Revista AMAzônica, LAPESAM/GMPEPPE/UFAM/CNPq
ISSN 1983-3415 (versão impressa) - eISSN 2558 – 1441 (Versão digital)

Vol. 16, número 1, jan-jun, 2023, pág. 622-644

Effects of the COVID-19 lockdown on bike-sharing usage:

Empirical evidence comparing men and women on cycling activities

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Abstract: The pandemic of the new coronavirus (SARS-CoV-2) motivated several social changes, and the prevention measures to prevent the spread affected all modes of transport. The World Health Organization (WHO) recommends walking and cycling for urban transportation. In this way, this study aims to analyze bicycle usage during the pandemic period. The study surveyed 821 cyclings from March 1, 2021, to April 30, 2021, in three phases: pre-lockdown, lockdown, and post-lockdown. We evaluate bicycle use in Leisure, Work, Physical Activity, and Not Used, comparing the McNemar test responses. Then we compute the phi coefficient (φ) for each activity, lockdown phase, and gender. The data was analyzed by Smallest Space. The results showed a decrease in the system during the lockdown, mainly utilizing physical activities and leisure. In addition, males used the system more than females. At the same time, men are likely to use bicycles mostly for physical exercises and partially for leisure activities, while women show less eagerness to bike usage, mainly during the lockdown period and partial use for leisure activities (excluding the lockdown phase). In conclusion, public policies must promote cyclist safety. Actions to reduce urban violence and better cycle lanes can facilitate the inclusion of female users.

Keywords: bike-sharing; pandemic; COVID-19; urban mobility; lockdown; public policy.

Resumo: A pandemia do novo coronavírus (SARS-CoV-2) motivou diversas alterações sociais, sendo que as medidas de prevenção para

evitar a propagação afetaram todos os modos de transporte. A Organização Mundial da Saúde (OMS) recomenda caminhar e andar de bicicleta como transporte urbano. Desta forma, este estudo visa analisar o uso da bicicleta durante o período de pandemia. O estudo pesquisou 821 ciclistas de 1º de março de 2021 a 30 de abril de 2021, em três fases: pré-bloqueio, bloqueio e pós-bloqueio. Avaliamos o uso da bicicleta em Lazer, Trabalho, Atividade Física e Não Uso, comparando as respostas do teste de McNemar. Em seguida, calculamos o coeficiente phi (φ) para cada atividade, fase de bloqueio e gênero. Os dados foram analisados por Smallest Space Analysis (SSA). Os resultados mostraram uma diminuição do sistema durante o confinamento, utilizando principalmente atividades físicas e lazer. Além disso, os homens usaram mais o sistema do que as mulheres. Simultaneamente, é provável que os homens usem bicicletas principalmente para exercícios físicos e parcialmente para atividades de lazer, enquanto as mulheres mostram menos interesse pelo uso da bicicleta, principalmente durante o período de bloqueio e uso parcial para atividades de lazer (excluindo a fase de bloqueio). Pode-se concluir que as políticas públicas precisam promover a segurança do ciclista. Ações para reduzir a violência urbana e melhorar as ciclovias podem facilitar a inclusão de mulheres usuárias.

Palavras-chave: compartilhamento de bicicletas; pandemia; COVID-19; mobilidade urbana; confinamento; políticas públicas.

1. INTRODUCTION

A highly infectious viral pneumonia outbreak caused by a new coronavirus, called SARS-CoV-2, gets started in 2019. (Hu et al., 2021). In late December 2019, the first registration was in Hubei province, located in Wuhan, a city in China (Zhu et al., 2020). On March 11, 2020, the World Health Organization (WHO, 2020) decreed that this is a pandemic (GISONDINI et al. 2020) that persists today and represents a threat to public health worldwide. On February 26, 2020, Brazil registered the first case in Latin America (Rodriguez-Morales et al., 2020; Croda & Garcia, 2020).

To contain the transmission of the virus, some control and prevention strategies and measures needed to be implemented by

municipal, state, and local health authorities. Actions such as expanding the service capacity of health services, economic support to citizens, families, companies, and, above all, isolation and social distance have brought about significant changes in several aspects of the world population's life (Pires, 2020).

Public transport and urban mobility also have been affected by demands for alternatives that reduce the risk of contagion. The WHO recommendation is that, whenever possible, the population chooses to use a bicycle or go for walks (World Health Organization, 2020). In some European places, there are already initiatives to increase the use of bicycles, with an increase in the availability and use of cycle paths (Mendes et al. 2020).

Faced with the challenge of stimulating forms of commuting compatible with WHO recommendations, governments have encouraged cycling through the redistribution of road space in cities, creating temporary infrastructure for bicycles, resulting in substantial increases in their use (Kraus; Koch, 2021). Brazil still faces some challenges to implement, like the high number of private cars on the streets (Mendes et al., 2020).

Encouraging the implementation of measures aimed at active mobility contributes to the user's physical and mental health, based on the benefits of regular physical activity and, with the environment, as it avoids pollution. In Brazil, for example, according to data from the System for Estimating Emissions and Removal of Greenhouse Gases (SEEG), an initiative of the Climate Observatory, transport is responsible for 47% of emissions in the energy sector. Trucks and cars are the two primary sources, representing 40% and 31%, respectively (SEEG, 2020).

Therefore, in addition to the pandemic issue, the encouragement of active forms of commuting, such as cycling and walking, is compatible with a new vision of cities and urban mobility, planned sustainably.

The bicycle does not emit polluting gases and does not cause noise. Thus, this vehicle is fundamental for the promotion of a sustainable urban environment. The increase in cycling brings several benefits: air quality, low traffic, cost reduction, and economic development (ITDP, 2017).

Therefore, the difficulties and challenges imposed by the pandemic may represent an opportunity for urban planners to rethink displacement in cities and seek more sustainable strategies. In Italy, the study carried out by Barbarossa (2020) analyzed ten of the most important Italian towns and found that nine of them had sustainable mobility plans approved or in the process of approval. Five of them had plans for bike use approved or in the process of approval.

A prevalent form of promoting cycling is through sharing systems, in which registered users can use the bike for a specified time, free of charge or for a fee. According to the ITDP, sharing systems can increase the number of cyclists on the streets as they reduce some barriers to the use of bicycles, such as acquisition and maintenance costs, the time needed to purchase, storage space, and the risk of having the bike stolen or damaged (ITDP, 2018).

The covid-19 pandemic impacted sharing systems in some locations. In the city of Beijing, there was a reduction in the daily average of travel during the covid-19 outbreak, not returning to the usual level in the initial phase of resumption of activities. Furthermore, after the pandemic outbreak, there was an increase in the average time of the trip (Shang et al., 2021). New York, Boston, and Chicago showed a decrease in the amount of travel carried out during the period of high transferability. As the number of cases decreased, there was an increase in the average travel time (Padmanabhan et al., 2020). In New York, the reduction in the use of bicycles was smaller than that presented by the subway system. In addition, the shared bicycle system showed an increase in the average

travel time (Teixeira; Lopes, 2020), indicating a preference for a vehicle that does not cause high contact during the pandemic.

In a study with the users of the sharing system of San Antonio in the United States, 48% of the participants had no impact on the use. More than a quarter (26%) said they had increased, and 22% said they had reduced or stopped using. Asked if they intended to increase the use of the system after the end of the imposed pandemic restrictions, they stated the intention to use it at least occasionally, with the most significant growth for the use of 1-2 times a month (from 22 to 34%) (Jobe; Griffin, 2021).

In this context, this research sought to identify how restrictive social measures influenced the use modalities of bike use in pre, during and post lockdown periods.

2. MATERIAL AND METHODS

2.1 Study Design, Setting and Participants

We perform the study in the city of Recife, the capital of the Brazilian state of Pernambuco. We built a questionnaire in the Google Forms application and sent it by email to the Tembici company. Following the study, the company sent the survey to users registered with Bike-PE, a bicycle sharing system that operates in Recife, Olinda, and Jaboatão dos Guararapes.

Bike-PE is the only bicycle-sharing service operating in these cities, with 800 bicycles distributed in 80 stations. Tembici manages other sharing services in Brazil, such as Bike Rio, Bike Sampa, and other Latin American countries, such as Bike Santiago, Chile, and Ecobici Buenos Aires, Argentina (Tembici, 2021).

Recife has 183 km of cycle paths and cycle lanes, 153 km of which are permanent, and 30 km of operational routes that operate on Sundays and holidays (Recife, 2021), the so-called tourist cycle lane, and leisure.

The first Covid-19 case in the city was on March 12, 2020. Although some services had their activities suspended in the same month, the most significant restriction occurred from the 16th to May 31, 2020 (Pernambuco, 2020), a period that will be called here as lockdown. After this period, activities in the town were progressively resumed, according to the calendar and protocols defined by the "Covid-19 Coexistence Plan" prepared by the state government.

It is noteworthy that the city of Recife went through different phases of activity restrictions during the year 2020. Therefore, in this study, three periods were defined: pre-lockdown, during the lockdown, and post-lockdown, as well as the purpose of using bicycles (leisure, physical activity, and commuting to work).

We applied a digital and remote questionnaire by Google Forms and sent it to a local Managing Bicycle Share Company. The company published the survey in the email address of registered customers. All the participants should be over 18 years old, live in Recife City and use the bicycle. We received 1178 responses from March 1, 2021, until April 30, 2021. We removed 90 respondents under 18 years, 271 who did not live on bicycles and 129 who did not live in Recife. The sample was 821 participants.

2.2 Data Sources, Study Size, and Variables

The data collection took place in four stages: questionnaire design, pretest, distribution by the sharing company, and data evaluation. The pretest covers 133 random respondents witch contributed to improving its structure. We sent the questionnaire to a bicycle-sharing company witch sent it to 10 thousand registered users.

ISSN 1983-3415 (versão impressa) - eISSN 2558 – 1441 (Versão digital)

We aim to identify the profile, frequency and barriers to sharing bicycle users during the COVID-19. We cover three periods: before the lockdown, during the lockdown, and after the lockdown.

3. THEORY/CALCULATION

Since the aim of the research was to assess in the pandemic context which activities had a greater impact on participants for cycling in the phase before, during and after the lockdown, the percentage of bicycle use in four types of activities was initially computed, comparing these responses in these three phases using the McNemar test.

Then, in order to establish a relationship of each activity in each phase of the lockdown with the gender of the participants, the phi coefficient (or φ) was computed to measure this association. Finally, aiming to investigate the interrelationships between the various activities in the different lockdown phases, and how they were structurally related to male and female participants, a Similarity Structure Analysis or Smallest Space Analysis was computed (SSA), supported by the method of “external variables as points”. The SSA is a practical technique for aiding comprehension of the structure of interrelations among variables in which each variable are treated as a point in a Euclidean space such that the higher the correlation between two variables, the closer they are in the space (Guttman, 1968, 1991; Roazzi & Souza, 2019; Roazzi, Souza & Bilsky, 2015). Statistical analyzes were carried out using IBM SPSS Statistic version 26 for Windows.

4. RESULTS

We calculated the percentage of bicycle use in three moments: before, during, and after the Lockdown. The results cover four activities Leisure, Work, Physical Activity, and Not Used. Next, we performed the chi-square test. Table 1 shows the data summary.

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Table 1. Percentage and standard deviations of the participants' answers for the use of a bicycle in four activities - Leisure, Work, Physical Activity, Not Used - covering Pre-Lockdown, Lockdown, and Post-Lockdown and the McNemar's Chi-Square test.

	Pre-Lockdown		Lockdown		Post-Lockdown		χ^2	χ^2	χ^2
	%	**SD**	**%**	**SD**	**%**	**SD**	**1x2**	**1x3**	**2x3**
Leisure	54	.499	26	.440	52	.500	153.34[c]	.51	189.44[c]
Work	16	.364	11	.319	**22**	.411	8.32[b]	13.63[c]	65.28[c]
Physical Activity	49	.500	27	.442	45	.498	129.80[c]	3.79	120.66[c]
Not Used	11	.316	48	.500	**20**	.402	281.37[c]	26.64[c]	289.46[c]

Note: a = p < .05; b = p < .01; c = p < .001

As it is possible to observe, leisure and physical activity present the highest use of the bicycle both in the pre-lockdown (54 and 49, respectively) and in the post-lockdown (52 and 45, respectively). The work activity presented the lowest percentage of use in all phases, probably due to the distance from the workplace, which must have implied another type of displacement. During the lockdown, naturally, not using the bicycle has the highest percentage (48). Table 01 also presents the statistical comparisons of each activity between the three phases of lockdown using the McNemar test. All activities during the lockdown

showed a statistically lower usage in both the pre-lockdown and post-lockdown stages. Examining the bicycle use before and after the lockdown, while no statistically significant differences were observed in leisure and physical activity, for work and non-use activities in the post-lockdown phase, the percentages of use are statistically higher than in the pre- lockdown.

Then, we analyze the user pattern by gender in the three lockdown stages. To measure this association with each activity in the three phases, considering the dichotomous nature of the variables, we used the phi coefficient (φ) shown in Table 02. As can be seen, there is a strong statistically significant positive association of women with not using a bicycle in all three phases of the lockdown. In the case of male participants, the other activities showed a statistically significant positive association in the three phases, except for leisure in the pre-lockdown and physical activity in the post-lockdown

Table 2. Percentage of responses from male and female participants (coded as 1 and 0, respectively) for cycling in the various activities - "Leisure", "Work", "Physical Activity", and "Didn't Use It" - in the three phases of the “Pre-Lockdown”, “Lockdown” and “Post-Lockdown” pandemic and phi coefficient (φ) to measure the association.

Phase /	**Female** (0)	**Male** (1)	**Phi**	
Activity	%	%	rφ	p
Pre-Lockdown				
Leisure	57.5	51.4	-.061	.082
Work	11.1	**19.3**	.112	.001
Physical Activity	43.6	**53.1**	.095	.007

Not Used	**15.3**	08.0	-.114	.001
Lockdown				
Leisure	20.6	**30.6**	.113	.001
Work	06.9	**15.0**	.125	.001
Physical Activity	20.3	**31.5**	.126	.001
Not Used	**54.7**	42.7	-.119	.001
Post-Lockdown				
Leisure	47.5	**56.4**	.088	.011
Work	15.0	**26.7**	.141	.001
Physical Activity	42.2	47.7	.055	.116
Not Used	**25.8**	15.8	-.124	.001

In order to better understand the interrelationships between the various activities for the use of the bicycle in the different lockdown phases, the data was analyzed with a Smallest Space Analysis (SSA (Guttman, 1991; Roazzi & Souza, 2019; Roazzi, Souza & Bilsky, 2015). That is a subset of the broad family of data analysis called Multidimensional Scaling (MDS), which allows portraying the data's structure spatially. In addition to the content variables, that is, the various activities for the use of bicycles in the different lockdown phases, the gender variable of the participants - male and female - were also included in the map through the method of "external variables as points". The result of this analysis is shown in Figure 1.

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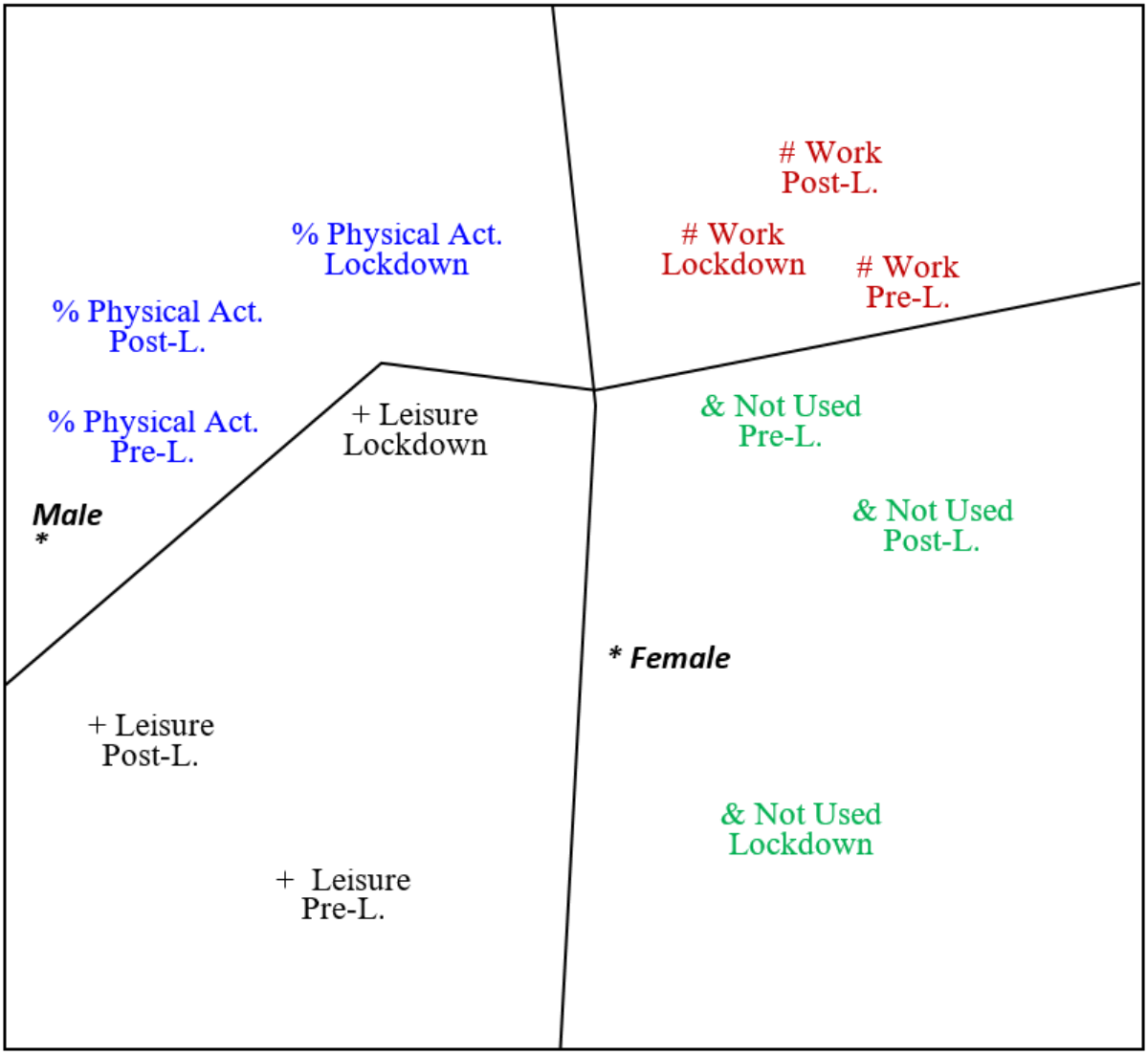

Figure 1. SSA of the participant's responses to the question "What activities did you use the bicycle for?" considering the items Physical Activity, Leisure, Work, Not use in the three phases of the pandemic Pre-Lockdown, Lockdown, and Post-Lockdown considering as external variables Gender (Male and Female) (Jaccard Coefficient; Two-Dimensional Projection, Coefficient of Alienation 0.15)

In Figure 1, the partition of the Euclidean dimensional field of the projection was observed not as a function of the three phases of lockdown but as a function of the four types of activities, which can be easily visualized in four regions that correspond to the four types of

ISSN 1983-3415 (versão impressa) - eISSN 2558 – 1441 (Versão digital)

activities. While on the left side are located the activities with the highest percentages, physical activity above and leisure below, on the right side, have found the activities with the lowest rates, work, that is, work above and not used below. It is interesting to observe that the two activities in the upper part of the physical activity and work projection present a clustering with the items of the three phases much closer than the other activities in the lower regions, which show the items much more dispersed.

Regarding the external variables gender of the participants included in the projection to verify their relationship with the structural organization of bicycle use activities in the three lockdown phases, a very relevant difference is observed, with the male participants located on the left side of the map in the intermediate region between physical activities and leisure, and the female participants are located in the area of non-use activities.

5. DISCUSSION

During the COVID-19, several countries adopted restrictive procedures to mitigate its transmissibility. Social isolation and the individual transport is a vital strategy to reduce the contagious. In this context, bicycles have become one of the safest transport options in this pandemic.

The Brazilian Urban Mobility Policy (Brazil, 2012) prioritizes sustainable public transport and the practice of physical activity. In 2017, according to a survey carried out by the National Association of Public Transport (ANTP), the bicycle was responsible for 3% of all daily trips in Brazil (Aliança Bike, 2021).

According to Guerra (2021), the Northeast is the second Brazilian region with the highest number of bicycles (approximately 7 million units), only behind the Southeast region (with about 15 million). Pernambuco

stands out as the third state in the Northeast with the highest concentration of bicycles (over 1 million). Recife is the second capital of the Northeast with the highest number. Efforts aimed at urban mobility have stimulated bicycles in Recife city, which expand the cycle lanes and Bicycle-sharing system. Since 2013, there has been a 500% increase in the city's network (CTTU, 2021). According to Institute for Transportation and Development Policy (ITDP-Brasil, 2019), 26% of the population of Recife can access cycle lanes, which is the fifth most accessible network among Brazilian capitals.

Long periods of social isolation are related to high mortality rates (Xia and Li, 2018), affect the continuity of physical activities, and cause physical and mental damage (Füzéki et al., 2020). Several studies recommend regular activities during the pandemic (Blume et al., 2020; Deschasaux-Tanguy et al., 2021) as a strategy to mitigate the effects of isolation. Aerobic physical exercises can make people less vulnerable to viral diseases (Jiménez-Pavón, Carbonell-Baeza, and Lavie, 2020; Lee et al. 2014), providing physical and psychological benefits and an increase in the quality-of-life population (Nieuwenhuijsen & Rojas-Rueda, 2020).

Cycling, in any dose-response relationship (Oja et al. 2011; Østergaard, Jensen, Overvad, Tjønneland, and Grøntved, 2018), has emerged as a potent activity for the reduction of cardiovascular disease (Nordengen, Andersen, Solbraa, and Riiser, 2019), type 2 diabetes (Rasmussen et al. 2016), cancer (Celis-Morales et al. 2017), and maintenance of cognitive resources (Leyland et al. 2019).

As in other modes of transport (Bucsky, 2020; Falchetta & Noussan, 2020), bicycles presented changes in their use during the pandemic periods (Nikiforiadis et al., 2020). We observed some changes in the bicycle use frequency. The government's restrictive global sanitary

measures aimed at containing the increase in the number of cases and deaths caused by COVID-19 could explain part of this phenomenon.

After the lockdown period, there is evidence of recovery in bicycle use, but the number does not return to the level identified in the pre-lockdown period. Several hypotheses can justify this finding, such as people with comorbidities works in the home and virtual classes.

Despite the evident variation in frequency, the purpose of use has not changed. In the three-time periods, bicycles for leisure remained the first, followed by physical activity and work. This finding differs from the studies by Kaviti et al. (2019) and McKenzie (2019), who observed that uses related to leisure are less frequent than uses related to work. According to Miñano and Santos (2015), the shared bicycle modal replaced many journeys on foot (30% of total trips by bicycle would have been made on foot). However, findings such as the one by Fuller (2021) indicate that the use for recreational purposes increased during the COVID-19 pandemic periods, corroborating our results. One of the hypotheses for this finding may be associated with the imposition of restriction and social isolation, having, from the use of the bicycle, the opportunity to leave the house, to get around, to perform physical activity and, mainly, to rescue the feeling of freedom.

When analyzed by gender, the pattern of use changed significantly. In the period before the lockdown, women used the bicycle more than men for leisure purposes. This situation was reversed in the two subsequent moments, diverging from the result found in the Fuller study (2021). A possible explanation may be related to urban violence experienced in Recife. Data from the stolen bicycle registry show a 78% increase in stolen bicycles in Recife in 2020 (CNBR, 2020). In a study carried out in the Netherlands, encompassing financial, safety and physical factors, they pointed out that men are more inclined to take risks than women (Cobey et al., 2013). There were no significant differences

between the periods for work and physical activities, with men prevailing as the most frequent user.

The results showed that the lowest use of bicycles was on commuting to work. Even so, there was a slight increase in frequency in the post-lockdown period. The lack of cycling infrastructure may be responsible for the low use of this modal for commuting trips.

The open questions of the questionnaire indicated as challenges the lack of structure and integration between other modes. In this way, an increase in the network can make it more viable to use it daily commuting to work. Along these lines, Furth, Putta and Moser (2018) state the benefits of improving alternatives for connecting the population to employment centres to use bicycles. It is clear from the study presented that it is vital to check the work centres and provide accessible roads for safe cycling. At the same time, the authors state that different populations have different types of behaviour for the use of bicycles to work and that even with a viable structure for using bikes, long distances result in a low propensity for cycling to work.

The challenges pointed out by women in using bicycles during the coronavirus pandemic were different, as they chose the lack of traffic safety and urban violence concerning bicycle theft. These data may be one of the reasons for the higher percentage of non-use of bicycles by women during the pandemic period. Data from the stolen bikes registry show a 78% increase in stolen bikes in Recife in 2020. Another critical data is the number of injured and killed cyclists in traffic. According to Ernst, M. (2011), traffic deaths and injuries are growing health problems, bringing economic losses and social stress. Another relevant piece of data presented in the study by Chia-Yuan (2014) is the correlation between the number of cyclist accidents and the poverty rate. The study states that areas with high poverty rates have a higher number of cyclist accidents and deaths. In conclusion, improving public safety and traffic

safety policies help to increase the use of bicycles by women. The data suggest the improvement of public safety policies with rounds on the main routes and the expansion of investment in traffic education and traffic moderation measures, such as, for example, reducing the speed of roads.

6. CONCLUSIONS

The COVID-19 pandemic, brought about profound changes in social behaviour, aggravated by quarantine measures and restrictions on individual freedom. The economic and social repercussions culminated in the global decline in the physical and mental health of populations. The practice of systemic physical activities endorsed by the WHO as a coping strategy for these harmful effects revealed the need for interdisciplinary approaches that encourage active transport, such as cycling. This appears to be a global trend supported by the potential benefit of global health status evidenced by the scientific literature.

The data revealed and discussed in this research have as a primary limitation the convenience of the sample, subjecting it to selection bias because they were sampled in a Brazilian city. Thus, the study is not representative of the behaviour of the Brazilian population as a whole but only of the sampled universe. Accordingly, new studies are being developed using a sample from all country regions, taking into account the climate issues and the others pointed out in this study.

This prospective study revealed differences in motivations for cycling that can support interventions and guidelines for public mobility policies and efficient programmatic approaches. Encouraging the use of bicycles is beneficial for physical and mental health and, consequently, for the population's quality of life. Since COVID-19 is an essentially respiratory disease that compromises lung capacity and aggravates comorbities, activities such as cycling are essential to rehabilitate and

preserve lung saturation, strengthen heart function and reduce blood sugar. In addition, their practice can also contribute from an environmental, social and economic point of view. Thus, it is crucial to invest and encourage the use of this modal for travel, regardless of its purpose.

ACKNOWLEDGEMENTS

The authors of this study would like to thank Tembici, especially Renata Rabello, for the help on spreading our questionnaire with the users of Bike-PE sharing system.

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Recebido: 27.12.2022 Aceito: 29.12.2022 Publicado: 01.01.2023

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Revista AMAzônica, LAPESAM/GMPEPPE/UFAM/CNPq
ISSN 1983-3415 (versão impressa) - eISSN 2558 – 1441 (Versão digital)

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