TO CYCLE OR NOT TO CYCLE? FACTORS INFLUENCING THE DECISION TO USE THE BICYCLE AS ACCESS MODE TO PUBLIC TRANSPORT

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ABSTRACT

The role of the bicycle as a feeder mode to public transport (PT) is often neglected by researchers, transport planners and policy makers. In Brazil, previous surveys show that the share of multimodal trips in Rio de Janeiro is quite high. Better understanding the main combinations of modes in the public transport trip chain is relevant when referring to PT trips, because all PT trips require an access trip. The modal share of PT and Non-Motorized Transport (NMT) in Rio de Janeiro indicates a high share of both modes. In this context a better insertion of the bicycle in integration with PT may increase the competitiveness of these sustainable modes, which may lead to a higher quality transport system. This paper presents the preliminary results of a survey conducted with 722 Public Transport users to investigate the main factors influencing the potential for bicycling to PT in two different areas of Rio de Janeiro, Brazil. It is hypothesized that socioeconomic, transport and location factors may influence this potential. By analyzing the frequencies of access mode attributes, barriers and opportunities for bicycling, target groups are defined and the factors affecting each group are presented. Finally, recommendations are suggested in order to reveal the potential for bicycle in the case study areas.

Keywords: bicycle potential, access mode, integration, public transport, mode choice

INTRODUCTION

The use of bicycle when properly integrated to public transport systems can increase greatly its benefits, since it results in better level of accessibility to PT and consequently it improves overall level of accessibility, facilitating access to a wide range of opportunities all over the city.

When the bicycle replaces the car in access trips, it reduces energy use, air and noise pollution, it can lower congestion levels and it diminished the need of car parking spaces. In addition, the bicycle is faster than walk and it is cheaper and more flexible than public transport options, which have fixed timetables and routes.

Despite all its benefits, not much attention has been paid to the bicycle as feeder mode to PT. There is still a lack of knowledge regarding the characteristics of bicycle and PT integration, what factors affect this integration, as in most countries the data are collected on the main mode rather than in the whole transport chain, including the access trip. As a consequence, bicycle is not considered separately (Martens, 2004). Furthermore, studies which focus on the consequences of the implementation of measures to promote bicycle in integration with PT are also scarce (Martens, 2007).

When access and egress trips to the station are disregarded, the role of certain modes of transport, such as bicycle and walking is underestimated (Rietveld, 2000). In general, non-motorized modes have not received much attention in transportation research (Rietveld, 2000a).

In order to fill this gap, and address the access leg of the transport chain, with special attention to the potential for the use of bicycle in this trip, the paper aims to look at the factors which influence the potential use of bicycle in integration with PT.

BACKGROUND

Multimodal trips can capitalize the strengths and avoid the weaknesses of each separate mode (van Nes, 2002). In addition, it gives opportunities for segments of travellers that do not have a unimodal alternative, for instance the car, achieving a more equity transport alternative. In the context of developing countries, more than being an alternative for individual private transports as in developed countries, a high quality public transport service improves low income people quality of life, as usually this stratum does not have an alternative otherwise.

However, some authors emphasize the importance of consider the transport system and multimodal trips as whole rather than as disaggregated parts (Keijer and Rietveld, 2000; Givoni and Rietveld, 2007).

In order to be competitive and to provide good transport service quality, all the individual components of transport chain have to be highly and consistently integrated. This means that interchange between transport modes and services should be seamless (Givoni and Rietveld, 2007). Users perceive the transfer process negatively (Hine and Scott, 2000; Givoni and Rietveld, 2007), and therefore, providing a seamless integration is crucial to encourage and attract trip makers to this alternative. Using continuous modes, such walking and bicycle, in access and egress trips soften impedances of multimodal trips by enabling seamless integration with PT (Rietveld, 2000).

Looking at the access mode choice, there are some factors that can affect it. If the cost to access a certain transport mode is too high (in terms of monetary cost or distance or any other barrier), the propensity to choose for this mode tend to be very low, when other alternatives are available (Murray et al 1998).

Distance plays an important role in access mode choice. In The Netherlands, in trips up to 3km, the bicycle is the most used mode, followed by walking and PT. On the other hand, for trips with distance longer than 3km, the main mode is PT, followed by bicycle and then by private car (Keijer and Rietveld, 2000; Givoni and Rietveld, 2007).

Comparing cycling and walking, people accept longer distances when cycling (Krygsman et al. 2004) and this is probably because of the higher speed of this mode which allow people to go further within the same time and people also admit to cycle longer distances if the overall distance is longer (explained by the interconnectivity ratio). But naturally, as cycle and walk are human powered modes, and therefore requires physical effort, there is a limit for this distance, people won't cycle or walk indefinitely (Krygsman et al. 2004) and this limit can vary depending on the individual.

For bus users in UK, the time to access the bus stop is considered in the decision-making process and finally it is determinant in the actual decision in using the bus (Hine and Scott, 2000).

Density has influence as well in access trips. Krygsman et al (2004) find out that for access trips, as density increases, time decreases up to an inflection point, when density reach a certain level that causes pedestrian and cyclist congestion as people converge to a single station, resulting in longer times.

Facilities provided in the station is found to be relevant for access modes, since improved facilities, such as car parking facilities, bicycle parking (both guarded and unguarded) tend to attract more people, increasing the modal share of this mode (Givoni and Rietveld, 2007).

This can be confirmed by a pilot project conducted in The Netherlands, which shows that enhancing the quality of bus stops by providing bicycle parking facilities, shelters, public telephones and marketing campaign not only increase the overall passengers' number but also generates an increase in the use of bicycle as feeder mode (Martens, 2004).

Finally, according to Martens (2007), there are lower barriers for changing travel behaviour in access trip than overall mode change and this could be a target. Instead of trying to stimulate people to change the whole trip mode, it would be more feasible to tackle specifically on the feeder modes, especially in large cities, where the main mode usually cover long distances and access motorised trip tend to be not that long, meaning that there is a great potential for cycling to substitute this part of the trip.

METHODOLOGY

The main goal of this paper is to investigate what are the factors affecting the use of the bicycle as access mode to public transport and if it is possible to identify segments, or target groups. In order to achieve this goal, some questions have to be, firstly, answered:

- Which are the main factors affecting access mode choice and which segments can be identified?

- Which are the main hindrances for the use of bicycle as feeder mode to PT and which segments can be identified?

- Which are the main opportunities for the use of bicycle in access trips to PT and which segments can be identified?

It is hypothesized that the factors affecting access mode choice and the opportunities and barriers for bicycle can vary according to:

- Socioeconomic and personal factors: age, gender, income and availability of other transport modes, namely car and bicycle can affect the choice of the access mode. Furthermore, it is also taken into account whether the individuals are able to ride a bicycle and whether respondents have ever considered using the bicycle for access trips.

- Transport modes used in transport chain: each access mode itself has its own intrinsic characteristics which might be strong enough to determine the choice for this mode. In addition, it might be assumed that the main mode also has also effect on the access mode choice. Regarding the main mode, it will be possible to determine whether this mode influences the choice of the access mode only in Santa Cruz (one of the chosen survey location at metropolitan area of Rio de Janeiro), as in this location two main mode are considered (bus and train), whereas in Colegio (another surveyed location) only the metro is considered as the main mode. Hence, it is not possible to determine whether the location or the main mode is influencing the choice for this neighborhood.

- Location: as mentioned above, the two case study areas (Santa Cruz or Colegio) present quite different characteristics. The neighborhood of Santa Cruz has an enormous area, with low density and scarce provision of public transport services. The neighborhood of Colegio has a small area, presents high density and is well served by PT. Due to these opposite characteristics; it is assumed that access mode can vary depending on the location where the user lives.

The figure below illustrates how the analysis will be conducted. Initially, based on frequencies analysis, the main attributes affecting the access mode choice, the opportunities and the barriers for the use of bicycle as feeder mode to PT will be identified. An attribute is considered a "main attribute" if its frequency is equal or greater than 10% of the responses. Subsequently, the main attributes are associated with the socioeconomic variables, transport chain variables and the location. Again based on frequencies analysis, it is identified which factors influence each of the main attributes. On the next stage, the main attributes of the three categories (access mode, barriers for bicycle and opportunities for bicycle) are confronted amongst each other. Then, derived from this analysis the target groups are defined. Once the target groups are defined, the factors influencing each of the groups are shown and finally recommendations to policy makers to tackle those groups are presented.
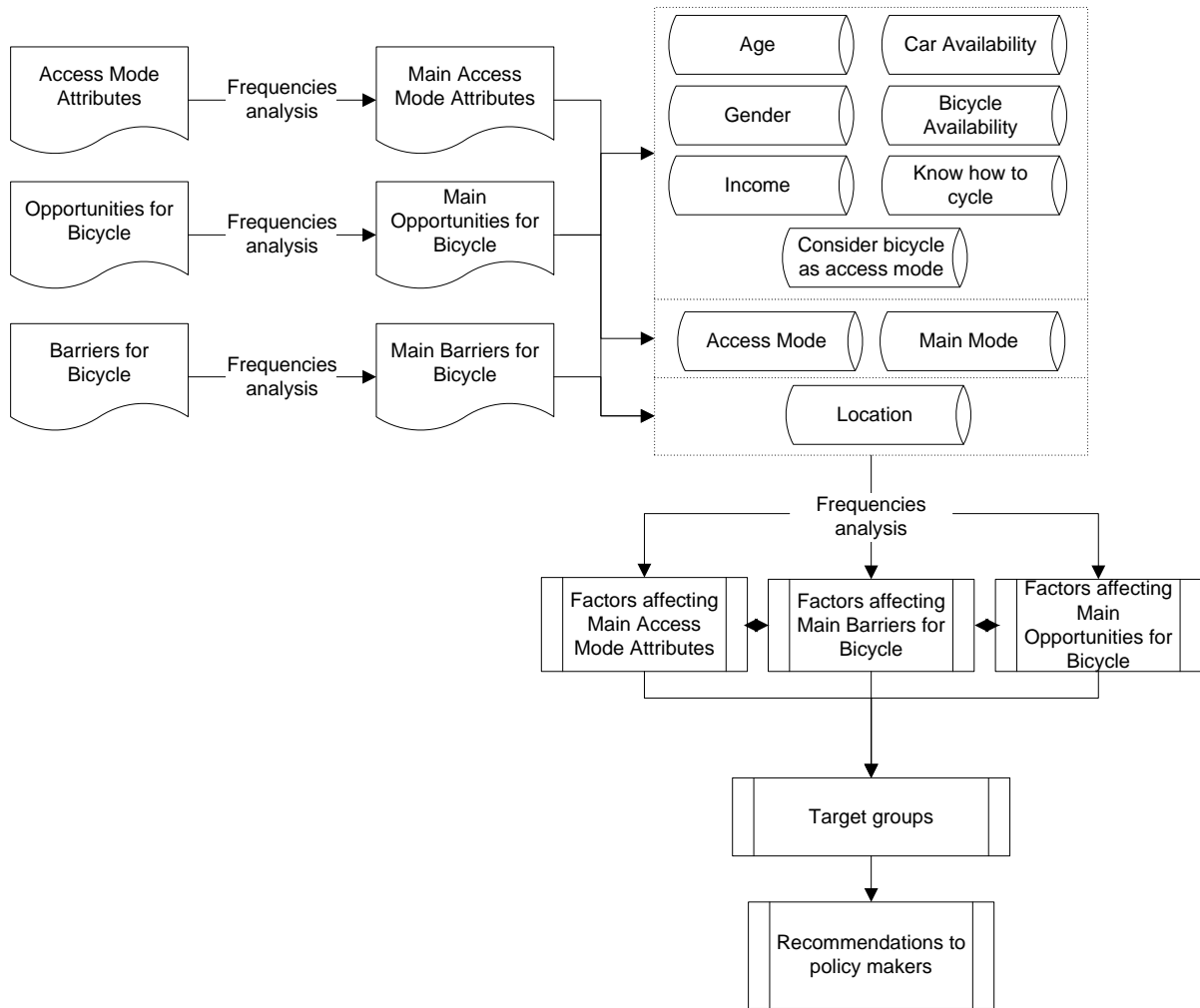
Figure 1 – Methodology Framework

Case study description

The survey was conducted with 272 bus users and 249 train users in October 2009, for four week days during peak hours, in the Santa Cruz neighbourhood, and with 201 metro users in the neighbourhood of Colegio, for two weekdays and also during peak hours.

Santa Cruz is located in a suburban area at the West Zone of the city of Rio de Janeiro, whereas Colegio is located at the North Zone of the city, as illustrated in Figure 2. The choice of the location was based on some characteristics of each area. The neighborhood of Santa Cruz has a higher percentage of use of bicycle in the modal split, indicating already a propensity for this mode; it is a low income area and the development of this mode would improve the inhabitants' quality of life; it relies on scarce PT services, specially feeder services, as the area is too large and the density is too low. On the other hand, Colegio neighborhood presents a higher density, and counts on a better provision of PT services, even though it is also a low income residential area.

Figure 2 – Map of Case Study Location

Survey design

The first step in order to the design survey was to understand the behavior of PT users regarding each component of transport chain and specifically towards the access trip – in particular bicycle access trips. It was decided that qualitative techniques were the most appropriate for this stage of the research.

In order to accomplish it, bicycle users were approached in two different locations: a metro station and in a private bicycle parking facility. In the bicycle parking, the users were approached when they were coming to collect their bicycle. They were invited to join a focus group in the suggested data. A focus group was conducted with 4 bicycle users approached in the parking facilities

Other bicycle users were approached in a metro station with free bicycle parking was chosen as the approaching point. The approach was made when the bicycle users were parking their bicycles. It was not possible to convince metro users to join the focus group. Instead, in-depth telephone interviews were performed with those users.

The set of attributes affecting each component of the transport chain was derived from the results of this stage and based on literature review, and the survey instrument was designed.

The Survey

The survey consisted of two phases. The first was to approach PT users waiting in bus stops and metro/train stations during peak hours. Using a handheld computer, the interviewers asked filter questions to check whether the user fits the desired profile. The desired profile consisted in people living within the city of Rio de Janeiro borders and having the destination also within these borders; people making trips to work or study (compulsory trips) and people who use the same transport mode(s) everyday. If the person matched these conditions, the

surveyors invited the interviewee to take part in a longer interview to be performed by telephone and the call would be made in an appropriate time and date indicated by the person. The approach interview takes a maximum 1 minute.

The second phase was the telephone interview, using the survey instrument derived from focus group and in-depth interviews. The interview was carried out with the help of a handheld computer as was the case in the approach interview. The use of such electronic device is of great help not only for the ease to treat the data, but also for saving time and minimizing errors both of digitizing the data and also in carrying out the interview itself. The telephone interview took, on average 5 minutes and contained questions regarding preferences of the individuals towards the modes of transport used in the multimodal trips for work/study purpose, barriers and opportunities for bicycle as well as socioeconomic characteristics.

Sample profile

A total of 722 interviews were completed. The majority of the interviewees were women. Regarding age, more than half of the interviews were aged between 25 and 44 years old. As expected, the income range in both neighborhoods is quite low, with more than two thirds of the sample earning up to two minimum Brazilian wages (approximately 380 Euros). Less than half of the participants have access to a car, whereas two thirds have access to a bicycle. More than 80% of the participants know how to ride a bicycle.

CHARACTERIZING RIO DE JANEIRO

The city of Rio de Janeiro has approximately 6 million inhabitants, and a 52.3 inhabitant/ha average density, though significant differences can be found, with the highest density found in Rocinha (446,8 hab/ha) and the lowest in Guaratiba (8,5 hab/ha), as shown in Figure 3. The density of the two case study areas are highlighted in the map below.
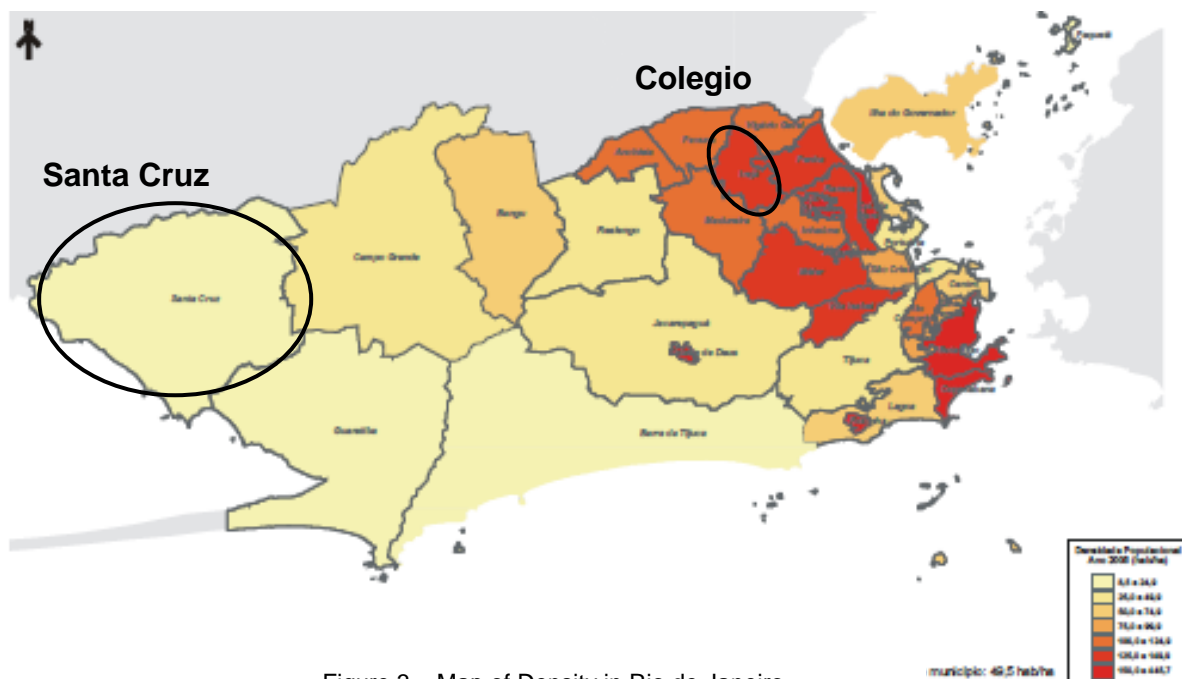

Figure 3 – Map of Density in Rio de Janeiro

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An estimation provided by IBGE (Brazilian Institute for Geography and Statistics) indicates that there are approximately 3.22 millions job positions in the city. The job distribution is as illustrated in the following map (Figure 4), the darker the area is, the higher the job concentration in this area. The two areas with higher concentration of job positions are the Central Area/South Zone and Barra da Tijuca. The former areas are already consolidated areas of urbanization, whereas the latter has been facing more recently this process. The arrows indicate the movement of people living in Santa Cruz typically does to access their jobs. The dashed arrows indicate the typical movement of people living in Colegio.
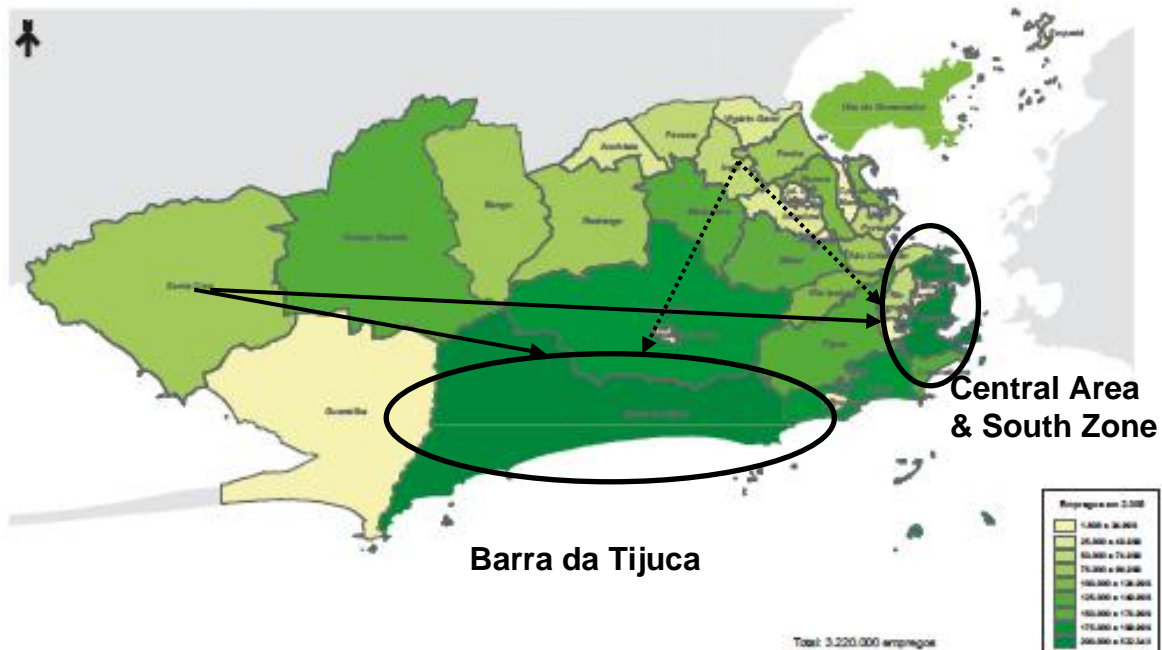
Fonte: PME-IBGE, Pesquisa O/D 2003

Figure 4 – Map of Job Distribution in Rio de Janeiro

Rio de Janeiro's transport system and transport habits

In order to enable the individuals to reach their jobs and also take part in other activities, the transport system in the city of Rio de Janeiro is composed of 3357km of roads, 35.7km of metro railways (divided in 2 lines, with 33 stations), and 149.9km of urban trains (divided in 5 corridors with 71 stations). Figure 5 allows the visualization of the train and metro lines.

According to an Origin Destination (OD) survey conducted in 2003, approximately 11 millions trips are made per day in the city of Rio de Janeiro. From all these trips, 67.1% are made by motorized mode whereas the remaining is made by non-motorized modes. Figure 6 illustrates the modal split, indicating a higher share of PT among the motorized modes and a concentration of walk trips among the non-motorized modes. Figure 7 shows how the 47% of PT share is divided among the different public modes, with a strong dominance of urban bus followed by informal transport. Metro, train and other modes (tram, boat and charter transport) play a minor role.

Figure 5 – Mass Transport System Representation

The significant share of walking presented in Figure 6 is mainly due to financial issues, since transport is a relevant expense in household budget (IBGE, 2003), especially for low income groups, and walking is mode which involves no cost. When asked how often do they walk in order to save the money used to pay transport fare, 8% of respondents answered everyday or almost everyday, 28% occasionally and 13% seldom (FETRANSPOR, 2007).

It is clear from figures 5 and 8 that the transport system has a radial configuration, with the train lines connecting the west zone to the city center and the metro lines the south zone and north of the city to the city center. In addition, the road network follows the same pattern and links all the regions to the central region of the city, with several express ways from all regions.
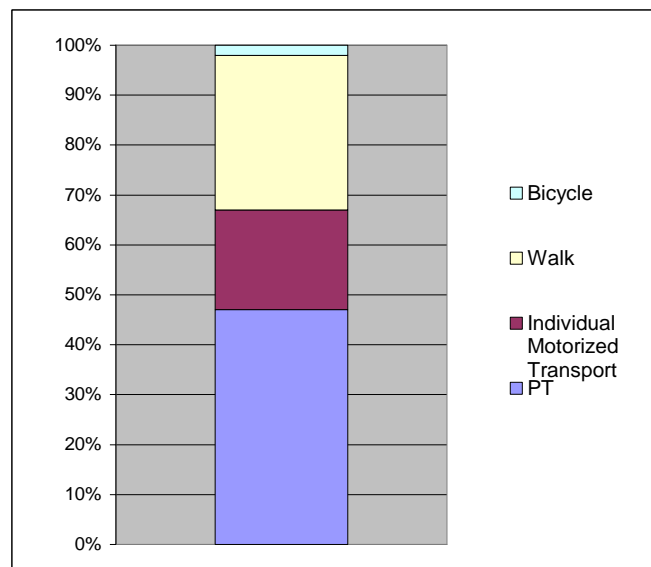

Figure 6 – Modal Split in Rio de Janeiro

*To cycle or not to cycle? Factors influencing the decision to use the bicycle as access mode
to Public Transport*
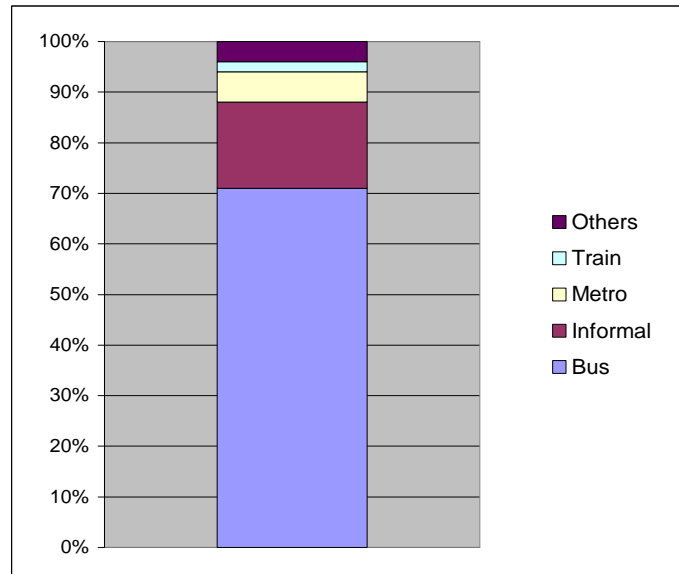*SOUZA, Flavia; BODMER, Milena; ZUIDGEEST; Mark; BRUSSEL, Mark, AMER, Sherif*

Figure 7 – PT Modal Split in Rio de Janeiro

Referring to Figure 4, it is evident that there is a high concentration of job offers in the city center, where a variety of PT options is available (train, metro and bus lines). However, currently those alternatives seem not to be enough to cope with the high demand originated from different areas of the city, as trains, metro lines and some of bus lines are operating in their maximum capacity during peak hours.

As for the area of Barra da Tijuca, another zone with a high concentration of jobs no mass transport such as train or metro is available. It is only possible to reach this area by road transport namely car, bus or informal transport.

The need of individuals living in different regions of the city to move to their far away job locations in association with a high percentage of road public transport and considerable use of individual motorized transport modes lead to an overloaded road network. Unsurprisingly, as a consequence, congestion and an inefficient transport system are unavoidable.
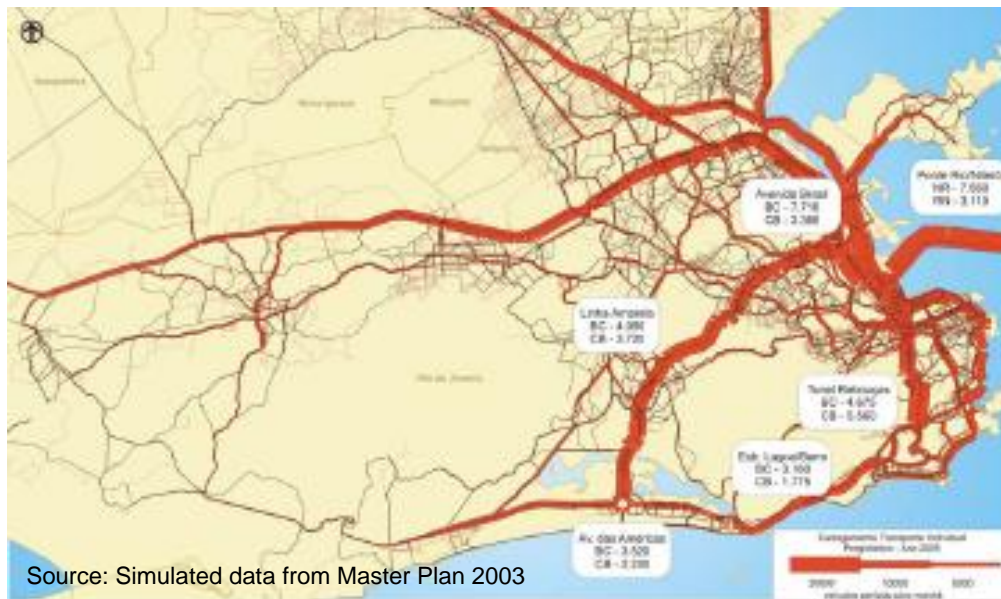
Source: Simulated data from Master Plan 2003

Figure 8 – Estimated flow of vehicles in morning peak

RESULTS

Transport chain analysis

Prior to proceeding with the analysis, it is necessary to give an overview of how the respondents currently travel. In Santa Cruz, where the users of train and metro (main mode) were interviewed, the main access mode is bus, followed by informal transport and walking, regardless the main mode. The small share of "other" when the train is the main mode regards to residents of neighboring stations who take the train to Santa Cruz in order to take a seat, as Santa Cruz is the final station (Figure 9).

In Colegio, where the metro is the main mode analysed, the preferred access mode is walking followed by bus (Figure 9). The greater share of car use (both passenger and driver) in this neighborhood as compared to Santa Cruz is due to the income level, which is higher in Colegio. The fact that none of the interviewees use informal transport in Colegio is justified by the urban form and formal transport services provides in this region. Differently from Santa Cruz, where the density is low and the PT provision is scarce, Colegio counts on public transport services with satisfactory frequencies and good coverage.
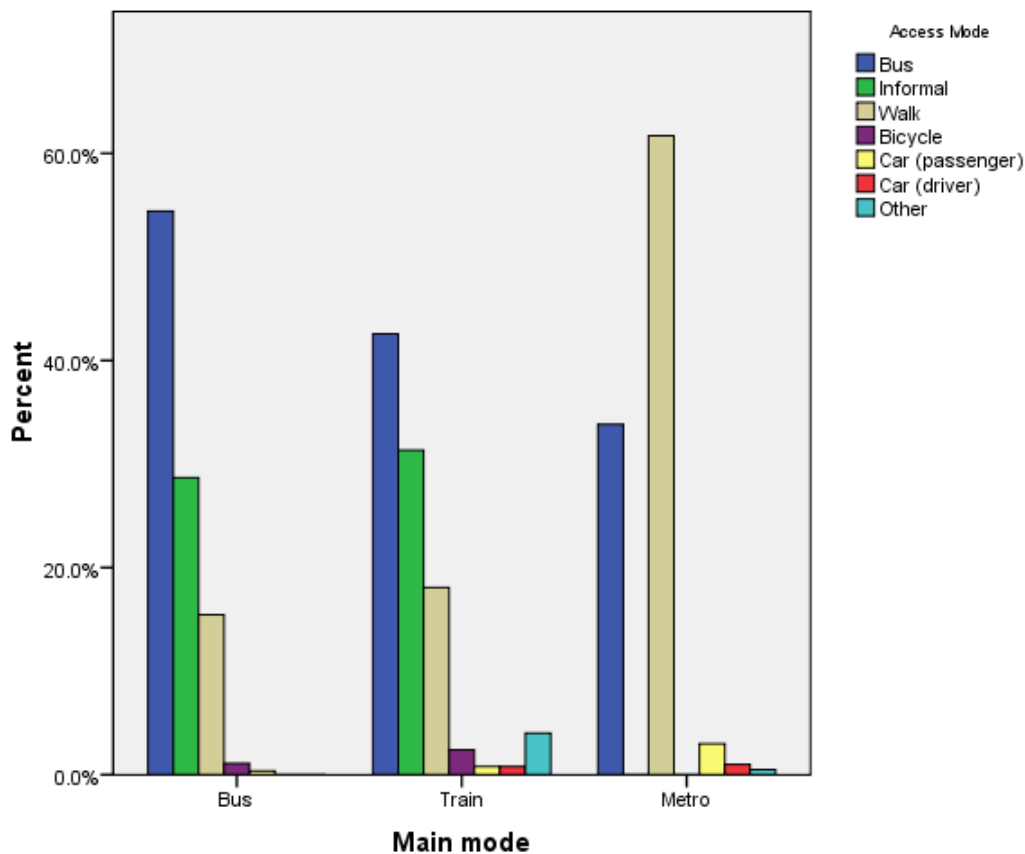
Figure 9 – Access mode share by Main mode

In terms of the number of legs in the transport chain, three quarters of the interviewees use two modes (access mode and main mode) and one quarter needs three modes to reach their destination. The great majority of 3-legs trips are originated in Santa Cruz.

Access Mode choice

The respondents were asked about the main reasons they have to choose their current access mode, and the most relevant answers were "proximity from home", frequency", "travel time", "captivity" and "cost", in this order. Looking at each one separately, differences can be perceived regarding socioeconomic, local and transport characteristics (Figure 10).

The attribute "proximity from home" is especially related to the mode "walk", as expected. And as this is the preferred access mode in Colegio, this is also very important in this neighborhood. This attribute is also relevant for individuals who consider bicycle for access trips, who use 2 modes and do have an alternative to move to work/study location. Gender, age, income, bicycle and car availability and if the person can ride a bicycle do not play an important role.

On the other hand, "frequency" is a very important attribute in Santa Cruz, and particularly by informal transport users and this is justified by the large area of the neighborhood, which requires motorized modes for long distance trips, in association with the scarce and poor quality PT service provision. Regarding the main mode, bus users give more importance to the frequency in access trips than train users, and this may be justified by the lack of reliable timetables for bus lines, meaning that missing a connection can lead to a considerable delay.

Neither transport chain characteristics nor socioeconomic characteristics seem to have influence on this attribute. However, those who consider the bicycle as access trips attach more weight to frequency than those who do not consider it.

Figure 10 – Access mode attributes frequencies

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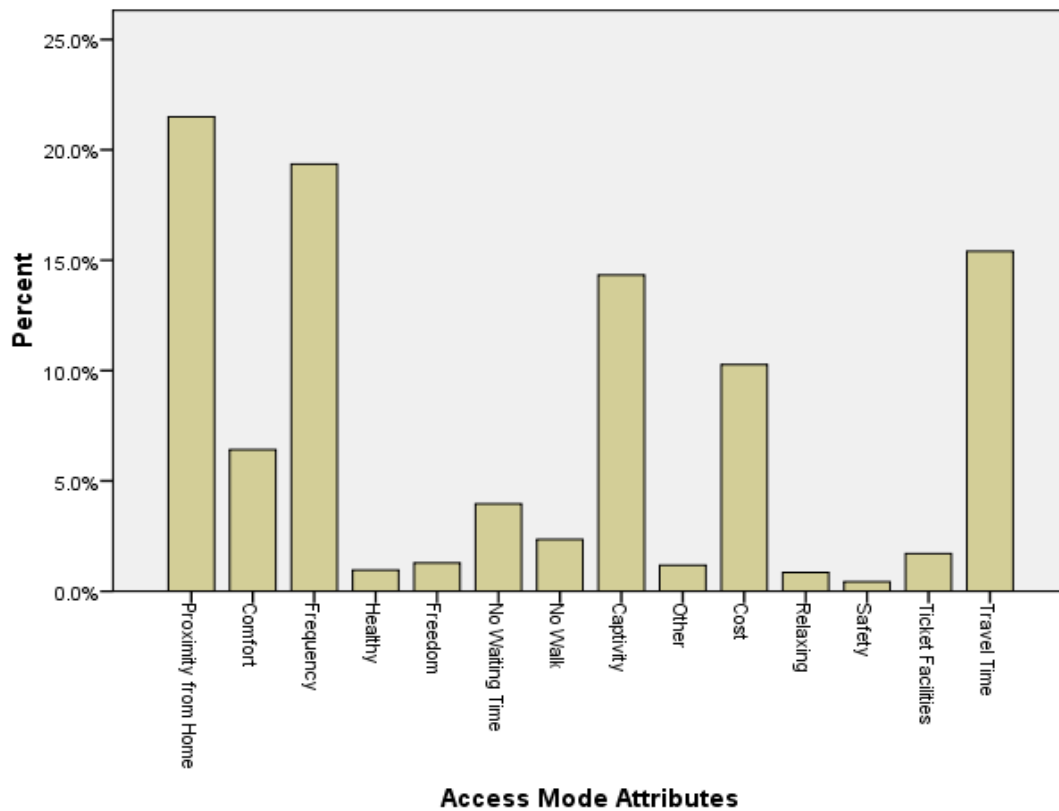
Travel time is pointed at by residents of Santa Cruz, mainly for current informal transport users, and by people who have alternative transport options. No significant variation is found by bus and train as mains mode. Regarding socioeconomic characteristics, individuals who earn up to 2 Brazilian minimum wages (MW) and own a bicycle also attach weight to travel time.

Captivity is an issue for residents of Santa Cruz and again the scarce PT provision, including limited coverage, is the reason. This is especially valid for those who use the bus in their access trips and also in the main trip. Gender and age are not important, differently from income, as the captivity is mentioned by individuals with income up to 2 MW, who do not own

a car, who can not ride a bicycle and for those who do consider the bicycle as an access mode.

For the individuals who walk to PT in Santa Cruz, the cost is relevant, confirming the statement made above that in Brazil some people do replace motorized stretches of the transport chain by walk to save the money of the respective fare. This is also confirmed by the fact that cost influence the choice of respondents who take 3 modes of transport, suggesting that if one leg is not for free, they will have to pay three fares. As expected, the lower income ranges (up to 2MW) walk because this is a free mode. The cost is important for people who do not have another alternative to reach their destination, but do have a bicycle available.

Considerations

Next, the barriers and the opportunities for the bicycle as access mode will be investigated. It is assumed here that the following barriers to use the bicycle as feeder mode to PT are unbreakable barriers, "distance from home", "proximity from home" "personal preferences", "personal constraints" and "external factors" as they are perceptions expressed by the respondents and are difficult to be tackled. On the other hand, "lack of respect from drivers", "quality of pavement", "public safety", "no bicycle available" and "parking conditions" are regarded as "target barriers" as they can be overcome if necessary actions are taken.

Likewise, the following improvements are considered feasible to reveal a potential use of bicycle in access trips: bicycle available, cycleways, parking infrastructure, public safety, dress room at destination and take the bicycle in vehicle. All of these features can be improved or implemented by the local government, operators or job locations, hence they are considered feasible. Differently, "know how to cycle" and "change home location" depend exclusively on the individual, and are not sensitive to external actions.

Barriers for cycling

Regarding the reasons for the participants are not using the bicycle as feeder mode to PT, the main responses were "distance from home, "no bicycle available", and "parking conditions", by order of preference (Figure 11). Nonetheless, it is possible to identify differences when those attributes are associated to socioeconomic characteristics, transport-related factors as well as the access mode attributes and opportunities for bicycling.

The **distance from home** to PT boarding point is a barrier for individuals living in Santa Cruz, regardless the main mode, but particularly for those who use bus in access trips. Respondents aged between 25 to 34 years, who earn up to 1 MW and who do not owe a bicycle also base their choice on this attribute.

Frequency is the most cited access mode attribute, what makes sense, as bus is the most used access mode, followed by captivity and travel time. As expected, due to the distance, the answer "nothing" is given by almost three thirds of the individuals, when they were asked what can be done to encourage them to cycle to PT. This shows that people are not willing to shift to bicycle when a long distance has to be covered. However, other feasible improvements (bicycle available, cycleways, parking infrastructure, public safety and dress room at destination) still reach the considerable share 15%, meaning that some of the individuals could be tackled.
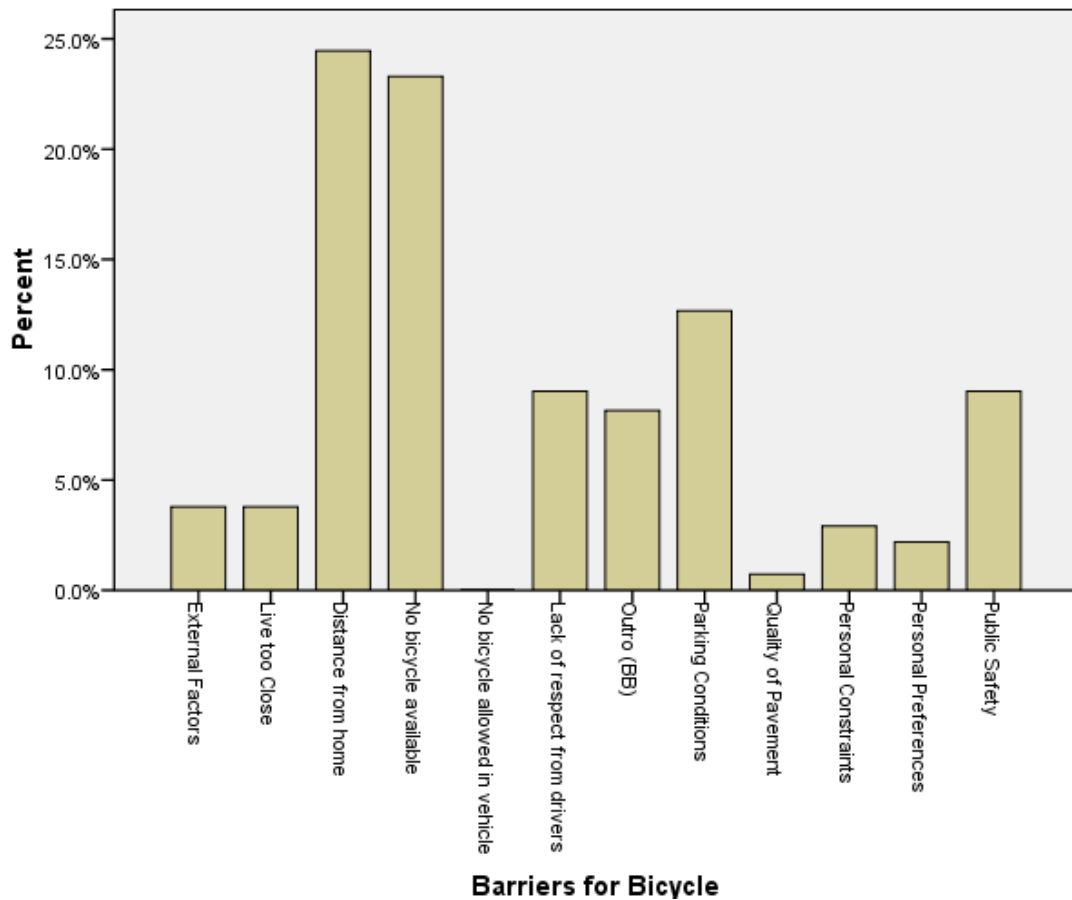
Figure 11 – Barriers for bicycling frequencies

Some interviewees stated that the main barrier for them to use the bicycle as access mode is that they do **not have a bicycle available**. This reason is the main one for women, for individuals who can not ride a bicycle, for youngsters (up to 25) or for individuals older than 45 years, and for those who earn up to one MW or more than three MW. Individuals who currently walk to PT, who live in Colegio and who do not have a bicycle, obviously, also pointed not having a bicycle as the main hindrance for bicycle use.

With respect to access mode, those respondents based their choice firstly on the proximity from home, followed by captivity, frequency and travel time. Again here, the attribute "proximity from home" is strongly related to the neighborhood Colegio, where "walk" is the preferred access mode.

When it comes to the actions which could stimulate the use of bicycle for this segment, not surprisingly, having a bicycle is the most important attribute (40.2%). Other feasible improvements, such cycleways, parking infrastructure and safety are also mentioned and totalize approximately one fifth of the answers. The attribute "nothing" corresponds to less than one third of the responses.

The current bicycle **parking conditions** are also considered a problem for a substantial portion of the participants. It is the second hindrance mentioned by people who have a bicycle available and use the bus as the main mode and the third for men, individuals with no income or earning from two to three MW. This segment can ride a bicycle, they consider bicycle as access mode, but their current option is the informal transport.

This segment based their access mode choice mainly on the proximity from home, followed by frequency and travel time. Unsurprisingly, more than half of this group pointed that better parking infrastructure would encourage them to shift to the bicycle in this trip. Other feasible improvements such as bicycle available, cycleways, public safety and dress room at destination, would encourage extra one quarter of this group.

Opportunities for cycling

When the participants were asked about what could be done for them to use the bicycle as feeder mode to PT, "nothing" was the first option for all categories, indicating that those people can not be considered potential users, as they would not change from their current access mode to the bicycle even if improvements are implemented. Nevertheless, there is still a substantial share of interviewees willing to change if the conditions for cyclists improve. Overall, the main changes suggested by the participants are "cycleways", "parking infrastructure" and "bicycle available", in this order. The table below illustrates the difference according to socioeconomic and mode characteristics.

Figure 11 – Opportunities for bicycling frequencies
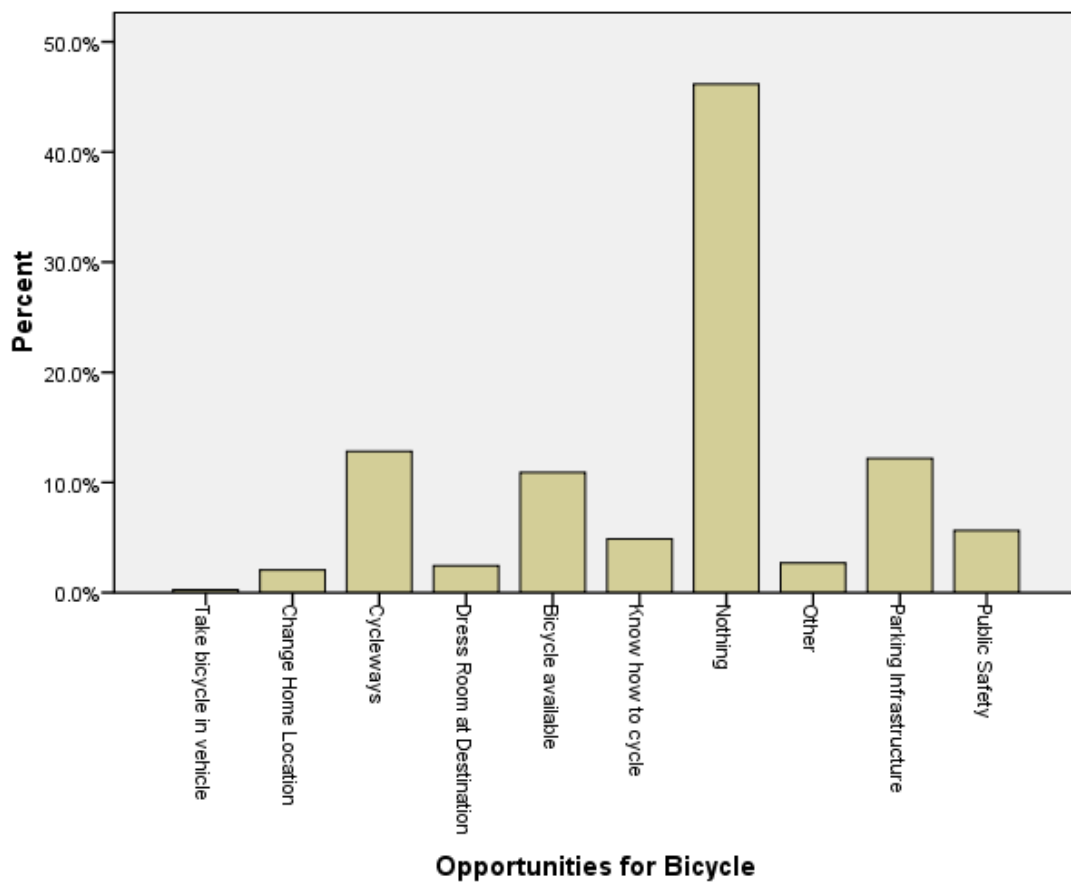
Looking at those respondents who stated that **nothing** could be done to make them use the bicycle as access mode, there are not much difference considering socioeconomic characteristics or transport-related aspects. The exceptions are for individuals who do not have a bicycle available, who do not consider bicycle for access trips and also for the residents of Colegio.

Regarding the access mode choice of this segment, the most relevant reasons for choosing it are proximity from home and frequency, with a share of less than one quarter each, followed by captivity and travel time, with approximately 15% each.

When it comes to the barriers for bicycling, "distance from home" is mentioned as the most important barrier, with almost 43%. The other unbreakable barriers represent nearly 18% of the answers. Nonetheless, the portion of "not having a bicycle" is quite significant, about 20% and the other feasible improvements correspond to approximately 14% of the responses.

Apart from those bicycle-averted, there is still a considerable share of respondents willing to shift to bicycle as long as current conditions are changed. The implementation of **cycleways** is considered the main improvement for residents of Santa Cruz, especially for those who currently use informal transport as feeder mode and bus as the main mode, for women, people who earn one to two MW, who do not have a car available, but do have a bicycle available, who can ride a bicycle and do consider it for access trips.

For these individuals, frequency, captivity and proximity from home are the main access mode attributes being responsible for more than half of the answers. "Travel time" and "cost" are also relevant and account for approximately 13% each.

With respect to the problems of using the bicycle as feeder mode, the lack of respect from drivers is the most relevant, responding for almost one third of answers, followed by public safety and having "no bicycle available", responsible for another third of responses.

The provision of bicycle **parking infrastructure** is considered the most relevant improvement for male, for individuals aged up to 25 years, who have car and bicycle available, who can ride a bicycle and consider it as feeder mode. Residents of Santa Cruz, particularly those who currently use informal transport to access PT also give high importance to parking infrastructure improvements. When the access mode "walk" is associated with the neighborhood is taken into account, it is detected that in Santa Cruz those people also consider it important.

The access mode choice is based firstly on frequency, followed by proximity from home, cost and travel time. In terms of the problems in using the bicycle, more than half of the respondents pointed the present parking conditions as the main one. And the second most important, with more the one fifth of the responses is public safety.

Having a **bicycle available** would stimulate the use of this mode to access PT for young people (up to 25 years), lowest income group (up to one MW), individuals who do not have a car available, and obviously do not have a bicycle available, even though they can ride it and do consider it as a feeder mode. Individuals living in Colegio also pointed that having a bicycle would encourage them to use the bicycle. This is evident in this neighborhood (and not in Santa Cruz) due to the lack of "bicycle culture" and consequently low share of bicycle there.

The most relevant access mode attributes for this group are proximity from home, frequency, captivity and travel time. When it comes to the reasons for these individuals not to use the bicycle in those trips, the dominant answer was not having a bicycle available, corresponding to almost 80%.

Homogeneous groups

When the access mode attributes, the barriers and the opportunities for bicycle are associated, there is no strong relation between access mode attributes and the other two attributes. However, there is a strong relation between barriers and opportunities for bicycle, and four distinct groups can be derived from this association.

The first is the **bicycle-reluctant** group, and it comprises individuals who choose "distance from home" as the main barrier for cycling to PT and state that "nothing" can be done to change it. There is an intense relation between these two attributes. From the respondents who stated that the distance from home is the main hindrance to use the bicycle in access trips, 66% declares that nothing can be done for them to shift to it. When the barrier "nothing" is taking into account, the "distance from home" is the main barrier, with 43% of the responses.

This bicycle-reluctant are people between 25-34 years old, who earn up to 1MW, who have no car or bicycle available. They live in Santa Cruz and they currently use the bus as access mode, this can be again explained by the long distances covered by the busses in this neighborhood.

The second group is the **bicycleless** and it is composed by people who answered that not having a bicycle available is the main barrier for them to cycle to PT and that having a bicycle could make them use it for this trip. This two attributes are highly correlated.

People aged up to 24 years or from 35 to 44 years, low income group (up to 1MW), who have no car or bicycle available, who can ride a bicycle and consider it for access trips belong to this group. In addition, individual who live in Colegio are also part of this segment, and again, this is due to the low level of bicycle availability as a consequence of the lack of "bicycle culture" in this neighborhood.

There is another group which is mainly related to the parking facilities. This is the **parking-concerned** group, and the main barrier for the bicycle is the current parking conditions and the main improvement that could be done to reveal this potential is providing better parking infrastructure, with free, safe and well located parking facilities close to stops and stations.

The parking-concerned group is composed by men, youngsters (up to 24 years), people who have a bicycle available, can ride it and consider it as access mode. Residents of Santa Cruz and who presently use 3 modes in their trips also belong to this segment.

The last group is the **safety-concerned** individuals. Their main problems to use the bicycle in access trips are the lack of respect from the drivers towards cyclists and public safety and what can be done to make them shift to the bicycle is building cycleways, to make sure they are physically separated from the drivers and also to improve current public safety.

This group is composed by women, who are usually more concerned with safety than men, people aged from 45 to 54 years old, individuals who have a bicycle available, can ride it and consider it as feeder mode to PT. Residents of Santa Cruz are also in this segment, mainly those who use informal transport as their present access mode, regardless the main mode (both bus and train users). These individuals use 2 modes of transport to get to their destination.

CONCLUSIONS AND RECOMMENDATIONS

This paper aimed to identify the main factors affecting the potential use of bicycle based on the access mode attributes, barriers and opportunities for bicycle. It was hypothesized that socioeconomic factors, current transport patterns and location aspects could influence this potential.

The exploratory analysis presented in this study shows that the current access mode attributes seems not to be directly related to the individuals' potential to use the bicycle. This means that there are no significant associations between the access mode attributes and the barriers or opportunities for bicycle as feeder mode. However, the current access mode (bus, informal transport or walking) is highly related to the barriers or opportunities for bicycle, as opposed to the main mode, which showed to have no connection.

Confirming the hypothesis, the location where the respondents live is an important factor to explain the reasons for choosing or not choosing the bicycle for access trips. In terms of socioeconomic characteristics, bicycle availability is also a strong factor, as well as if the person can ride a bicycle or consider it for feeder trips. Age, gender and income are also relevant factors.

Distance was mentioned as an important attribute both for access mode and for a barrier for bicycle. However, as the spatial dimension was not consider for this study, it would be necessary to know the exact location of the residence and consequently the distance from home to the boarding point to establish what is consider "too far" or "to close" by the interviewees. In addition, the inclusion of the spatial component would allow further analysis regarding the bicycle-behavior and its possible spatial patterns.

Regarding the improvements necessary to reveal the potential demand for bicycle in integration with PT, there are three main groups to be tackled: the "bicycleless", the parking-concerned and the safety-concerned.

For the first group, the simple provision of a bicycle could make them shift to this mode in access trips. This could be made by financing the purchase of bicycle, which could be done by the local government, with programs to encourage the use of this mode, or also by the employers, as they currently pay part of the travel expenses of their employees.

Providing good quality parking infrastructure would attract individuals who belong to the parking-concerned group. Bicycle parking facilities should be placed close to boarding points should be safe and preferably free. The provision of such facilities can be promoted either from local government or by the transport operators, as this could generate extra demand for their services.

Finally, the safety-concerned group could be tackled by improving overall public safety and implementing cycleways network. The former, apart of generating an additional demand for cycling, it would firstly improve individuals' quality of life, and should be a primary goal of local authorities. The latter would address the insecurity generated by the lack of respect of drivers towards cyclists, and building bicycle dedicated facilities would encourage individuals to use this mode.

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