economic activities, and bicycle commutes to work, for example, are longer than for lower-middle-class residents. (Despacio 2014)
- The cyclable distance is the most important of the variables related to extra trips or detours, (Cervero *et al.* 2019), , this author suggests that having long stretches of lanes with direction to urban centers encourages the use of this mode.
- For the city of Bogota, the results of a study conducted by Despacio (2014) show that socio-economic groups with less purchasing power make few trips, but they travel longer distances by bicycle. In comparison, the upper groups make more trips of short distance and shorter duration. Bogotá's wealthiest people own bicycles but mainly use motorized mobility even for short trips that could easily be made by bicycle.

b. Density:

- Higher densities are related to lower levels of car ownership and use, which positively affects cycling.(Heinen *et al.* 2010)

- Land use diversity, density, and active modes-oriented designs significantly reduce travel and encourage active mobility. (Cervero and Kockelman 1997).
- Cervero et al. (2019) associate a higher urban density with increased bicycle use, mainly when origins and destination are closer. Additionally, this author mentions that people living close to the center of a city, in a denser and more mixed environment, have more probability of moving by bicycle. This author also mentions that, on average, neighborhoods with companies and fast-food outlets have more trips. Studies from European communities also have similar findings.

c. Dedicated infrastructure:

- Unexperienced cyclists, women, and younger cyclists consider bicycle facilities more important. Building bicycle paths increased the bicycle share by between 1 and 2% in some places. Also, People say they would cycle more often if they had bicycle paths and if the network was easy to reach and connected.. (Heinen *et al.* 2010)
- The mobility infrastructure with no cycling facilities could determine the use of bicycles for someone; it seems more important for inexperienced than experienced cyclists. More bicycle paths have resulted in a higher share of cycling; it depends on the case.(Heinen *et al.* 2010)
- according to Ospina et al. (2020) the dedicated infrastructure helps, especially at the origin of the trip, to limit exposure to traffic, which is also applicable to long-distance travel. Complementarily Handy et al. (2014) mentioned that the availability of infrastructure is positively associated with cycling for transport.
- Not even the presence of cyclists' dedicated infrastructure generates the use of it. One study by Cervero et al. (2019) in Bogotá reveals that bicycle-lane density did not influence cycle commuting. However, the high density was related to work and utilitarian activities.

- As the infrastructure increases in a corridor (proportion among nodes and connections), the proportion of movements in bicycles also increases. This research suggests the network can promote cycling by having comfortable links and a low-stress infrastructure. Features such as protected lanes and paths close to other nearby infrastructure of interest by reducing detours are desirable, especially over long travel distances. In a context in which the modal share is too low, the construction of dedicated and low-stress lanes could increase the tendency to use the bicycle (Cervero *et al.* 2019)
- According to Cervero et al. (2019) corridors with a mix of land uses and commercial activities should be prioritized for implementing and defining safe bicycle parking.
- Corridors with higher vehicular volumes and small guarantees for cyclist should have intensely segregated infrastructure (Cervero *et al.* 2019)
- Fernández-Heredia et al. (2016) argue that dedicated bicycle networks favor using the mode, especially where the modal share is low. This author recommends further development of this type of facility.
- Regarding other types of infrastructure for cyclists, such as showers, toilets, and lockers for storing clothes, Fernández-Heredia et al. (2016) consider that they contribute significantly to improving the image that non-users have regarding the mode and the possibility of using it. However, the same author assures that these facilities are valued differently by men and women.
- It is worth mentioning that, according to Cámara de Comercio de Bogotá et al. (2010), urban bicycles, in general, should not have to use suspension, and cycling paths should be mainly flat. A suspension system implies an increase of 25% on average per pedal stroke.
- In the case of Bogotá's "Ciclovía" strategy and infrastructure for cycling, Despacio (2014) indicates that this is what they like most about cycling in this

city, which is a great promotional strategy related to installed capacity and infrastructure.

d. Presence of infrastructure:

- Fewer people cycle in cities with significant stops (including when stop signs, traffic lights, and other traffic-controlling systems are necessary). Cyclists generally avoid traffic lights when choosing a route. (Heinen *et al.* 2010)

- People living in neighborhoods with grid street layouts and restricted vehicle parking travel fewer kilometers and rely less on single-occupant vehicles for non-work trips. (Cervero and Kockelman 1997)

- It is crucial to intervene in the network integrally, for example, to reduce the circuitry of the infrastructure and the level of stress simultaneously, since it is always intervened separately. (Cervero *et al.* 2019)

- In the UK, there are cities built during the automobile boom era with origins and destinations with no bicycle trips. This is due to the privileges of this infrastructure over the automobile rather than the lack of cycling infrastructure. (Cervero *et al.* 2019) If the infrastructure offers privileges to other modes, there will be very high impacts on active modes.

- Factors contributing to shorter travel distances, such as denser network layout, higher density, and mixed land use, affect cycling positively. Cyclists prefer dedicated infrastructure, and their preferences are based on subjective notions of safety. They also prefer access to continuous infrastructure and avoid parking.

- There are five quality criteria mentioned by Cámara de Comercio de Bogotá *et al.* (2010) for bicycle infrastructure that should be the result of the analysis of the constraints as follows:

1. Individuals must be able to perceive other people and be able to ride at least in pairs.
2. Comfort and direct routes must be a constant in the routes.
3. Having enough free space generates a perception of safety and comfort.
4. Attention to safety issues generates a decrease in the vulnerability of the users.
5. The infrastructure must be understandable and complete, connected and coherent.

4.2.3. Natural Environment

It contains environmental variables that depend only on the nature of the place as terrain, weather, wind, and others. This factor condenses very particular characteristics that could influence the gap between the bicycle and other means if they are representative enough to impact the gap between the bicycle and other means.

Some characteristics of importance to take into account for bicycles in this determinant are:

- Green and blue landscapes at the beginning and end of the routes induce the use of bicycles, according to the results obtained by Cervero et al. (2019)
- Steep terrains and wet climates work against cycling. A high temperature is preferred by users, at least in spring, in seasonal countries. (Cervero *et al.* 2019)
- Temperature, rain, snow, or humidity can reduce the volume of cyclists by up to 20%, but this depends on the period of variability, the purpose of the trip, and the location. (Fernández-Heredia *et al.* 2016)

4.2.4. Socioeconomic variables

These are characteristics related to the dynamic of the people in the habitat and the correlation with the other factors depending on the role played in the society. If this factor is representative enough, it can also influence the gap

between the bicycle use rate and other means. Some characteristics of importance to take in account for bicycles in this determinant are:

a. Social Status:

- Students, people without children, people with temporary jobs, people with part-time jobs without children, people who work less than 40 hours per week, divorced or widowed people are more likely to use bicycles for transportation. High social status and a young family reduce the likelihood of cycling. (Heinen *et al.* 2010)
- The results of the research made by Ospina *et al.* (2020) show that there are no significant effects of cyclist demographics in Medellín, which contradicts the available literature.
- According to Cervero *et al.* (2019) and in the case of the United Kingdom, professionals, and senior managers tend to use the bicycle to commute to work, the use of the bicycle to commute to work even after assessing the influence of the automobile (very harmful) on their behavior. This author associates this with attitude and conviction concerning environmental and lifestyle reasons to keep fit and contribute environmentally.

b. People's employment status:

- Part-time workers commute more by bike than full-time workers. (Heinen *et al.* 2010)

c. Affordability and acquisitive power:

- The relationship between income and cycling needs to be clarified. A higher income creates the possibility to spend money on a bicycle. People with more acquisitive power may also pay greater attention to health, conditions and consequently cycle more. In contrast, more money implies spending more on transport, including buying a car. Car ownership has a heavy negative effect on cycling mode share. (Heinen *et al.* 2010)

d. Car ownership:

- Fewer cars increase cycling frequency. Some people argue that having a car is a reason for not commuting by bicycle. Bicycle ownership increases the probability of individuals cycling. (Heinen *et al.* 2010)

e. Age:

- Cycling levels decline with age. A relationship between age and cycling exists. (Heinen *et al.* 2010)
- Bicycle commuting increases with the average age of a sector of origin, but after that, bicycle commuting tends to decrease as people's age increases. (Cervero *et al.* 2019)
- Age plays an important role and has much more influence in places with low cycling rates. People in the 18 to 45 age range play are the primary users. (Fernández-Heredia *et al.* 2016)

f. Particular factors:

- Certain socio-economic factors and cycling do not have available analysis or are very particular. The significant differences between attitudes, countries, and social aspects play a vital role in this determinant. (Heinen *et al.* 2010)

4.2.5. Cost of time, effort and safety

Refers to travel particularities and macro variables related to the basic principles of choosing one means, some characteristics of importance to take into account for bicycles related to the representativeness that this factor could have in the gap in the rate of use between the bicycle and other means are:

a. Cost and investments:

- Cycling is cheap compared to other modes, which is a big reason for some people to choose this mode, but the cost of cycling alone is unimportant. Free public transport reduces cycling, and paying cyclists would have an impressive impact. In Britain, he suggested that if people were paid two pounds every day

they went to work, the level of cycling would at least double. Finally, offering credits to buy a bicycle would not be a popular option. (Heinen *et al.* 2010)

- Based on a study made in the United States, the price and costs of the bicycle, compared to other modes, is not a strong barrier, according to Fernández-Heredia *et al.* (2016).

b. Travel time and effort:

- Travel time by bicycle is three times more unpleasant than other modes of transport, and comfort decreases with increasing travel time; this does not occur with other modes in general, a high travel time by bicycle may involve more effort, and this generates a less positive attitude towards cycling, it is preferable to have short travel times. On the other hand, some cyclists choose this mode because of the effort to be made and may be willing to have longer travel distances. Finally, the perceived value of time is significant for mode choices.(Heinen *et al.* 2010)
- Cervero *et al.* (2019) mention that frequent stress-level transitions deter bicycle commuting, which means anxiety related to the variations of the stress levels during the trip.
- Many people in Bogotá like the feeling of cycling through congested areas. This suggests that the positive feeling of riding through traffic jams could be used to encourage cycling in congested areas. (Despacio 2014)
- High slopes have a significant negative impact and are directly related to other factors such as accessibility, urban density, type of interaction with other vehicles, and presence of dedicated infrastructure. (Fernández-Heredia *et al.* 2016)

c. Road safety:

There are two concepts related to safety; cyclists' fundamental safety, measured by the number of bicycle-related incidents, and subjective safety, which refers to

how individuals perceive safety. People think that cycling is less safe than walking. (Heinen *et al.* 2010)

- Bicycle users give bicycles a higher safety value than non-users. This is the result of various experiences or values given by users of other modes. (Heinen *et al.* 2010)
- Concerning the characteristics of the trip, distance, time, and cost have lost importance in the implementation of safer infrastructure, especially in trips of up to 15 km in the case of the United States. (Fernández-Heredia *et al.* 2016)

4.3. Factors that condition gender, children, reduced mobility and minorities

Since more profound research on these aspects is an entirely different field of study, some key concepts were taken for the development of conditioning factors for bicycle use; this chapter influences hardly the obtained results.

Despacio (2014) mentions that special attention should be paid to the needs of women, children, and potential older users to understand the city's bicycle dynamic clearly. In this sense, it is imperative to analyze those characteristics among the population to obtain information to improve bicycle use in Medellín and understand the Gap between bicycle use and other means according to reality.

4.3.1. Gender-oriented Approach

One of the most prevalent conditions is the fear of using some modes of transportation due to the possibility of sexual harassment, especially for women, and public safety problems, mainly at night. Thus, studies in the global south define fear among women as a social construction rather than a biological factor, according to Alcaldía de Medellín *et al.* (2022).

Apart from fear, some authors mention other variables such as physical appearance, especially women who consider it can negatively affect how they are viewed in their daily roles. (Alcaldía de Medellín *et al.* 2022)

It is also important to mention that, according to Alcaldía de Medellín et al. (2022) women who typically use bicycles cannot do all their daily activities on it, for example, mothers who have to coordinate their trips to transport their children. Women need more agile trips than men.

It seems that gender impact in cycling activity is relative to the country. In countries with low use rates, it was found that women tend to cycle less, but in countries with high cycling rates, the activity is most common for them. (Fernández-Heredia *et al.* 2016).

Gender is essential, especially when cycling rates are low, possibly due to women's risk avoidance and due to cycling facilitating commuting for their activities. (Fernández-Heredia *et al.* 2016)

In Argentina, it can be noticed that there is a preference for bike paths segregated from vehicular traffic. One example of these is the city of Rosario, which is considered an extreme case without a gender perspective but with less gap related to gender equity in use due to adequate road safety conditions. (Alcaldía de Medellín *et al.* 2022)

Alcaldía de Medellín et al. (2022) mention that women have the motivation to migrate to conventional or electric bicycles, an essential part of its population. However, this author presents the lack of economic resources and the increase of travel time as limiting factors.

The primary motivation for cycling is economic, followed by activities close to home, although cycling is not used as a means of transportation, as it is said by Alcaldía de Medellín et al. (2022)

The women of Medellín, based on Alcaldía de Medellín et al. (2022), have particular beliefs such as that their physical appearance is affected when using the bicycle and after the activity, that there is a high effort due to the slopes, that the weather conditions do not allow it, among others. It is also said that women

do not have much space to carry things and that if Women do not feel comfortable.

One of the findings from Alcaldía de Medellín et al. (2022) is that women feel it is unsafe to use active mobility in Medellín because they do not want to be victims of aggression and road incidents, especially at night. At the same time, women have developed strategies to avoid these factors, such as going with other people, choosing the hour according to the sun's availability, and choosing a well-known route and routes with police or the presence of public servants. Concerning the transgender community, the most common situations are related to gender discrimination, but they highlight harassment and gender violence as more important than infrastructure. It also encourages motorized mobility as the preferable way to move.

The bicycle is the desired mode of transportation for many women and other genders in Medellín and is considered beneficial in different aspects; some women have recently become bicycle users, recognizing a solid fear due to the abovementioned factors. The trans community has the same desire but cannot access this mode mainly due to economic limitations. (Alcaldía de Medellín *et al.* 2022)

part from the ideal vision related to using the bicycle feeling comfortable, there is a strong tendency to use modes that isolate other genders in controlled environments based on the evidence presented by Alcaldía de Medellín et al. (2022) to avoid uncomfortable personal situations such as harassment. It can be said that women have restricted autonomy in decision-making mainly because they cannot meet their mobility needs.

Transgender community from Medellín highlights that the solution is not the improvement of infrastructure. The solution for them must be based on the improvement of the people.(Alcaldía de Medellín *et al.* 2022)

Alcaldía de Medellín et al. (2022) has published as appendices the Methodology

to analyze projects of active mobility with a focus on gender, and it is the most significant effort made until now in Colombia to have gender inclusion in bicycle infrastructure projects.

a. Autonomy principle

In order to talk about gender in mobility, it is essential to mention the concept of autonomy, which mentions Alcaldía de Medellín et al. (2022) directly related to women:

"For women, autonomy means having the capacity and concrete conditions to make decisions that affect their lives freely. Achieving greater autonomy requires diverse factors, including freeing women from exclusive responsibility for reproductive and care-giving tasks, including exercising reproductive rights; ending gender-based violence; and taking all necessary measures to ensure women participate in decision-making on equal terms." (Alcaldía de Medellín *et al.* 2022)

Thus, autonomy also refers to three approaches that can be seen deeply in Alcaldía de Medellín et al. (2022): economic, physical, and decision-making.

In a nutshell, the concept of autonomy is crucial to the generation of measures to allow a more inclusive perspective on bicycle use for the two biological gender conditions and to generate effective measures (based on the five groups of factors that condition the use of bicycle) that support this principle and its approaches. It applies to the field of mobility in bicycle in general, but it is necessary in the context of Medellín.

4.3.2. Children-oriented Approach

An analysis conducted in Sao Paulo reveals that having children negatively impacts cycling among women, possibly due to lack of time and poor infrastructure conditions. Accordingly, a study conducted in Bogotá indicates that having children can be a barrier to cycling, especially concerning road safety, and it is an opportunity for care-giving trips (possibility for recreation).

Concerning this, according to a study conducted in Mexico, it is concluded that the situation may vary according to the context, the expertise of each user, and the distance of the trip. (Alcaldía de Medellín *et al.* 2022)

4.3.3. Reduced mobility Approach

It is fundamental to recognize reduced mobility needs. For them, traffic costs increase, and they are generally not recognized as active mobility users of bicycles because they are categorized as pedestrians or vehicles, which is only partially true. (Alcaldía de Medellín *et al.* 2022)

4.3.4. Minorities Approach

There is no clarity on the mobility of people from different minority groups in Colombia. However, Alcaldía de Medellín *et al.* (2022) mention the Indigenous and Afro-descendant populations of women. In this sense, this study mentions that for the population of indigenous women, the adaptation to the regulations in the Spanish language and their lack of understanding of the way of living together in the city of Medellín is challenging. The document also mentions that the indigenous population suffers under stereotypes and is discriminated against; for the Afro-descendant population of women, as mentioned in this study, Women have special care regarding how they dress because their ordinary way of dressing facilitates the possibility of harassment. Afro women are generally observed for their physical characteristics, and some avoid bicycles because of their fear of being observed.

There is no study on ethnic minorities and their relationship with bicycle transportation in the Colombian context, specifically in Medellín, and just some characteristics can be assumed from the men population.

5. Chapter III – Methodology of research

This chapter analyzes the methodological characteristics of this research and details the main characteristics of the decisions made to obtain the following chapters.

5.1. Hypothesis

According to the information presented in the previous chapter, the main hypothesis is established as follows:

The lack of adequate conditions for the use of bicycle by the inhabitants of the National University of Colombia at Medellín as a sample of the city, between 2012 and 2023, creates a gap between the rate of use of this means and the others derived from determinant modal choice factors that influence a trade-off to motorized mobility.

5.2. Research question

Based on the analysis of the population, the exposure, and the outcome, known as framework PEO (Elsevier Language Editing Service 2023), and the Holistic Research Methodology (Hurtado de Barrera 2000), the research question is as follows:

Could the bicycle be a more attractive mobility alternative for the National University of Colombia inhabitants at Medellín as a sample of the city's population, reducing the gap between this means of transportation and others by understanding and counteracting crucial negative trade-off factors?

5.3. Questions derived from the research question

- What are the characteristics of user and non-user groups related to their modal choice by biological gender?

- What are the limitans and constraints related to the choice of cycling as a preferred mode of transport by the population?
- What can be suggested from this study for each variable with a particular focus on non-users by gender?

5.4. Objectives

5.4.1. Main Objective

To understand the characteristics related to the choice of the bicycle as the preferred means of transport according to the representativeness that inhabitants of the National University of Colombia at Medellín, as a sample of the city population, give to significant variables to make the decision of cycling.

5.4.2. Specific objectives

- To review concepts related to the topic, cases of study, and available literature.
- To analyze specific characteristics of the bicycle users and non-users of the National University of Colombia at Medellín by biological gender, as an example of the city and the correlation with the gap related to the selection of the bicycle as a preferred mode of transport as an example of the population of the city.
- To analyze specific characteristics of the cycling network of the city of Medellin by biological gender and the association with the gap related to the use of bicycle as a means of mobility based on the population of the National University of Colombia at Medellín.
- To understand the main characteristics of the behavior of the citizens and the potential opportunities for the city based on the National University of Colombia at Medellín population by biological gender.

5.5. Desirable results

- Diagnostic from the review of the related case studies, references, and concepts

- Analysis of the main challenges and opportunities related to the characteristics mentioned by the population.

- Definition of the limitans and constraints of the inhabitants of the National University of Colombia at Medellín as a sample of a city based on the results of the questions by biological gender.

5.6. Research characteristics and process

The research process was based on a mixed holistic methodology based on Hurtado de Barrera (2000) with mainly quantitative elements. The holistic methodology of the author mentioned above was selected because it has open elements that allow interaction with other types of methodological concepts and provides flexibility when carrying out studies with a mixed orientation between quantitative and qualitative.

Thus, due to the background presented in the previous chapters, the characteristics of the planning and mobility of the National University of Colombia, the city of Medellín, and the details of its mobility dynamics, the following methodological characteristics were desired for the understanding of this complex phenomenon within the research:

1. Increased flexibility concerning possible influencing quantitative and qualitative cycling-related factors.

2. Implicit recognition of phenomena beyond systems and modeling for research for the complete description and understanding of complex phenomena.

3. Possibility of approaching open and little explored systems.

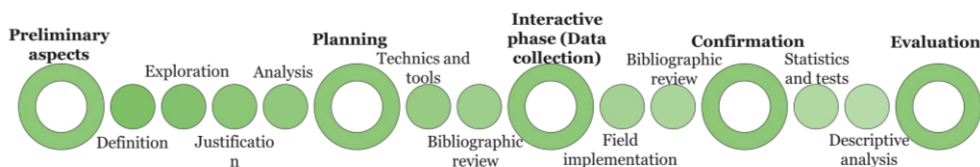
Looking for a research methodology that would allow the approach of the subject from these three perspectives, an intense search was carried out exploring

different authors such as (Lucas 2013), (Darbéra 1982), (Burge 2015), and (Sampieri 2014).

The present research is classified as analytical according to Hurtado de Barrera (2000) and is centered on the quantitative paradigm defined by the same author because it uses quantitative data collection techniques, pays little attention to subjective states, measures in a controlled manner, is oriented to verify, confirm or deduce, is result-oriented, requires reliability in the data, attempts to generalize studies of several cases and assumes reality as stable.

This research has a particular focus on the analytic stadium defined by Hurtado de Barrera (2000) due to it tries to understand a complex problem by identifying patterns of relationship between components in order to reach a deeper understanding of the phenomenon and the definition of Musicca as central premise (Methodical, universal, systematic, Innovative, Clear, Communicable and Applicable) according to Hurtado de Barrera (2000).

The phases of the research were as shown in the following figure:



(Fig. 8) phases of the research applied
Source: Hurtado de Barrera (2000)

6. Chapter IV – Study Case

With the methodology described above, the case study of the city of Medellin was developed. It is essential to highlight the participation of volunteers from the Sapiencia - EPM fund, managed by the University Welfare office of the National University of Colombia at Medellín. Thanks to them, It was possible to obtain a great number of surveys.

6.1. Surveys design

For an accurate and authentic result, it was necessary to find a place where a scalable population with the greatest possible diversity in the following aspects could be found:

1. Gender
2. Age
3. Location in the city
4. Professions

Thus, it was decided to use the National University of Colombia at Medellin as the sample universe. This sample universe is considered finite because the number of students, professors, employees and visitors is known or can be approximated.

6.1.1. Unit of study

The unit of study defines the context of the unit to be studied. In this case, the unit of study is all the individuals of the city of Medellín, whose travel destination is the National University of Colombia at Medellín, as a representative population of the city based on Hurtado de Barrera (2000).

6.1.2. Sampling universe

All persons whose travel destination is the campus of the national University of Colombia at Medellin based on Hurtado de Barrera (2000).

6.1.3. Sapling Technique

After defining the sampling universe, the sampling technique and the sampling instrument were determined in order to design the necessary sample subsequently; the following techniques and instruments were evaluated:

Techniques	Instruments
Observation	Observation guide
	Checklist
	Observation scale
Interview	Interview questionnaire
Survey	Questionnaire
	Observation scale
	Test
	Knowledge test
Sociometry	Sociometric test
In-depth session	Observation guide
Documentary review	Matrix of categories

(Tab. 3) Tested techniques and instruments
Source: Hurtado de Barrera (2000).

After evaluating these techniques and instruments, it was decided to conduct a questionnaire of interviews and a quantitative documentary review.

6.1.4. Population

Five different groups were identified among the population at the National University of Colombia at Medellín based on their activities within the institution. The profiles are:

1. Students of courses or careers taught in “El Volador”, “El Rio” or “Robledo” Campuses.
2. Students from the school who go to “El Volador”, “El Rio” or “Robledo” Campuses.
3. Teachers of “El Volador”, “El Rio” or “Robledo” Campuses.
4. All employees who perform their work in “El Volador”, “El Rio” or “Robledo” Campuses.
5. Visitors to “El Volador”, “El Rio” or “Robledo” Campuses.

These population groups allow the development of stratified random sampling, in which the strata correspond to each population group inhabiting the University.

(Tab. 4) shows the size of each of the defined stratum, while (Tab. 5) shows the values defined for the present study with which the sample size was calculated.

No	Stratum	Population
1	Students of courses or careers taught in “El Volador”, “El Rio” or “Robledo” Campuses.	13777
2	Students from the school who go to “El Volador”, “El Rio” or “Robledo” Campuses.	100
3	Teachers of “El Volador”, “El Rio” or “Robledo” Campuses.	544
4	All employees who perform their work in “El Volador”, “El Rio” or “Robledo” Campuses.	1941
5	Visitors to “El Volador”, “El Rio” or “Robledo” Campuses.	3800
Total Population		20162

(Tab. 4) Size of the population stratum

Source: Author based on information from the National University of Colombia at Medellín

6.1.5. Sample design

Stratified random sampling was proportional. The sample size of each stratum was proportional to the size of the corresponding stratum. The sampling units are the persons belonging to each of the five population groups. The sample size was calculated using the equation that belongs to stratified random sampling with proportional allocation (Scheaffer and Mendenhall 2007), which is indicated below:

$$n = \frac{\sum_{i=1}^k N_i p_i q_i}{N \sigma_p^2 + \frac{1}{N} \sum_{i=1}^k N_i p_i q_i}; \text{ where } \sigma_p^2 = \frac{\epsilon^2}{Z_{\alpha/2}^2}$$

(Eq. 1) Stratified random sampling with proportional allocation (1)

Source: (Scheaffer and Mendenhall 2007)

Where:

n: Total sample size.

i: Stratum number.

k: Total number of strata.

N: Total population size.

p: Population proportion.

q: Complement of the population proportion, given by (1-p).

ε: Relative error; for the present study, it was set at 5%.

$Z_{\alpha/2}$: It is the confidence level established from the standard normal distribution, which will correspond to 95% for the present study.

The population proportion p can be calculated from the development of surveys prior to the study. However, for the present study, the value of the proportion was not previously known, so a 50% probability will be assumed.

The following formula was used to determine the sample size corresponding to each stratum.

$$n_i = \frac{N_i}{N} n$$

(Eq. 2) Stratified random sampling with proportional allocation (2)

Source: (Scheaffer and Mendenhall 2007)

n: Total sample size.

i: Stratum number.

k: Total number of strata.

N: Total population size.

p: Population proportion.

q: Complement of the population proportion, given by (1-p).

ε: Relative error; for the present study, it was set at 5%.

$Z_{\alpha/2}$: It is the confidence level established from the standard normal distribution, which will correspond to 95% for the present study.

Variable	Value
N : Total population size.	20162
$(Z_{\alpha/2})$: Confidence level 95%	1.96
i : Strata number	From 1 to 5
k : Total number of strata.	5
P : Population proportion	0.5
(q) : Complement of the population proportion, which is given by (1-p).	0.5
(ϵ) : Relative error	0.05

(Tab. 5) Defined values to determine the sample size

Source: Author

With the known information, it was possible to obtain the total and sample sizes for each of the strata, as shown in (Tab. 6).

Stratum	Sample
1	258
2	2
3	10
4	36
5	71
Total	377

(Tab. 6) Sample Size according to stratum
Source: Author

In a nutshell, the total sample size for the development of the study is 377 people, which is distributed proportionally among the defined strata.

Additional surveys were conducted, reaching a cipher of 815 surveys. The questionnaire is part of the appendices of this work.

6.1.6. Description of the procedure of collecting information

The data collection procedure consisted of the following:

- a. Training of the support staff in charge of conducting the surveys (10 People)
- b. Distribution of the team to obtain the most dispersed sample possible within the university's campuses.
- c. Definition of goals related to the amount of people to be surveyed (Only inhabitants of Medellín; 50% men; 50% women; and number of surveys per profile).
- d. Implementation of the survey, reading the complete questions and avoiding forcing respondents to select a specific answer during the survey.

6.1.7. Data cleaning and randomization for the final sample

A total of 948 people were surveyed, and surveys with inconsistencies (such as missing data, wrong GPS location, and doubtful information) were discarded, leaving a valid database of 816 respondents; The erroneous data were retained in an alternate database, part of the appendices.

Finally, the database was loaded into the software ArcGis, to correlate each respondent's data concerning their place of residence, using the WGS84 coordinated system for the origin and destination of each user. The databases are also part of the appendices.

6.1.8. Selection of data for calculations

In order to have a correlation between the data collected and the population of the city, it was decided to review the population data by communes of the district of Medellín as shown in the (Tab. 8) and can be identified in the appendix. “Desarrollo_Economico_gdb”.

After this distribution, the GPS points of the origin were overlapped in the Arcgis software and grouped into polygons corresponding to various communes according to (Fig. 9).the result of the data selection can be seen in (Fig. 10)

Thus, according to the percentage of men and women in each polygon, the necessary data were taken according to the gender proportions to create a correlation, as shown in (Tab. 7):

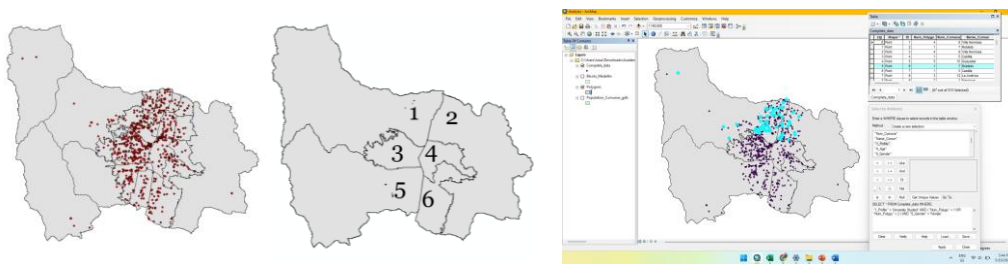
Projected population of Medellín to 2023						
Polygon	Population		Male		Female	
1	677,645	26%	321,548	47%	356,097	53%
2	628,791	24%	302,088	48%	326,703	52%
3	365,125	14%	166,536	46%	198,589	54%
4	251,180	9%	122,448	49%	128,732	51%
5	443,717	17%	206,741	47%	236,976	53%
6	287,271	11%	133,389	46%	153,882	54%
Total	2,653,729	100%	1,252,750		1,400,979	

(Tab. 7) Population of Polygons
Source: Author based on Alcaldía de Medellín (2018)

ID	Number comuna	Name Comuna	Men 2023	Women 2023	Total 2023
1	1	Popular	72,607	76,979	149,586
2	2	Santa Cruz	58,823	63,750	122,573
3	3	Manrique	86,198	93,595	179,793
4	4	Aranjuez	69,003	76,834	145,837
5	5	Castilla	59,679	67,610	127,289
6	6	Doce de Octubre	86,589	97,300	183,889
7	7	Robledo	98,288	110,017	208,305
8	8	Villa Hermosa	83,193	88,583	171,776
9	9	Buenos Aires	83,111	91,903	175,014
10	10	La Candelaria	39,255	40,149	79,404
11	11	Laureles Estadio	45,083	56,713	101,796
12	12	La América	39,384	48,823	88,207
13	13	San Javier	82,069	93,053	175,122
14	14	El Poblado	50,278	61,979	112,257
15	15	Guayabal	30,291	34,422	64,713
16	16	Belén	99,681	117,820	217,501
17	50	San Sebastián de Palmitas	3,329	3,156	6,485
18	60	San Cristóbal	73,663	78,014	151,677
19	70	Altavista	21,429	23,236	44,665
20	80	San Antonio de Prado	55,340	61,498	116,838
21	90	Santa Elena	15,457	15,545	31,002
Total			1,252,750	1,400,979	2,653,729

(Tab. 8) Population distribution according to comunas

Source: (Alcaldía de Medellín 2018)



(Fig. 9) – Location of the data regarding to Comunas; Graphical representation of the grouping of communes in polygons; Process of selection of Data in software
Source: Author based on Alcaldía de Medellín (2018)

The data shown above were correlated with the data obtained in the survey, obtaining that the following parameters were required randomly to ensure that polygons fit with the gender of population equilibrium:

Sample iteration distribution				
Population National University				20,162
Population City				2,653,729
Polygons			Population in the area Vs population in the city proportion	Sample distribution according to proportion
1+2	M	48%	49%	46
	F	52%		51
3+5	M	46%	30%	43
	F	54%		46
4+6	M	48%	20%	43
	F	52%		46

(Tab. 9) Population of Polygons and correlation with sample – Part 1
Source: Author based on Alcaldía de Medellín (2018)

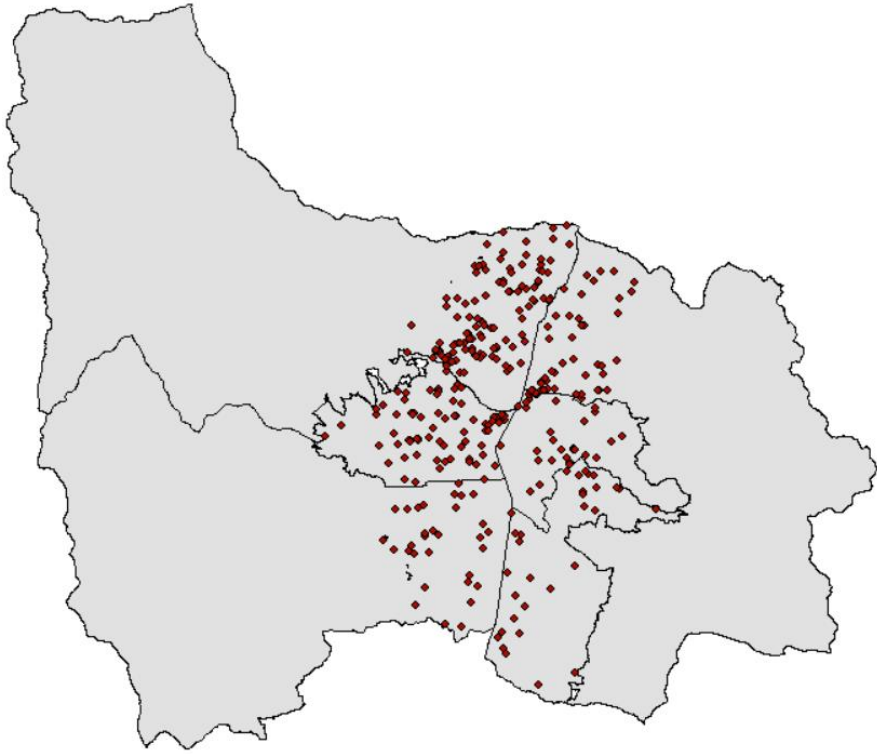
Polygons		Sample distribution according to the polygons				
		Sample stratum				
		1 (Students)	2 (Elementary)	3 (Professors)	4 (Employees)	5 (Visitors)
1+2	M	60.63	1.00	2.35	8.46	16.69
	F	66.38	1.00	2.57	9.26	18.27
3+5	M	36.29	0.00	1.41	5.06	9.99
	F	42.35	0.00	1.64	5.91	11.65
4+6	M	24.87	0.00	0.96	3.47	6.84
	F	27.48	0.00	1.06	3.83	7.56
Total sample		258	2	10	36	71
Adjusted total		257	2	10	35	72

(Tab. 10) Population of Polygons and correlation with sample – Part 2
Source: Author based on Alcaldía de Medellín (2018)

6.1.9. Result of the implementation of the process

As a result of the random selection shown, 376 results were obtained, correlated according to gender with the city of Medellín population, as shown in the following figure.

The result in the software Arcgis is as shown in the following figure. The original and filtered database are part of the appendices.



(Fig. 10) Selected data as a sample overlapped to polygons
Source: Author based on Alcaldía de Medellín (2018)

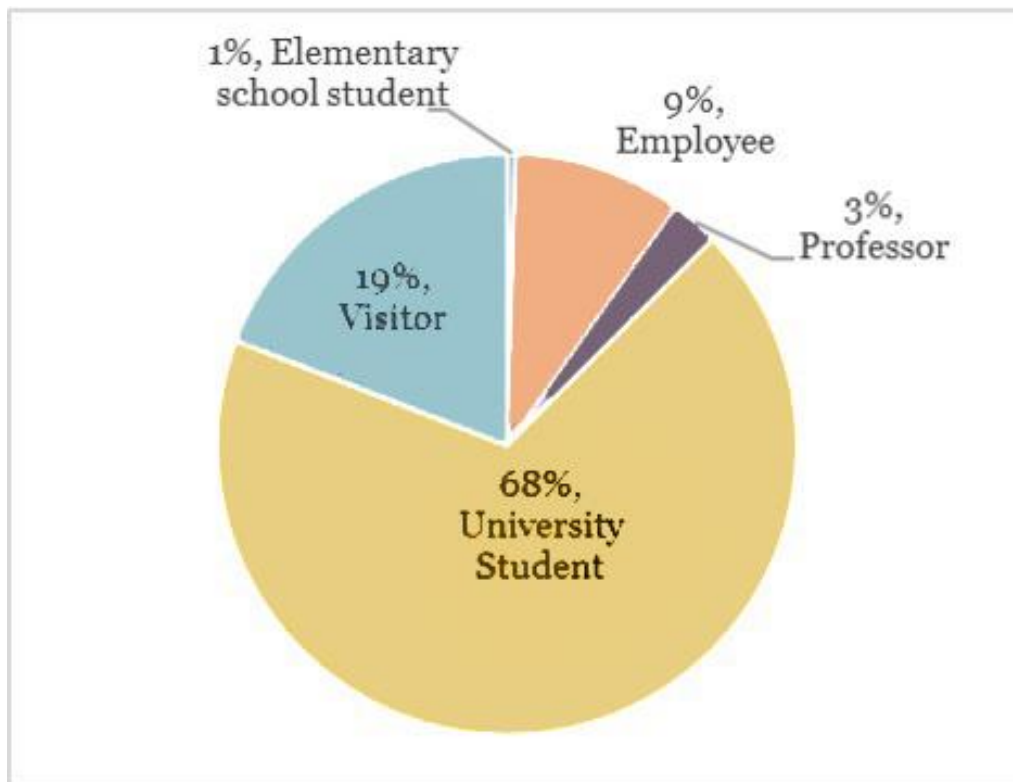
7. Chapter V – Analysis of Results

In order to understand the dynamics of the territory, review the incidence of the variables shown in the theoretical framework in the modal choice and the gap between the bicycle and other means, the results of the selected questions and their impact on bicycle mobility in the city; A review of the obtained results was conducted grouped according to what was stated by Heinen et al. (2010) in its conditioning categories

7.1. Descriptive data statistics

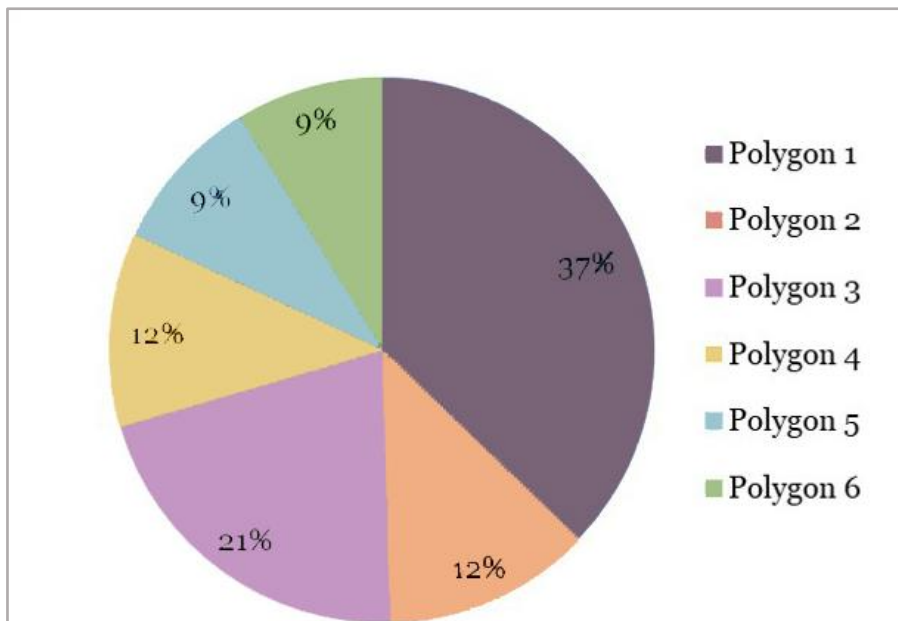
According to

(Tab. 6), the percentage of distribution obtained for the sample is as shown in the following figure:



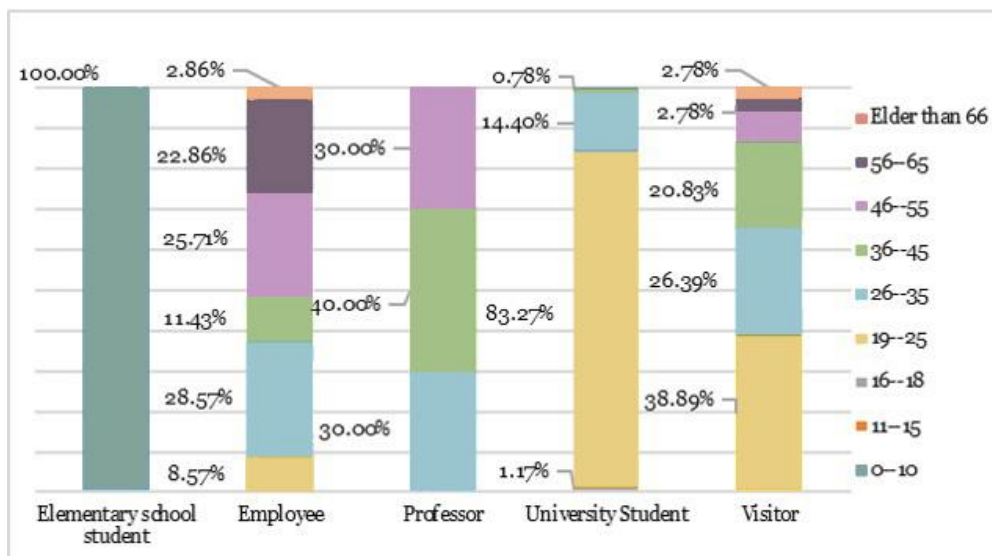
(Fig. 11) profiles (Stratum) distribution in percentage (Entire sample)
Source: Author

The polygons showed in the (Fig. 9) have a spatial population distribution according to the following figure.



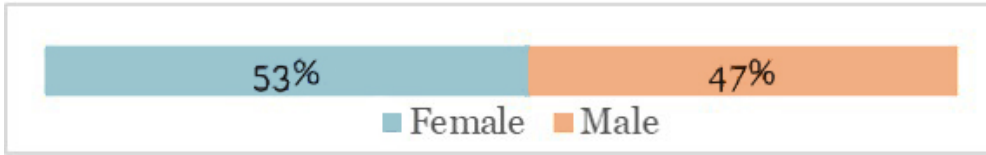
(Fig. 12) Population distribution in the polygons (Entire sample)
Source: Author

The age distribution obtained shows a concentration of users between 19 and 25 years of age, mainly in the profile of university students, followed by users aged 26 - 35 years, mainly distributed among teachers, employees, visitors, and students; the third most popular age group corresponds to people aged 36 - 45 years which are mainly distributed among visitors, teachers, and employees as can be seen below.



(Fig. 13) Profile Vs age (Entire sample)
Source: Author

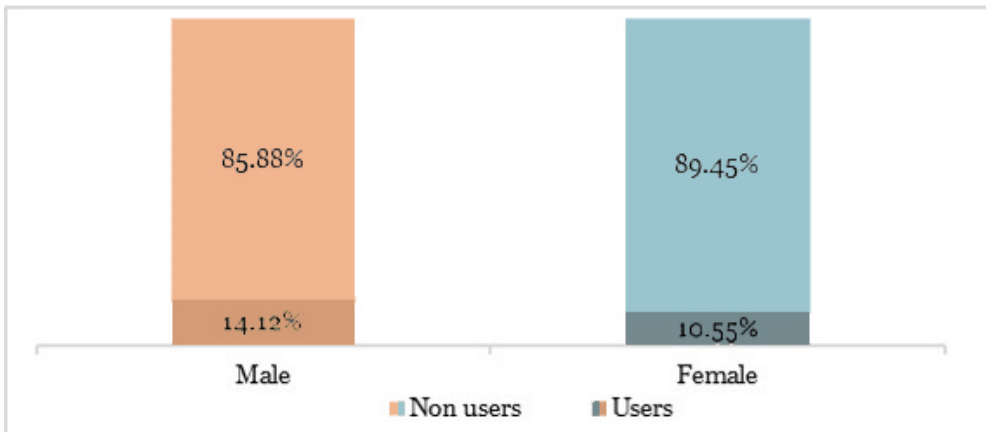
The sample also has a homogeneous gender distribution, as shown below:



(Fig. 14) Gender distribution (Entire sample)
Source: Author

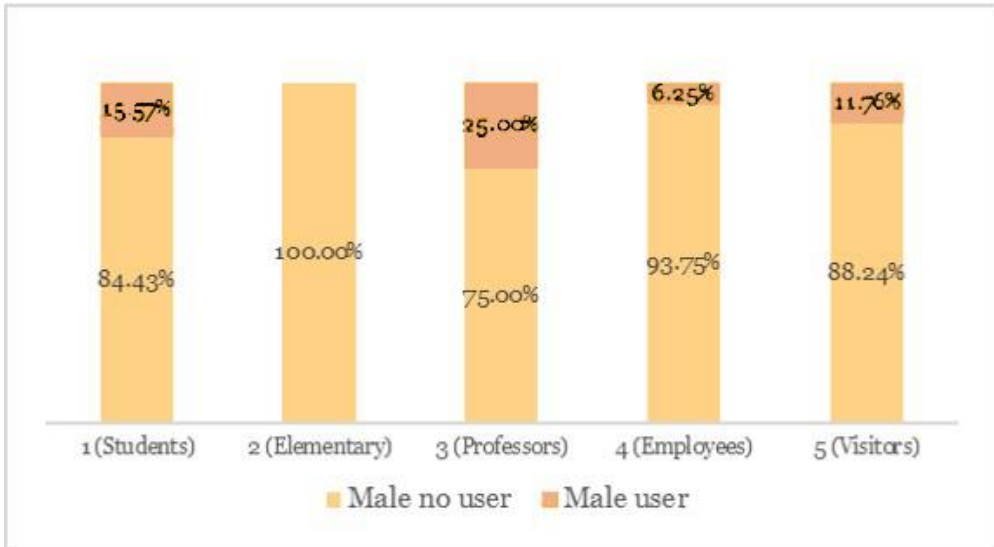
7.2. Use of Bicycle

The following figure shows the rate of bicycle use by gender. For males, the rate of routine use is around 14%, and for females around 11%. This is one of the most important differences between the sample taken from the National University of Colombia and the city compared to the information showed in the section 3.8.4 The behavior of the bicycle users in the district.

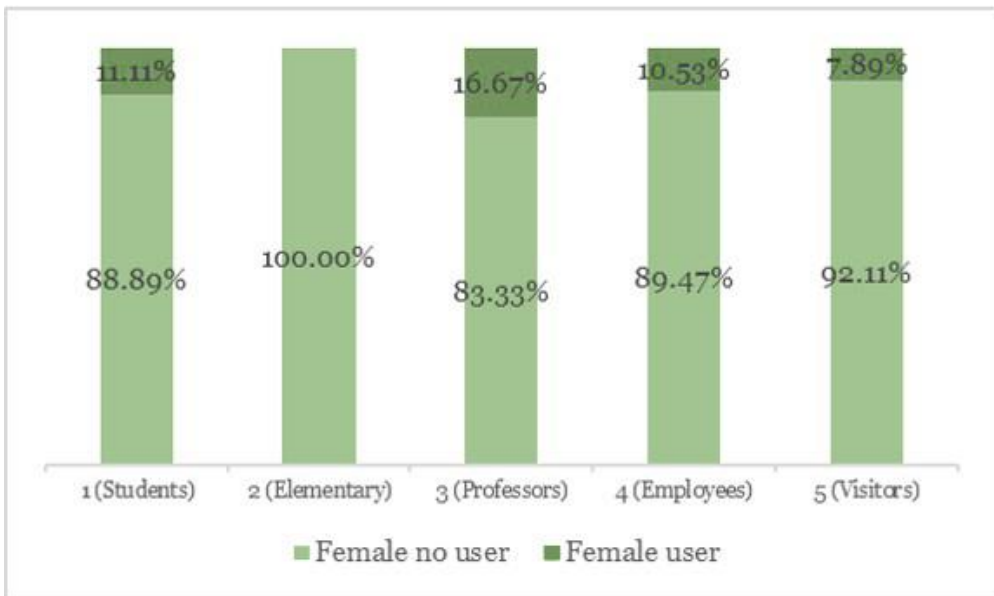


(Fig. 15) Use of Bicycle (Entire sample)
Source: Author

According to this distribution, the profiles (stratum) have the following characteristics in relation to bicycle use and gender for users and non-users.



(Fig. 16) Stratum vs Male use of bicycle (Users)
Source: Author



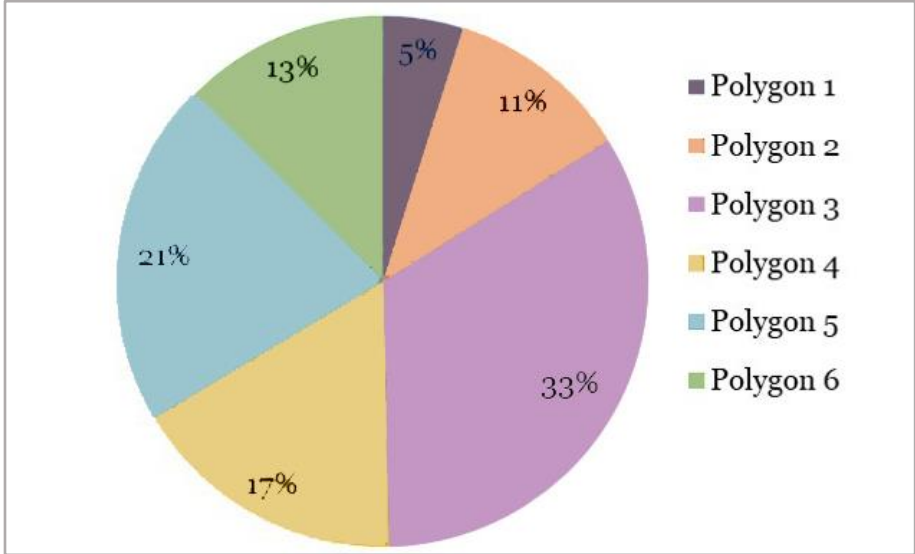
(Fig. 17) Stratum Vs female use of bicycle (Users)
Source: Author

From the graphics above, it is important to highlight the high presence of users in all the groups, Particularly among professors and except for elementary school students).

The following is the distribution of bicycle use according to the polygons, showing that the users of bicycle are mainly found in polygons 3 (center-west), 5 (south-

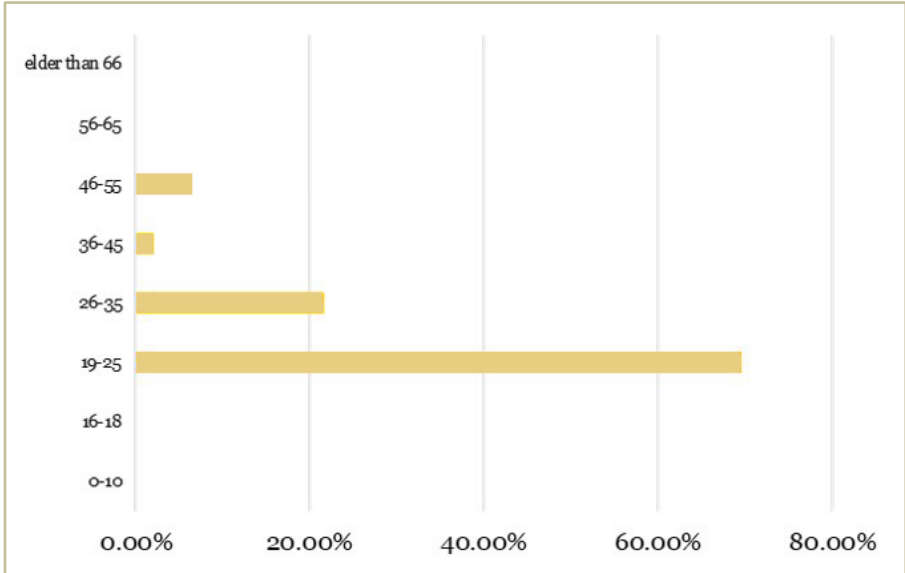
west), and 4 (center-east), the flattest areas of the city with the most developed bicycle infrastructure according to (Fig. 18).

The majority of users of the study are located in the comunas 11 (center-west), 7 (south-west), 10 (center-east), 12 (center-west) and 4 (south-east), and it is similar to the location of users in the city.



(Fig. 18) Use of bicycle in the polygons (Users)
Source: Author

The following is the distribution of users according to age groups.

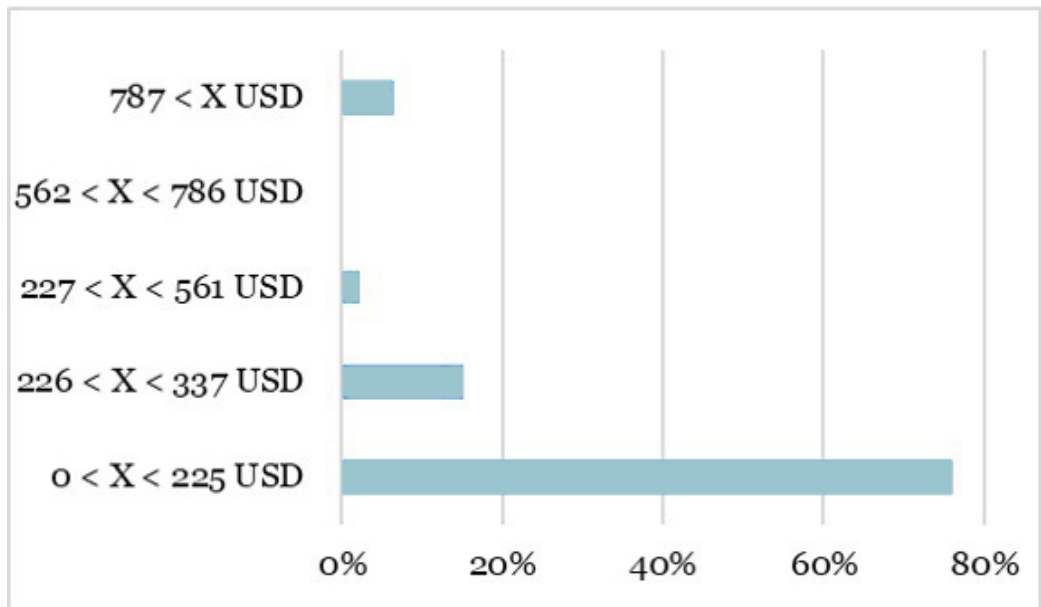


(Fig. 19) Rate of use of bicycle in the sample and age range (Users)

Source: Author

According to the figure above, there is a high tendency to use bicycles among younger adults (approximately 70% of users). It is also important to note the absence of the participation of underage and elderly users and the reduction of use between 26 and 55 years, particularly in users between 36 and 45 years.

The following is the distribution of users according to incoming money:



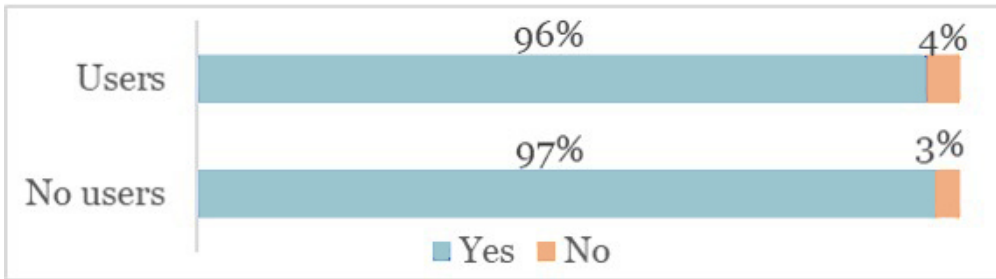
(Fig. 20) use of bicycle regarding incoming money (Users)
Source: Author

From the previous figure, users with lower acquisitive power tend to use the bicycle more, probably because of the economic benefits. However, people with higher incomes use the bicycle more than people with middle incomes; this trend is probably due to the health benefits, particular conviction, and the pleasant experience of its use.

The gradual reduction of bicycle users as income increases until they reach to zero users earning between \$562 and \$786 is quite particular. Additionally, the sharp peak between \$0 and \$225 must be attributed to the strong presence of students in the sample.

Concerning the information above, it is essential to review the acceptance of the use of bicycles since this may provide an answer to the question generated in the

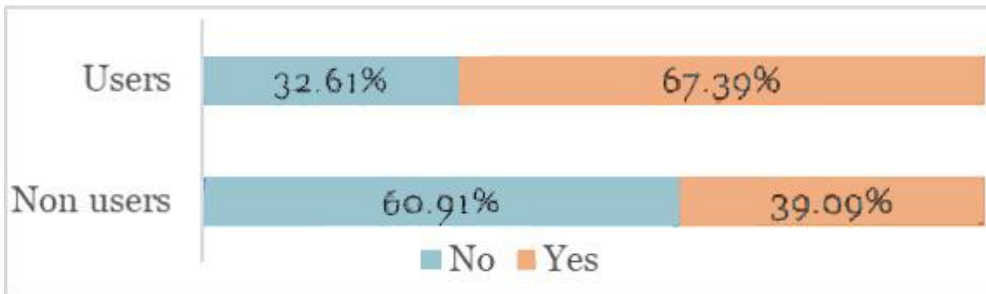
previous paragraph. However, as seen in the following figure, there is a general acceptance of the users socially.



(Fig. 21) Social acceptance if someone use bicycle (Entire sample)
Source: Author

7.2.1. Bicycle ownership and users

It should be mentioned that 61% of participants in the survey are not users and do not own a bicycle; this factor shows that the interaction with the means of transportation encourages its use. The following figure shows the preferences.



(Fig. 22) Bicycle ownership (Entire sample)
Source: Author

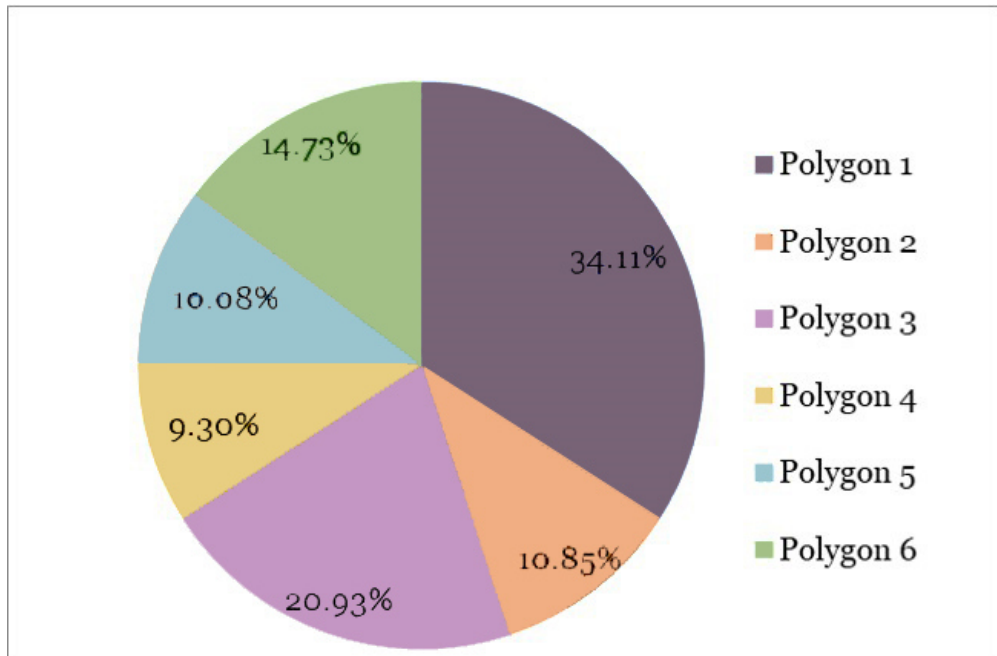
This research took the task of reviewing the relationship between owning a bicycle and being a user. Thus, the most significant number of users (67.39%) own a bicycle, and 32.61% do not own one but still recognize themselves as users. This particular situation may be due to the presence of the city's public bicycle system.

7.2.2. Bicycle ownership and non-users

It is crucial to see that among those who define themselves as non-users, some own the vehicle but do not use it routinely, and there is also great potential, as shown in the following figure (39.09% of non-users own a bicycle).

Next, we can see the relationship between bicycle ownership and polygons

among non-users. We found, according to the (Fig. 23), that the highest number of bicycles owned by non-users is also found in the north-west and center-west of the city, followed by the south-east of the city (according to the polygons).



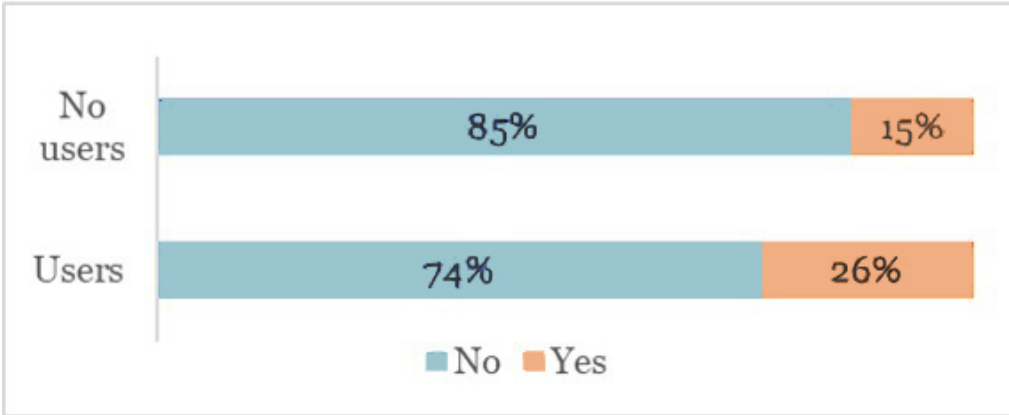
(Fig. 23) Bicycle ownership distribution in the polygons (Non-users)
Source: Author

7.2.3. Particular characteristics from the context

a. Ciclovía

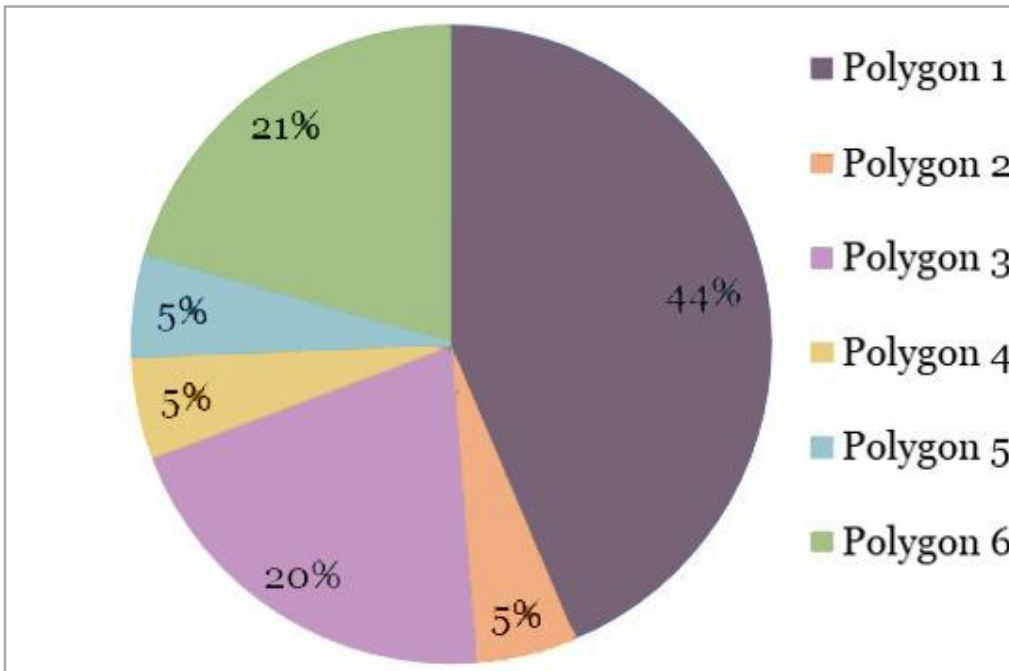
In the city of Medellín, there is a weekly event to promote the use of bicycles and physical activity among citizens. This event is known as "Ciclovía" although its name may have another context for users outside the city or the country in the Spanish language.

In any case, in this research, it was decided to ask about the presence of routinary users and non-users of bicycles in the "Ciclovía," and it was determined that only 15% of non-users attended the event. According to the following figure, this implies an opportunity for formulating strategies to attract users and the remaining 85% of non-users to the use of the bicycle as transport.



(Fig. 24) Use of Ciclovía (Entire sample)
Source: Author

There is also significant potential in citizens who have bicycles, attend the "Ciclovía" and are not daily users; these people are mainly located in the north-west and south-east areas of the city.



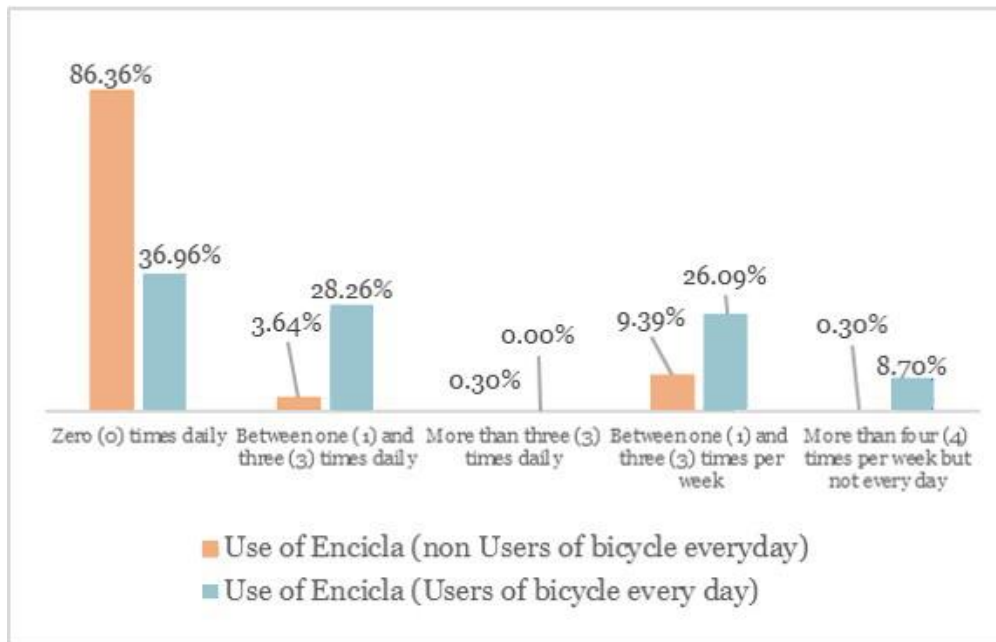
(Fig. 25) Bicycle owners that attend to "Ciclovía" and their location in the polygons (Non-users)
Source: Author

b. Public bike-sharing system (Encicla)

Another particular characteristic of the city environment is the free public bike-sharing system. The results show that most who do not consider themselves

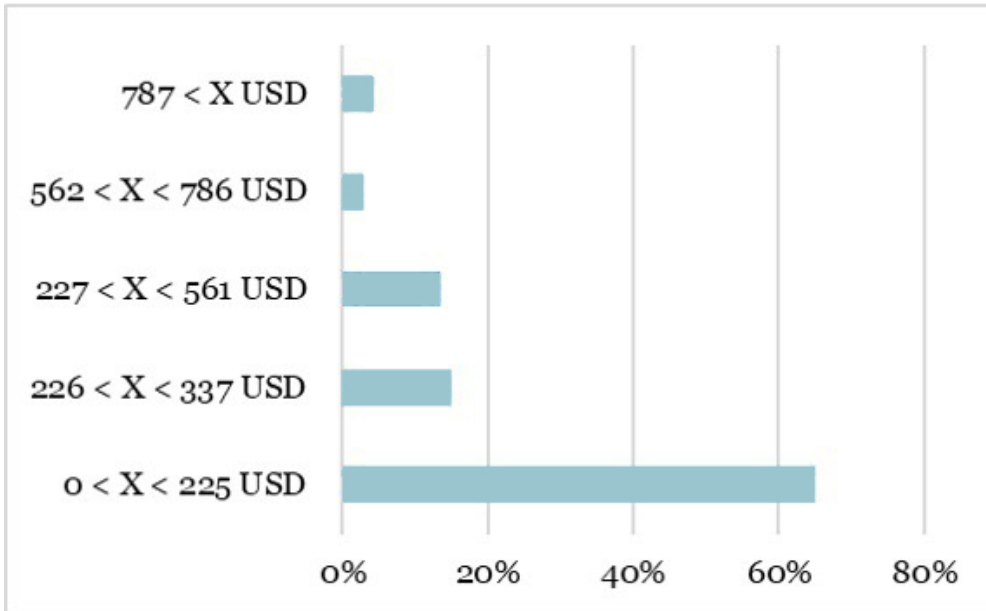
frequent users do not use the system (86.36%), and some non-users occasionally use it (13.64%).

This analysis also confirms a contribution to the rate of bicycle use by the EnCicla system (Bicycle users who do not own a bicycle). The above-mentioned argument can be evidenced in the following figure.

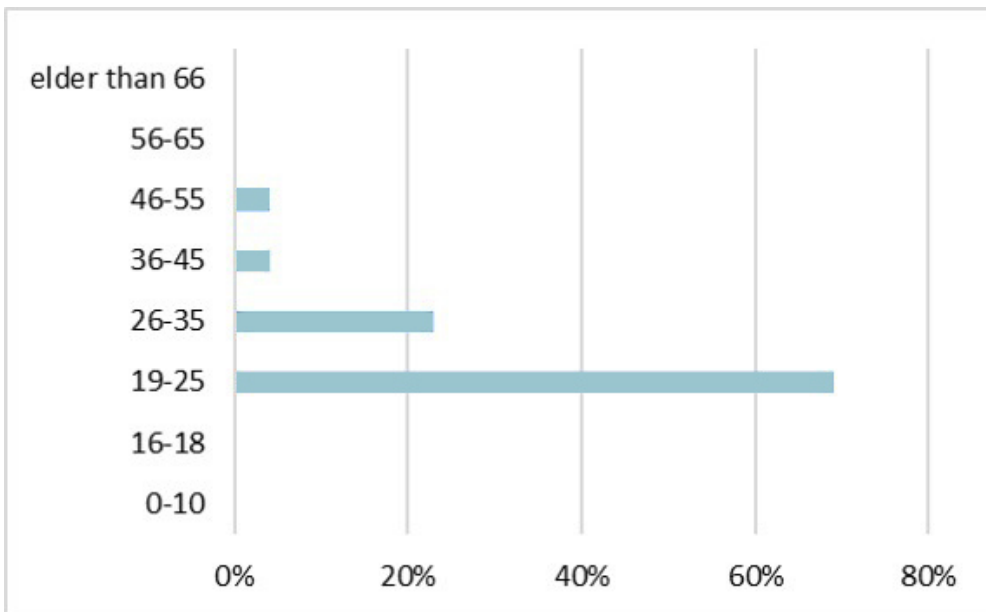


(Fig. 26) Frequency of Encicla use (Sample)
Source: Author

Thus, when analyzing the use of the public bicycle system and the incoming money it is obtained that majority of users have incomes between zero and 225 dollars (Fig. 27). According to (Fig. 28), users are primarily between 19 and 25 years old, the typical student population.



(Fig. 27) Encicla use regarding to Incoming money (Sample)
Source: Author



(Fig. 28) Use of Encicla and Age (Sample)
Source: Author

7.3. Factors that condition the use of bicycles in Medellín

The variables selected and asked in the survey for the case of Medellín were organized and worked according to the groups suggested by Heinen et al. (2010).

In the same way, each variable was subdivided according to gender and the origin of the information for its analysis. The results for females and males were taken from the sample (quantitative).

Thus, there are 20 questions related to the factors that condition the use of bicycles, and the following methodology was created for their prioritization according to the representativeness that users gave to each one.

7.3.1. Studied variables and representativeness

The questions regarding the factors that condition bicycle use had six options: "not at all", "almost none", "a little", "neither too much, not too little", "a lot" or "quite a bit important"; the first three correspond to non-representative options to each variable and the following three correspond to people who give representativeness to this variable and had the possibility of choosing the level of it in three sub-categories.

In this way, for each variable, the proportion of people who gave representativeness was determined. After determining the proportions, it was possible to compare the variables according to the percentage in each question according to gender and profile and determine which variables are more or less representative for the population without taking into account the sub-level "neither too much not too little", a "lot" or "quite a bit important", to do it practical.

This exercise was carried out to compare the variables and prioritize them. The results can be seen in (Tab. 12) (Tab. 13) (Tab. 14) and (Tab. 15) according to the gender and the profile shown in the conclusions.

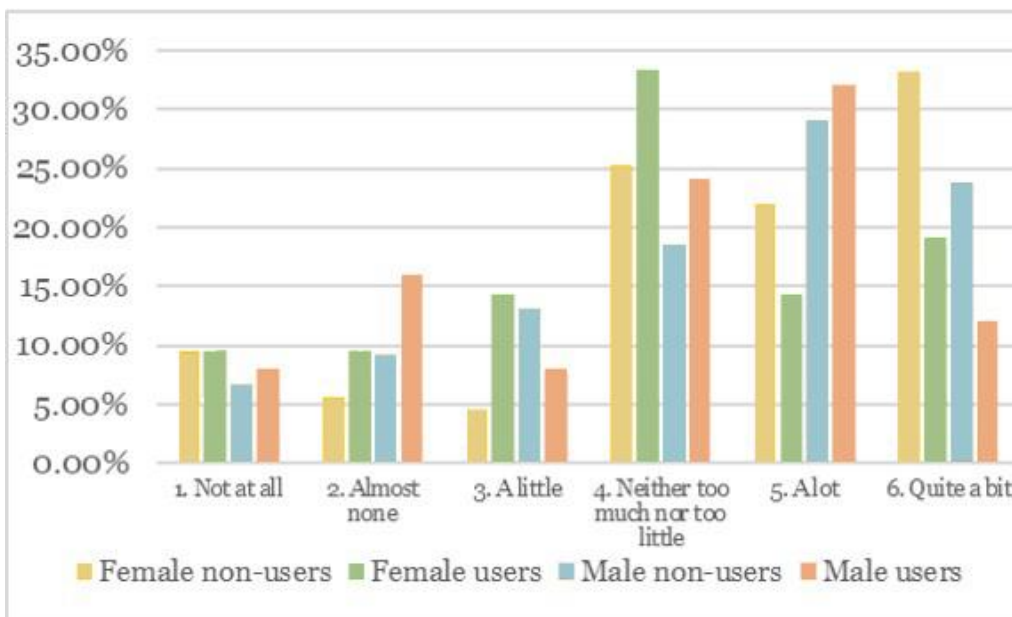
The general behavior of each variable will be studied, and the five variables with the highest representativeness in each profile and gender (for the non-users) will be further analyzed.

7.3.2. Psychological factors

a. Limitation or concern about the fear of being robbed or the bicycle stolen

This variable ranked first in importance among female non-users, female users and male non-users, as well as the second place in importance for male users.

In general, the options "neither too much nor too little", "a lot" and "Quite a bit" are the most common (together above 65%). Complementarily, Over 80% of the female non-users give importance to the variable, being their preferred option "quite a bit" (33.15%). For female users, the preferred option is "neither too much nor too little" (33.33%), showing how when they use the bicycle, the importance given to this variable reduces in comparison between female non-users and female users. In the case of males, the option "a lot" was the most responded to in the case of both (users and non-users), and for the cases of male non-users, the 71% showed interest in the variable according to the following figure.



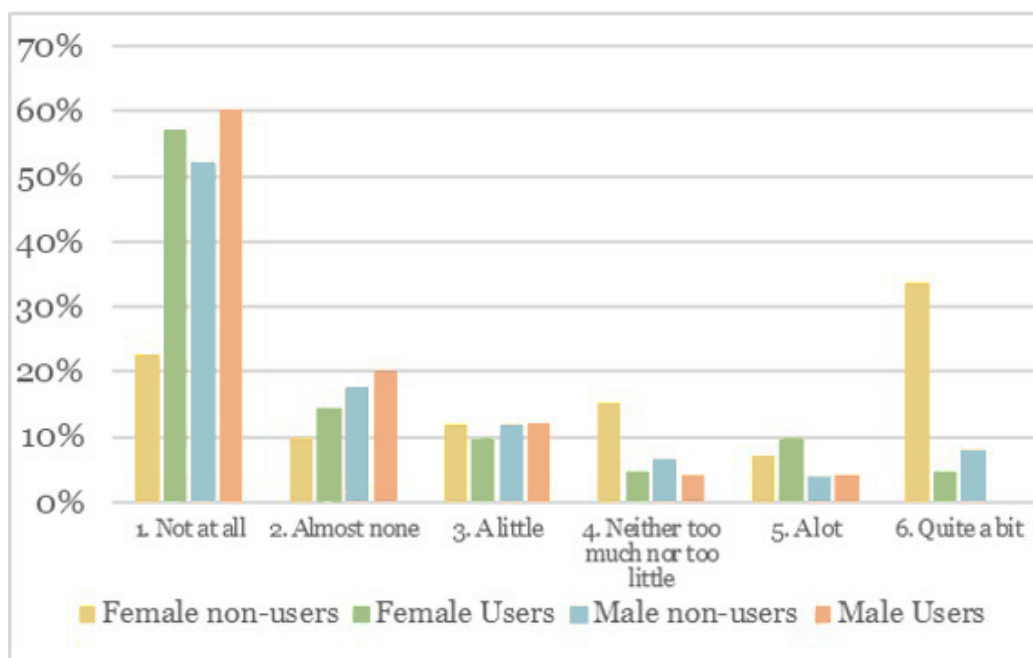
(Fig. 29) Limitation or concern about the fear of being robbed or the bicycle stolen
Source: Author

For female non-users, the main comunas of the city where importance is given to the variable are 7, 10, and 11, according to (Fig. 54).

For the male non-users, the main comunas of the city where importance is given to the variable are 7, 11 and 5, according to (Fig. 55).

b. Limitation or concern about the possibility of an incident due to lack of expertise

This variable is particularly interesting for female non-users since 34% of the respondents stated that this influences "quite a bit" their choice of bicycle. For female users, male non-users, and male users, this variable is not relevant since their answers were always oriented above 80% towards the variables "Not at all", "almost none", and "a little".



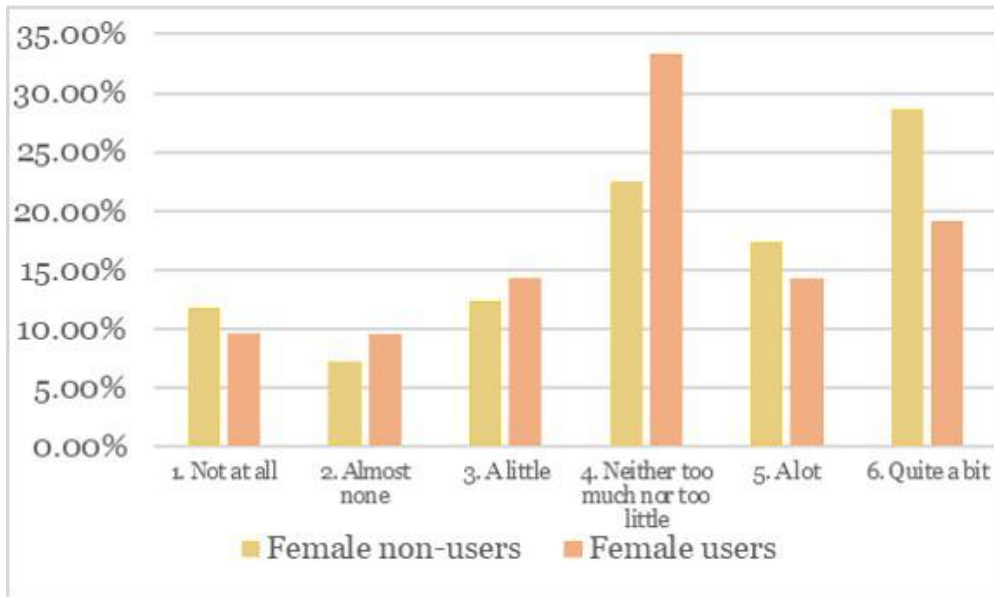
(Fig. 30) Limitation or concern about the possibility of an incident due to lack of expertise
Source: Author

c. Limitation or concern about harassment of female gender

It is believed that this variable is one of the most important for female non-users when deciding on their means of transportation. The results indicate that the options "neither too much nor too Little" (22.47%), "a lot" (17.42%), and "quite a

bit" (28.65%) are the ones most responded by them with 68.54% of predilection as a whole; for female non-user, the choice does not vary too much, with "neither too much nor too little" (33.33%), "a lot" (14.29%) and "quite a bit" (19.05%) being the most responded variables and totaling 66.67%.

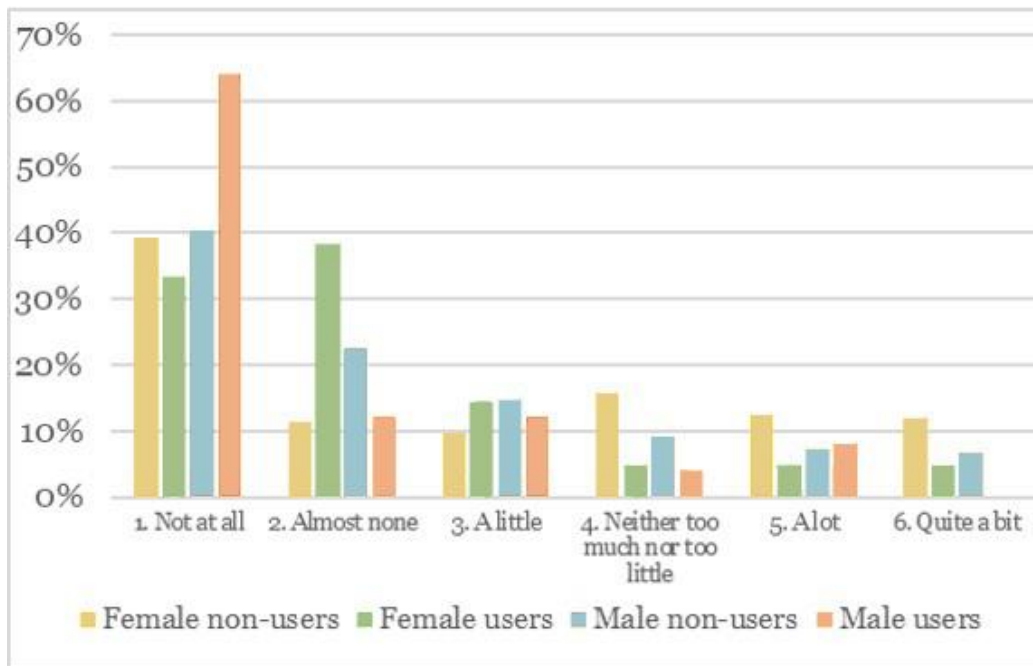
It should be noticed that for female users, the option "neither too much nor too little" intensifies compared to female non-users, going from 22.47% to 33.33%.



(Fig. 31) Limitation or concern about harassment of female gender
Source: Author

d. Limitation or concern about not having a pleasant experience

The majority of survey participants leaned towards the options "not at all", "almost none" and "a little", in the case of female non-users (60%), female users (86%), male non-users (77%) and male users (88%) selected these options. These numbers suggest that non-users find the activity pleasurable, but users find the experience even more pleasurable and enjoy it more.

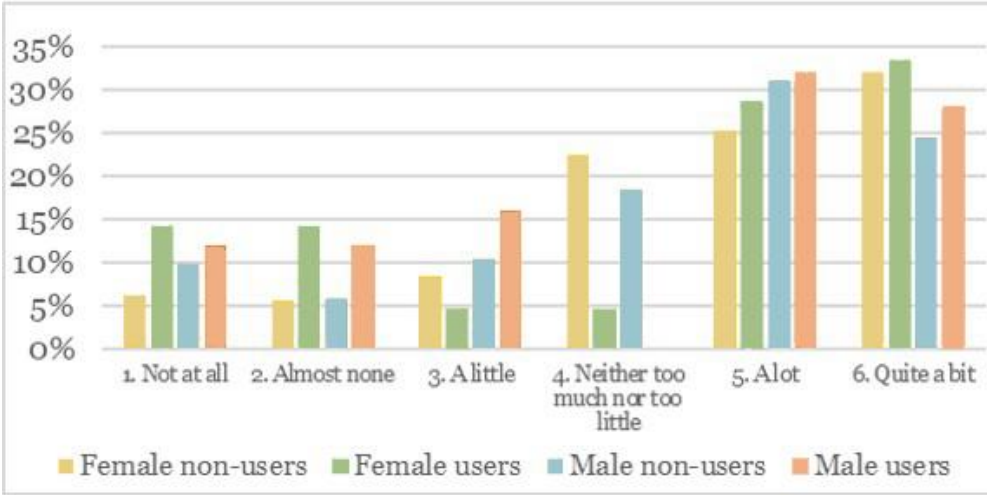


(Fig. 32) Limitation or concern about not having a pleasant experience
Source: Author

7.3.3. Natural Environment

a. Limitation or concern about rain and bad weather

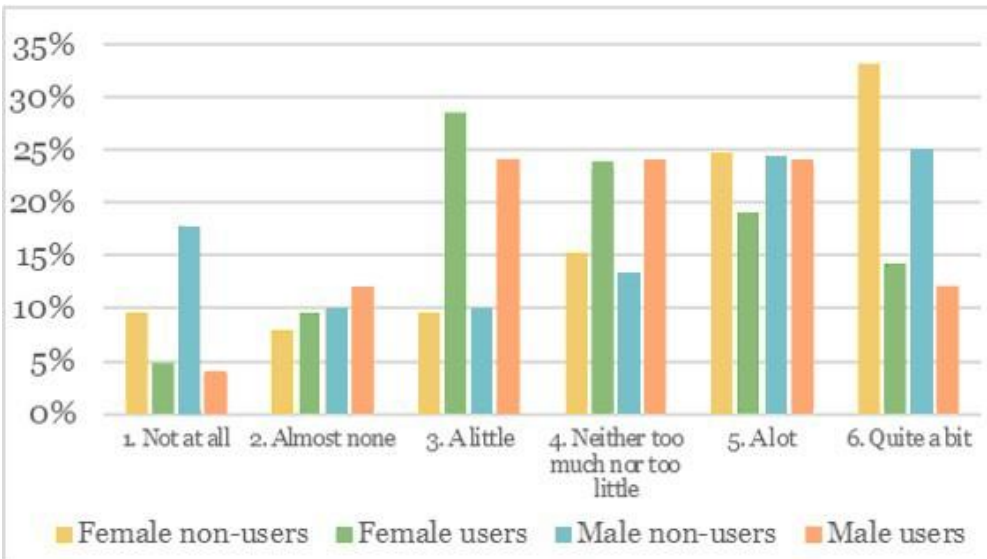
The strong trend in this variable is evident. It is essential and occupies the first place of importance for male non-users, second place in importance for the female non-users and male users, and third place in importance for female-users, being "neither too much nor too little", "A lot" and "quite a bit" the response trends for a percentage of population above 60% (in the worst case) and reaching up to 80% as maximum. The results can be seen next.



(Fig. 33) Limitation or concern about rain and bad weather
Source: Author

b. Limitation or concern about having air pollution

The third most crucial variable for female non-users, the fifth for female users and male non-users, and the fourth for male users. For non-users, the variable strongly tends to be "A lot" and "quite a bit" important; for users, the level of importance of this variable drops a little, especially for females, who give less importance than males to this variable, putting the options "a little" (29%), "neither too much nor too little" (24%) and "a lot" (19%) above the others; for male, the same options are around 24% each as can be seen next.

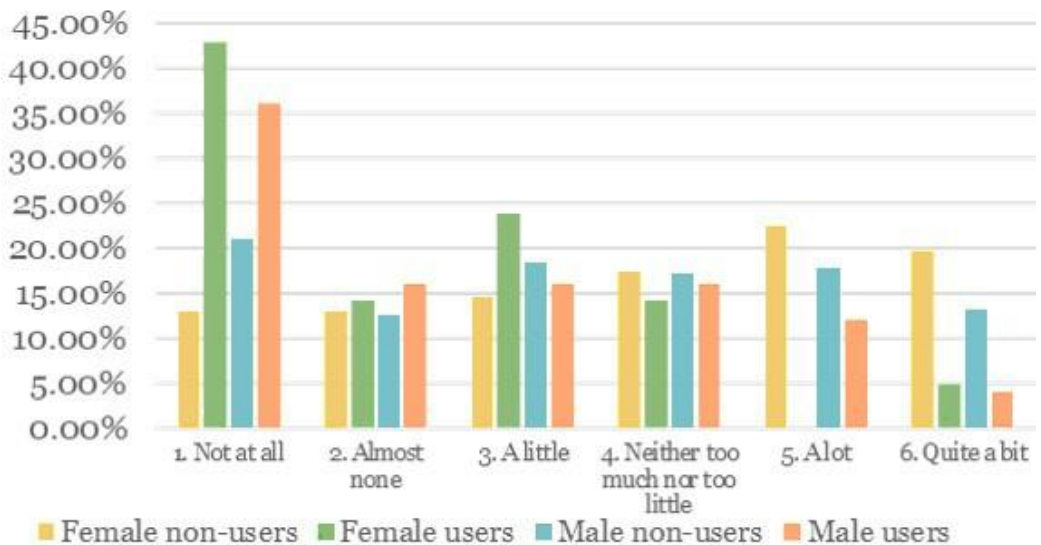


(Fig. 34) Limitation or concern about having air pollution
Source: Author

This variable has affected the city for several decades because air quality decreases considerably at certain times of the year. The measures taken by the metropolitan and district entities have yet to be conclusive and have generated impacts on active mobility since, during the most critical periods, people are advised to limit their exposure to the sun at specific times of the day.

c. Limitation or concern about getting sunburnt

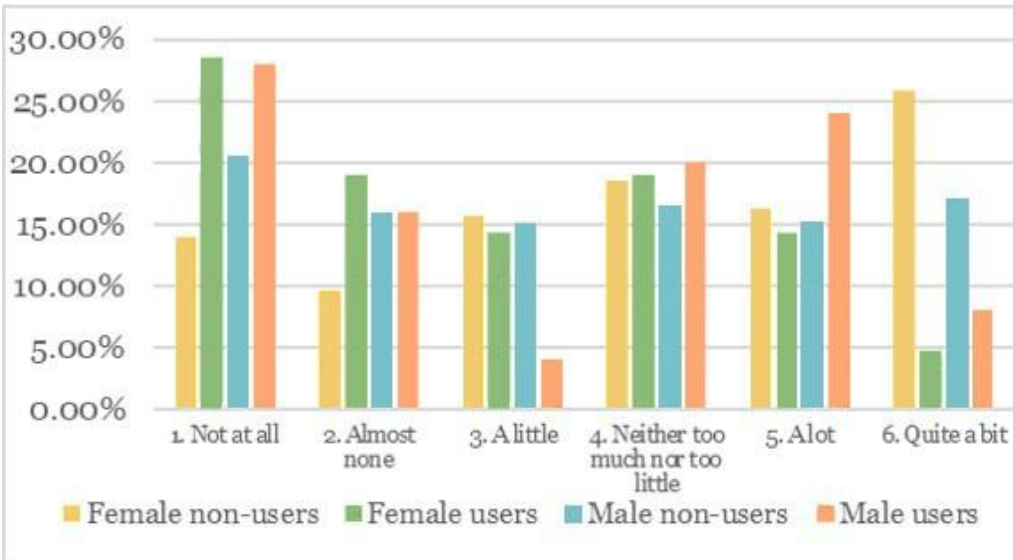
This variable is more critical for female non-users who mostly (59.55%) chose the options "neither too much nor too little" (17.42%), "A lot" (22.47%), and "quite a bit" (19.66%), for non-user male there is no clear trend as their answers are almost equally distributed among the options. For users, the variable is not representative, 81% of females and 68% of males were oriented to the answers "not at all", "almost none", and "a little" as their preferences. "not at all" is the most popular answer among males (36%) and females (43%).



(Fig. 35) Limitation or concern about getting sunburnt
Source: Author

d. Limitation or concern about having noise contamination

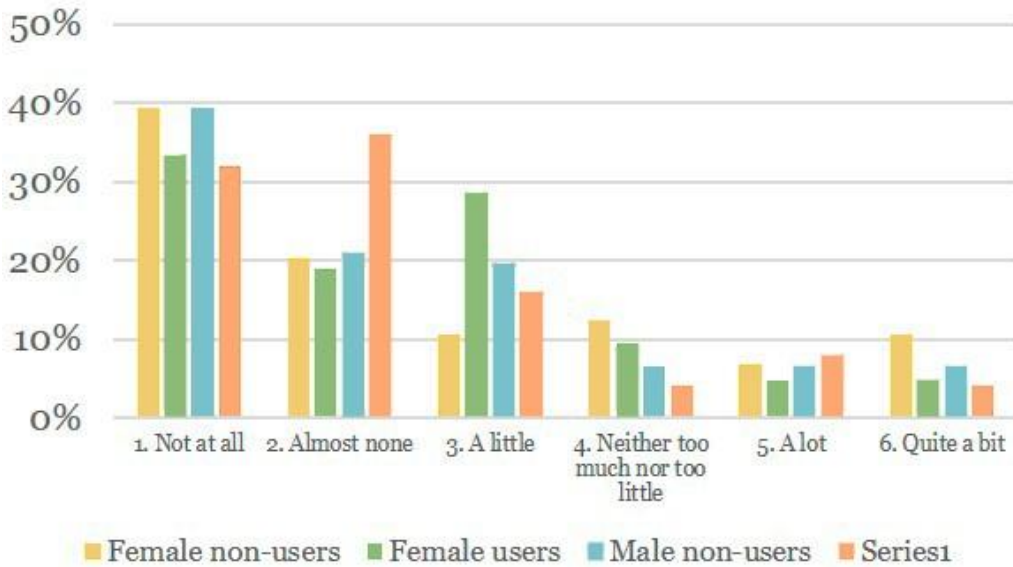
This variable has a pretty particular behavior. The majority of female non-users (61%) leaned towards the options "neither too much nor too little", "a lot", and "quite a bit"; for female users, the behavior tends to reverse towards the variables "not at all", "almost none" and "a little" (62%). In the case of males, there is no clear trend, and the result is inconclusive.



(Fig. 36) Limitation or concern about having air contamination
Source: Author

e. Limitation or concern about having visual contamination

The majority of people preferred the options "not at all", "almost none" and "a little" (more than 70% of the surveyed people).



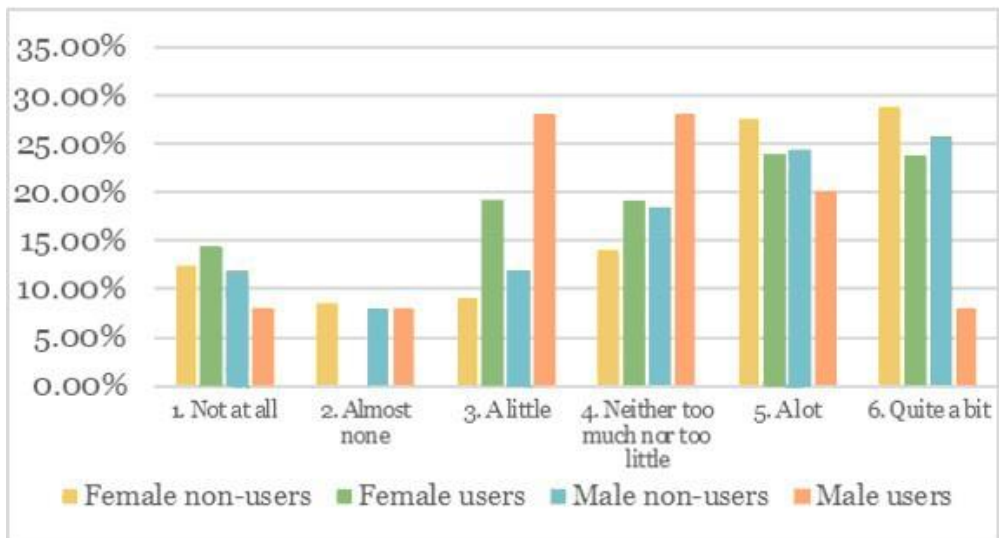
(Fig. 37) Limitation or concern about having visual contamination
Source: Author

7.3.4. Socioeconomic variables

a. Limitation or concern about arriving poorly presented to the destination and not having a place to groom

The third most crucial variable for male non-users, the fourth most important for female gender, and the fifth for male users.

In the case of female non-users, this variable is representative of 70.22% of the respondents that leaned towards the options "neither too much nor too little" (14.04%), "a lot" (27.53%), and "quite a bit" (28.65%); female users also show this tendency (66.67% of preference for the options "neither too much nor too little", "a lot" and "quite a bit"). for male non-users there is a preference similar to the female users (68% of the participants consider representative the variable in different levels); however, for male users, the most important options are "a little" (28%) and "neither too much nor too little" (28%).



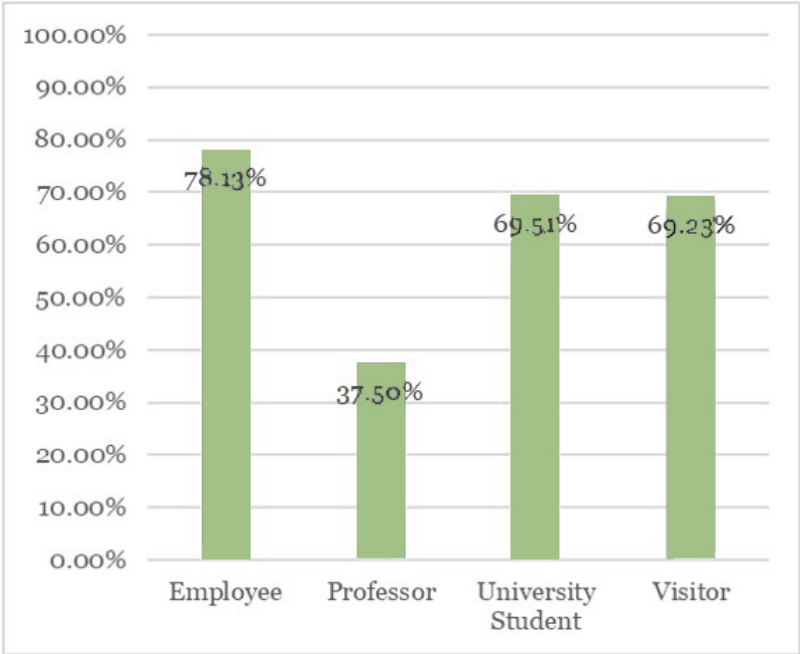
(Fig. 38) Limitation or concern about arriving poorly presented to the destination and not having a place to groom
Source: Author

Even though this is the third variable to which the male non-users gave representativeness, the percentages of users and non-users who gave representativeness are higher for the female gender.

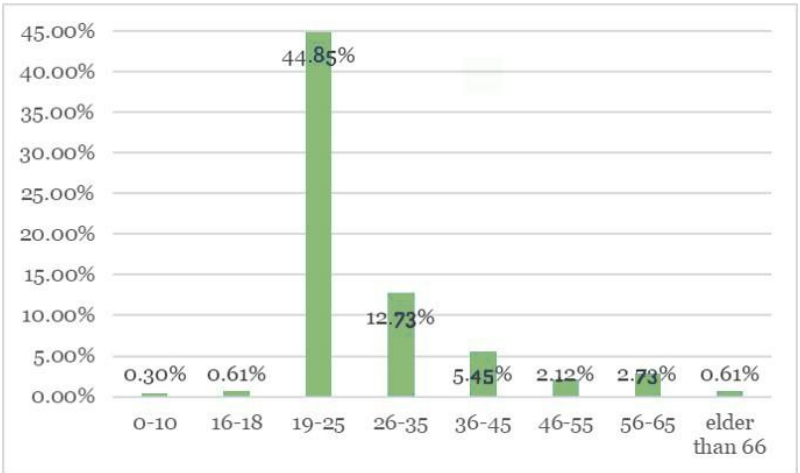
For the case of adult non-users, the variable influences more employees (78.13%

of the stratum), university students (69.51% of the stratum), visitors (69.23% of the stratum) and professors (37.50% of the stratum) in that order according to the (Fig. 39).

Correlating this variable with age, it is clear that the variable has a considerable influence on young people, at least for the non-users of the National University of Colombia, as seen in (Fig. 40).



(Fig. 39) Non-users that gave representativeness to arriving poorly presented by stratum to the destination and not having a place to groom in the stratum
Source: Author

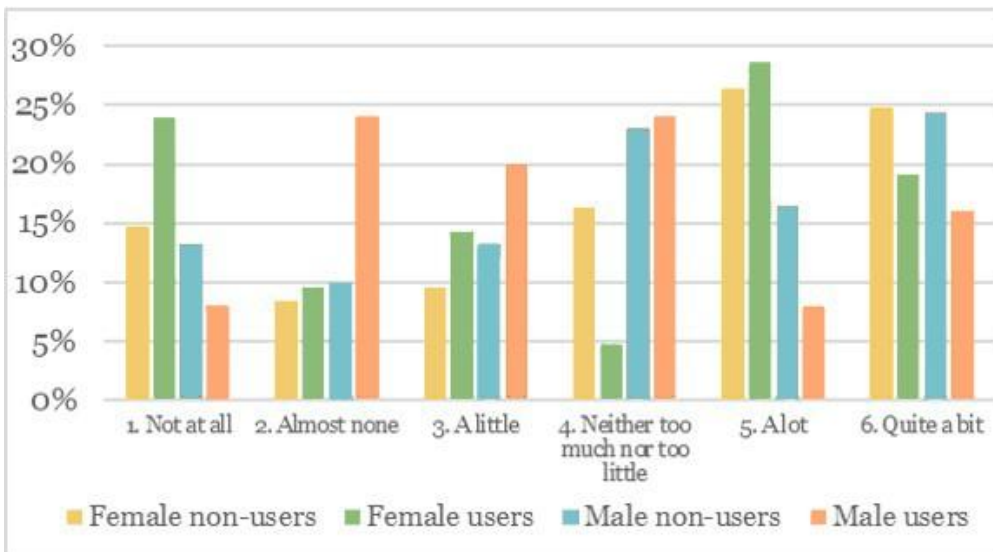


(Fig. 40) Non-users that gave representativeness to arriving poorly presented by age to the destination and not having a place to groom according to age
Source: Author

b. Limitation or concern about requiring more time for personal presentation after arriving at the destination

This variable is the fourth most crucial variable for the male non-users, and it is not as relevant as the other fifth variables for the female gender and male users. However, it is still vital for the respondents.

64% of the male- users consider the variable "neither too much nor too little", "a lot" and "quite a bit" important. For the majority of female non-users (67%), this variable is also "neither too much nor too little", "a lot" and "quite a bit" important; for female users, the importance related to this variable reduces to (52%); for male users the same phenomenon occurs but they do not put too much attention to the variable (less than 50% of male users consider the variable representative).



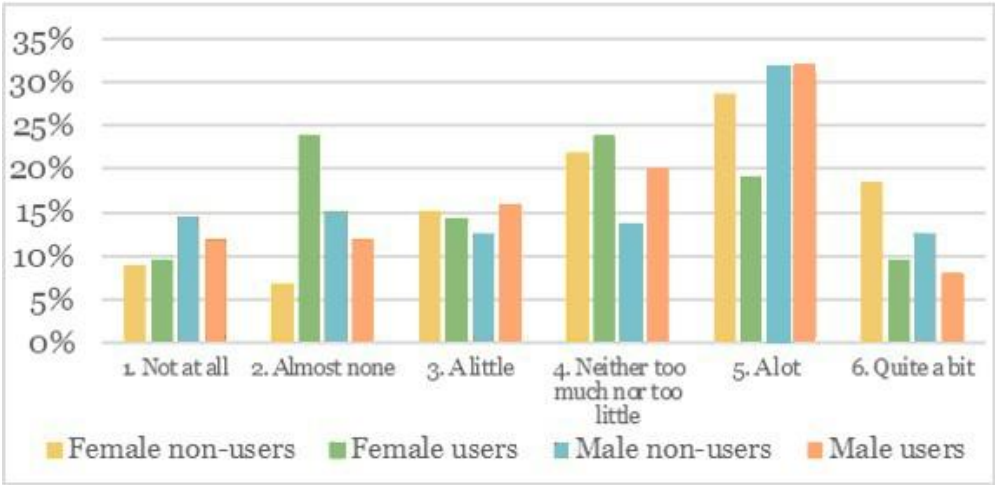
(Fig. 41) Limitation or concern about to require more time for personal presentation after arrive to the destination
Source: Author

7.3.5. Built environment

a. Limitation or concern about finding obstructions in the way

The third most crucial variable for male users (60% gave different levels of importance to this variable), and the fifth for female non-users (70% gave different levels of importance to this variable). For non-users (in general) and male users, the majority of the population, the most popular options of answer

were "Neither too much, not too little", "a lot" and quite a bit". The preferred tendency is "a lot" for female non-users (29%), male non-users (32%) and male users (32%). However, for female users, there is no characteristic trend. Preferences are distributed without a defined tendency for this gender, as shown in the following figure.

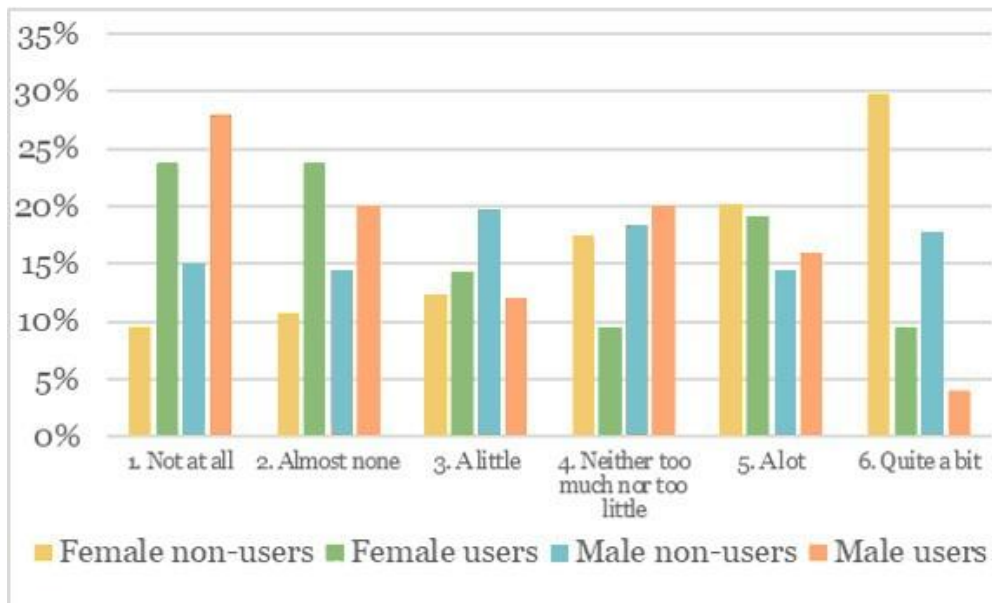


(Fig. 42) Limitation or concern about finding obstructions in the way
Source: Author

The Comunas in which there was more interest in this variable for female non-users are 7, 11, and 5. For male non-users, the variable is not among the five most representative variables, according to the (Fig. 56).

b. Limitation or concern about the possibility of an infrastructure-related incident

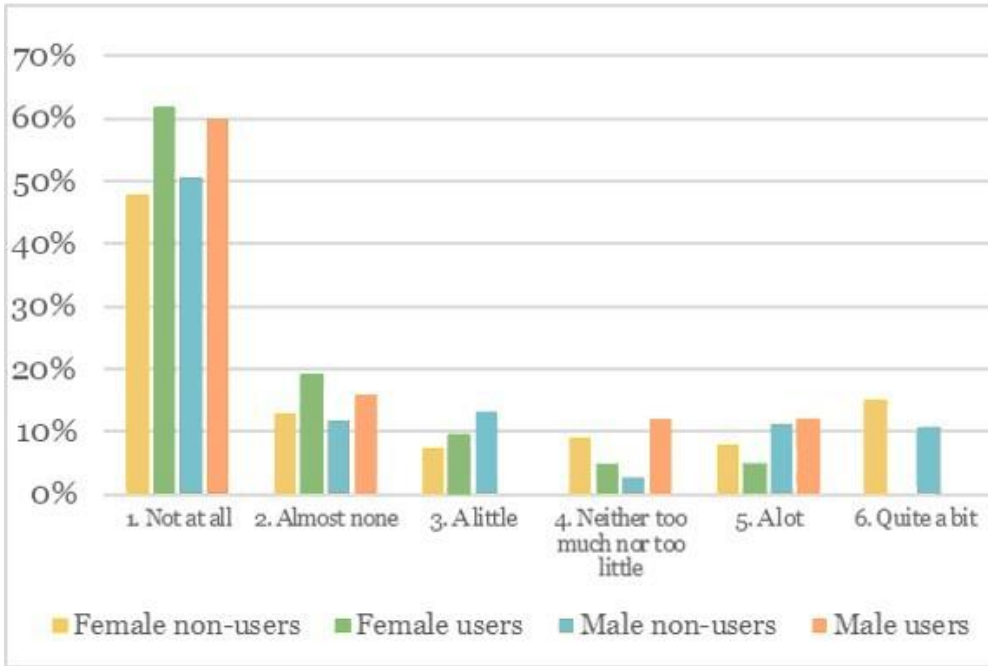
The majority of female non-users (67%) consider the variable to be “neither too much not too little”, a “lot” or “quite a bit important”; female users have a tendency (62%) to consider “not at all”, “almost none” or “a little” important; among male non-users there is no clear tendency in concerning the representativeness and among male users, there is a tendency similar to female users (62%), also giving no too much representativeness to this variable (60%) as shown in the following figure.



(Fig. 43) Limitation or concern about the possibility of an infrastructure-related incident
Source: Author

c. Limitation or concern about the perception of difficulty to use the bicycle with other people

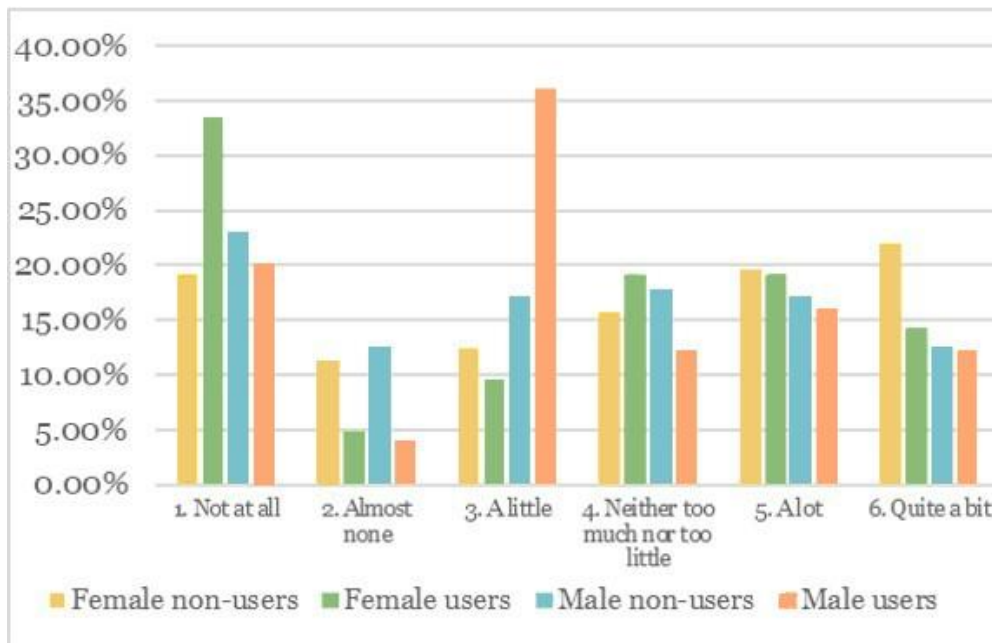
Tendency shows that male and female gender do not see any inconvenience in using the bicycle with other people. The options are given "not at all", "almost none", and "a little" were above 65% of preference as a whole. It is noteworthy that for female users, this percentage was extremely high (90%), and in all cases, the most popular response option was "not at all" (over the 45%), as shown in the following figure.



(Fig. 44) Limitation or concern about the perception of difficulty in using the bicycle with other people
Source: Author

d. Limitation or concern about the perception of difficulty in carrying things

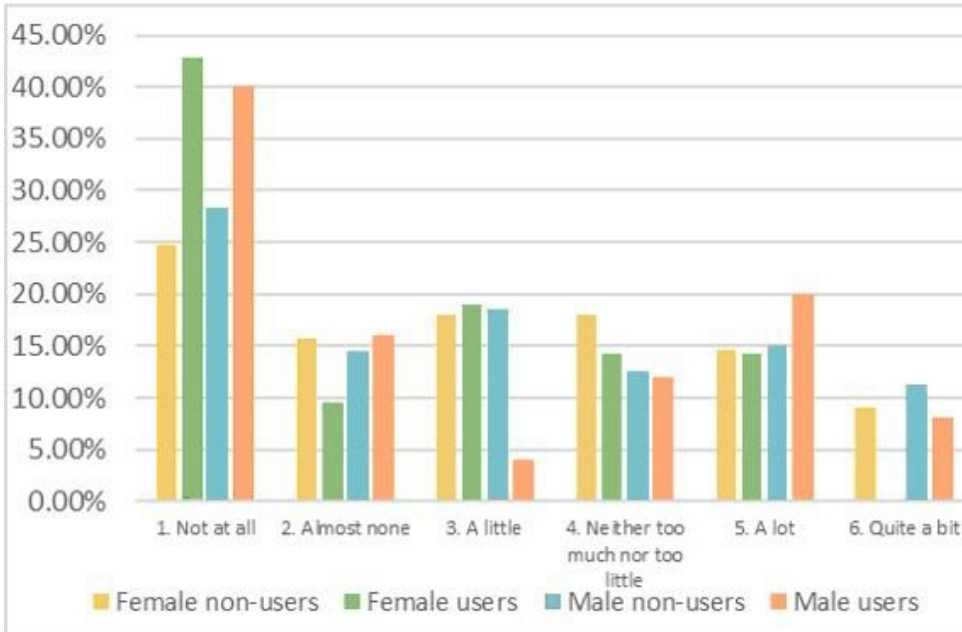
For non-user females, the majority (57.3%) leaned towards the options "neither too much nor too little" (15.73%), "a lot" (19.66%), and "quite a bit" (21.91%); for female users, the option "not at all" increases strongly concerning non-users (from 19% to 33%); for male non-users, there is no clear trend although the majority (53%) selected the options "not at all", "almost none" and "a little" as their preferences; for male users the option "a little" increases for non-users (from 17% to 36%), it is possible to say that for male this variable only becomes "a little" important when they are users (the tendency is defined) as shown in the following figure.



(Fig. 45) Limitation or concern about the perception of difficulty in carrying things
Source: Author

e. Limitation or concern about the difficulty of finding parking at the destination

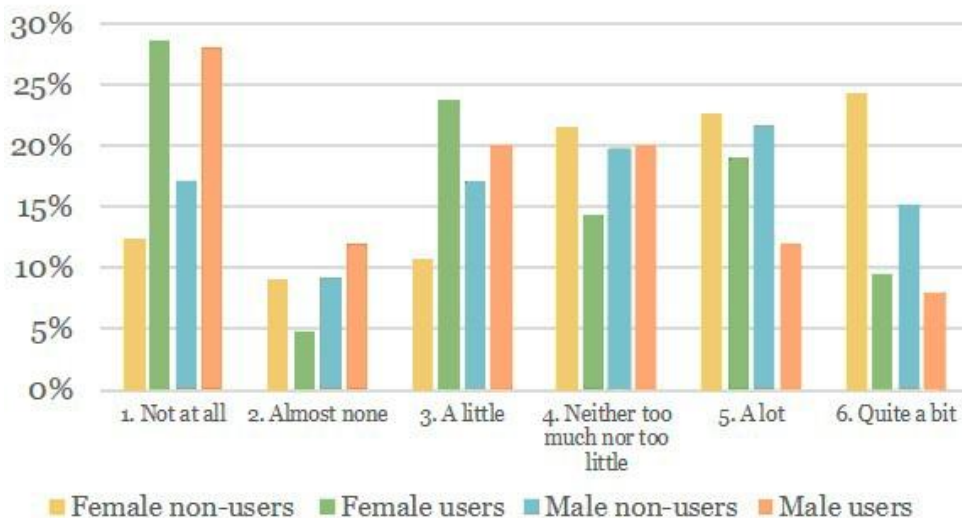
For female non-users, this is not a representative phenomenon, the "not at all" option reaches 25% preference, and this trend is reinforced among female users, with 43% of preference for this option; for male non-users, the situation is similar to female non-users and the trend is reinforced for male users (40% preference for the option "not at all", however, it should be noted that some male users (20%) also lean towards the option "a lot" and this generates two peaks of preference for male non-users as shown in the following figure.



(Fig. 46) Limitation or concern about the difficulty in finding parking at the destination
Source: Author

f. Limitation or concern about lack of integration

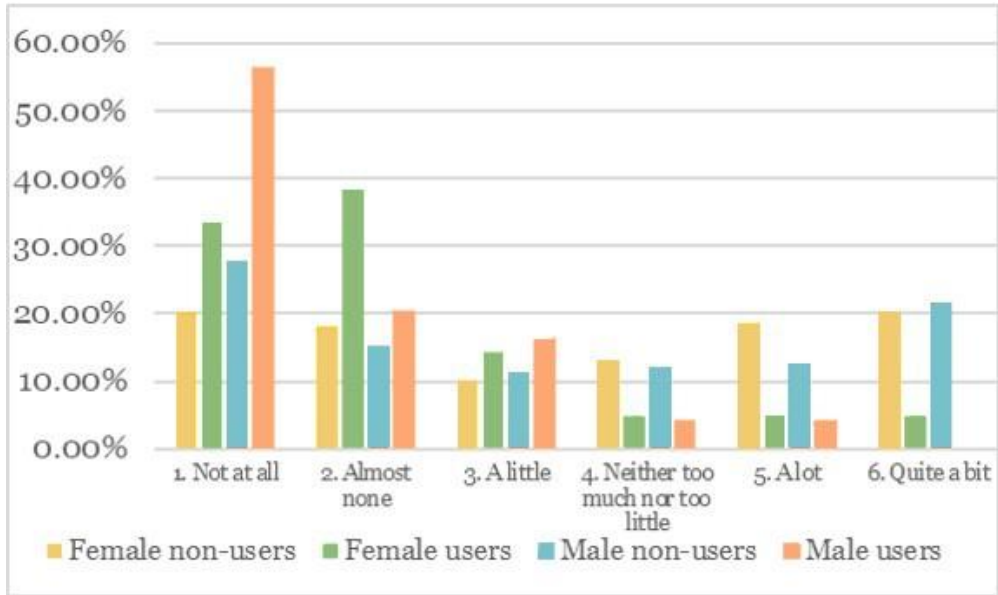
68% of non-user females consider this variable to be "neither too much not too little", "a lot" and "quite a bit" important; however, the results for user females show the opposite trend, with 60% of them considering it to be "not at all", "almost none" and "a little" important; for male user, compared to non-users, the picture is the same.



(Fig. 47) Limitation or concern about lack of integration
Source: Author

g. Limitation or concern about having trips of more than 15 minutes

The perception regarding this variable is divided into two extremes for non-users (Really high or low importance). At the same time, the majority of female users (38%) tend to put "almost none" importance to the variable, and male users put lower importance trending to "not at all" (56%).

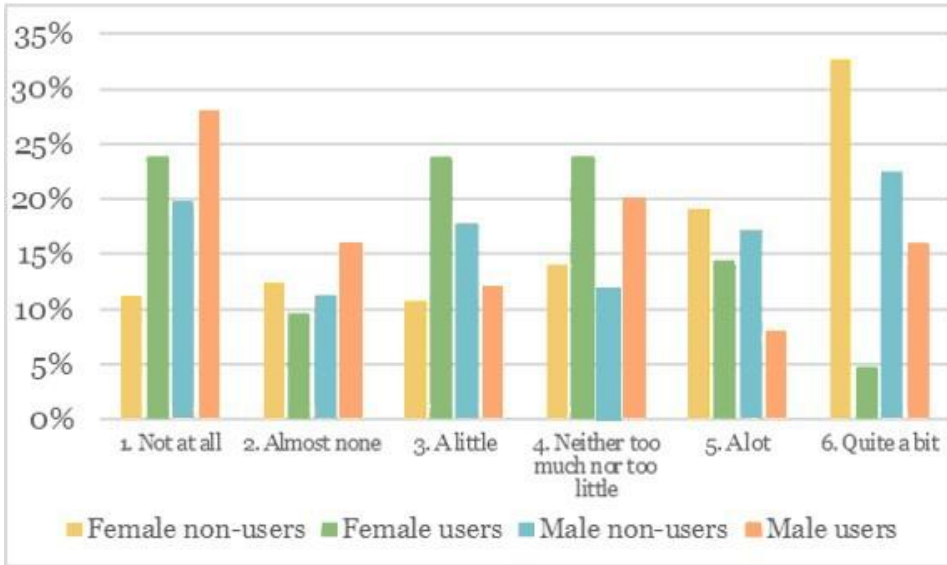


(Fig. 48) Limitation or concern about having trips of more than 15 minutes
Source: Author

7.3.6. Cost of time, effort, and safety

a. Limitation or concern about cycling due to the effort on the slopes

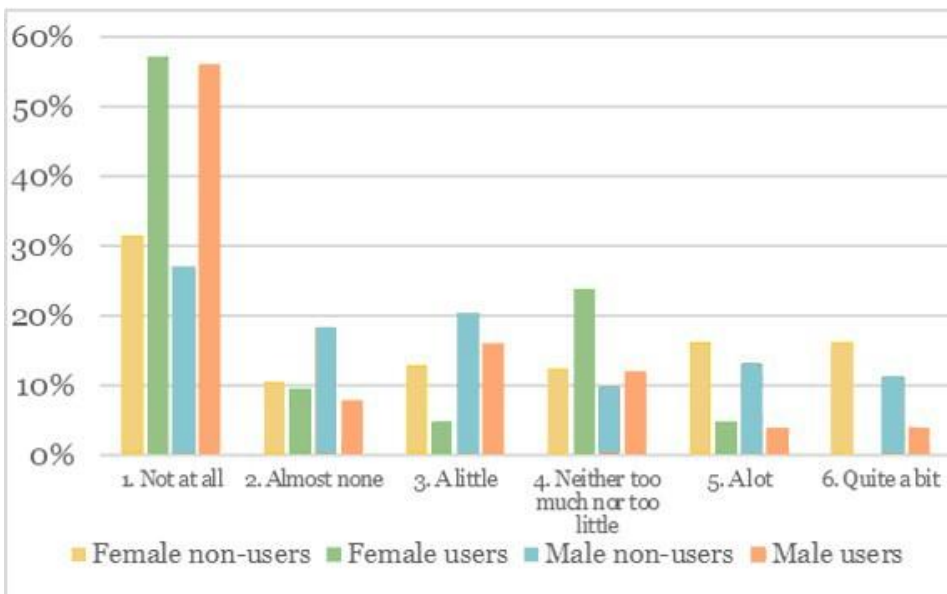
Medellin is a city with steep slopes in its territory. It is believed that this variable has great importance among the inhabitants. The survey results show 65.73% of the non-user female population considers the variable to be "neither too much too Little", "A lot", and "quite a bit" important, especially inclined to "quite a bit" important (32.58%); In contrast, the female user population has a predilection (57%) for the variables "not at all", "almost none" and "a Little", with only 5% of users favoring the option "quite a bit"; for male non-users the most popular option is "quite a bit" (22%), although the preferences are more evenly oriented in the options; Finally, for male users, this variable is less important than for non-users, and the maximum is in the option "not at all" (28%).



(Fig. 49) Limitation or concern about cycling due to the effort on the slopes
Source: Author

b. Limitation or concern about the perception of not having significant reduction in time

For all participants in the study, there was a clear trend (between 55% and 80%) to the options "not at all", "almost none" and "a Little", however it can be seen that for users, the option "not at all" is much more popular (57% in female users and 56% in male users), showing that people who use bicycles perceive more clearly the reduction of time using the bicycle and its benefits.



(Fig. 50) Limitation or concern about the perception of not having significant reduction in time
Source: Author

8. Chapter VI – Conclusions and further studies

8.1. Key findings

- (Non-users) Promotion strategies should especially target people earning between \$226 and \$786 for public and private bicycles. Users decrease at the same time that people earn more money as Heinen et al. (2010) proved but just until reach 787 USD, may be due to factors related to social standards regarding the ideal of mobility of the middle class, such as the acquisition of their own motorized vehicle. In the near future this phenomenon must be explored for the entire city.
- (Non-users) Non-users in the north-west and central-west of the city are the ones who own the most bicycles (39.09% of the non-users). Planning programs must take advantage of this situation because these people can use their bicycles for their activities and do not require a new vehicle, as Heinen et al. (2010) mentioned. The spatial prioritization of interventions oriented to attract non-users that own a bicycle must be prioritized as shown in (Fig. 53).
- (Non-users) "Ciclovía" has a high potential for promotion among participants of this event who own bicycles but are not routinary users, as the evidence shows in Despacio (2014) for the case of Bogotá; the potential is significantly related to the north-western and south-eastern areas of the city and the proportion of the use of the bicycle as a means of transport beyond an entertainment vehicle. The spatial prioritization of interventions oriented to attract non-users using Ciclovía must be as shown in (Fig. 53).
- (General) Polygons with the highest population in the sample (that also correspond to the highest population in the city) do not correspond to the highest rate of bicycle use, probably due to the lack of infrastructure. Based on that, interventions should be directed mainly to the comunas 11, 7, 10, 12, and 4 in order to generate more significant growth in the number of users, the spatial prioritization of interventions oriented to maintain users and improve

their conditions, must be as shown in (Fig. 53). According to the Origin destination, the comunas 11, 10, 16, 13, and 15 are the comunas with more users. It reminds us that this study applies to the National University of Colombia population and could be expanded to the city but is focused on that population.

- (Non-users) EnCicla system should focus on the connection that the young population (less than 35 years), especially non-users, have with the city to attract more users. The use of EnCicla by younger populations shows significant potential for users in this age group; The system is also a fantastic alternative for people with incomes below 225 dollars. It implies that the free-of-charge system works, but the possibility of payment must be explored.
- (General) According to the methodology described for the prioritization of variables, the ranking for each gender and profile is shown in the
 - (Tab. 11), (Tab. 12), (Tab. 13), (Tab. 14), and
 - (Tab. 15)
- (Top variable) (Non-users) (Psychological) The importance of the fear of being robbed or having the bicycle stolen is exceptionally high since it is the most essential variable for female non-users, female users, and male non-users and the second most important for male users. We can see that as people get used to bicycle use, they perceive this variable as less impactful. In comunas 7 "Robledo", 10 "La Candelaria", and 11 "Laureles" there should be a decisive intervention regarding the perception of non-users and their human safety. The most prioritized must be the comuna number 7, and the intervention must be done according to the level of representativeness shown in (Fig. 54), and (Fig. 55) according to biological gender.
- (Top variable) (Non-users) (Psychological) In Medellín, human safety is an issue with immense concern. Strategies focused on increasing the human safety of cyclists beyond the traditional fight against criminality and the traditional way to deal with thieves are urgent to reduce the gap effectively.

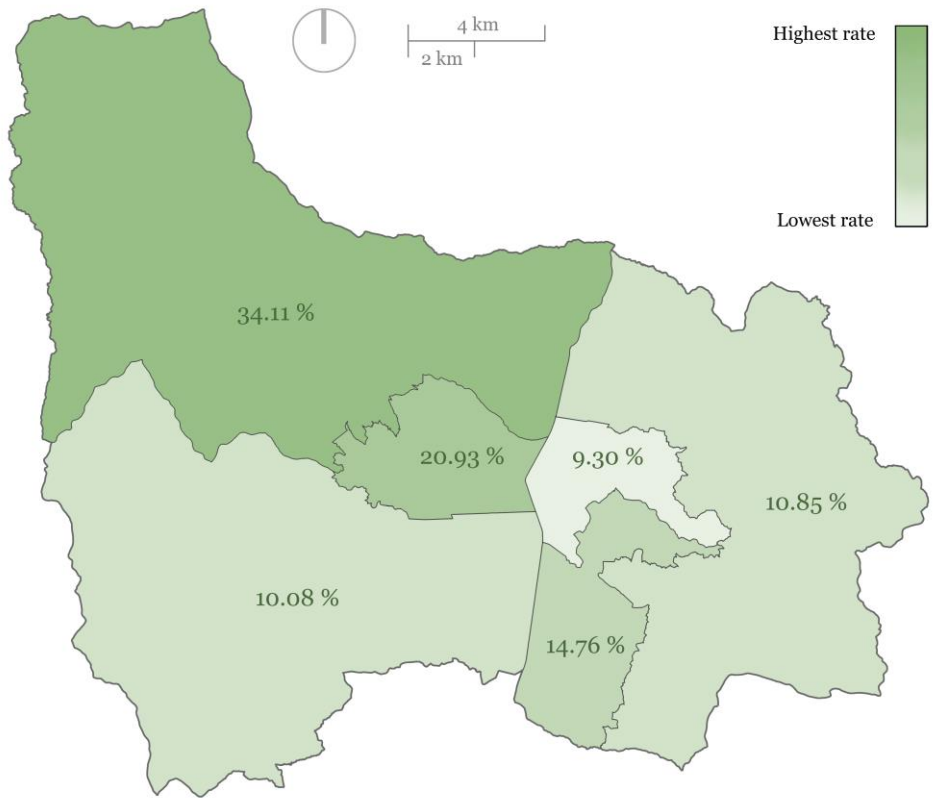
The findings show a different picture concerning the findings made by Despacio (2014) in Bogotá.

- (Top variable) (General) (Psychological) Regarding harassment towards the female gender, it must be prioritized, especially for non-users. Although for female users, it seems to be less critical (but still very representative), it is essential that female citizens feel safe and very calm when using the means of transport and make the decision to use bicycles routinely.
- (Top variable) (General) (Environmental) Rain and bad weather are firmly conditioning variables of the dynamic in Medellín for users and non-users, especially for female non-users but with a massive impact on everybody. The need for radical measures to counteract this phenomenon is urgent. Solutions based on infrastructure as indicators of possible rain for users, shelters in some uncovered zones, strategies to equip the users properly, and additional interventions are required. Further analysis of the period of variability, the purpose of the trip, and the location must be correlated with the environmental factors soon.
- (Top variable) (General) (Environmental) It is required to develop protocols to facilitate the transport of bicycles by other means and the possibility of using safe parking in long rainy events in order to facilitate users to leave their bicycles and return later or take the bicycles with them to other destination in another means, among others.
- (Top variable) (General) (Environmental) Infrastructure measures are fundamental in all senses to facilitate the cyclist's interaction with the rain without limiting the activity in such an intense way. The mentioned measures would be proper solutions to ensure more confidence in the network, especially for non-users.
- (Top variable) (General) (Socio-Economic) Current urban planning strategies should take into account the aesthetic and the possibility of grooming as crucial

factors. It is the third most representative variable for male non-users, the fourth most representative for female gender, and the fifth for male users. It can be said that aesthetics is critical in the city context based on the perception of the people from the National University of Colombia at Medellín. And the non-users who pay the most attention to this variable are between the ages of 19 and 35 years in accordance to Heinen et al. (2010) and Cervero et al. (2019)

- (Top variable) (Non-users) (Socio-economic) To require more time for personal presentation after arrival to the destination is the fourth most crucial variable for the male non-users. Infrastructure-based solutions such as changing clothes facilities, drinking fountains, resting and refreshment areas, and taking into account the time people spend grooming as part of the working hours would significantly improve the perception of this variable.
- (Top variable) (Non-users) (Built environment) To find obstructions in the way shows a tendency to have "a lot" of importance, especially for female non-users. This variable must be worked predominantly in the north-west of the city, prioritizing female non-users (comunas 7, 5, and 11) to reduce the impact of this variable in the mobility gap related to bicycle use. The prioritization must be as (Fig. 56) shows.
- (Non-users) (Built environment) People think that cycling is less safe than walking, and Bicycle users give bicycles a higher safety value than non-users; as Heinen et al. (2010) mentioned the tendency of the non-users shown in (Fig. 57) and (Fig. 58), related to the possibility of an infrastructure related incident, shows that for male and female non-users from the comunas 7, 5, and 11, this variable must be prioritized, and it is necessary to reinforce the infrastructure for bicycles to reducing the impact of this variable in the mobility gap related to the use of bicycle, counteracting the problems with the Design "Ds" suggested by Cervero et al. (2009) and proving the statements of Heinen et al. (2010)

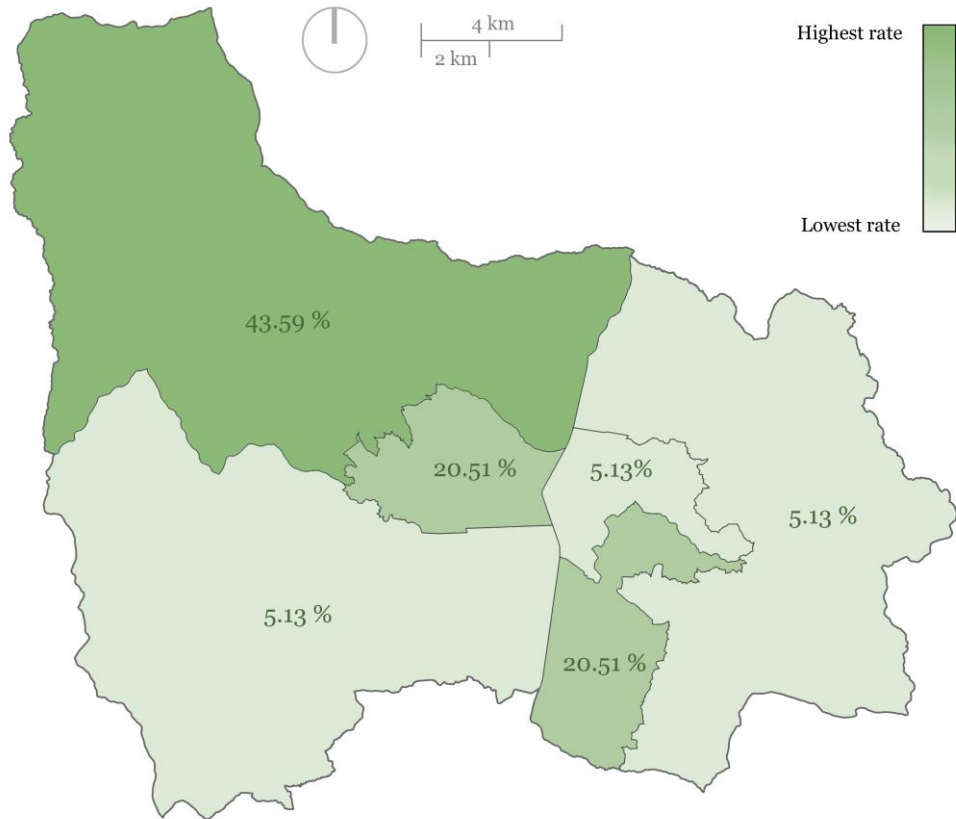
- (General) (Built environment) More dense areas of the city of Medellín must be prioritized to the develop of integrated infrastructure according to the statements presented by Cervero et al. (2019) and Heinen et al. (2010)
- (General) (Built environment) Having trips longer than 15 minutes is not very impactful for the user and. the non-user tendency is not defined. The aim must be to promote the bicycle as the fastest vehicle for short distances (between 0,5 and 3,5 km), as Heinen et al. (2010) suggest, people do not recognize the importance of this variable. The implementation of planning instruments to create short-distance zones to reduce long displacements in the city and incent this means is essential to reduce the gap between the use of bicycle and the other means based on the argument that the resistance to travel is likely to increase exponentially if the distance is very long due to the physical effort required presented by Heinen et al. (2010). Also, as Ospina et al. (2020) mentions, the allocation of commercial districts close to residential areas is crucial to promote short trips, and, long stretches of lane with direction to urban centers encourages the use of this mode, according to Cervero et al. (2019)



	Polygon 4	Polygon 5	Polygon 2
Users %	9.30%	10.08%	10.85%
	Polygon 6	Polygon 3	Polygon 1
Users %	14.73%	20.93%	34.11%

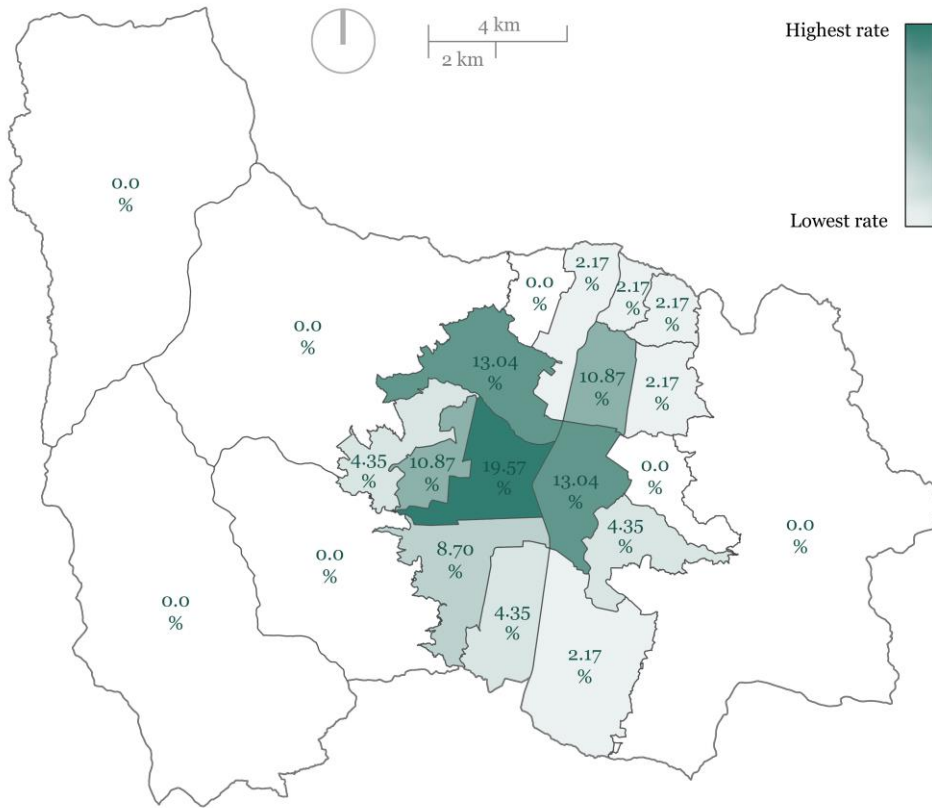
(Fig. 51) Map of prioritization of interventions to attract non-users that own a bicycle (Sample)
Source: Author

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	Polygon 2	Polygon 4	Polygon 5
Users %	9.30%	10.08%	10.85%
	Polygon 3	Polygon 6	Polygon 1
Users %	14.73%	20.93%	34.11%

(Fig. 52) Map of prioritization of interventions for non-users owning a bicycle and attending the Ciclovía (Sample)
Source: Author



Comuna	1 - Popular	2 - Santa cruz	3 - Manrique	5 - Castilla	14 - Poblado
Users %	2.17%	2.17%	2.17%	2.17%	2.17%
Comuna	9 - Buenos Air	13 - San Javier	15 - Guayabal	16 - Belen	4 - Aranjuez
Users %	4.35%	4.35%	4.35%	8.70%	10.87%
Comuna	12 - La Americ	7 - Robledo	10 - La Cande	11 - Estadio	
Users %	10.87%	13.04%	13.04%	19.57%	

(Fig. 53) Map of comunas vs use of bicycle (Sample)
Source: Author

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Category
Psychological
Natural Environment
Built environment
Socio economical
Cost, Time and effort

(Tab. 11) Conventions for the prioritization of variables according to the representativeness in the survey
Source: Author

#	Variables Female non-users	"neither too much nor too little", "a lot" and "quite a bit" Representativeness
1	Fear of being robbed or the bicycle stolen	80.34%
2	Rain and bad weather	79.78%
3	To have air pollution	73.03%
4	To arrive poorly presented to the destination and do not have a place to groom	70.22%
5	To find obstructions in the way	69.10%
6	Harrasment of female gender	68.54%
7	Lack of integration	67.98%
8	Possibility of an infrastructure-related incident	67.42%
9	To require more time for personal presentation after arrive to the destination	67.42%
10	Effort in the slopes	65.73%
11	To have noise contamination	60.67%
12	To get sunburnt	59.55%
13	Dificulty to carry things	57.30%
14	Possibility of an incident due to lack of expertice	56.18%
15	To have trips of more than 15 minutes	51.69%
16	To have not significative reduction of time	44.94%
17	Difficulty to find parking at the destination	41.57%
18	To have not pleasant experience	39.89%
19	Difficulty to use the bicycle with other people	32.02%
20	To have visual contamination	29.78%

(Tab. 12) Representativeness of variables for Female non-users
Source: Author

#	Variables Female users	"neither too much nor too little", "a lot" and "quite a bit" Representativeness
1	Fear of being robbed or the bicycle stolen	66.7%
2	Harrasment of female gender	66.7%
3	Rain and bad weather	66.7%
4	To arrive poorly presented to the destination and do not have a place to groom	66.7%
5	To have air pollution	57.1%
6	Dificulty to carry things	52.4%
7	To find obstructions in the way	52.4%
8	To require more time for personal presentation after arrive to the destination	52.4%
9	Effort in the slopes	42.9%
10	Lack of integration	42.9%
11	Possibility of an infrastructure-related incident	38.1%
12	To have noise contamination	38.1%
13	Difficulty to find parking at the destination	28.6%
14	To have not significative reduction of time	28.6%
15	Possibility of an incident due to lack of expertice	19.0%
16	To get sunburnt	19.0%
17	To have visual contamination	19.0%
18	To have trips of more than 15 minutes	14.3%
19	To have not pleasant experience	14.3%
20	Difficulty to use the bicycle with other people	9.5%

(Tab. 13) Representativeness of variables for Female users
Source: Author

#	Variables Male non-users	"neither too much nor too little", "a lot" and "quite a bit" Representativeness
1	Rain and bad weather	74%
2	Fear of being robbed or the bicycle stolen	71%
3	To arrive poorly presented to the destination and do not have a place to groom	68%
4	To require more time for personal presentation after arrive to the destination	64%
5	To have air pollution	63%
6	To find obstructions in the way	58%
7	Lack of integration	57%
8	Effort in the slopes	51%
9	Possibility of an infrastructure-related incident	51%
10	To have noise contamination	49%
11	To get sunburnt	48%
12	Difficulty to carry things	47%
13	To have trips of more than 15 minutes	46%
14	Difficulty to find parking at the destination	39%
15	To have not significative reduction of time	34%
16	Difficulty to use the bicycle with other people	24%
17	To have not pleasant experience	23%
18	To have visual contamination	20%
19	Possibility of an incident due to lack of expertise	18%

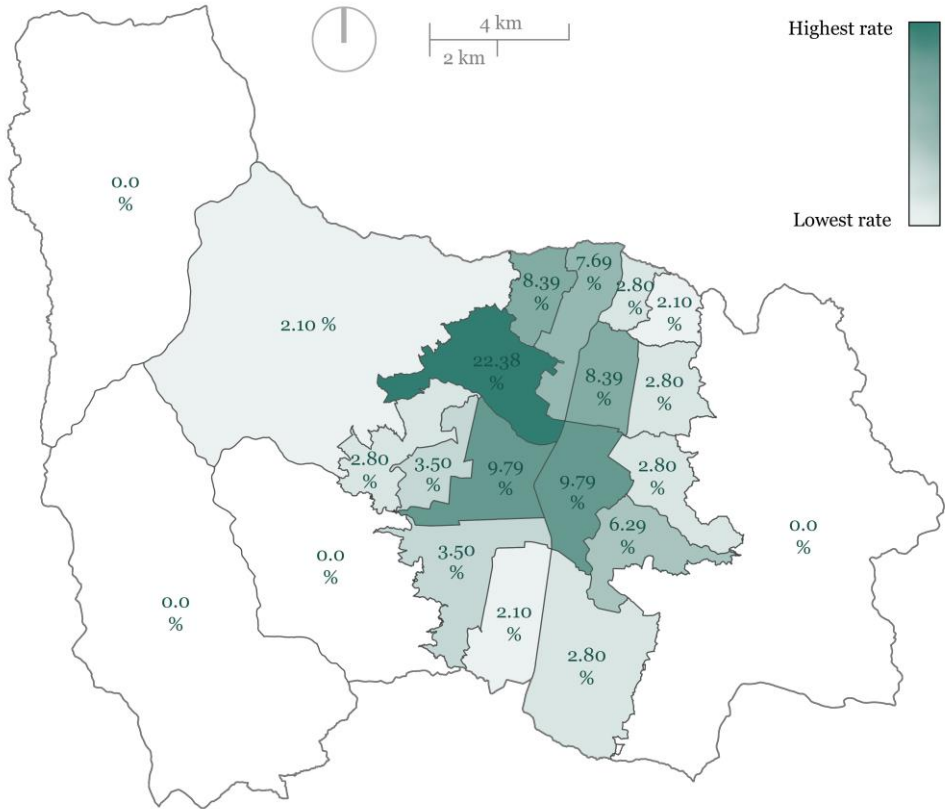
(Tab. 14) Representativeness of variables for Male non- users
Source: Author

#	Variables Male users	"neither too much nor too little", "a lot" and "quite a bit" Representativeness
1	Fear of being robbed or the bicycle stolen	68%
2	Rain and bad weather	60%
3	To find obstructions in the way	60%
4	To have air pollution	60%
5	To arrive poorly presented to the destination and do not have a place to groom	56%
6	To have noise contamination	52%
7	To require more time for personal presentation after arrive to the destination	48%
8	Effort in the slopes	44%
9	Difficulty to carry things	40%
10	Difficulty to find parking at the destination	40%
11	Lack of integration	40%
12	Possibility of an infrastructure-related incident	40%
13	To get sunburnt	32%
14	Difficulty to use the bicycle with other people	24%
15	To have not significant reduction of time	20%
16	To have visual contamination	16%
17	To have not pleasant experience	12%
18	Possibility of an incident due to lack of expertise	8%
19	To have trips of more than 15 minutes	8%

(Tab. 15) Representativeness of variables for Male users

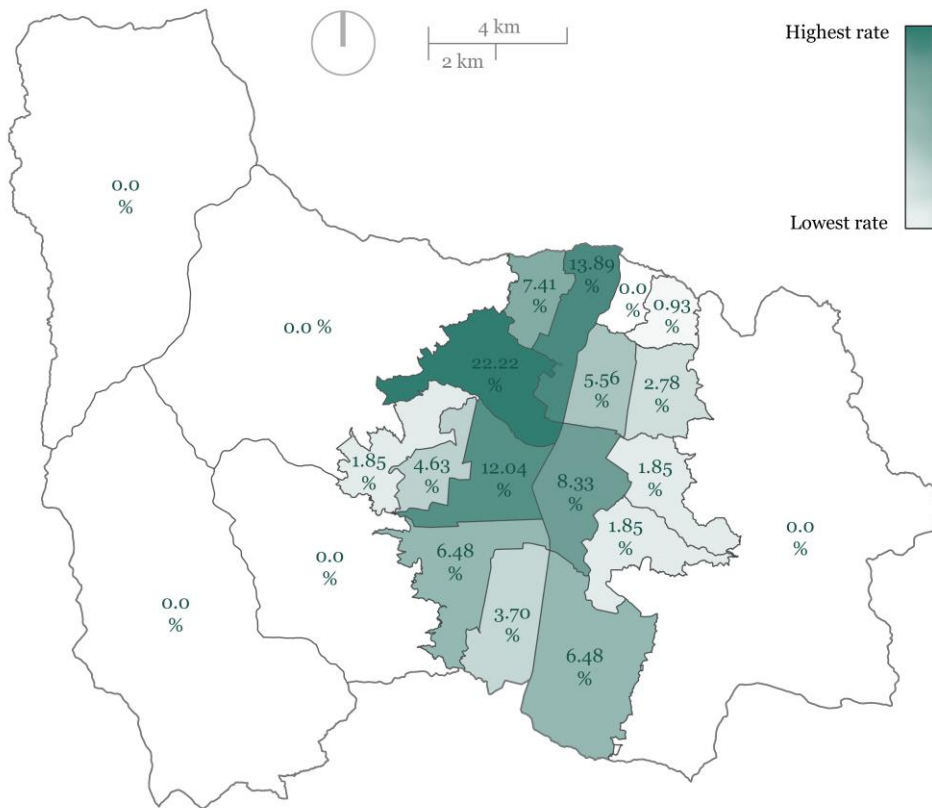
Source: Author

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Comuna	7 - Robledo	10 - La candelaria	11 - Laureles	4 - Aranjuez	6 - 12 de octubre
Users %	22.38%	9.79%	9.79%	8.39%	8.39%
Comuna	5 - Castilla	9 - Buenos Aires	12 - La America	16 - Belen	2 - Santa cruz
Users %	7.69%	6.29%	3.50%	3.50%	2.80%
Comuna	3 - Manrique	8 - Villa hermosa	13 - San Javier	14 - El Poblado	1 - Popular
Users %	2.80%	2.80%	2.80%	2.80%	2.10%
Comuna	15 - Guayabal	60 - San cristobal			
Users %	2.10%	2.10%			

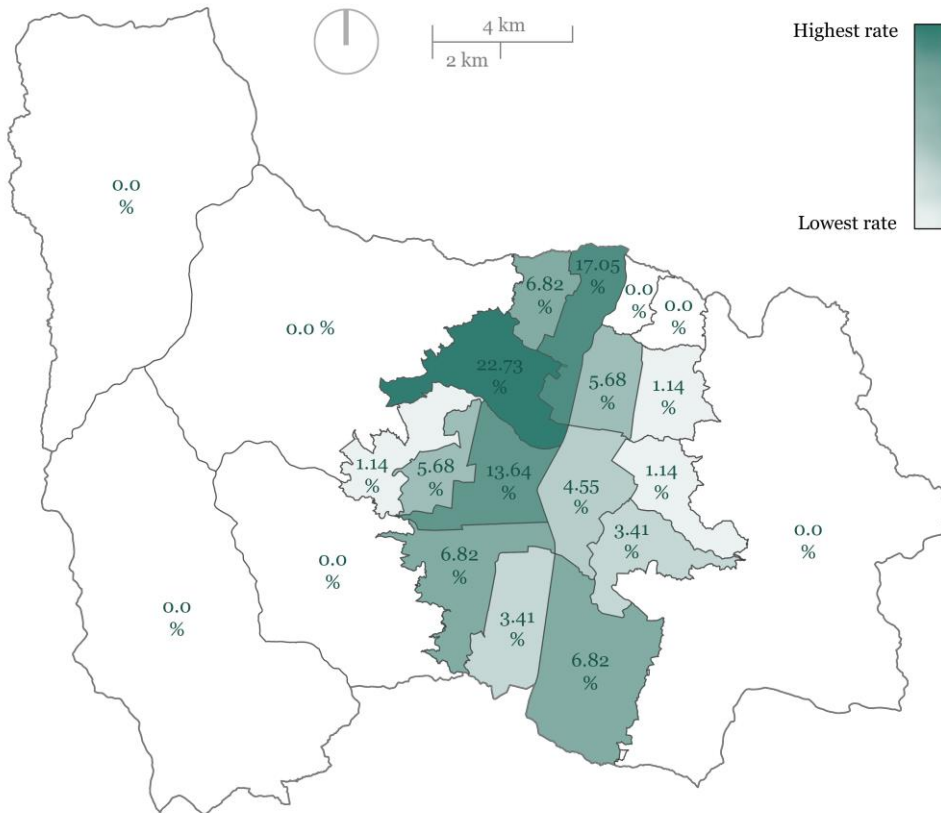
(Fig. 54) Map of representiveness for fear of being robbed for female non-users
Source: Author



Comuna	7 - Robledo	5 - Castilla	11 - Laureles	10 - La candelaria	6 - 12 de octubre
Users %	22.22%	13.89%	12.04%	8.33%	7.41%
Comuna	14 - El Poblado	16 - Belen	4 - Aranjuez	12 - La America	15 - Guayabal
Users %	6.48%	6.48%	5.56%	4.63%	3.70%
Comuna	3 - Manrique	8 - Villa hermosa	9 - Buenos Aires	13 - San Javier	1 - Popular
Users %	2.78%	1.85%	1.85%	1.85%	0.93%

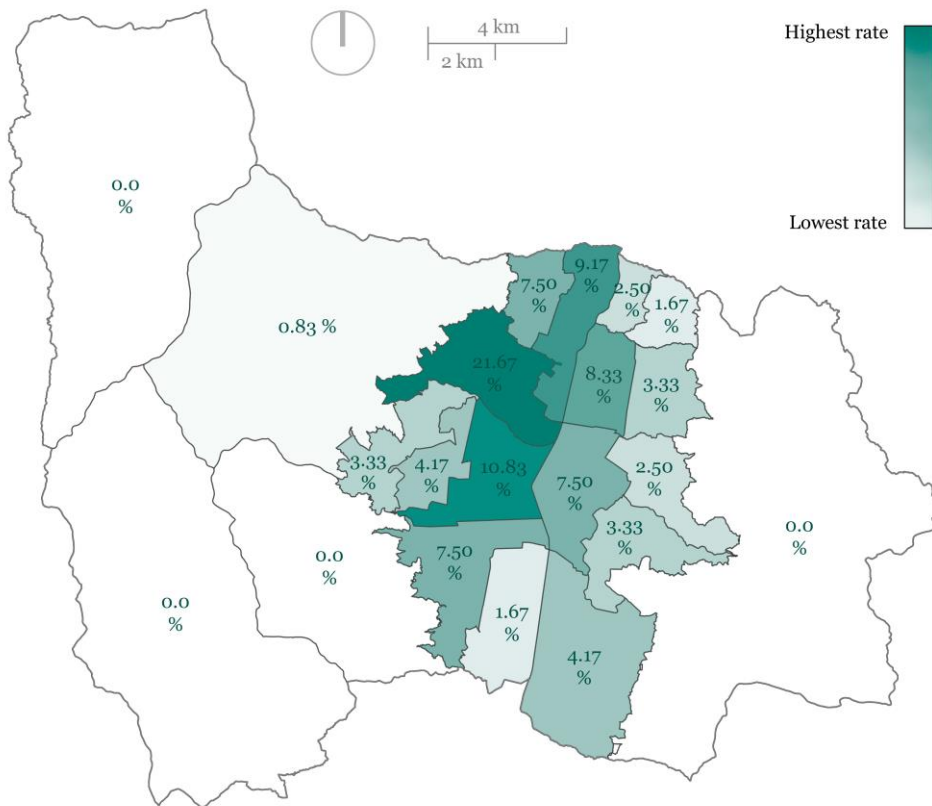
(Fig. 55) Map of representativeness of fear of being robbed for male non-users
Source: Author

Understanding the gap related to bicycle mobility in Medellin



Comuna	7 - Robledo	5 - Castilla	11 - Laureles	6 - 12 de octubre	14 - El Poblado
Users %	22.73%	17.05%	13.64%	6.82%	6.82%
Comuna	16 - Belen	4 - Aranjuez	12 - La America	10 - La candelaria	9 - Buenos Aires
Users %	6.82%	5.68%	5.68%	4.55%	3.41%
Comuna	15 - Guayabal	3 - Manrique	8 - Villa hermosa	13 - San Javier	1 - Popular
Users %	3.41%	1.14%	1.14%	1.14%	0.00%

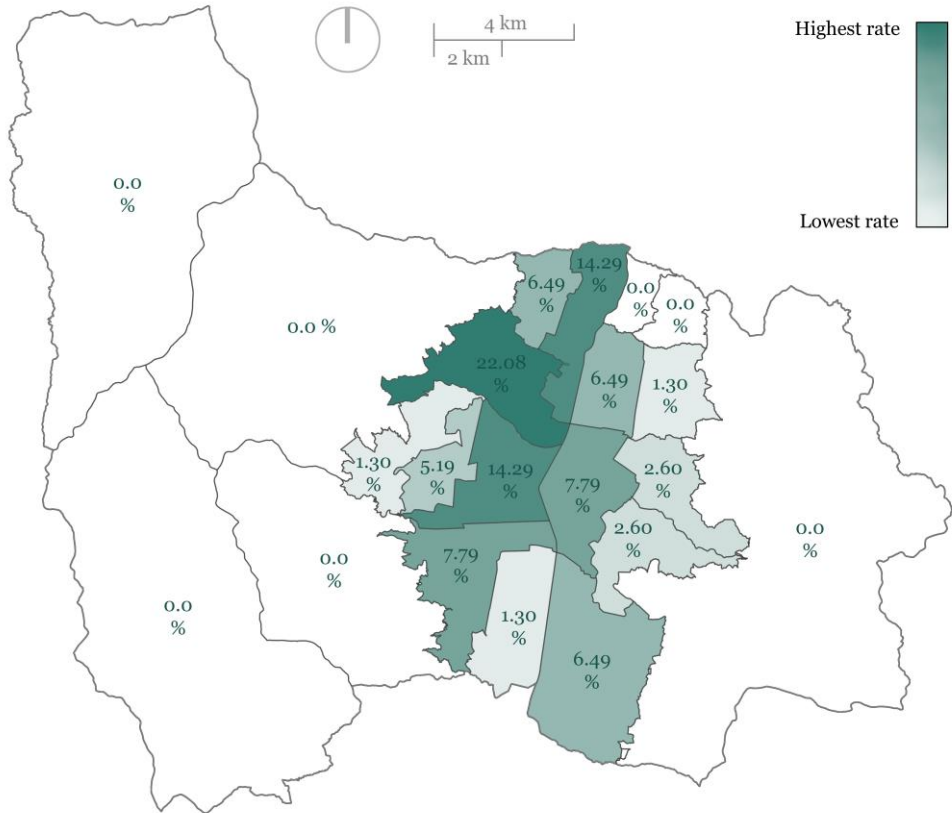
(Fig. 56) Map of representativeness about finding obstructions in the way of female non-users
Source: Author



Comuna	7 - Robledo	11 - Laureles	5 - Castilla	4 - Aranjuez	6 - 12 de octubre
Users %	21.67%	10.83%	9.17%	8.33%	7.50%
Comuna	10 - La candelaria	16 - Belen	12 - La America	14 - El Poblado	3 - Manrique
Users %	7.50%	7.50%	4.17%	4.17%	3.33%
Comuna	9 -Buenos Aires	13 - San Javier	2 - Santa cruz	8 - Villa hermos	1 - Popular
Users %	3.33%	3.33%	2.50%	2.50%	1.67%
Comuna	15 - Guayabal	60 - San cristobal			
Users %	1.67%	0.83%			

(Fig. 57) Map of representativeness about fear of an infrastructure related incident for female non-users
Source: Author

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Comuna	7 - Robledo	5 - Castilla	11 - Laureles	10 - La candelaria	16 - Belen
Users %	22.08%	14.29%	14.29%	7.79%	7.79%
Comuna	6 - 12 de octubre	4 - Aranjuez	14 - El Poblado	12 - La America	8 - Villa hermosa
Users %	6.49%	6.49%	6.49%	5.19%	2.60%
Comuna	9 -Buenos Aires	3 - Manrique	13 - San Javier	15 - Guayabal	1 - Popular
Users %	2.60%	1.30%	1.30%	1.30%	0.00%

(Fig. 58) Map of representativeness about fear of an infrastructure related incident for male non-users

8.2. further findings

- (General) Continuous exposure to the bicycle (if possible, from an early age) generates a better understanding of its dynamics, increasing the possibilities of routinely using this means of transport. The use reduces the importance of critical factors related to the choice of this means according to the comparison between users and non-users in the explored variables.

- (General) The bicycle alone is not a comprehensive mobility solution for the city. It requires innovative social, technological, and infrastructure strategies to encourage its use, especially in the Border and Rural planning categories.

- (General) The points mentioned by Ministerio de Transporte de Colombia et al. (2022) in section 3.9 must become a strict premise to reduce the bicycle mobility gap in Medellín.

- (General) The bicycle in the city of Medellín should be shown as a fast, practical, healthy, economical, and environmentally friendly vehicle in that order (for all citizens), and this argument should be supported by planning. Avoiding extra routes for cyclists and prioritizing them at intersections over motorized means should be a priority. The opposite phenomenon cannot continue to be a political strategy to avoid the reality of the mobility network.

- (General) (Psychological) To reduce the impacts of psychological factors, Real benefits should be offered in companies and institutions. According to Heinen et al. (2010), the possibility of having trips in company should be reinforced based on Cámara de Comercio de Bogotá et al. (2010), cycling activity should be normalized (Handy et al. 2014), and all actions should mainly be aimed at generating new habits in the population for the creation of new perceptions and routines.

- (Non-users) (Psychological) The lack of expertise mainly influences female non-users, and efforts should be done to address their learning needs to encourage their use. An excellent alternative is to involve the bicycle in the

learning process in schools and kinder gardens, generating an approach to the means, especially from early childhood. This approach must be oriented to the bicycle as a means of transportation and not as recreative activity.

- (General) (Psychological) It is required to show the use of bicycles as a mode of transport more than a recreative vehicle and as a pleasant activity, emphasizing that users tend to enjoy the activity even more than expected according to the results.
- (General) (Environmental) Grey infrastructure does not work alone. Creating permanent contact with blue and green infrastructure in bicycle lines and streets is fundamental, as mentioned by Cervero et al. (2019). The existing network of bike lines shown in (Tab. 1) must be evaluated concerning the presence of these infrastructures to increase the connection as much as possible and attract more users.
- (General) (Environmental) Although the results suggest that sun exposure is not essential for everybody, the relationship between sun exposure and sweat is strong and indicates the variable's representativeness. This is part of the analysis and conclusions for the variable "Limitation or concern about arriving poorly presented to the destination and not having a place to groom".
- (General) (Environmental) User must not be exposed to the sun radiation for an extended period, and the infrastructure must have enough shade to certify the less possible exposure to the sun and the minimum of pauses to ensure minimum waiting periods under the sun; this variable is directly related to the "limitation or concern about to require more time for personal presentation after arrival to the destination" also.
- (General) (Environmental) In the case of female non-user, Sun exposure has a high impact on the decision to use bicycles; female users do not pay much attention to this variable, and bicycle promotion should be oriented to show the reality of this variable, future studies must be developed to understand the

dynamic entirely. There is no clear trend among the male population regarding this variable.

- (General) (Environmental) Visual contamination has no apparent impact on the decisions made by the users and non-users. The perception is also not changing drastically among genders.
- (General) (Built environment) The five criteria mentioned by Cámara de Comercio de Bogotá et al. (2010) must be a premise for developing grey infrastructure
- (General) (Built environment) Design and distance are the "Ds" examined in this research based on Cervero et al. (2009) in the built environment. These are density, diversity, Design, distance (to transit), and accessibility at the destination, and these components would be the basis for the findings related to the built environment in the Colombian context due to the similarities with the capital city.
- (General) (Built environment) People would use more the bicycle if they had proper bicycle paths for transport (Handy et al. 2014) and (Fernández-Heredia et al. 2016), and if the network was easy to reach and well connected as Heinen et al. (2010) mentioned. If more bicycle paths are adequately built (according the conclusions of this research), the bicycle share could increase, but the variable would not have ever the tendency to increase, according to Cervero et al. (2019)
- (General) (Built environment) Female and male users and non-users do not evidence limitation or concern about using the bicycle with others.
- (General) (Built environment) representativeness of the perceived difficulty in carrying things shows no limitation or concern. The primary interventions in the network must be focused on other variables.

- (General) (Built environment) Comfortable parking standards should be provided to users, but, the difficulty in finding parking tendencies shows "not at all" as the preferred option. The National University of Colombia at Medellín has comfortable parking areas and private guarding inside the campuses, which may explain the respondents' tendency not to give much importance to this variable. This behavior confirms the tendency described by Heinen et al. (2010). Finally, corridors with a mix of land uses and commercial activities should be prioritized for parking based on Cervero et al. (2019). According to Fernández-Heredia et al. (2016) this is the most essential infrastructure element.
- (General) (Built environment) Having integration with other means is significant for non-users. If the integration is increased, it incents cycling among non-users. So, efforts should be directed at providing greater modal integration possibilities to non-users. However, early education aimed at promoting cycling as a means of transport is a fundamental element more important than integration.
- (Non-users) (Cost, time and effort) Regarding the slope of the terrain, it has a particular impact on the decision to use the bicycle by non-users, a targeted approach to them (especially the female gender) and strategies to reduce the impact of this factor are necessary. The strategies can be directed to the infrastructure and the implementation of programs of modal integration to go to the hills when needed.
- (General) (Cost, time, and effort) About the Limitation or concern about the perception of not having a significant reduction of time using the bicycle, there should be much greater visibility of the advantages related to the time of using the bicycle than current users see, and show the point of view of the users. Although non-users already visualize these advantages, it is important to reinforce this component to make it more robust and compelling. Furthermore, do not assign privileges to motorized mobility, such as reduced time in traffic

lights taking the time that corresponds to the bicycle and the pedestrians to benefit motorized mobility or the creation of detours to do faster trips, among others. The gap will not be reduced if accurate and adequate strategies are not implemented.

- (General) (Cost, time, and effort) Showing people how the cyclist can circulate safely and quickly when other vehicles are stopped in traffic in the city of Medellín can be a good strategy, as mentioned by Despacio (2014); however, the presence of motorcycles cannot be forgotten, i.e., the infrastructure must be adequate for bicycle circulation and must limit the possibility of motorcycle access. Creating independent infrastructures and to defining strategies to make the trip uncomfortable for motorcycles in bicycle-dedicated infrastructure is mandatory to achieve success with the strategy
- (General) When contrasting the results of this research with the results of the (Tab. 2) Most Adverse factors related to bicycle use in Bogotá, it is possible to identify that there are similar factors that predominate within the options chosen by the participants of both surveys (Fear of being robbed or the bicycle stolen, Rain and bad weather, to have air pollution and to find obstructions in the way), This is evidence of factors that can be analyzed nationally among those that most impact the bicycle dynamics. Nationally there must be strategies to counteract the harmful effects of these factors. Cities cannot work alone against the impacts of these factors, and the gap must be counteracted nationally, inclusive when Bogotá has a rate of use much higher than Medellín.
- (General) The database obtained in this study is a solid tool to conduct more research related to qualitative and quantitative information for the National University of Colombia at Medellín, The city, or even the country for some variables.

8.3. Further studies

- Studies for ethnic minorities in order to understand their bicycle mobility dynamics and the situation of other genders must be done.

- Needs of people with reduced mobility, children and other gender identities should be explored to determine an appropriate user profile that allows the generation of inclusive infrastructure and concepts adapted to their realities.

- The behavior of each of the variables highlighted should be studied in depth to obtain much more technicality regarding their behavior.

- More specific analyses could be developed for the population of the Universidad Nacional de Colombia Medellín and its mobility situation according to internal planning instruments.

- Behavior of the studied variables should be monitored when implementing improvement alternatives, as this will determine the effectiveness of the measures.

- Diversity, density, and active modes-oriented design evaluation in the entire city of Medellín must be one of the following studies to conduct in regards to encouraging active mobility and reducing movements according to the point of view of Cervero and Kockelman (1997).

9. Chapter VIII – Bibliography

- Alcaldía De Medellín (2014) 48th Agreement of 2014 - Land Management Plan, Gazeta Oficial.
- Alcaldía de Medellín (2016) Plan de Desarrollo Medellín 2016-2019, Gazeta oficial Concejo de Medellín, available: https://www.medellin.gov.co/irj/go/km/docs/pccdesign/SubportaldelCiudadano_2/PlandeDesarrollo_o_17/Publicaciones/SharedContent/Documentos/2016/Proyecto de Acuerdo Plan de Desarrollo.pdf.
- Alcaldía De Medellín (2018) ‘Bicycle parking places’.
- Alcaldía de Medellín (2018) Proyección Año a Año, Hasta 2030 de Medellín Por Comunas.
- Alcaldía de Medellín (2022a) ‘Answer 202330051331’.
- Alcaldía de Medellín (2022b) Incidentes Viales En Bicicleta, Medellín.
- Alcaldía de Medellín (2023a) ‘built bike lanes’.
- Alcaldía de Medellín (2023b) ‘Non integrated bus routes information’.
- Alcaldía de Medellín, South Korean Government - Ministry of Economy and Finance, Swiss Embassy in Colombia, International Finance Corporation, Institute for Transportation and Development Policy, Universidad Eafit, and Despacio (2022) Infraestructura Para La Movilidad Activa y Género - Guía Metodológica, ‘Medellín: Alcaldía de Medel.
- Alcaldía Mayor de Bogotá (2014) ‘El libro de la Bici’, Alcaldía Mayor de Bogotá, available: http://www.culturarecreacionydeporte.gov.co/sites/default/files/el_libro_de_la_bici_bogota_2014.pdf.
- Alvarez Orrego, A.M. (2021) Análisis Comparativo de Las Percepciones y Las Actitudes de Las Mujeres de Medellín Frente a Los Diferentes Modos de Transporte: Un Estudio Para Promover La Bicicleta Como Medio de Transporte., Universidad EAFIT, available: <https://repository.eafit.edu.co/handle/10784/27221>.
- Anaya, E.D.N.A. (2017) Description and Classification of Active Mobility Measures Including Factors Affecting Their Effectiveness: Literature Review and Assessment of State-of-the-Art of Active Mobility, available:

- <https://www.researchgate.net/publication/360066374>.
- Área Metropolitana del Valle de Aburrá (2012) Encuesta Origen Destino de Hogares Para El Valle de Aburrá, Gobernacion de Antioquia, available: <http://www.bdigital.unal.edu.co/13787/1/1408-6745-1-PB.pdf>.
 - Área Metropolitana del Valle de Aburrá (2018) Encuesta de Movilidad Origen-Destino 2017, available: <https://www.metropol.gov.co/observatorio/Paginas/encuestaorigendestino.aspx>.
 - Área Metropolitana del Valle de Aburrá (2022a) Integrated Transportatino System of the Aburra Valley [online], available: <https://www.metropol.gov.co/movilidad/Paginas/transporte-publico/sitva.aspx> [accessed 11 Nov 2022].
 - Área Metropolitana del Valle de Aburrá (2022b) ‘Estaciones En cicla’, available: <https://datosabiertos.metropol.gov.co/dataset/estaciones-encicla-18072022>.
 - Bike Anjo, União de Ciclistas do Brasil, and Transporte Ativo (2016) Incluyendo A Bicicleta Nos Planos.
 - Burge, S. (2015) System Thinking: Approaches and Methodologies An Overview of the Soft Systems Methodology.
 - Cámara de Comercio de Bogotá (2009) Movilidad En Bicicleta En Bogotá, Bogotá.
 - Cámara de Comercio de Bogotá and Despacio (2014) Integración de Transporte No Motorizado y DOTS, Bogotá.
 - Cámara de Comercio de Bogotá, Deutsche Gesellschaft für Internationale Zusammenarbeiit, and Cycling Expertise (2010) Manual de Políticas Amables Con La Bicicleta, Bogotá.
 - Castillo, A.D. del, González, S.A., Ríos, A.P., García, J., Bastidas, A., Lemoine, P., Alvarado, A., Pardo, C., Triana, C.A., and Sarmiento, O.L. (2016) ‘¿Nos Movemos Hacia Ciudades Más Saludables?’, available: <http://www.despacio.org/portfolio/transporte-activo-en-bogota-y-colombia/>.
 - Cervero, R., Denman, S., and Jin, Y. (2019) ‘Network design, built and natural environments, and bicycle commuting: Evidence from British cities and towns’, *Transport Policy*, 74(July 2018), 153–164, available: <https://doi.org/10.1016/j.tranpol.2018.09.007>.

- Cervero, R. and Kockelman, K. (1997) ‘Travel demand and the 3Ds: Density, diversity, and design’, *Transportation Research Part D: Transport and Environment*, 2(3), 199–219, available: [https://doi.org/10.1016/S1361-9209\(97\)00009-6](https://doi.org/10.1016/S1361-9209(97)00009-6).
- Cervero, R., Sarmiento, O.L., Jacoby, E., Gomez, L.F., and Neiman, A. (2009) ‘Influences of built environments on walking and cycling: Lessons from Bogotá’, *International Journal of Sustainable Transportation*, 3(4), 203–226, available: <https://doi.org/10.1080/15568310802178314>.
- Darbéra, R. (1982) *Una Metodología Para La Planificación Del Transporte Urbano*.
- Despacio (2014) *Bicycle Account*, Bogotá.
- Elsevier Language Editing Service (2023) *Clinical Questions: PICO and PEO Research | Author Services Blog* [online], available: <https://scientific-publishing.webshop.elsevier.com/research-process/clinical-questions-pico-and-peo-research/> [accessed 14 Jan 2023].
- Embajada del Ecuador en los Países Bajos (2013) *El Uso Masivo de La Bicicleta Para El Buen Vivir*, available: <http://www.embassyecuador.eu/site/images/descargas/uso-masivo-bicicleta-buen-vivir.pdf>.
- Federal Ministry for Digital and Transport (2020) *Mobility in Germany* [online], available: <https://www.bmvi.de/EN/Services/Statistics/Mobility-in-Germany/mobility-in-germany.html> [accessed 20 Jun 2022].
- Fernández-Heredia, Á., Jara-Díaz, S., and Monzón, A. (2016) ‘Modelling bicycle use intention: the role of perceptions’, *Transportation*, 43(1), 1–23, available: <https://doi.org/10.1007/s11116-014-9559-9>.
- Gärling, T. and Axhausen, K.W. (2003) ‘Habitual travel choice’, *Transportation*, 30, 1–11, available: <https://doi.org/DOI:10.1023/A:1021230223001>.
- Handy, S., van Wee, B., and Kroesen, M. (2014) ‘Promoting Cycling for Transport: Research Needs and Challenges’, *Transport Reviews*, 34(1), 4–24, available: <https://doi.org/10.1080/01441647.2013.860204>.
- Handy, S.L., Boarnet, M.G., Ewing, R., and Killingsworth, R.E. (2002) ‘How the built environment affects physical activity: Views from urban planning’,

- American Journal of Preventive Medicine, 23(2 SUPPL. 1), 64–73, available: [https://doi.org/10.1016/S0749-3797\(02\)00475-0](https://doi.org/10.1016/S0749-3797(02)00475-0).
- Hans Koster, V.M.N.F.O.J. van O. (2022) Cars Make Cities Less Compact | CEPR [online], available: <https://cepr.org/voxeu/columns/cars-make-cities-less-compact> [accessed 12 Aug 2022].
 - Heinen, E., van Wee, B., and Maat, K. (2010) ‘Commuting by bicycle: An overview of the literature’, *Transport Reviews*, 30(1), 59–96, available: <https://doi.org/10.1080/01441640903187001>.
 - Hurtado de Barrera, J. (2000) ‘Metodología De Investigación Holística’, Fundación Sypal, available: <https://ayudacontextos.files.wordpress.com/2018/04/jacqueline-hurtado-de-barrera-metodologia-de-investigacion-holistica.pdf>.
 - Institute for Transportation and Development Policy (2011) *Manual Integral de Movilidad Ciclista Para Ciudades Mexicanas*, Manual integral de movilidad ciclista para ciudades mexicanas, Ciudad de México.
 - Interamerican Development Bank (2017) *Mujeres y Ciclismo Urbano - Promoviendo Políticas Inclusivas de Movilidad En America Latina*.
 - Interamerican Development Bank, Despacio, and Bicivilízate (2015) *Ciclo-Inclusión En America Latina y El Caribe - Guía Para Impulsar El Uso de La Bicicleta*.
 - Interamerican Development Bank and Gehl Studio (2016) *¡ A Todo Pedal !*, available: <https://publications.iadb.org/handle/11319/7530>.
 - Interamerican Development Bank, Institute for Transportation and Development Policy, and Universidad de los Andes (2017) *Aprender de Los Países Vecinos - Experiencias de Ciudades de América Latina En La Promoción de La Bicicleta Como Modo de Transporte Cotidiano*.
 - Krizek, K.J., Handy, S.L., and Forsyth, A. (2009) ‘Explaining changes in walking and bicycling behavior: Challenges for transportation research’, *Environment and Planning B: Planning and Design*, 36(4), 725–740, available: <https://doi.org/10.1068/b34023>.
 - Kyte, R. (2013) *City Transport: It’s About Moving People, Not Vehicles* [online], January 10th, available: <https://blogs.worldbank.org/voices/city-transit-it-s-about-moving-people-not-vehicles> [accessed 12 Aug 2022].

- Lucas, K. (2013) Qualitative Methods in Transport Research: The ‘action Research’ Approach [online], available: <http://eprints.whiterose.ac.uk/79256/>.
- McNally, M.G. (2000) Handbook of Transport Modelling [online], Handbook of Transport Modeling, Amsterdam; Oxford: Pergamon, available: <http://www.escholarship.org/uc/item/or75311t> [accessed 12 Aug 2022].
- Medellín cómo vamos (2019) Medellín Cómo Vamos [online], available: <https://www.medellincomovamos.org/medellin> [accessed 5 Jan 2023].
- Medellín cómo vamos (2020) Informe de Calidad de Vida 2020 - Pobreza y Equidad, Medellín.
- Mejia Jimenez, J. (2023) Análisis Del Capital En La Smart City, Una Mirada Desde Los Recursos y Las Capacidades, available: https://www.researchgate.net/publication/369920346_ANALISIS_DEL_CAPITAL_EN_LA_SMART_CITY_UNA_MIRADA_DESDE_LOS_RECURSOS_Y_LAS_CAPACIDADES_TESIS_DOCTORADO.
- Minciencias (2016) Colombia, El Segundo País Más Biodiverso Del Mundo [online], November, available: https://minciencias.gov.co/sala_de_prensa/colombia-el-segundo-pais-mas-biodiverso-del-mundo [accessed 10 Nov 2022].
- Mincultura (2022) Política de Diversidad Cultural, available: <https://www.mincultura.gov.co/ministerio/politicas-culturales/de-diversidad-cultural/Paginas/default.aspx> [accessed 10 Nov 2022].
- Ministerio de Transporte de Colombia, Agencia Nacional de Seguridad Vial, Internationale, Deutsche Gesellschaft für Zusammenarbeit - GIZ, G., and Universidad Eafit (2022) Estrategia Nacional de Movilidad [online], Bogotá, available: www.minambiente.gov.co.
- Mosquera, M. (2016) ‘El transporte en bicicleta: consolidando inequidades en las calles de Cali, Colombia’, *Sociedad y Economía*, 31, 110.
- Municipio de Santiago de Cali and Universidad del Valle (2019) Encuesta de Percepción de La Calidad de La Infraestructura Para La Movilidad En Los Subsistemas de Transporte Peatón y Bicicleta En Santiago de Cali Entre El Municipio de Santiago de Cali, Contrato Interadministrativo No. 4132.010.26.1.631 suscrito entre el Municipio de Santiago de Cali –

Departamento Administrativo de Planeación Municipal y la Universidad del Valle.

- Observatorio de Políticas Públicas del Concejo de Medellín, Universidad Eafit, and Universidad de Medellín (2017) *Calidad Del Aire En Medellín y El Area Metropolitana, Un Enfoque de Política Pública*.
- Ospina, J.P., Botero-Fernández, V., Duque, J.C., Brussel, M., and Grigolon, A. (2020) ‘Understanding cycling travel distance: The case of Medellín city (Colombia)’, *Transportation Research Part D: Transport and Environment*, 86(June), 102423, available: <https://doi.org/10.1016/j.trd.2020.102423>.
- Oxford University Press (1989) *Oxford Web Dictionary, Second Edition* [online], available: <https://www.oxfordlearnersdictionaries.com/definition/english/dictionary> [accessed 7 Jan 2023].
- Portafolio (2022) ‘Pobreza en Colombia creció y es superior a la media en América Latina’, November, Nov, available: <https://www.portafolio.co/economia/finanzas/pobreza-en-colombia-crecio-y-es-superior-a-la-media-en-america-latina-cepal-caf-y-ocde-573718>.
- Poveda, G. (2004) ‘La Hidroclimatología de Colombia: Una síntesis desde la escala interdecadal hasta la escala diurna (Colombia’s hydroclimatology: A synthesis from interdecadal to diurnal timescales).’, *Ciencias de la Tierra*, (June), 22.
- Real Academia de la lengua Española (2022a) *Real Academia Española* [online], available: <https://www.rae.es/> [accessed 7 Jan 2023].
- Real Academia de la lengua Española (2022b) *Brecha - Definición* [online], available: <https://dle.rae.es/brecha?m=form> [accessed 7 Jan 2023].
- Redman, L., Friman, M., Gärling, T., and Hartig, T. (2013) ‘Quality attributes of public transport that attract car users: A research review’, *Transport Policy*, 25, 119–127, available: <https://doi.org/10.1016/j.tranpol.2012.11.005>.
- Sampieri, R. (2014) *Metodología de La Investigación*.
- Scheaffer, R. and Mendenhall, W. (2007) ‘Elementos de Muestreo’, available: https://books.google.com/books/about/Elementos_de_muestreo.html?hl=es&id=05OwlT7hceoC [accessed 21 Jul 2023].
- Secretaria Seccional de Salud y Protección Social de Antioquia (2022) *Analisis*

de La Situación de Salud - Actualizacion 2021.

- De Sousa, A.A., Sanches, S.P., and Ferreira, M.A.G. (2014) ‘Perception of Barriers for the Use of Bicycles’, *Procedia - Social and Behavioral Sciences*, 160, 304–313, available: <https://doi.org/10.1016/j.sbspro.2014.12.142>.
- Walker, J. (2011) ‘Beyond rationality in travel demand models’, *ACCESS Magazine*, 39, 8–15.
- Walta, L. (2018) ‘On the methodologies and transferability of bicycle research: A perspective from outside academia’, *Journal of Transport and Land Use*, 11(1), 811–814, available: <https://doi.org/10.5198/jtlu.2018.1458>.
- Weather Spark (2023) Medellín Climate, Weather By Month, Average Temperature (Colombia) [online], available: <https://weatherspark.com/y/22535/Average-Weather-in-Medellín-Colombia-Year-Round> [accessed 16 Apr 2023].

10. Appendices



Appendices and databases can be found in the next link or the Qr code:

<https://tinyurl.com/ThesisMScLuisSanchez>

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خلاصة

التنقل بالسيارات الخاصة جذاب في مقارنة مع وسائل أخرى؛ إلا أن مستويات استخدام السيارات الحالية لا تسمح بتحقيق مستويات مستدامة من الاقتصاد ورفاهية المجتمع ومرونة البيئة التي تعطي الأولوية للتنقل النشط ووسائل النقل العام، وفقاً لريدمان وآخرين (2013). كما ينبع آخر نوع من الظواهر التي تثبط استخدام وسائل التنقل النشطة والعام من ظروف معينة (سيرفيرو وكوكلمان 1997؛ هاينين وآخرون 2010؛ دي سوزا وآخرون 2014؛ فيرنانديز-هيرديا وآخرون 2016).

بالنسبة لمعظم الناس، تُحَفِّز الظاهرة المذكورة أعلاه هجرة وسائل التنقل بناءً على السرعة والأمان والراحة والتكلفة، ما يُعرَّف باسم "تفاضل" (واكر 2011). وقد أدى ذلك إلى ظهور فجوة كبيرة بين معدل استخدام الدراجات ووسائل التنقل الأخرى، في هذه الحالة بالنسبة لميديين، وفقاً للأرقام التي قدمتها منطقة متروبوليتانا ديل (2018) فاي دي أبورا.

كاستراتيجية لمواجهة الآثار السلبية لهذه الظاهرة، تركز هذه الدراسة على تفضيلات الأشخاص والقيود أو المخاوف المتعلقة بالمتغيرات التي تؤثر في استخدام الدراجات يومياً، وذلك من أجل توضيح ملامح المستخدمين وغير المستخدمين لهذه الوسيلة، واقتراح تدخلات محددة والمساهمة في زيادة الاستخدام الروتيني وتحسين المنظر الحالي، وتركز خصوصاً على عينة من جامعة كولومبيا الوطنية في ميديين كحالة دراسية للمدينة. تتبع هذه الدراسة منهجية كمية بمنهج جنساني حيث تختلف الشروط المطلوبة لاستخدام الدراجات بين المواطنين والمواطنات.

تشمل الدراسة مراجعة للأدب المتعلق بسياق المدينة؛ واستعراضاً للأدب المتعلق بالمتغيرات التي تؤثر في استخدام الدراجات في السياق العالمي والقاري والوطني والمحلي؛ واستكشافاً ميدانياً تم بتصميم استبيانات للمسح في المنطقة؛ وتحليل للنتائج؛ واستنتاجات استناداً إلى النتائج وتحليل الإطار النظري.

السيارة لاستخدام الحالية المستويات تسمح لاء الأخرى بالأوضاع مقارنة جاذبية الآلية المركبات رحلات تعتبر والنقل النشط للأولوية تعطي البيئة والمرونة الاجتماعية والرفاهية الاقتصاد من مستدامة بمستويات ظروف من والعام للنشطة الأنماط استخدام على تشجع لا التي الظواهر من آخر نوع يأتي العام

والراحة والأمان السرعة على بناء الرسائل هجرة إلى أعلاه المذكورة الظاهرة تؤدي، الناس لمعظم بالنسبة في، الأخرى والوسائل الدراجات استخدام معدل بين كبيرة فجوة أوجد لقد المقايضة باسم والمعروفة، والتكلفة أظهرتها التي للأصفر وفقاً لميديين بالنسبة الحالة هذه

القلق أو القيود الأشخاص تفضيلات على البحث هذا يركز، الظاهرة لهذه السلبية الآثار لمواجهة كاستراتيجية وغير المستخدمين تعريف ملفات بتوضيح يتعلق فيما للدراجة اليومي الاستخدام على تؤثر التي المتغيرات بشأن البانوراما وتحسين الروتيني الاستخدام نمو في والمساهمة محددة تدخلات لاقتراح، الوسائل لهذه المستخدمين هذا يتبع كمدينة للدراسة عينة من ميديين في الوطنية كولومبيا جامعة على خاص بشكل التركيز مع، الحالية من المواطنين تختلف الدراجات لاستخدام المطلوبة الشروط لأن بيولوجي جنساني نهج مع كمية منهجية البحث والذكور الإناث

الدراجات استخدام على تؤثر التي للمتغيرات الأدبيات مراجعة؛ المدينة لسياق بيليوغرافية مراجعة البحث يتضمن الإقليم في المسح منهجيات باستخدام الميداني الاستكشاف إجراء؛ والمدينة والقطرية والقارية العالمية السياقات في النظري الإطار وتحليل النتائج إلى تستند استنتاجات؛ النتائج تحليل؛

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام. إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة 2023

هذا ويقر الباحث أن العمل المقدم هو خالصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كل في مكانه في مختلف أجزاء الرسالة..

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث لويس ألبيرتو سانتشيز مونيوز

التاريخ: 24.07.2023

فهم الفجوة المتعلقة بالتنقل بالدراجة في ميدلين ،التفاوت الكبير بين معدل استخدام الدراجات والوسائل الأخرى بناءً على حالة جامعة كولومبيا الوطنية في ميدلين

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

أعداد: لويس ألبيرتو سانثيز مونيوز

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جامعة شتوتغارت-شتوتغارت أستاذ التخطيط العمراني

جامعة عين شمس

لجنة الحكم أ.د.
الممتحن الخارجي

أستاذ.....
جامعة.....

أ.د.....
أستاذ.....
جامعة.....

أ.د.....
أستاذ.....
جامعة.....

التوقيع

تاريخ المناقشة:.....

الدراسات العليا

ختم الإجازة

موافقة مجلس الكلية .../.../...

أجيزت الرسالة بتاريخ:.....
موافقة مجلس الجامعة .../.../...

جامعة عين شمس



جامعة شتوتغارت



07/20/2023



فهم الفجوة المتعلقة بالتنقل بالدراجة في ميديلين

التفاوت الكبير بين معدل استخدام الدراجات والوسائل الأخرى، بناءً على
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رسالة مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

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