Case Studies on Transport Policy 12 (2023) 100998

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

Travel behavior and activity resilience regarding the COVID-19 pandemic in Brazil: An approach based on smartphone panel data

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ARTICLE INFO

Keywords:
Cluster analysis
Resilience
Case study
Disruptive event
Remote activities
Post-pandemic scenario

ABSTRACT

The COVID-19 pandemic has caused significant changes around the world. The circumstances resulted in a radical shift in people's lives, including the way they move around the cities and/or carry out their activities. This study carries out a travel behavior analysis using commuting panel data collected over 7 days using smartphones. The study focuses on the Maceió Metropolitan Area (MMA), which is in the state of Alagoas in the northeast region of Brazil. Cluster analysis, using the k-means algorithm, divided the sample into three groups of travel behavior: Group A ("Infrequent travelers, for work or shopping trip purposes and very prone to do remote work"), Group B ("Intermediate travelers, for work or shopping trip purposes and prone to do remote work"), and Group C ("Frequent travelers, for work or meal purchases and not likely to do remote work"). Groups B and C are predominantly formed by individuals who carry out activities that are less likely to do remote work. By analyzing the groups, it is possible to understand the changes that occurred during the period studied (September/October 2020) and what are the expectations for a post-pandemic scenario, associated with each behavioral group. It was observed that "Working" was the main trip purpose during the pandemic and that the possibility of teleworking depends on the type of activity carried out. Making a scale of the resilience of activities considering the replacement of out-of-home activities by in-home remote activities, it can be observed that Group A was the most resilient, followed by Group B and C, respectively. For the post-pandemic scenario, Groups A and B are also the most likely to use Information and Communication Technologies (ICTs) and continue carrying out other remote activities, such as grocery shopping and meals, replacing, in the future, predominantly trips using ICTs.

1. Introduction

To accomplish their daily activities, people follow multiple patterns of commuting. Schönfelder and Axhausen (2003) report that individual daily behaviors particularly depend on individuals' habits and routines. Therefore, under normal conditions, behavioral changes do not occur very often. An external event is necessary for habitual routines to be disruptive, such as a change of job, place of residence or a pay rise (De Haas et al., 2020; Oakil et al., 2011; Pitombo et al., 2009). There are also disruptive events that change the behavior of several individuals at the same time, such as natural disasters and the occurrence of epidemics and pandemics. These changes can be temporary or permanent.

In this context, several studies (Aloi et al., 2020; Beck et al., 2020; De Haas et al., 2020; De Vos, 2020; Jenelius and Cebecauer, 2020; Lucchesi et al., 2022; Molloy et al., 2020; Parady et al., 2020; Pedreira Junior et al., 2022; Rodrigues da Silva et al., 2023; Shamshiripour et al., 2020) have been carried out to understand the impact of the SARS-COV2 virus and the pandemic on travel behavior. The first sector to suffer the impacts of these measures was the tourism sector, thus it was in this area that the first studies emerged. According to the United Nations World Tourism Organization (UNWTO) report, carried out on 6 April 2020, 96% of all destinations worldwide have introduced travel restrictions (UNWTO, 2020). International travel bans affected more than 90% of the world's population and tourism had largely come to halt in March 2020 (Gössling et al., 2020).

The non-pharmacological measures adopted also affect individual behavior regarding the performance of daily trips. Studies have pointed to important changes in individual behavior, especially concerning their commuting patterns during the pandemic. During the critical phases of the coronavirus crisis, there was a reduction in activities carried out outdoors and in indoor public places, an increase in the preference for using individual travel modes compared to public or shared travel modes, and the most long-distance trips started to be made using cars (De Haas et al., 2020; De Vos, 2020; Fatmi, 2020; Jenelius and

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https://doi.org/10.1016/j.cstp.2023.100998
Received 19 March 2022; Received in revised form 31 October 2022; Accepted 25 March 2023
Available online 30 March 2023

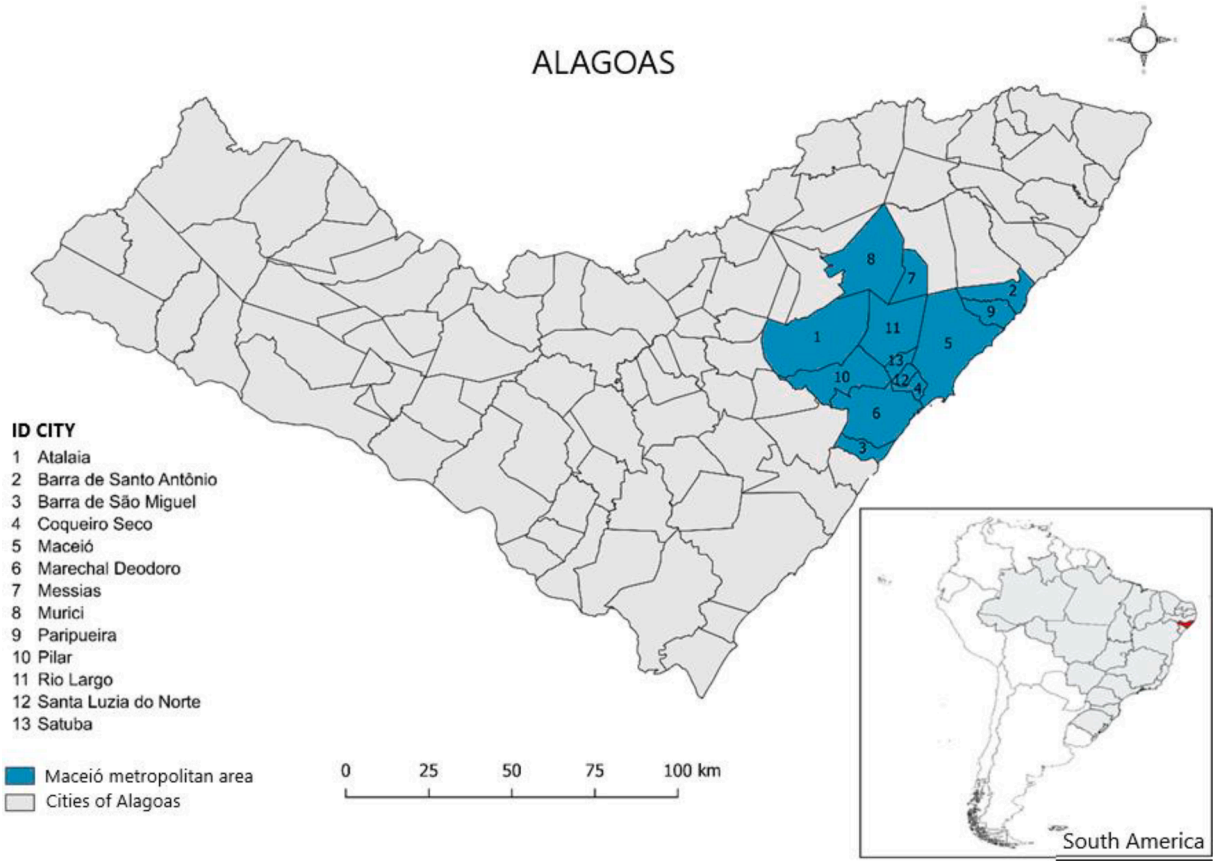

Fig. 1. Maceió Metropolitan Area (Alagoas - Brazil). Source - (IBGE, 2019) - Municipal Network 2019 Prepared by: Authors.

Cebecauer, 2020; Parady et al., 2020). These travel patterns have also been observed in other pandemics and epidemics (Blendon et al., 2008; Cowling et al., 2010; Goodwin et al., 2011; Ives et al., 2009; Jones and Salathé, 2009; Kim et al., 2017; Lau et al., 2003; Liao et al., 2015; Sadique et al., 2007).

New habits can be established when individuals are willing to try something new or are driven by some external factor. The COVID-19 pandemic is occurring in a world where technology is increasingly present and because of social distancing, people have had to use it to carry out their activities. There was a significant increase in remote work and remote learning, and a reduction in face-to-face public events (Beck and Hensher, 2020; Parady et al., 2020; Shamshiripour et al., 2020).

After experiencing this new scenario, there is a strong tendency for teleworking to continue to exist, albeit on a smaller scale, after the pandemic (Beck et al., 2020; De Haas et al., 2020; Shamshiripour et al., 2020), especially if individuals have an adequate structure to carry out their activities in the domestic environment and if employers encourage remote work. Thus, providing positive future impacts on mobility, considering the reduction of work trips (Beck et al., 2020; Shamshiripour et al., 2020).

It is worth mentioning the non-travel concept, or many activities within the household, showing the resilience of carrying out activities (in an ICTs usage context) despite the impediment of physical displacement, as a change that can possibly remain, on a smaller scale, in a post-pandemic scenario. It is noteworthy that the coronavirus crisis has different effects in different countries, depending on the number of cases observed, the response capacity of health systems, adopted government policies, and previous behavioral trends (De Haas et al., 2020).

In January 2022, Brazil had 24,560,093 confirmed cases of SARS-CoV-22 (Johns Hopkins, 2022a), ranked fourteenth in the number of deaths per 100 K inhabitants (296.00/100 K pop) (Johns Hopkins, 2022b) and 70.73% of the population were fully vaccinated (Johns Hopkins, 2022a). When the COVID-19 pandemic hit Brazil, the transportation sector was still recovering from the Brazilian economic recession (CNT, 2020). The first transportation category impacted was air transport, which, according to the National Civil Aviation Agency (*Agência Nacional de Aviação Civil - ANAC*), in 2020 had the worst annual result in demand for domestic flights since ANAC started its historical series in 2000. Compared to 2019, the drop in demand for domestic flights was 48.7% in 2020 and for international flights was 71% in 2020 (ABEAR, 2021). Comparing 2020 with 2019, the supply of domestic flights fell by 47% and the supply of international flights dropped by 62.6% (ABEAR, 2021).

The Brazilian subway and train sector also faced drastic drops in demand; the worst period was the second quarter of 2020 when demand decreased by 74.2% (ANPTrilhos, 2021). The National Association of Passenger Transporters (*Associação Nacional dos Transportadores de Passageiros - ANPTrilhos*) indicated in its balance sheet of the Brazilian subway sector 2020/2021 that, during the pandemic period from March to December 2020, the subway-railway demand decreased by 55.9% compared to the same period in 2019 (ANPTrilhos, 2021). Public transport by bus, which was already facing a significant drop in the number of users due to an increased demand for ridesourcing services and other reasons, had a demand reduction of 80% at the beginning of the pandemic (end of March 2020). Users began to return gradually, but until February 2021 the public transport sector by bus had not yet returned to the pre-pandemic level of demand. In February 2021, demand was 40% lower than in the same month in 2019 (NTU, 2021).

The present study aims to analyze the travel behavior in a pandemic period adopting an approach based on panel data from a passive collection by smartphones and Cluster Analysis. This paper presents an analysis of the behavior observed during a pandemic period (September/October 2020) for seven consecutive days in a Brazilian context. It was observed that some behavioral patterns occurred

Table 1
Summary of the data collected.

Information	Origin
Latitude, longitude, date, and time	Smartphone's map app
Distance and travel time, speed, degree of motorization and recurrence, total days with travel and days at home, total number of trips made, average travel distance.	Information derived from the smartphone's data mentioned above
Socioeconomic information - age, gender, activity, income, household composition, number of cars and motorcycles;	Questionnaire
Commuting habits - frequency of trips and main travel mode used before and during the pandemic;	
Information about work and study - interruption of in-person activities, degree of satisfaction and remote working conditions;	
Resilience of activities – how they intend to carry out their work activities, grocery shopping and meal purchases after the pandemic, the company where they work intends to adopt a home office regime after the pandemic.	

regardless of being a pandemic period or not. Moreover, it was found that some behavioral patterns are typical of disruptive events. Important contributions regarding the resilience of activities were observed, such as the relationship between the type of occupation performed and the travel behavior of individuals during the pandemic. In addition, possible scenarios may be forecasted for the post-pandemic period based on the individuals' travel intentions and the conduct of the companies they work for.

It is critical that decision makers, as well as urban and transport planners understand the changes and positive impacts on mobility introduced by the COVID-19 pandemic. Part of these changes are ephemeral, that is, they last for as long as the sanitary measures to contain the spread of the virus are maintained or until a new scenario of normality is established. Maintaining, at least partially, some of the positive impacts observed on mobility, due to the implementation of transport policies, is one of the great challenges for the post-crisis period.

This paper consists of 4 sections, in addition to this introduction. Section 2 describes the materials and method followed in the study. In Section 3, the results are presented, divided into 6 subsections: Sample analysis; Clusters and commuting over seven days, Clusters and socio-economic characteristic, Clusters, place of residence, and distance to work, Clusters, activity resilience, and post-pandemic behaviors, and Synthesis of behavioral groups. Section 4 describes the methodological constraints, and the last section of this article draws the conclusions of the study.

2. Materials and method

The database of this research consists of panel data from the passive collection by smartphone carried out in September and October 2020 with 101 residents of the Maceió Metropolitan Area - MMA (Alagoas - Brazil) for seven consecutive days. The MMA is in the northeast region of Brazil (Fig. 1). During this period, the region was in a less restricted phase of controlled social distancing, where commercial establishments, such as shopping malls, stores, bars, and restaurants, could operate at reduced hours and with 50% of their capacity in September and 75% in October. Gyms and fitness centers were allowed to operate at 50% of capacity. Intercity and tourist transport was also allowed, if operating at up to 50% of its capacity and with open windows. During this period, face-to-face meetings with more than 10 people were still prohibited. Essential activities were not interrupted at any phase of controlled social distancing (Alagoas, 2020).

The MMA (Fig. 1) includes the following municipalities: Atalaia, Barra de Santo Antônio, Barra de São Miguel, Coqueiro Seco, Maceió, Marechal Deodoro, Messias, Murici, Paripueira, Pilar, Rio Largo, Santa Luzia do Norte and Satuba.

According to the latest survey conducted by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística - IBGE*), the MMA had an estimated population of 1,346,973 in 2020 (IBGE, 2020). Maceió, which is the capital of the state of Alagoas, is the most populous municipality with 1,025,360 inhabitants. In addition, MMA has a land area of 2,877,304 km^2 and a GDP of approximately R $26.5 billion (US$4.8 billion on 10/14/2021 currency rate).

The methodological procedures followed in this research have six steps: data collection via smartphones; composition of the data panel;

Table 2
Trip-chaining example.

	Travel chain	Number of trips
day 1	['home']	0
day 2	['home']	0
day 3	['home']	0
day 4	[(1, 'NR'), (1, 'R'), (1, 'NR'), (0, 'R')]	4
day 5	[(0, 'NR'), (1, 'NR'), (1, 'NR'), (0, 'R')]	4
day 6	['home']	0
day 7	['home']	0
Total	['home'], ['home'], ['home'], [(1, 'NR'), (1, 'R'), (1, 'NR'), (0, 'R')], [(0, 'NR'), (1, 'NR'), (1, 'NR'), (0, 'R')], ['home'], ['home']	8

Table 3
Attributes obtained from the trip-chaining presented in Table 2.

Attribute	Value
Degree of motorization	63%
Degree of recurrence of locations	38%
Total number of trips	8
Average commuting distance (m)	1966
Days with commuting	29%
Days at home	71%
(Days at home) / (Days with commuting)	2.5

Date	Hour	Latitude	Longitude	Distance (m)	Time (s)	Speed (m/s)	Speed (km/h)	Motorization	Recurrence
11/09/2020	21:19	-9.7559478	-35.872125	1395.975	1620	0.86	3.10	0	R
11/09/2020	22:42	-9.7559478	-35.872125	1395.741	360	3.88	13.96	1	R
11/09/2020	22:48	-9.7683808	-35.870374	1395.741	1260	1.11	3.99	0	NR
11/09/2020	23:16	-9.767897	-35.870756	3275.354	960	3.41	12.28	1	R

0: non-motorized travel mode; 1: motorized travel mode; R: recurring location; NR: non-recurring location

Fig. 2. Example of obtaining time, distance and average speed of commuting, motorization, and recurrence of locations.

Table 4
Sample characterization: socioeconomic.

Year	2020				
Total number of individuals	101		**Gender**	n	%
Age			Male	47	47%
Average	36		Female	54	53%
Income			**Main occupation**		
	n	**%**		**n**	**%**
No income	17	17%	Student	36	26%
0–2 minimum wages	37	37%	Intern	7	5%
2–4 minimum wages	27	27%	Housewife	17	12%
4–6 minimum wages	12	12%	Unemployed	4	3%
6–8 minimum wages	6	6%	Retired or pensioner	8	6%
8–10 minimum wages	1	1%	Employee	47	33%
Above 10 minimum wages	1	1%	Freelance	15	11%
		Employer or entrepreneur	Freelance	7	5%
Household composition					
	n	**%**			
1 person	5	5%	**Number of children under 12 years old**		
2 people	16	16%		**n**	**%**
3 people	24	24%	0 children	76	75%
4 people	35	35%	1 child	22	22%
5 people	18	18%	2 children	3	3%
6 people	2	2%			
7 people	1	1%			
Number of vehicles at home					
Cars	**n**	**%**	**Motorcycles**	**n**	**%**
0	28	28%	0	94	93%
1	45	45%	1	7	7%
2	21	21%	2	0	0%
3	4	4%	3	0	0%
More than 3	3	3%	More than 3	0	0%
Activities interrupted due to COVID-19					
Work	**n**	**%**	**Study**	**n**	**%**
Yes	20	20%	Yes	34	34%
No	39	39%	No	7	7%
Partially	19	19%	Partially	10	10%
Not applicable	23	23%	Not applicable	50	50%

construction of trip-chaining; application of k-means algorithm; analysis of the different behavioral groups obtained; and complementary analysis regarding the resilience of activities.

2.1. Data collection via smartphones and data panel composition

To perform the passive collection of displacement data by smartphone, the participants were instructed to activate the "location history" tool in the Maps application of their devices. When the "location history" is activated, the device starts to accumulate and store information of time, latitude and longitude referring to the displacements performed. Participants were asked to maintain the tool activated for a period of 7 days. At the end of the collection period, the user submitted their data, anonymously, on an online platform, implemented to accumulate this data and compose the data panel. It is noteworthy, that participants agreed to participate through a free consent form, which ensured their privacy and anonymity of information.

During the data submission, participants answered a questionnaire that was designed to trace their socioeconomic profile (age, gender, education, activity, income, household composition, number of cars and motorcycles) and to investigate commuting habits (frequency of travel and travel mode used before and during the pandemic). In this questionnaire, it was also asked whether the respondent's face-to-face study and/or work activities were interrupted due to the COVID-19 pandemic. In a supplementary survey, participants answered questions about their work activity, indicated the degree of satisfaction and conditions of remote work, and informed how they intend to carry out their work activities, grocery shopping and meal purchases after the pandemic. Table 1 summarizes all the information collected considering the questionnaires and smartphones.

Table 5
Sample characterization: data collected by smartphones.

Period of data collection	Sep/Oct 2020		
	Average	Maximum	Minimum
Total number of trips	31	128	0
Days at home	2	7	0
Days with displacement	4	7	0
Total displacement (m)	42,067	450,102	0
Average travel distance (m)	1.622	29,803	0
Total motorized trips	22	88	0
Total non-motorized trips	10	51	0
Total trips to recurring locations	4	54	0
Total trips to non-recurring locations	27	94	0
Motorized - recurring	2	31	0
Motorized - non-recurring	19	72	0
Non-motorized – recurring	2	23	0
Non-motorized – non-recurring	8	42	0
Number of days	**At home**	**Days with displacement**	
0	30%	7%	
1	14%	13%	
2	18%	8%	
3	13%	8%	
4	7%	11%	
5	6%	14%	
6	8%	13%	
7	5%	27%	

To align the unprocessed data with the research objectives, preprocessing was carried out following the techniques presented in the studies by Assirati (2018), Assirati and Pitombo (2019), Pedreira Junior et al. (2021) and Ciriaco (2022). For the pre-processing step, an algorithm was developed in Python language whose purpose was, from the unprocessed data, grouping time and distance to identify the places of activities of the individuals.

This agglutination is essential because when an individual remains in a certain place for a long time, there is a generation of many spatially close georeferenced points. As all these consecutive records refer to the same location, they need to be agglutinated. To promote this agglutination, a geographic fence is defined, which in this study was adopted at a value of 250 m. Once the fence is defined, the algorithm agglutinates all consecutive records that are inside it and replaces the agglutination with a single record that has the geographic coordinates of the first point.

From the georeferenced data, the travel time and distance between two locations, average travel speed, travel mode choice (motorized/non-motorized) and recurrence of locations (recurring or non-recurring location) were obtained. Fig. 2 illustrates how this information is obtained. To determine whether a location is recurrent or not, it is verified whether a given location - latitude and longitude - is repeated over the seven days. Moreover, to indicate whether the displacement was performed using a motorized or non-motorized travel mode, the average speed of displacement is verified. If the speed is above 6 km/h, the individual used a motorized mode, below 6 km/h and greater than 3 km/h non-motorized mode and speed below 3 km/h, the individual is considered to be stationary (this cut-off value was adopted to increase the accuracy of the displacements).

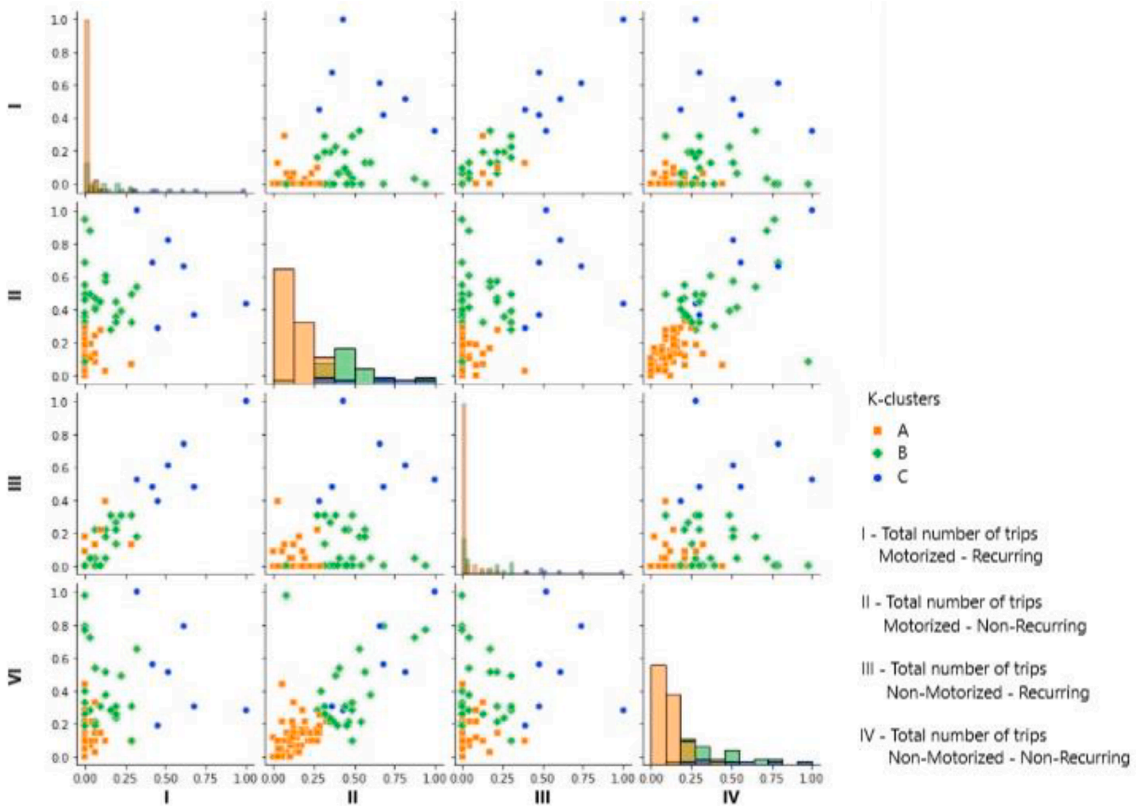

Fig. 3. Clustering established by the k-means algorithm.

2.2. Composing trip-chaining

After composing the complete panel, trip chains were built. They were used in the investigation stage of individual behaviors. In this paper, trip-chaining is defined as a sequence of displacements performed by each individual throughout seven days. Each day generates a trip chain, and the concatenation of these daily trip chains generates the individual's total trip-chaining. For the construction of the chains, two characteristics were concatenated: motorization and recurrence of locations. As during the pandemic, people commonly stayed at home more often, for the days when there were no trips, a "home" label was assigned to the chain.

Thus, in this study, a trip chain can be formed by a set of the following encodings:

- [1; R]: motorized travel mode to a recurring location
- [1; NR]: motorized travel mode to a non-recurring location
- [0; R]: non-motorized travel mode to a recurring location
- [0; NR]: non-motorized travel mode to a non-recurring location
- [home]: non-travel (individual stayed at home).

Table 2 illustrates an example of composing an individual's trip-chaining.

From the trip chains and the data panel, the following information was obtained:

- Degree of motorization, which is the ratio between the number of motorized commuting and the total number of label pairs
- Degree of recurrence of locations, which is the ratio between the number of commuting to recurring locations and the total number of label pairs
- Total number of trips made (the total number of labels pairs)
- Average commuting distance, which is the average of the distances of all commuting performed (information obtained from the data panel)
- Percentage of days with commuting
- Percentage of days spent at home (non-travel)
- Ratio between days spent at home and days commuting.

Table 3 provides an example of the attributes listed above obtained for the trip chaining of Table 2.

To measure individual travel behavior, the attributes listed above and the characteristics from the questionnaire were used.

2.3. k-means Clustering algorithm

In this paper, for the composition of the clusters, a vector of characteristics was defined that incorporates the total number of trips performed by each participant for each type of label pair from the generation of the chains:

- Motorized - Recurring [1, A]
- Motorized - Non-recurring [1, NR]
- Non-motorized - Recurring [0, A]
- Non-motorized - Non-recurring [0, NR]

It was considered that these characteristics should have the same analytical weight, to prevent the magnitude of the highest values from imposing a wrong trend in the process of partitioning the groups. Therefore, the values were normalized thus the vector of characteristics had all values between 0 and 1. Finally, to determine the optimal number of groups, the Elbow algorithm was used (Thorndike, 1953).

2.4. Cluster analyses, activity resilience, and post-pandemic behaviors

In order to understand the behavioral similarities and differences

Table 6
Summary of the characteristics of the groups and the total sample: data collected by smartphones.

		GA	GB	GC	TS*
Group Nomenclature		Infrequent travelers, for work or shopping trip purposes and very prone to do remote work	Intermediate travelers, for work or shopping trip purposes and prone to do remote work	Frequent travelers, for work or meal purchases and not likely to do remote work	
Total number of individuals		69	26	6	101
TOTAL NUMBER OF TRIPS		**GA**	**GB**	**GC**	**TS***
Average		14	59	99.5	31
Minimum		0	39	56	0
Maximum		38	94	128	128
Percentage of days at home					
0 day		5.80%	80.77%	83.33%	30%
1 day		13.04%	19.23%	0%	14%
2 days		24.64%	0%	16.67%	18%
3 days		18.84%	0%	0%	13%
4 days		10.14%	0%	0%	7%
5 days		8.70%	0%	0%	6%
6 days		11.59%	0%	0%	8%
7 days		7.25%	0%	0%	5%
AVERAGE TRIP DISTANCE (m)					
		GA	**GB**	**GC**	**TS***
		1,829.37	1,243.62	872.08	1,621.72
MOTORIZED AND NON-MOTORIZED DISPLACEMENT					
		GA	**GB**	**GC**	**TS***
Motorized	average	10.42	40.58	66.5	21.51
	maximum	29	60	88	88
	minimum	0	7	39	0
Non-Motorized	average	4.59	18.35	33	9.82
	maximum	19	42	51	51
	minimum	0	8	17	0
RECURRING AND NON-RECURRING PLACES					
		GA	**GB**	**GC**	**TS***
Recurring	average	0.87	5.62	33.17	4.01
	maximum	13	16	54	54
	minimum	0	0	23	0
Non-Recurring	average	14.14	53.31	66.33	27.33
	maximum	38	94	94	94
	minimum	0	36	33	0
AVERAGE OF TYPES OF TRIPS					
		GA	**GB**	**GC**	**TS***
Motorized – Recurring		0.39	3.15	19.00	2.21
Motorized - Non-Recurring		10.03	37.42	47.50	19.31
Non-Motorized – Recurring		0.48	2.46	14.17	1.80
Non-Motorized - Non-Recurring		4.12	15.88	18.83	8.02

*TS = total sample

Table 7
Summary of socioeconomic characteristics of groups and total sample.

	GA	GB	GC	TS*
AGE				
Average	37	36	26	36
Median	30	34	29	30
GENDER				
Masculine	33% (49%)	77% (43%)	67% (9%)	47%
Feminine	67% (85%)	23% (11%)	33% (4%)	53%
Student	25% (67%)	26% (28%)	25% (6%)	26%
Housewife	14% (76%)	11% (24%)	0% (0%)	12%
Retired	5.3% (63%)	7.9% (37%)	0% (0%)	5.7%
Unemployed	4.2% (100%)	0% (0%)	0% (0%)	2.8%
Employee	35% (70%)	32% (26%)	25% (4%)	33%
Freelancer	8% (53%)	16% (40%)	13% (7%)	11%
Employer or Entrepreneur	4% (57%)	3% (14%)	25% (29%)	5%
INCOME				
no income	19% (76%)	12% (18%)	17% (6%)	17%
0–2 minimum salaries (0 - $398.92 – Sep 2021 currency)	35% (65%)	50% (35%)	0% (0%)	37%
2–4 minimum salaries ($398.92 - $797.85 – Sep 2021 currency)	29% (74%)	12% (11%)	67% (15%)	27%
4–6 minimum salaries ($797.85 - $1196.77 – Sep 2021 currency)	13% (75%)	8% (17%)	17% (8%)	12%
6–8 minimum salaries ($1196.77 - $1595.69 – Sep 2021 currency)	3% (33%)	15% (67%)	0% (0%)	6%
8–10 minimum salaries ($1595.69 - $1994.61 – Sep 2021 currency)	1% (100%)	0% (0%)	0% (0%)	1%
Above 10 minimum salaries (Above $1994.61 – Sep 2021 currency)	0% (0%)	4% (100%)	0% (0%)	1%
HOME COMPOSITION				
1 person	4% (60%)	4% (20%)	17% (20%)	5%
2 people	17% (75%)	15% (25%)	0% (0%)	16%
3 people	30% (88%)	12% (13%)	0% (0%)	24%
4 people	32% (63%)	42% (31%)	33% (6%)	35%
5 people	16% (61%)	19% (28%)	33% (11%)	18%
6 people	0% (0%)	4% (50%)	17% (50%)	2%
7 people	0% (0%)	4% (100%)	0% (0%)	1%
Number of children under 12 years old				
0	83% (75%)	62% (21%)	50% (4%)	75%
1	17% (55%)	27% (32%)	50% (14%)	22%
2	0% (0%)	12% (100%)	0% (0%)	3%
NUMBER OF CARS IN THE HOUSEHOLD				
0	35% (86%)	12% (11%)	17% (4%)	28%
1	42% (64%)	50% (29%)	50% (7%)	45%
2	17% (57%)	35% (43%)	0% (0%)	21%
3	3% (50%)	0% (0%)	33% (50%)	4%
More than 3	3% (67%)	4% (33%)	0% (0%)	3%
NUMBER OF MOTORCYCLES IN THE HOUSEHOLD				
0	96% (70%)	96% (27%)	50% (3%)	93%
1	4% (43%)	4% (14%)	50% (43%)	7%
IN-PERSON WORK ACTIVITIES INTERRUPTED DUE TO COVID-19				
Yes	22% (75%)	19% (25%)	0% (0%)	20%
No	30% (54%)	58% (38%)	50% (8%)	39%
Partially	20% (74%)	12% (16%)	33% (11%)	19%
Not applicable	28% (83%)	12% (13%)	17% (4%)	23%
IN-PERSON STUDY ACTIVITIES INTERRUPTED DUE TO COVID-19				
Yes	35% (71%)	27% (21%)	50% (9%)	34%
No	6% (57%)	12% (43%)	0% (0%)	7%
Partially	10% (70%)	12% (30%)	0% (0%)	10%
Not applicable	49% (68%)	50% (26%)	50% (6%)	50%

*TS = total sample.
Values in parentheses refer to percentage in relation to the total sample. The values outside the parentheses refer to the percentage within the group.

between the groups established by the k-means algorithm, a comparative analysis was performed between the socioeconomic and displacement characteristics of each group. Additionally, an analysis of the resilience of activities during the pandemic was also carried out, in which we seek to understand the behavior of each of the groups during the pandemic and how they intend to carry out their activities in a post-pandemic scenario.

3. Results and discussion

This section presents the characterization of the complete sample, the results of the cluster generated by the k-means algorithm, highlighting the socioeconomic characteristics and displacements of each group, as well as activity resilience analyses.

3.1. Sample analysis

Table 4 presents a summary of socioeconomic characteristics of the total sample, which comprises 101 individuals. As can be seen in Table 4, there is an almost uniform distribution between the male (47%) and female (53%) genders. Regarding age, the average age is 36 years. As for the composition of the household, in 2020, 58% of the sample lived in a household comprising 3 or 4 people and 75% of households do not have children. It can also be observed that, in 2020, 63% of the sample earned between 0 and 4 minimum wages. Regarding the activity they perform, in 2020, 26% of the sample were students and 49% were employed, self-employed or entrepreneurs. Regarding the influence of the COVID-19 pandemic on face-to-face study activities, 34% of the participants indicated that, in September/October 2020, their in-person study activities were fully interrupted and 10% partially interrupted. In addition, regarding in-person work activities, 39% of the participants normally carried out their in-person activities in September/October 2020, and 39% had their in-person activities totally or partially interrupted.

Table 5 presents the characterization of the Sample related to displacement information obtained from data collected by smartphones.

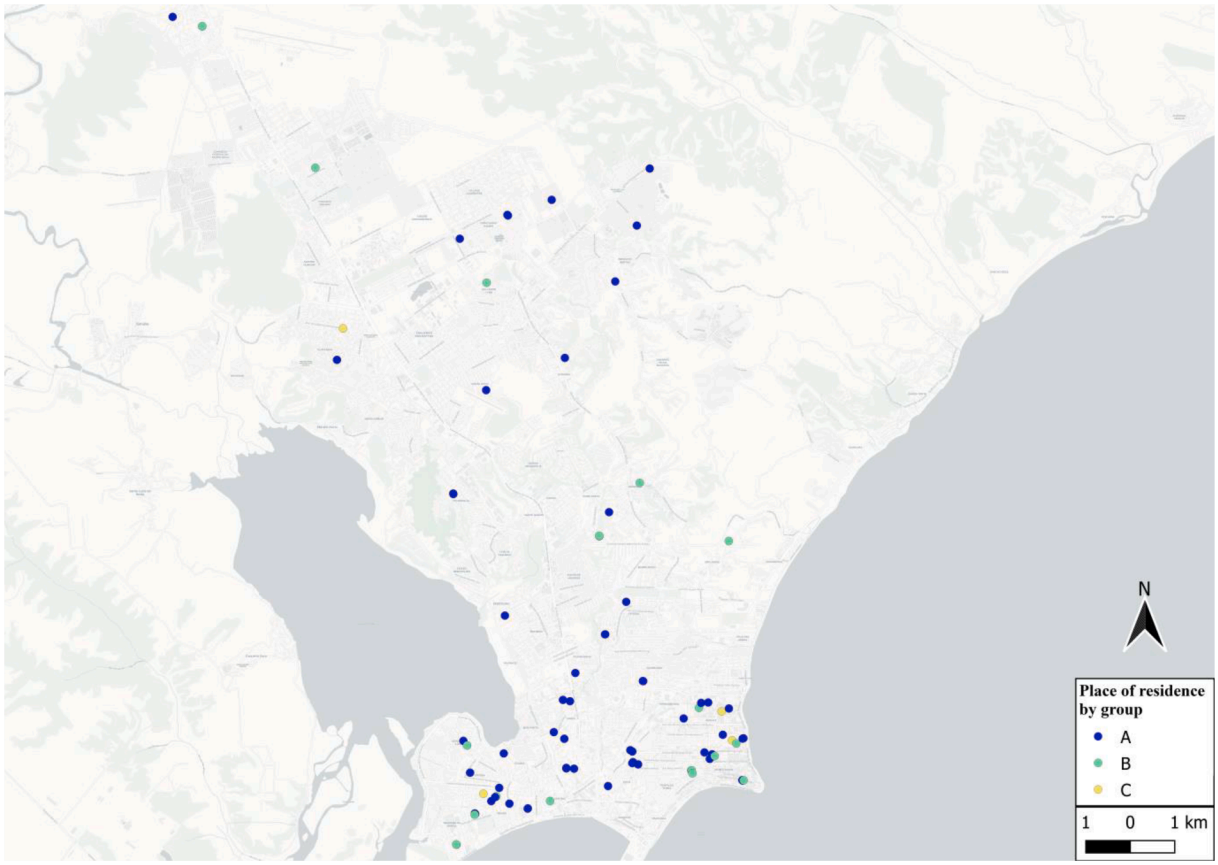

Fig. 4. Place of residence by group.

According to the data obtained from the map application on the participants' smartphones (Table 5), in September/October 2020, the individuals in the sample made an average of 31 trips per week, 22 of which were motorized and 10 non-motorized. Regarding the recurrence of location, individuals made an average of 4 trips to recurring locations and 27 trips to non-recurring locations. It is worth mentioning that the algorithm counts the distance between two consecutive georeferenced points as displacement, and that, despite the cutoff values adopted to increase the accuracy of correct displacements (about 250 m and speed above 3 km/h), the number of trips in this type of collection is high, especially in case studies in larger cities that have congestion and a greater number of traffic lights. However, although the number of trips is not precise, there are no losses in relation to the groups' characterization.

3.2. Clusters and commuting over seven days

As can be seen in the Voronoi diagram (Fig. 3), the k-means algorithm successfully segmented the elements into 3 distinct groups of commuting patterns (Group A - GA, Group B - GB and Group C - GC). The result obtained must be considered effective, as the Voronoi cells (a region demarcated by elements belonging to the same class) are well delimited, presenting little or almost no superposition of elements belonging to different groups.

Table 6 presents a summary of the characteristics of the groups and the total sample related to the data collected by smartphones.

As can be seen in Table 6, according to the data obtained from the map application of the participants' smartphones, in September/October 2020, the individuals in the sample made an average of 31 trips per week, of which about 22 were motorized and 10 were non-motorized. Displacements above 250 m are considered travel (which was the value adopted for the geographic fence). As for the recurrence of location, individuals made an average of 4 trips to recurring locations and 27 trips to non-recurring locations. When analyzed by motorization and recurrence pair, individuals made nearly 8 times more motorized trips to non-recurring locations (19.31) than to recurring locations (2.21), and approximately 4 times more non-motorized trips to non-recurring locations than to recurring locations. recurrent. It can also be observed in Table 6 that the maximum number of days spent at home was 7 days (5%).

Regarding the groups, it emerges that:

- Group A ("**Infrequent travelers, for work or shopping trip purposes and very prone to do remote work**"): comprises the largest number of individuals (69) and is the group that makes the fewest trips per week, approximately 14 trips on average. Consequently, it is the group that spends the most days at home, in which 7 is the maximum number of days at home. Possibly, these individuals accumulate activities throughout the week and take more trips or longer trips when they leave home (average distance higher when compared to the other groups).
- Group B ("**Intermediate travelers, for work or shopping trip purposes and prone to do remote work**"): comprises 26 individuals who travel 6 or 7 days a week and make an average of approximately 59 trips a week. Regarding motorization and recurrence, individuals in this group performed approximately twice as many motorized trips compared to non-motorized ones and about 9.5 times more trips to non-recurring sites than to recurrent sites.
- Group C ("**Frequent travelers, for work or meal purchases and not likely to do remote work**"): comprises the smallest number of individuals (6) and is the group that makes the most trips per week, on average, approximately 100 trips. Most individuals in this group travel every day of the week (83.33%). As for motorization, they perform about 2 times more motorized trips than non-motorized

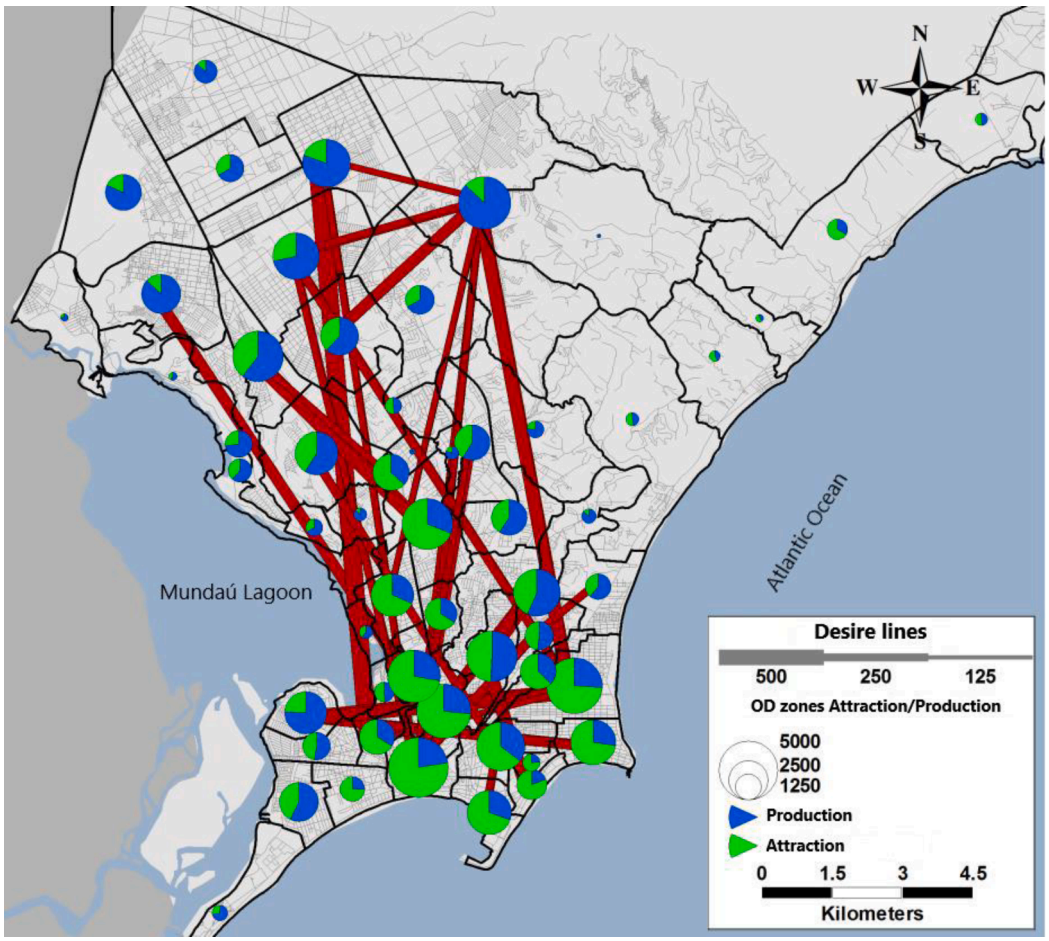

Fig. 5. Representation of attraction and production zones and desire lines. Source - (Guerra et al., 2014) Adapted by Authors.

ones. Regarding trips to non-recurring locations, they make twice the number of trips to recurring locations.

3.3. Clusters and socioeconomic characteristic

Table 7 presents the main socioeconomic characteristics associated with each group of traveler behaviors and the total sample.

Some characteristics observed in GA ("**Infrequent travelers, for work or shopping trip purposes and very prone to do remote work**") already signaled that it would be the one which would have less travel even in a non-pandemic context. According to Table 7, the group has twice as many women as men. This group holds 85% of the women of the total sample and 49% of the men. In addition, in relation to the number of children under 12 years of age, 83% of the GA individuals indicated that there are no children in this age group in their household. The literature indicates that women without children have a lower frequency of travel and their trip-chaining is less complex (Gordon et al., 1989; McGuckin and Murakami, 1999).

The GA holds 67% of the students in the total sample, in a non-pandemic context, it would be expected that there would be a greater frequency of travel for study purposes (Ichikawa et al., 2002; Pitombo et al., 2011; Rodrigues, 2020). However, due to travel restrictions and social distancing, 35% of the members of this group said that their in-person study activities were disrupted due to the COVID-19 pandemic.

Other socioeconomic characteristics that explain the fact that this group has the least number of trips compared to the other groups in the period of September/October 2020 are:

I. Compared to the total sample, they have 76% of the homeowners, 100% of the unemployed and 63% of the retirees or pensioners. Within the group they represent 23%.
II. They have most individuals who said that their in-person work activities were totally or partially interrupted due to the COVID-19 pandemic in September/October 2020. Considering only individuals who belong to GA, 42% indicated that their work activities were totally or partially interrupted, in September/October 2020, due to the pandemic.
III. The group has 76% of the individuals in the total sample who have no income.

Group B ("**Intermediate travelers, for work or shopping trip purposes and prone to do remote work**") includes mostly of men, in which the number of men is more than 3 times the number of women. Women in GB represent only 11% of the women in the total sample. The literature indicates that during disruptive events, men are less likely to change their travel pattern when compared to women (Hotle et al., 2020; Molloy et al., 2020), and therefore this group was expected to travel more than GA. The same behavior is observed in GC ("**Frequent travelers, for work or meal purchases and not likely to do remote work**"), in which 2/3 of the group is male.

It is noteworthy that only GB has homes that contain 2 children under 12 years old, which is the maximum number observed in the total sample and according to the literature, presence of children at home is associated with a higher frequency of travel (Feng et al., 2013; Gordon et al., 1989; Pitombo et al., 2011; Zwerts et al., 2010b), even in non-pandemic periods. It is also noted that GB is the only group that has homes composing 7 people. Nevertheless, 50% of CG live in households

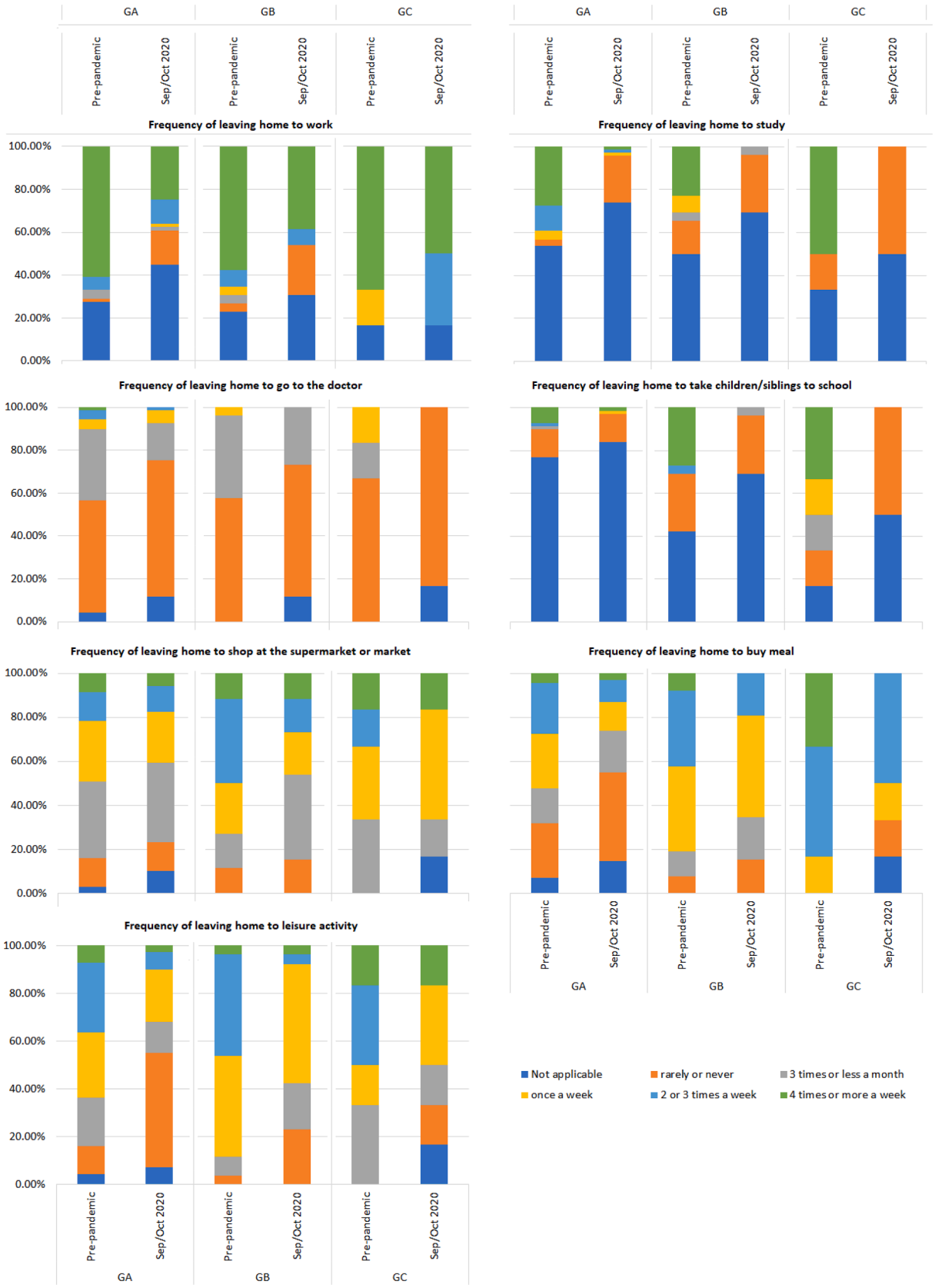

Fig. 6. Purposes regarding out-of-home activities.

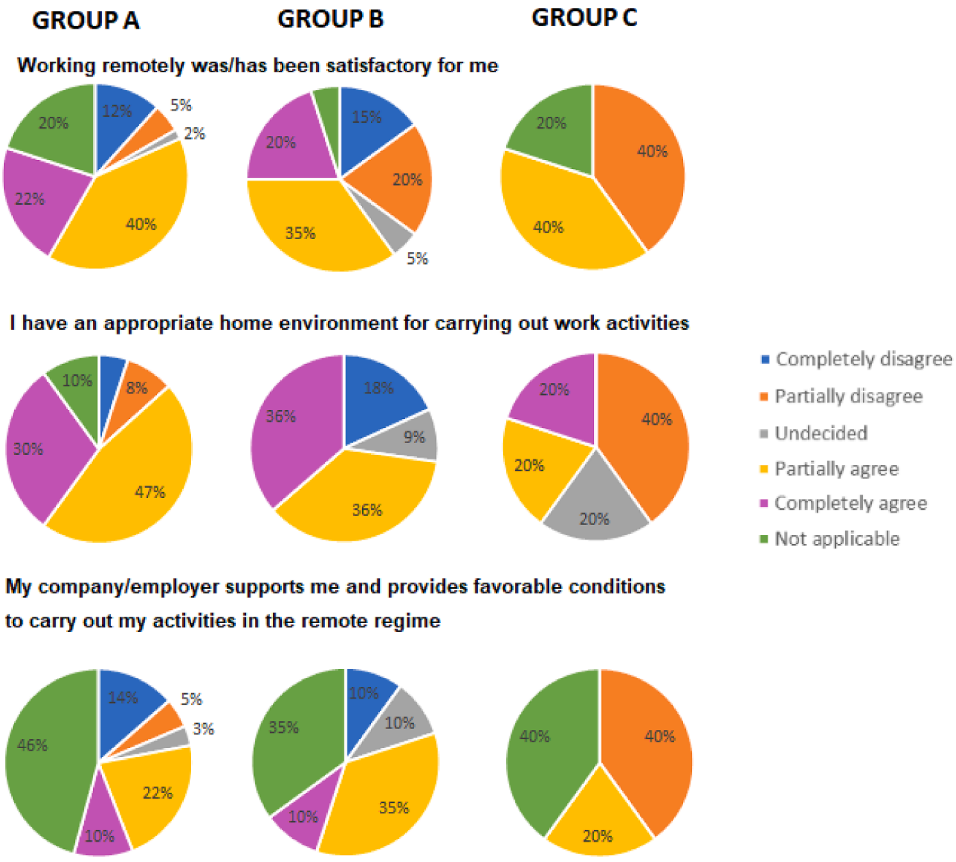

Fig. 7. Answers regarding the remote work system.

with 5 people or more, while in GB they are 27% and in GA only 16%. The composition of the home is one of the factors that influences the number of trips made.

In Table 7, it is noted that GB is the group with the highest percentage of its members conducting study activities in-person during September/October 2020, about 24% considering fully or partially in-person. Regarding in-person work activities, 70% of GB indicated that they were not interrupted due to the pandemic or were partially interrupted.

Group C is the smallest group, consisting of 6 individuals. All GC students had their in-person study activities interrupted in September/October 2020 due to the COVID-19 pandemic. Moreover, in this same period, all CG workers carried out their work activities totally in-person, which explains why they travel more frequently to recurring places during the week (Table 6).

Income is another factor that influences travel behavior – the higher the income, the greater the number of trips per day (FHWA, 2022; ISL and Banister Research & Consulting Inc., 2006). When compared to income distribution of the other groups, GC is the one with the highest percentage of members distributed in the ranges of 2–4 minimum wages (67% of the GC) and 4–6 minimum wages (17% of the GC). Only 8% of the total sample has an income above 6 minimum wages, which are distributed in GB and GA, representing respectively 19% and 4% of the members of each group. Although these groups present this portion with an income higher than that observed in CG, 50% of GB and 35% of GA have an income between 0 and 2 minimum wages while CG has no one in this income range. Income distribution explains the fact that GC presents more trips per week (Table 6).

Another socioeconomic characteristic that explains the fact that GC is the group that has more trips in September/October 2020 is car and motorcycle ownership. According to the literature, cars and motorcycle ownership is directly related to the number of trips. According to Barff et al. (1982), Hartgen (1974), Ichikawa et al. (2002), Pitombo et al. (2011), Li and Zhao (2017), Zhang and Zhang (2018), Gomes et al. (2021), and Masoumi et al. (2022), the greater the car ownership, the greater the number of trips, especially motorized trips. Table 7 shows that 33% of individuals in CG have 3 cars at home, while only 6% of GA and 4% of GB have 3 or more cars. In addition, 50% of the CG has a motorcycle and in the other groups, the largest portion does not have a motorcycle.

3.4. Clusters, place of residence, and distance to work

As can be seen in Fig. 4, which brings the place of residence by cluster group, none of the three groups presents a pattern of spatial distribution. Therefore, the number of trips made by each group is not related to the individual's place of residence.

Fig. 5 presents the trip attraction and trip production per Traffic Analysis Zones (TAZs) in Maceió for a morning period. It can be observed that the TAZs that attract more trips are located in the south region of the city. This is due to the fact that this region is where most of the business and service establishments, as well as public institutions and tourist activities are located. Fig. 4 shows that most people also live in the south region. Comparing the maps (Fig. 4 and Fig. 5), it can be concluded that the distance to work is not a factor that interferes with the number of trips made by each group.

3.5. Clusters, activity resilience, and post-pandemic behaviors

As can be seen in Fig. 6, which shows the frequency with which individuals conduct their out-of-home activities, some changes in behavioral patterns could be predicted as they had already been observed during other disruptive events. "Supermarket/market shopping", for example, presents a moderate reduction in the frequency of trips, this

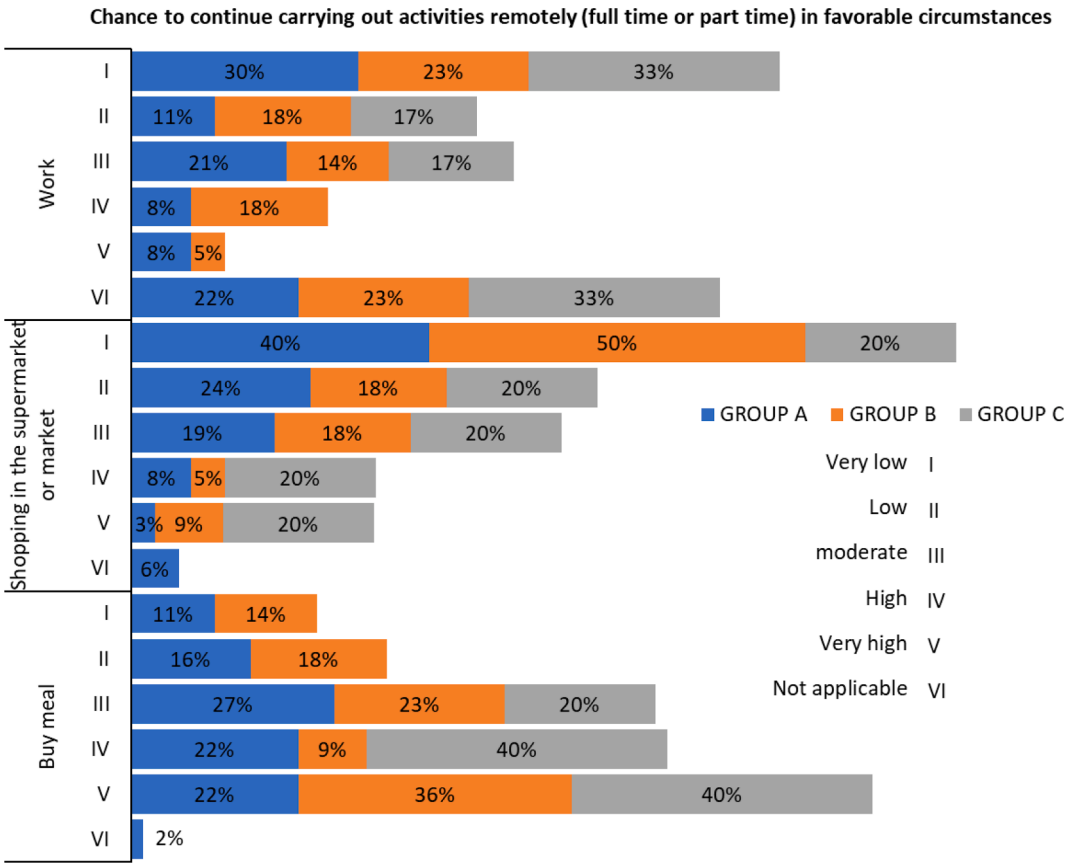

Fig. 8. Chance to continue carrying out activities remotely (partially or fully) in favorable circumstances.

Table 8
How do you intend to carry out the activity after the COVID-19 pandemic.

		How do you intend to carry out the activity after the pandemic					
		Fully in person	More in person than virtually/ remotely	Impartial	More virtually/remotely than in person	Fully virtually/ remotely	Not applicable
Work	GA	40%	23%	5%	11%	3%	18%
	GB	48%	24%	14%	0%	0%	14%
	GC	67%	17%	0%	0%	0%	17%
Shopping in the supermarket or market	GA	61%	24%	6%	6%	2%	0%
	GB	60%	30%	5%	0%	5%	0%
	GC	50%	33%	17%	0%	0%	0%
Buy meal	GA	21%	27%	16%	31%	5%	0%
	GB	15%	20%	35%	25%	5%	0%
	GC	40%	0%	20%	40%	0%	0%
Leisure activities	GA	62%	30%	8%	0%	0%	0%
	GB	52%	38%	10%	0%	0%	0%
	GC	80%	0%	20%	0%	0%	0%

had already been shown in Parady et al. (2020). Aloi et al. (2020) mention that work remains the main trip purpose, and in the present study it can be verified that "Work" appears as the main trip purpose in the three groups of travel behavior.

Fig. 6 shows that the main reasons that led GA individuals ("**Infrequent travelers, for work or shopping trip purposes and very prone to do remote work**") to leave home, in September/October 2020, were "Work" and "Supermarket/market shopping". However, observing the percentage distribution in the bar graph in Fig. 6, GA is the one with the lowest percentage of individuals belonging to the group performing these activities weekly (1 or more times a week). Only 38% of GA individuals left home at least once a week to work, before the pandemic it was 67%. In the "Supermarket/market shopping" activity, 41% of GA went out to do it at least once a week, with only 5.8% going out 4 times or more a week. It is also noted that this was the activity that had the smallest reduction compared to the period before the pandemic in GA.

The GB individuals ("**Intermediate travelers, for work or shopping trip purposes and prone to do remote work**") had as main trip purposes, in September/October 2020, the "Work" and "Supermarket/market shopping" activities (Fig. 6). The frequency distribution of GB explains why it has more trips than GA and fewer trips than GC. Analyzing the CG ("**Frequent travelers, for work or meal purchases and not likely to do remote work**"), the main reasons that led individuals in this group to leave home, in September/October 2020, were "Work" and "Buy a meal". GC was the group that mostly went out weekly to buy a meal. This group also presents a large number of weekly trips, at

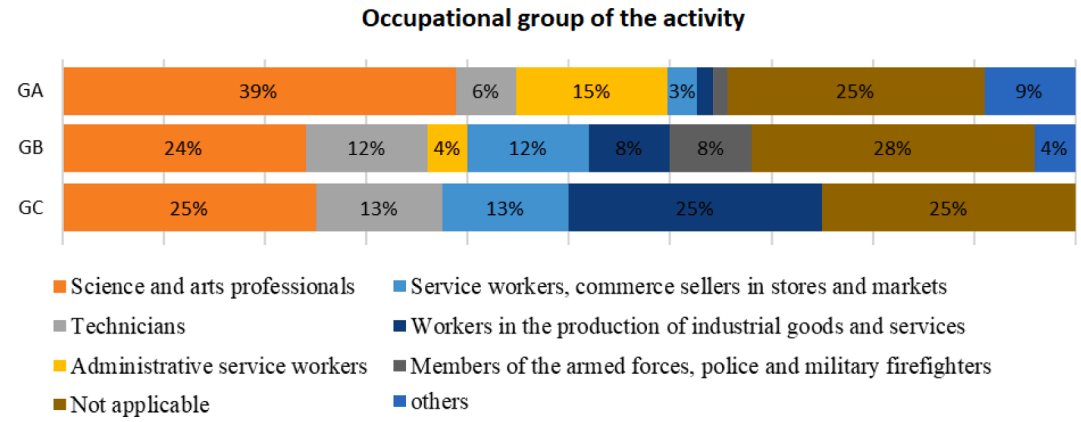

Fig. 9. Occupational group of the activity performed.

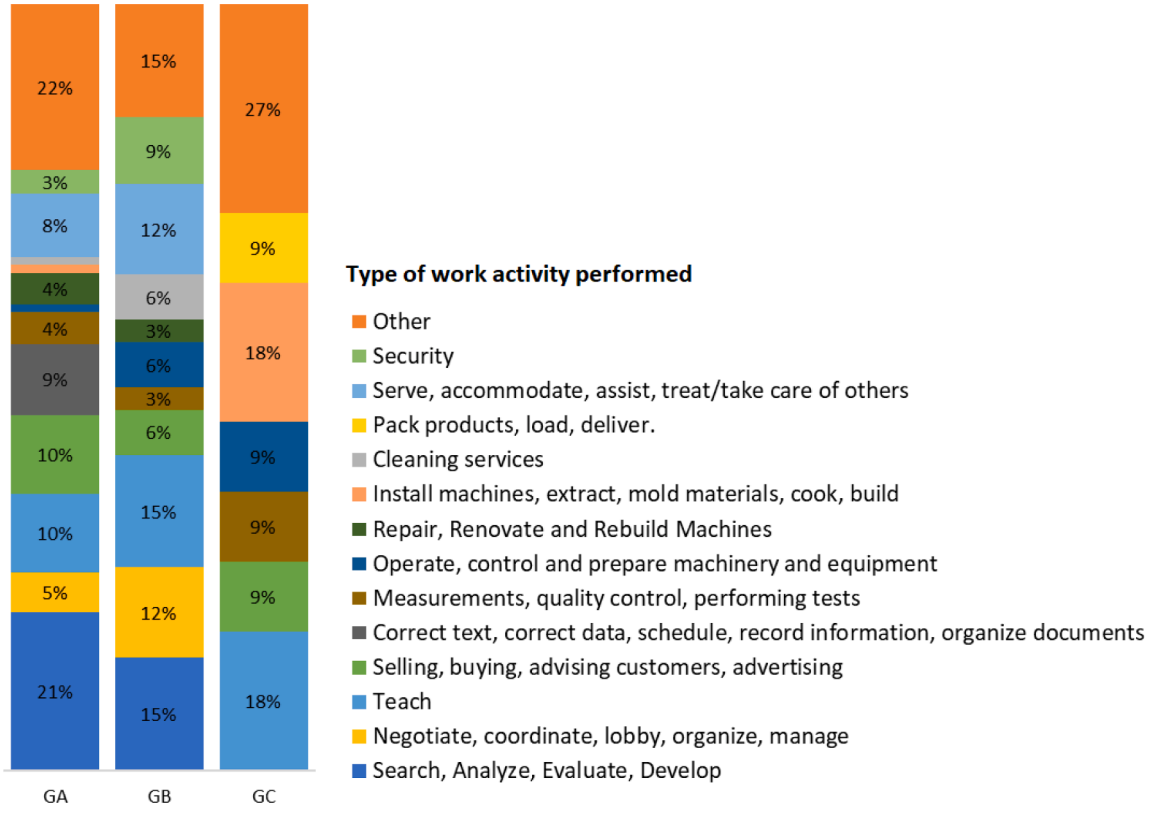

Fig. 10. Type of work activity performed.

least once a week, for "Supermarket/market shopping" and "Leisure activities". The fact of individuals of CG go out more often throughout the week to perform leisure activities is consistent with the higher salaries observed in this group and the presence of children in the households (Cheng and Witlox, 2021).

Fig. 7 presents the individuals' opinions regarding the remote work system. It shows that the GA is the group that would be more familiar with remote work – 40% of the GA partially agreed and 22% completely agreed with the statement that "Working remotely was/has been satisfactory for me". In addition, observing the responses in agreement with the statement "My company/employer supports me and provides favorable conditions to carry out my activities in the remote regime", it can be said that GA and GB were the groups that had the best incentive for the teleworking – 10% of both groups totally agreed with the statement. In addition, 77% of GA and 72% of GB declare that they have an adequate domestic structure to conduct work activities in the remote work regime, while in GC it was only 40%.

Based on the characteristics observed in GB, it would be the second most prone group to do remote work. It is observed that 35% of the individuals partially agree with the statement "Working remotely was/has been satisfactory for me", while 20% of the group totally agree. GC is the one least likely to conduct work activities remotely. It is associated with what is observed in Fig. 8, where CG is characterized as the group that most performs work outside the home on a weekly basis (83%), despite the restrictions of the pandemic period.

In Table 8, which shows how individuals intend to conduct activities after the COVID-19 pandemic, GA is again the most likely to conduct work activities remotely after the pandemic period. Moreover, 37% of GA intend to continue carrying out work activities remotely, either fully remote (3%), more remote than in-person (11%) or more in-person than remote (23%). In GB, 24% of individuals would be willing to perform remote work partially, in which the activities are mostly in-person.

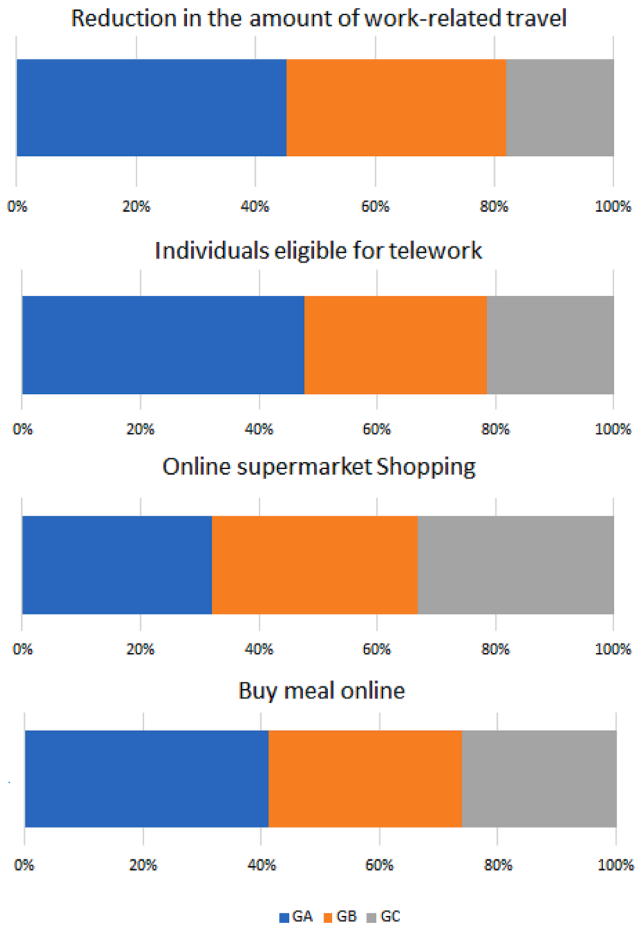

Fig. 11. Resilience scale of activities in the pandemic and future post-pandemic behaviors.

Thus, the propensity to conduct remote work activities follows the descending order: Group A, Group B and Group C. Regarding virtual supermarket shopping or meal purchases, groups GA and GB showed to be quite likely.

Table 8 shows the intention of individuals to perform certain activities in a virtual/remote way, regardless of whether they performed these activities in this way during the pandemic. While Fig. 8 presents the results of the chances of individuals who were already conducting activities in a virtual/remote mode during the pandemic to continue conducting them in this way, either partially or fully, after the pandemic.

Complementing the previous analyses, for work activities, there is a greater propensity of GA followed by GB to continue performing them in a virtual/remote way. Regarding online grocery shopping, we observed a provision for the three groups, as well as online shopping for meals. It is observed, in the latter case, that GC has a greater willingness (high or very high) to purchase meals online in a post-pandemic scenario.

When analyzing the occupational group (Fig. 9) and the type of work activity (Fig. 10), the levels of interruption of in-person activities, the number of trips conducted and the work-related travel behavior that individuals intend to have after the pandemic can be understood. As can be seen, GA, which is the one with the highest percentage of individuals who indicated that their work activities were completely interrupted due to the pandemic (22% - Table 7), mostly comprises the occupational group "Science and arts Professionals" (39%), which includes professions that can be conducted (partially or fully) in a remote work system, followed by "Administrative service workers" (15%). In addition, the main types of activities that GA individuals perform are: "Research, analyze, evaluate, develop" (21%), "Teach" (10%), "Sell, buy, advise clients, advertise" (10%), and "Correcting text, correcting data, programming, recording information, organizing documents" (9%).

Table 9
Summary of the main characteristics of the groups.

Group	Commuting and sociodemographic	Resilience scale of activities
Group A Infrequent travelers, for work or shopping trip purposes and very prone to do remote work	- Individuals who make a small number of trips; - Possibly, accumulate activities throughout the week and take more trips or longer trips when they leave home; - Main reasons: "Working" and "Supermarket/market shopping"; - Spend more days at home (max. 7 days/week); - Female predominance; - Homes with few people; - Most homes do not have children under the age of 12.	– 37% intend to continue conducting work activities remotely, either fully or partially; - In a scenario of favorable circumstances for conducting these activities remotely (fully or partially), 37% indicated a moderate to very high chance of continuing to work remotely; - Most of the group has work activities that can be conducted remote work.
Group B Intermediate travelers, for work or shopping trip purposes and prone to do remote work	- Individuals who make a moderate number of trips; - Main reasons: "Working" and "Supermarket/market shopping"; - They go out 6 or 7 days a week; -Male predominance; - Homes with children;	- In favorable circumstances: 41% indicated a very low or low chance of continuing to conduct their work activities remotely (fully/ partially) and 37% indicated a moderate to very high chance.
Group C Frequent travelers, for work or meal purchases and not likely to do remote work	- Individuals who make a high number of trips; - Main reasons: "Work" and "Buy a meal"; - They go out almost every day; - Homes with many people; - Most individuals in this group did not have their in-person work activities interrupted; - High income.	– 67% indicated that they intend to continue carrying out their activities fully in person after the pandemic; - Most of the group has work activities that cannot be carried out in remote work.

The predominant occupational groups (Fig. 9) in the GB are "Science and art Professionals" (24%), "Technicians" (12%) and "Service workers, commerce sellers in stores and markets" (12 %). Moreover, in relation to the other groups, GB has the highest proportions of individuals in the group performing activities related to "Negotiate, coordinate, lobby, organize, manage", "Serve, accommodate, assist, treat/take care of others" and "Security". In addition, GB encompasses almost all individuals who indicated performing "Cleaning services".

Most CG members (67%) said that they intend to continue conducting their activities fully in person after the pandemic (Table 8), which is possibly related to the type of activity they carry out. As can be seen in Fig. 9, this group comprises the largest percentage of "Workers in the production of industrial goods and services" (25%), "Service workers, commerce sellers in stores and markets" (13%) and "Technicians" (13%). Compared to the other groups, it is the one with the highest proportions in the following categories that require in-person execution: "Measurements, quality control, performing tests", "Operate, control and prepare machines and equipment", "Install machines, extract, mold materials, cook, build", "Teach" and "Pack products, load, deliver" (Fig. 10).

Given the scenario observed in the responses to the questionnaire, it is likely that GC will continue to be the one that will make the most weekly trips after the COVID-19 pandemic. In addition, although GA

Table 10
Usual travel behavior observed in times of pandemics and epidemics.

Variable	Usual Travel Behavior	Impacts of pandemics/ epidemics on travel behavior	Literature	Behavior found in this work, associated with the pandemic period (Sep/Oct 2020) – K-means
Presence of children at home (Household structure)	Higher frequency of travel		Feng et al., 2013; Gordon et al., 1989; Pitombo et al., 2011; Zwerts et al., 2010b	Frequent Traveler (GC) and Intermediate Traveler (GB)
Women (no children)	Less frequent trips and less complex trip-chaining		Gordon et al., 1989; McGuckin and Murakami, 1999; Pitombo et al. (2009)	Infrequent travelers (GA)
Students	Higher frequency of travel for study trip purposes		Ichikawa et al., 2002; Zwerts et al., 2010; Pitombo et al., 2011; Daisy, et al.,2018; Rodrigues, 2020	In all groups - lower frequency of study trips as in-person study activities were interrupted due to the COVID-19 pandemic.
Higher wages, families with children, young people	Higher frequency of leisure trips		Cheng and Witlox, 2021	Intermediate Traveler (GB) and Frequent Traveler (GC)
Car ownership	Greater car ownership is related to greater number of trips, especially motorcycles		Hartgen, 1974; Barff et al., 1982; Ichikawa et al., 2002; Pitombo et al., 2011	Frequent Traveler (GC)
Supermarket shopping		Moderate reduction	Parady et al., 2020	In all groups
Gender		Men are less likely to change their travel pattern compared to women	Hotle et al., 2020; Molloy et al., 2020	Intermediate Traveler (GB) and Frequent Traveler (GC)
Work		Remains the main purpose for travel	Aloi et al., 2020	In all groups
Buy meal		Reduction in the number of trips to buy a meal	Parady et al., 2020	In all groups

Gray: divergent behaviors from traditional literature; White: behaviors similar to traditional literature

Table 11
Bicycle usage × other modes.

Activity	Bicycle	Other travel mode	Frequency of carrying out the activity by individuals who indicated using a bike
Work	1	100	rarely or never
Study	0	101	–
Doctor	0	101	–
Take children to school	0	101	–
Supermarket	2	99	once a week or not applicable
Buy meals	2	99	2 or 3 times a week
Leisure	1	100	4 or more times a week

individuals are expected to travel more after the pandemic, there is a good portion of the group that will likely continue to travel less, especially if companies adopt a partial remote regime. This same behavior is expected for GB. Thus, making a scale of resilience of in-home remote activities in the pandemic and future post-pandemic behaviors (Fig. 11), it can be observed that GA was the one that most reduced work trips, replacing them with remote work. In addition, GA is still the one most susceptible to teleworking in a post-pandemic scenario. The GC was the one that least reduced work travel and is the least susceptible to teleworking in a post-pandemic scenario. GB presents an intermediate scenario between GA and GC.

3.6. Synthesis of behavioral groups

Table 9 provides a summary of the main characteristics observed in each of the groups. Table 10 presents a list of behaviors usually associated with travel and behaviors observed in times of pandemics and epidemics.

4. Methodological constraints

Despite the small number of observations, important characteristics and insights were gained into how each group intends to behave after the pandemic. It is noteworthy that the study has some methodological restrictions, such as the precise identification of the number of displacements on longer trips using motorized travel mode due to stopping times at traffic lights and congestion.

Another restriction regarding travel data from smartphones is the identification of trip purposes and the travel mode used. Trips by bicycle can be erroneously classified as motorized, depending on the speed. However, bicycles are not a problem in this paper. As we saw previously in Table 1, there was a supplementary questionnaire that asked the participants which travel mode they most use to carry out their activities, and, as can be seen in Table 11, the number of people who indicated the use of bicycles was low. Therefore, for our sample, the adopted speed ranges are not a problem.

Also noteworthy is the existence of a possible sample bias due to the type of recruitment of participants. The sample was not random and probabilistic; it was a convenience sampling (Henry, 1990) as we did not have access to the complete list of the population over 18 years of age in the Maceió Metropolitan Area (MMA).

5. Conclusion

In view of the characteristics observed in the results obtained, it can be said that the COVID-19 pandemic is a window that can be used by companies to implement the remote work fully or partially. We highlight that in the context of the sample analyzed, located in the MMA, which is in the Northeast of Brazil, when individuals can carry out remote work, they are more prone to partial teleworking. However, in the Southeast region of Brazil there is a higher concentration of integral teleworkers (Dias et al., 2022). This is due to the fact that the greatest volume of professions subject to teleworking is located in this region of Brazil, especially in São Paulo city (Góes et al., 2020). Another important factor

is related to the distances of work commutes. The average of the distances of work trips carried out in São Paulo is around 20 km. In the rest of the country, we can observe, on average, work trip distances around 9.5 km. It is also important to mention that there is a significant difference in the total week distances between teleworkers and non-teleworkers in Brazil (Dias et al., 2022). In addition, we can find different studies that associate work commutes and teleworking propensity (Borkowski et al., 2021; De Haas et al., 2020; Kroesen, 2022; Reiffer et al., 2022). If there are public policies to encourage the full or partial remote work, there will be a good adhesion of this system by workers. As a result, there may be a reduction in travel using private vehicles at peak times, reducing congestion, and air pollution. It is noteworthy, that the proper implementation of remote work also depends on the formalization of labor policies in this category in Brazil. Costa et al. (2022) suggest policies to implement the positive impacts on mobility, such as increased use of active transport and teleworking. In addition, they suggest some public policies to mitigate the negative effects of the pandemic on mobility, such as the reduction of public transport usage.

Due to technological facilities, people were able to perform various essential activities without leaving their homes. Public policies can take advantage of the moment to encourage companies to continue offering online or app services even after the pandemic in order to reduce the use of cars and motorcycles in citizens' journeys, as the return to the use of public transport may be slower.

Future studies are needed to determine whether the behavioral patterns indicated for a post-pandemic scenario will actually be done. Future studies are also needed to analyze whether, after the pandemic, people who remain in remote work and those who continue to conduct their essential activities without leaving home will have a reduction in the number of trips made weekly or the trip purposes were replaced, and the number of trips taken was maintained.

CRediT authorship contribution statement

Thayanne Gabryelle Medeiros Ciriaco: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Cira Souza Pitombo:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision. **Lucas Assirati:** Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was carried out with the financial support from the National Council for Scientific and Technological Development (CNPq Processo 304345/2019-9) and CAPES (Coordination for the Improvement of Higher Education Personnel - Finance Code 88887.506114/2020-00).

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