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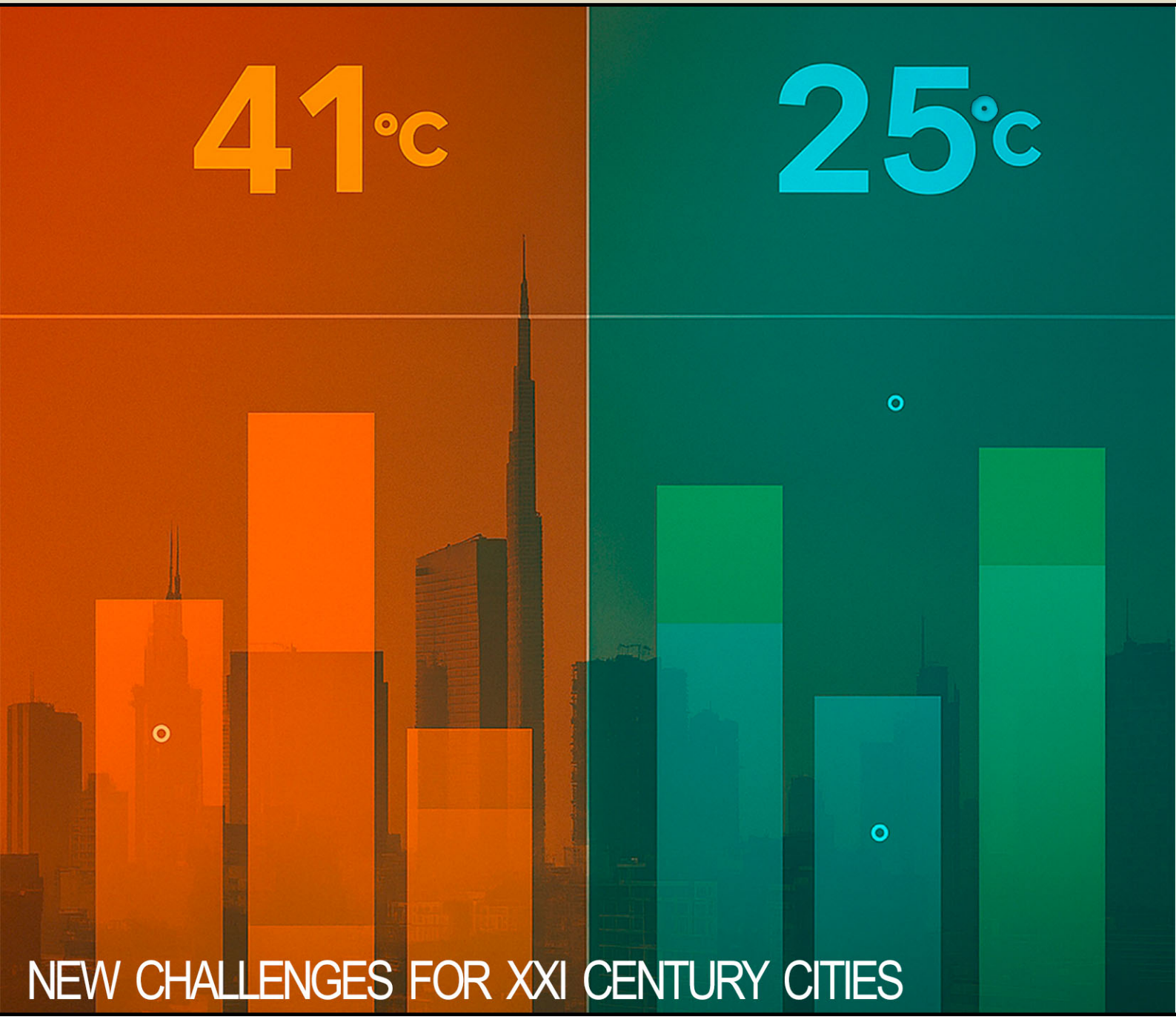

NEW CHALLENGES FOR XXI CENTURY CITIES

Multilevel scientific approach to impacts of global warming on urban areas, energy transition, optimisation of land use and emergency scenario

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The levels and correlates of paratransit use in Egypt and Lebanon before and during the outspread of COVID-19

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Abstract

Although studies address informal public transportation or paratransit, investigating the behavior and preferences regarding this mode in the Middle East and North Africa has not been proportional to its importance. Furthermore, with the outbreak of COVID-19, the relationship between paratransit use and different behaviors and preferences had to be investigated. Thus, this study aims to determine paratransit use for commute and non-commute purposes during and after the pandemic. The data of this study (N=3,285) is based on a survey conducted in Lebanon and Egypt from 2021 till 2023. The study aimed to answer three questions: how the correlates of choosing paratransit for non-commute travels in Egypt and Lebanon changed during the COVID-19 pandemic compared to before it, how the correlates of choosing paratransit for commute travel in Egypt and Lebanon changed during the pandemic compared to before, and was paratransit use in the four cities of Cairo, Alexandria, Beirut, and Jounieh different before and during COVID-19. The results of Binary Logistic modeling and Chi-square test of independence indicate a significant difference in the level of paratransit use throughout the four cities. Moving forward, these results can regulate and guide policymaking of paratransit use in the MENA region.

Keywords

Urban transportation planning; Paratransit; Public transportation; Covid-19; Middle East and North Africa (MENA)

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1. Introduction

Urban mobility has become a vital aspect of modern city life, complexly connected to socio-economic development, governance structures, and the evolving needs of diverse populations. Distinct urban mobility patterns in developed and less-developed countries exhibit fascinating diversity. Developed nations often feature well-established formal transport systems institutionalized and regulated by the state, reflecting stability and social justice ideals. In contrast, less-developed regions witness the emergence of informal paratransit services, filling in the gaps in public service provision as the welfare states weaken.

Academic discourse has extensively examined paratransit as a transport mode, criticizing issues related to the service such as traffic congestion, environmental pollution, safety concerns, quality of the service, and its regulatory bodies, which positioned paratransit as incompatible with the common urban transport systems. These studies have contributed to the negative perception of paratransit relative to the well-established formal transport services. The literature review offers the study a background and understanding of the dynamics that shape the use of Paratransit. Also, it highlights the common cultural, social, and economic features that influence urban mobility in the major cities representing Egypt and Lebanon, while pinpointing the different challenges these cities face. Furthermore, the review continues to analyze the change in travel patterns in these contexts during the outbreak of the COVID-19 pandemic. Understanding the dynamics of urban mobility before and after worldwide pandemics, specifically the use of paratransit services in these contexts, provides valuable insights into the adaptability of transportation systems and the impact of external shocks on urban mobility patterns. The literature review leads the way to analyze the different levels and correlates of paratransit use for commute and non-commute purposes in Egypt and Lebanon, comparing them before and during the COVID-19 pandemic.

The findings are explored, compared, and justified after clarifying the case study areas, explaining the data collection process, identifying the variables, and specifying the suitable statistical models. The comparative analysis of paratransit usage in the different case study areas of Egypt and Lebanon provides an understanding of how distinct socio-economic and infrastructural contexts shape transportation choices and travel patterns while revealing the common and different findings and the levels and correlates of paratransit use. Furthermore, the COVID-19 pandemic added another level of analysis to investigate the difference in travel patterns and mode choice before and during the pandemic, highlighting the adaptability of transportation systems and, most importantly, the resilience of the paratransit service in meeting the evolving needs of commuters, while facing unprecedented challenges. This study aims to contribute to the broader discourse on urban transportation, offering valuable insights for policymakers, researchers, and urban planners seeking sustainable and inclusive mobility solutions. This document has been meticulously crafted to comprehend the research thoroughly. The process begins with an extensive examination of existing literature, followed by a thorough explanation of how the data was gathered and the subsequent descriptive statistics analysis. The statistical analysis part showcases a rigorous technique, followed by the presentation of the results. Lastly, the research wraps up with a thorough analysis that connects the primary findings and their consequences.

2. Literature review

2.1 Overview

The variation of public transportation modes throughout the world's cities and the adoption of different operating models pinpoints the diversity in the urban mobility patterns between developed and less-developed countries. On the one hand, western and wealthier countries follow the ideal models of the welfare state, acting as the main representative of the 'Public', ensuring stability and social justice through the provision of public goods and services (UN-ESCWA, 2020). As a result, Institutional or Formal public transport operators were considered the main providers of urban mobility services in their cities. Institutional or formal transport

is commonly referred to throughout the literature as the 'scheduled transport services planned by the state's institutions, networks developed to meet the quality standards designed by their authorities and operators with regulated routes and trip fares (Ferro, 2015). Conversely, as the welfare state weakens, especially in the less developed and the global south economies, informal practices move in to fill the public services provision gap. Paratransit services jump in to serve the urban mobility needs of the public (El-Moussawi, 2016). As the prefix Para- in the term 'Paratransit' originates from the Greek meaning of 'next to, besides, alongside, or beyond, the meaning of Paratransit is simply phrased as "transportation service that supplements larger public transit systems by providing individualized rides without fixed routes or timetables" (Paratransit, 2024). Meanwhile, the diversion from formal transport modes to paratransit adds more complexity to the definition. Academic research has mainly focused on pinpointing the complexity of the term: how to define paratransit in different urban contexts and analyze its different forms and urban contexts that affect the correlation between Paratransit and formal transport.

Considered a service that "does not fit the idea of a modern urban public transport system", most Western studies inspired by high-income development plans have criticized and highlighted the dark side of paratransit (Ferro, 2015). Studies by Gauthier & Weinstock (2010), and Cervero & Golub (2011) analyzed the problems associated with an increase in paratransit services ranging from traffic congestion, street chaos, air and noise pollution, and the increase in road accidents, to fare variation, unsafe or dangerous driving behavior or even unlicensed operators. Furthermore, questioning the quality of the service, as utilizing or overloading unsuitable vehicles to meet the increasing needs for mobility while diminishing passengers' comfort within an environment of weak law and regulations enforcement, locates the paratransit service in an inferior position to the well-established formal transport service.

Escalating levels of traffic congestion and environmental problems associated with rapid motorization and the increasing dependency on private transport modes are considered the main challenges that face urban transport planning and management worldwide. More demand for urban mobility is due to inefficient and scarce resources to maintain a decent coverage of public mass-transport services, specifically in less-developed countries. Admitting that the Paratransit sector continues to grow to feed the needs of mobility strongly, studies had to highlight and build on the positive influence of service and analyze its dynamics and advantages, while offering decision-makers and transport planners the ideal measures that regulate and solve the problems associated with the service. Previously ignored, Cervero's (2000) study, for example, carried out at the request of the United Nations Centre for Human Settlements (Habitat), managed to move paratransit into the focus of transport management plans. The study presented a global overview of the characteristics of the informal transport sector around diverse urban contexts worldwide. Furthermore, the in-depth study analyzed different case studies from Southeast Asia cities (ex: Bangkok, Manila, Jakarta) extending to several cities in Africa and South America (ex: Jamaica, Brazil) giving a broader scope of the various shapes, and sizes, forms, land-setting and organizational framework of this influencing sector, while also stressing that these informal services don't only exist in the less developed countries but also commonly exist to some extent in any low-income or remote neighborhoods around the world (Palermo et al., 2025). Ranging from small-sized medium (e.g. motorbikes, Tuk-tuks, tricycles, microbuses, minivans and wagons, minibusses) to fully-sized buses, from licensed or unlicensed operators, from feeders especially in urban compact areas with narrow roads, newly developed or remote urban areas, to trunk servers competing with the institutional transport modes and operating together on the same main routes, from low-performance vehicles driven by individuals, franchises or co-operative operators to convenient, comfortable vehicles, to even environmentally friendly modes like pedal-powered modes (e.g. pedicabs); the study emphasized the benefits of the paratransit, pinpointed the global lessons learned to enhance and regulate the service, while eliminating associated problems (Cervero & Golub, 2011).

2.2 Paratransit in Egypt and Lebanon

Egypt and Lebanon, representing (MENA's) North African and Levant regions, share similar cultural, social, environmental, and political features. Concerning urban mobility, insufficient and unjust transportation systems are common. Abu-Eisheh et al., 2020 in their comparative study between four MENA region countries (Egypt, Jordan, Lebanon & Palestine) to tailor future mobility transition goals, they had to analyze the similar factors and the specific different local contexts that directly shape mobility in each country. Both with a background of increasing social, economic & political injustice, similar governance systems and legislations that are at a far distance from sustainable or even traditional mobility planning, the status reached the following: overlapping or conflicting laws and governmental bodies and involved parties, lack of transparency throughout the decision-making process, high dependency on individual private cars and taxis, lack of active transportation infrastructure. Despite the difference in the modal-sharing systems operating in the two countries, Paratransit became a major public transport service operating, either because of the insufficient, inaccessible institutional public network in Egypt, or its disappearance or limited service throughout the cities of Lebanon.

Lebanon, despite being a small country in size and population compared to Egypt, has had its share of transportation problems that can be considered a unique example of a country that shifted dramatically to 'Informality' as a self-managed practice or community-based of most social services provision (e.g. electricity, water supply, waste collection, and mobility). Starting with 15 years of instability during the Civil war (1975-1990), followed by waves of Syrian refugees from early 2011 in addition to facing its worst economic crisis in 2019, collapsing currency paired with the continuous political tensions followed by the Covid-19 pandemic, this all had its impact on Lebanon's urban transportation patterns (Assaf, 2022). As a result, cities of Lebanon, specifically the capital Beirut and its surrounding suburbs, are considered unequal cities, with clear spatial segregation that has produced uneven mobility and accessibility patterns (Assaf, 2023) Less investment in public transport infrastructure while focusing on improving roads, Beirut has witnessed on one hand, the increasing number of private cars ownership mainly in the wealthier areas, associated with increasing congestion, poor accessibility in other areas, and major environmental problems. On the other hand, the scarcity and unreliability of mass public transport led to the emergence of privately operated transport systems to fill in this wide gap in the mobility service provision. With the lack of large public buses and their operators, taxis, shared taxis, mini-buses, and vans are considered the main public transportation providers (Attari et al., 2020). Either regulated and registered by associations and unions or even operated illegally, these services are referred to as the 'informal transport or paratransit service', differentiating them from the bus services operated by large organizations with fixed routes and schedules (Assaf, 2023).

Conversely, according to international standards, Egypt presents a case of low private motorization percentage, where more than 2.16 billion individuals depended on public transportation in 2019/2020. With the increasing levels of movement, the institutional transport services could not cope alone despite their continuous development and increase in their fleet's frequencies and coverage; informal paratransit services had to take advantage of the rising transport demand. By the end of 2021, paratransit services continued to play a major role throughout Egypt's urban and rural areas, as 45% of the registered buses in Egypt were privately owned compared to 8.5 % owned by government institutions (Galal, 2023).

Although public bus transport operates solely in the two megacities: Alexandria and the Greater Cairo region, private-firm buses and paratransit services still dominate the scene. Considered one of the largest paratransit systems, with vehicles ranging from 14-seaters, 7-seaters, pick-up trucks, and tuk-tuks, paratransit services depended on more than 80,000 unlicensed and unregulated vehicles in Greater Cairo alone (Shaker et al., 2022). A system of Tuk-tuks offering trips through the narrow routes of informal and old compact urban areas, fleets of small and medium-sized vehicles connecting low-income neighborhoods and remote urban areas, with the main routes, or even fleets of vehicles competing with the public buses on the same route, offering more flexible service in terms of frequency of vehicles and stops with comparatively cheaper fares while

contributing to more congestion problems and irresponsible, chaotic driving behavior. Alexandria and Cairo present an example of the complexity of urban mobility in the developing world (Abu-Eishesh et al., 2020).

2.3 COVID-19 pandemic and urban travel behavior

As the number of people infected by the COVID-19 virus worldwide reached nearly 16 million by January 2020, the World Health Organization (WHO) declared it a Pandemic, calling for the world to implement control measures (WHO, 2020). With no protective vaccine or effective medical procedures, countries had to take drastic measures to control the escalating spread of the virus, disrupting regular social and economic human habits. As the world reached a standstill, significant income reduction, high unemployment rates, and the closure of small businesses, investment, and trading disruption were expected. Urban mobility by shared travel modes, air travel, or mass transit was blamed for increasing the risk of vastly spreading the infectious virus worldwide. Countries had to impose mobility restrictions to control the level of virus transmission. Borders between countries, ports, and harbors closed, complete or partial lockdowns, curfews, individuals working and studying and shopping online from home, stopping public transport services, and movement was minimized to essential travel trips (Thombre & Agarwal, 2021; Cirianni et al., 2022). Consequently, research studies focused on the impacts of the COVID-19 pandemic on humanity in general, specifically on the reshaping and change in travel behavior. (Barbieri et al., 2021), In their attempt to analyze the impact of the COVID-19 pandemic on mobility around ten countries representing developing and developed economies, they shed light on the related risk of all transport modes. While examining the different mobility patterns before and during the pandemic restrictions, the study pinpointed the severe disruption and reduction of both commute and non-commute travel. Mass transport modes: airplanes, trains, and public buses had to be widely avoided, as they were considered the riskiest modes not complying with social distancing. Furthermore, the cross-country study stressed that socio-economic inequality, specifically between developed and developing countries, had an impact not only on health risks but also on travel behavior during the pandemic. COVID-19 had the most severe socio-economic impact on the less wealthy countries, with their weak healthcare and economic systems, and non-comprehensive responsive emergency plans. On one hand, this resulted in a behavior shift within the upper and middle class in these countries, depending solely on adequate internet accessibility for remotely working, studying, shopping, and socializing while depending on individual transport (either driver or passenger) and active modes for urgent travel needs. On the other hand, low-income households and informal workers had to continue going to work, especially individuals surviving on a daily income. Thombre & Agarwal (2021) focused on the paradigm shift within urban mobility while analyzing the travel behavior before, during, and after COVID-19 in India. A developing country with a demographic, social, and economic context like Egypt, with densely populated cities where commuters depend heavily on public transport. Based on the uncertainty of how long the pandemic might take to disappear, the study highlighted that individuals (commuters and drivers) had to eventually accept the chance of getting infected in crowded, shared transport modes while deciding to travel. Paratransit, the informal way to travel, had to continue operating, securing the daily income for their drivers' wages, rentals, operational costs, and maintenance, while offering transport services to commuters risking infection while prioritizing their daily essential commute trips.

As the whole world was challenged socially and economically by the new COVID-19 pandemic, Lebanon, on the other hand, was already struggling. A country still not recovered from the effects of the civil war, the country faced one of the worst financial crises from early 2019, continuous political, economic, and social problems, followed by the Port of Beirut Explosion in August 2020 during the COVID-19 pandemic (World Bank, 2021). Lebanon had to rapidly respond like all countries worldwide to the pandemic by imposing strict public health and social measures to hinder the number of cases and hospitalization rates (Abou Hassan et al., 2023) Studies focusing on the shift of travel behavior in Lebanon had to acknowledge the early impact of the economic crisis that continued to affect the behavior and perception of commuters before and during the

COVID-19 pandemic. Hatoum & Barraj (2023) investigated the changes in travel behavior in the Greater Beirut area by analyzing the socio-economic factors that influenced the commuters' mobility decisions early before COVID-19 hit the country. Their study highlighted the decrease in all commuting and non-commuting trips with the prolonged economic crisis, which declined dramatically with the shift to online work and study during the pandemic. Apart from the wealthier urban areas, the economic crisis had already influenced the usage and ownership of private cars, as they could not secure operating, fuel prices, parking, and maintenance expenses; more middle-class commuters had to shift to less-expensive alternative transport modes. With the shift from private cars to other modes of transportation, but faced with poor, unreliable institutional public transport service with limited accessibility, commuters were not offered many choices. Carpooling, car sharing, and even motorcycles were an option for individuals previously using their private cars, shared taxis, and private paratransit services, leading to a higher risk of infection during the pandemic.

3. Methodology

Given the significant role of informal public transport modes in the MENA region, the study had to adopt a quantitative research approach to analyze the behavioral patterns and preferences related to paratransit use in Egypt and Lebanon before and during the COVID-19 pandemic illustrated in Fig.1.

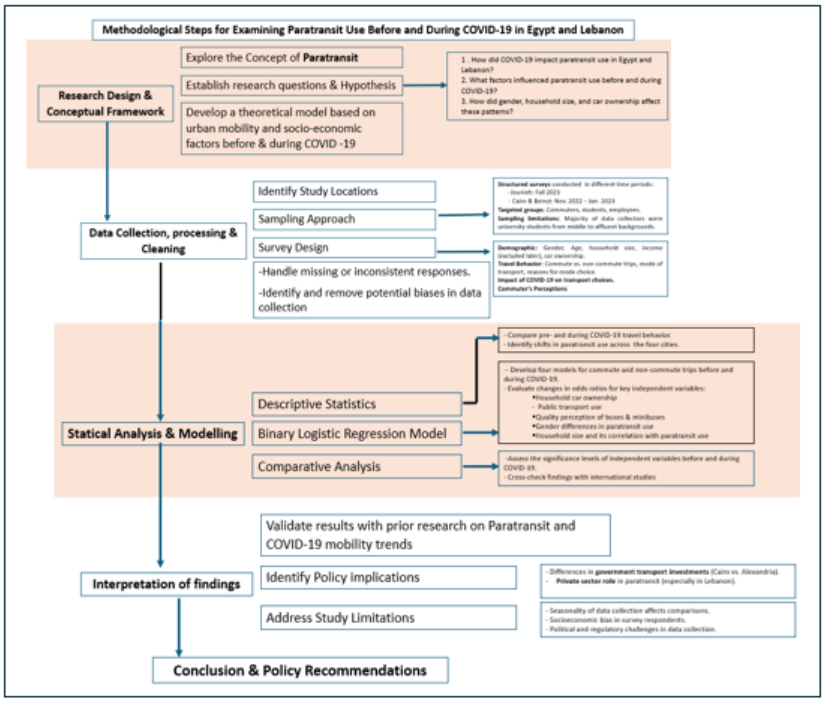

Fig.1 The Methodological steps for examining Paratransit Use before and During COVID-19 in Egypt and Lebanon

3.1 Research questions and hypotheses

The present study provides answers to the following questions: (1) How have the correlates of choosing paratransit for non-commute travels in Egypt and Lebanon changed during the COVID-19 times compared to before it?, (2) How have the correlates of choosing paratransit for commute travel in Egypt and Lebanon changed during the COVID-19 times compared to before it?, and (3) was the paratransit use in the four cities of Cairo, Alexandria, Beirut, and Jounieh different in times before and during COVID-19?

The study hypothesizes that although the levels of paratransit use are different in the case study cities, because of geographical and cultural similarities, the correlations can be considered generally. These socioeconomic and mobility-related correlations have partially changed after the outbreak of COVID-19.

3.2 Case-study cites

The targeted cities of the research, Cairo, Alexandria in Egypt, Beirut, and Jounieh in Lebanon are chosen based on and guided by several specific contextual factors, one of which is the diversity of their residents (ethnicity, religion, gender, etc.), allowing for the highly accurate conclusion of a generic picture. Another is that, like Beirut in Lebanon, Cairo is Egypt's capital and largest city. Like Jounieh in Lebanon, Alexandria is a linear seaside city in Egypt. The population of the case cities is 10.27 million in Cairo, 5.56 million in Alexandria (CAPMAS, 2023), 5.57 million in Beirut, and 150,000 in Jounieh (UN-Habitat Lebanon, 2021). They thus provide a strong foundation for a general sample that will optimize the accuracy of your study. 3,084.67 Km² and 2,818.77 Km², respectively, are the city's sizes (CAMPAS, 2023) and 111.22 Km² and 8.5 Km² (UN-Habitat Lebanon, 2021). These cities also have the most intricate transportation networks and the broadest distribution of paratransit, making them excellent candidates for study and a fantastic source of the data needed. These unique characteristics of cities provide an excellent case study for the usage of paratransit and its correlates both before and during the COVID-19 pandemic. We may learn more about the unique characteristics of these groups and how different factors influence the variations in paratransit behavior for the groups before and during COVID-19 that were chosen for this study.

3.3 Data and variables

This study is based on a general urban mobility survey conducted within the four major cities of Lebanon and Egypt, mainly focusing on the main travel behavior of commuters before and during the COVID-19 pandemic. The data collection for the general survey first started in Jounieh, Lebanon, during the Autumn of 2021. The same study was conducted a year later for three months in Beirut, Lebanon, and Cairo, Egypt, from November 2022 to January 2023. The same set of data was collected from the city of Alexandria, Egypt, over six months starting from November 2022 till May 2023. Furthermore, to guarantee covering the diversity of the social, and economic backgrounds, especially in the large cities of Cairo and Alexandria, the survey was conducted in diverse neighborhoods ranging from compact urban areas near the city center and the historic core to areas offering structured grid patterns mixed with organic urban fabric, to low-density suburban areas located at the peripheries of the city.

The population of Cairo and Alexandria Governorates was recorded as 10,100,166 and 5,469,480, respectively (CAPMAS, 2023). The adult population was 4,720,227 for Cairo, and 2,452,602 for Alexandria according to the 2017 census (CAPMAS, 2023). Furthermore, the estimated population of Jounieh and Beirut in 2022 was 94,000 and 1,870,000, respectively, and the adult population of Jounieh was around 72,000 and Beirut 1,444,500 (ZhujiWorld, 2023). As a result, around 3,285 face-to-face interviews were conducted, between 1,193 in Cairo, 617 in Alexandria, 938 in Jounieh, and 537 in Beirut.

Due to the expectation of high population variability in opinions, perceptions, and misinterpretation of the terms presented in the survey, along with potential inaccuracies during data collection, the margins of error for the sample sizes collected in Cairo and Alexandria were 2.84% and 3.95%, respectively. Adding to these factors, Jounieh and Beirut with a comparatively smaller population, higher margins of error for their sample sizes were 4% and 5%, respectively.

The survey was designed through 39 questions, over six sections that covered the demographic, social, and household profile, mobility and commuting habits, and personal preferences before and during the Covid-19 pandemic, and perception of public transport commuters and ride-sourcing users. The socio-demographic profile is formulated through questions targeting gender, age, employment status, education level, car and house ownership. Diverse and changing commuting behaviors were tested as the respondents were asked, for example, how many commute and non-commute trips were made within the last week. What transport mode was used for commute and non-commute trips, before and during the Covid-19 pandemic? Furthermore, the survey guided the questions to measure the level of satisfaction, perceived security, and perception of

commuters in public transport, in addition to the level of ease while using ride-sourcing applications. The level of satisfaction and perception was answered by a 0-100 numerical scale, where 0 is the lowest and 100 is the highest level. The overall variables generated from this questionnaire are 39, 6 questions focused on non-commute mobility habits before and after COVID-19, and 9 questions focused on commuting determinants before and after the COVID-19 pandemic. The data exploration phase initiated with four dependent variables: paratransit use for commute and non-commute purposes during and after COVID-19, along with 12 variables. Some variables were eliminated during the iteration process, which will be further elaborated in the analysis methods (section 3.4). The variables were quantified according to the methods elaborated in Tab. 1 and 2, and 3, which summarize the frequencies of the dependent variables and their breakdown throughout the four case study cities. Tab.4 shows the descriptive statistics of the continuous variables, while Tab.5 illustrates the frequencies of the categorical variables of the study.

	Variable	Type of variable	Quantification Method
Dependent Variable to be investigated	Paratransit use for non-commute purposes before Covid-19	Dummy	(No) or (Yes)
	Paratransit use for non-commute purposes during COVID-19		
	Paratransit use for commuting purposes before COVID-19		
	Paratransit use for commute purposes during COVID-19		
	Age	Continuous	The reported age of the respondent.
	Household car ownership	Continuous	The reported number of cars owned by the household members.
	Household size	Continuous	The number of household members reported by the respondent.
	Trip generation for commute purposes during the past 7 days	Continuous	The respondent reported the number of trips for commute purposes during weekdays.
	Trip generation for non-commute purposes during the past 7 days	Continuous	The respondent reported the number of trips for non-commute purposes during weekdays.
	Public transport Use	Continuous	The reported number is based on a numerical usage scale from 0 to 100. Which 0 is no usage, and 100 is the highest level of transportation usage
	Evaluation of the quality of buses and minibuses	Continuous	The reported evaluation uses a scale from 0 to 100, where 0 is the worst quality and 100 is the best quality.
	Perceived security when using public transportation	Continuous	The reported perception is using a scale from 0 to 100.
	Gender	Categorical	Female & Male
	Possession of an individual driving license	Categorical	No & Yes
	Commuting to work or study most of the days	Categorical	No & Yes
	Smartphone use for transport purposes	Categorical	No & Yes

Tab.1 Variables used in the study

Variable	Category	N	%
Paratransit use for non-commute purposes during COVID-19	No	3,194	97.2
	Yes	91	2.8
Paratransit use for non-commute purposes before Covid-19	No	3,157	96.1
	Yes	128	3.9
Paratransit use for commute purposes during COVID-19	No	3,206	97.6
	Yes	79	2.4
Paratransit use for commuting purposes before COVID-19	No	3,172	96.6
	Yes	113	3.4

Tab.2 Frequencies of the dependent variables

Variable	Category	Cairo (N=1193)		Alexandria (N=617)		Beirut (N=537)		Jounieh (N=938)	
		N	%	N	%	N	%	N	%
Paratransit use for non-commute purposes during COVID-19	No	1,181	99.0	560	90.8	533	99.3	920	98.1
	Yes	12	1.0	57	9.2	4	0.7	18	1.9
Paratransit use for non-commute purposes before Covid-19	No	1,176	98.6	540	87.5	532	99.1	909	96.9
	Yes	17	1.4	77	12.5	5	0.9	29	3.1
Paratransit use for commuting purposes during COVID-19	No	1,181	99.0	576	93.4	529	98.5	918	97.9
	Yes	12	1.0	41	6.6	8	1.5	20	2.1
Paratransit use for commuting purposes before COVID-19	No	1,175	98.5	560	90.8	529	98.5	908	96.8
	Yes	18	1.5	57	9.2	8	1.5	30	3.2

Tab.3 Frequencies of the paratransit use broken down on cities

Variable	N	Min.	Max.	Mean	Std. Deviation
Age	3,207	12	86	30.63	12.291
Household car ownership	3,206	0	10	1.66	1.26
Household size	3,272	0	14	4.15	1.57
Trip generation for non-commute purposes during the past 7 days	3,194	0	15	2.71	2.03
Public transport use	3,281	0	100	34.77	34.37
Evaluation of the quality of buses and minibuses	3,282	0	100	37.64	27.53
Trip generation for commute purposes during the past 7 days	3,000	0	70	5.86	4.48
Perceived security when using public transportation	2,845	0	100	47.50	32.38

Tab.4 The descriptive statistics of the continuous variables

Variable	Category	N	%
Gender	Missing	1	0
	Female	1,271	38.7
	Male	2,013	61.3
Possession of an individual driving license	Missing	8	0.2
	No	995	30.3
	Yes	2,282	69.5
Commuting to work or study place most of days	Missing	169	5.1
	No	876	26.7
	Yes	2,240	68.2
Smartphone use for transport purposes	Missing	32	1.0
	No	1,234	37.6
	Yes	2,019	61.5

Tab.5 The frequencies of the categorical variables

3.4 Analysis methods

The research utilized Binary logistic regression modeling to explore how the correlation with using paratransit modes for commuting and non-commuting purposes changed during COVID-19 to answer the research questions 1 and 2. A total of four models were designed the first two models ls for the correlations among the use of paratransit modes of transportation as an independent dummy variable for commute and non-commute travels in Egypt and Lebanon, and a set of categorical and continuous variables (e.g., gender, possession of an individual driving license, commuting to work or study place most of the days, use of a smartphone for transportation for categorical variables, and age, household car ownership, household size, trip generation for commute and non-commute purposes during the past seven days, use of public transportation, evaluation of the quality of buses and minibuses, trip generation for commute purposes during the past seven days, and perceived security when using public transportation for continuous variables).

These models have been altered by eliminating insignificant variables to obtain the best model. The best model fit was achieved by eliminating the following variables:

- For non-commute: possession of an individual driving license, perceived security when using public transportation, trip generation for non-commute purposes, trip generation for commute purposes, age, and commuting to work or study place most of the days;
- for Commute: perceived security when using public transportation, trip generation for commute purposes, possession of an individual driving license, commuting to work or study place most of the days, age, perceived quality of buses and minibuses, phone use for transportation.

The other two models have the same structure and were for paratransit use for commute and non-commute before COVID-19. The models were tested using two types of validation testing: the Omnibus test and the Hosmer and Lemeshow test (Archer & Lemeshow, 2006; Badi, 2017). Omnibus testing models with confirmed coefficients of 0.001 with P values of less than 0.05 indicate a valid model fit when using the Omnibus test. P values of more than 0.05 confirm the model validity for the Homser and Lemeshow test.

To answer the third research question, a Chi-square test of independence was performed on the tabular data to test if the levels of paratransit mode of transportation use vary significantly among cities in Egypt and Lebanon. P-values less than 0.05 were considered significant, and values between 0.05 and 0.10 were considered marginally significant. Proportional Reduction in Error (PRE) methods were used to show the association between the tested variables. Since the variables were nominal, Phi was applied to test the levels of association. In contrast, values of less than 0.2 showed a weak correlation, values between 0.2 and 0.4 reflected moderate correlation, and values higher than 0.4 showed a strong association.

4. Findings

4.1 Model fit

To answer the first two questions, four binary logistic models were developed to study how the correlations of using paratransit for commuting and non-commuting purposes changed during COVID-19. With four dependent variables: mode choice for non-commute trips before COVID-19, mode choice for non-commute trips during COVID-19, mode choice for commuting before COVID-19, and mode choice for commuting during COVID-19. The final models include 12 explanatory independent variables. The insignificant variables were eliminated, starting with two models for "during" iterations. P-values greater than 0.10 were considered insignificant. The following independent variables were considered after the alteration process for the four models: gender, household car ownership, household size, public transport use, evaluation of the quality of buses and minibuses, and smartphone use for transportation after the alteration process. Tab. 6 summarizes the four models.

The Nagelkerke R² value (Nagelkerke, 1991) for non-commute travel during COVID-19 is 0.21, indicating that the model explains 21% of the variances of the dependent variables, 22% of the variances of the dependent variables for non-commute travels before COVID-19, 16 % of the variances of the dependent variables for commute travel during COVID-19, and 14% of the variances of the dependent variables for commute travels before COVID-19. Two types of validation tests were performed on the models: omnibus and the Hosmer and Lemeshow Test, as shown in Tab.7. The omnibus test is a statistical concept that analyses the general fit of a model, where the P values for non-commute and commuting during and before COVID-19 are 0.001, confirming the model's validity. In contrast, the Hosmer and Lemeshow Test is used in logistic regression to assess the model's goodness-of-fit to the observed data. The test organizes the data based on estimated probability and compares observed and expected frequencies within these groupings. The null hypothesis states no difference exists between observed and predicted values, where B values greater than 0.05 refer to model fit. The results of P values for the four models were as follows for non-commuting travels during COVID-19: 0.07 for non-commute travels before COVID-19, 0.254 for commute travels during COVID-19, 0.12 for commute travels before COVID-19, and 0.27. These test results reflect the validity of the models.

Variable	Non-commute travels						Commute travels					
	During Covid-19 (Nagelkerke R²=21.2%)			Before Covid-19 (Nagelkerke R²=22.4%)			During Covid-19 (Nagelkerke R²=16.9%)			Before Covid-19 (Nagelkerke R²=14.2%)		
	B	P	β	B	P	β	B	P	β	B	P	β
Gender	-	0.158	-	-	0.330	-	-	0.099	-	-	0.082	-
Gender=Female	22.301	1.000	4,841,859,570	21.926	1.000	3,328,210,275	22.826	1.000	8,185,887,992	-19.731	1.000	≈0
Gender=Male	-0.539	0.055	0.583	-0.345	0.136	0.708	-0.634	0.032	0.530	-0.532	0.025	0.588
Household car ownership	-0.598	<0.001	0.550	-0.523	<0.001	0.593	-0.275	0.058	0.759	-0.252	0.032	0.777
Household size	0.115	0.081	1.122	0.149	0.009	1.161	0.110	0.121	1.117	0.065	0.291	1.067
Public transport use	0.025	<0.001	1.025	0.029	<0.001	1.029	0.029	<0.001	1.029	0.029	<0.001	1.029
Evaluation of the quality of buses and minibuses	-.011	0.025	0.989	-0.009	0.040	0.991	-0.003	0.617	0.997	-0.009	0.029	0.991
Smartphone use for transportation	-	0.009	-	-	0.052	-	-	0.324	-	-	0.574	-
Smartphone use=Yes	1.618	0.043	5.043	1.076	0.176	2.933	1.192	0.133	3.294	0.712	0.361	2.038
Smartphone use=No	0.690	0.009	1.993	0.484	0.029	1.623	0.053	0.842	1.054	-0.093	0.675	0.911
Constant	-4.571	<0.001	0.010	-4.690	<0.001	0.009	-5.203	<0.001	0.006	-4.229	<0.001	0.015

Tab.6 Binary logistic models explaining paratransit use for commute and non-commute trips before and after COVID-19

Non-commute travels						Commute travels					
During Covid-19			Before Covid-19			During Covid-19			Before Covid-19		
X²	df	P	X²	df	P	X²	Df	P	X²	Df	P
Omnibus Test											
148.073	8	<0.001	194.691	8	<0.001	107.254	8	<0.001	114.652	8	<0.001
Hosmer and Lemeshow Test											
14.304	8	0.074	10.159	8	0.254	12.772	8	0.120	9.880	8	0.274

Tab.7 The results of the Omnibus, Hosmer, and Lemeshow Tests for the four binary logistic models

4.2 Correlates of paratransit use for non-commute trips

To answer the first research question, the research compared the results of binary logistic models for non-commute trips before and after COVID-19 to see how the correlations changed during COVID-19 by comparing the significance levels and percentages for the explanatory independent variables.

The findings of binary logistic models for non-commute trips during and before COVID-19 indicate that three independent variables, household car ownership, public transport use, and evaluation of the quality of buses

and minibuses, are significantly correlated with non-commute paratransit use with no change in significance level before and during COVID-19. While the significance level of two independent variables, smartphone use for transportation, changed from marginally significant before COVID-19 to a highly significant correlation with paratransit use during COVID-19, the significance level of household size changed from highly significant before COVID-19 to a marginally significant correlation with paratransit use during COVID-19. The significance level of gender male changed from not significant before COVID-19 to marginally significant during COVID-19, in correlation with paratransit use. The findings confirm the inverse relationship between paratransit use for non-commute travel and male gender before and after COVID-19. At the same time, the percentages of using paratransit modes of transportation for males changed from 34% lower percentages before COVID-19 to 54% lower percentages during COVID-19. Also, each extra car owned by the entire household is correlated with a significantly increased likelihood of not using paratransit modes of transportation for non-commute purposes (52%). This ratio climbed to 59% during COVID-19. On the other hand, each subsequent increase in household size correlates with a significantly higher likelihood of using paratransit modes of transportation for non-commute purposes (15%) before COVID-19. This ratio has been reduced to 11% during COVID-19. Similarly, each increase in public transportation use is associated with a significantly higher probability of using paratransit modes of transportation for non-commute purposes (2.9%) before COVID-19. During COVID-19, this ratio was reduced to (2.5%).

4.3 Correlates of paratransit use for commute trips

To answer the second research question, the same procedure was used as the research went through the results of the binary logistic models for commute trips before and during COVID-19 to compare the results and find out how the correlations changed during COVID-19 by comparing the significance levels and odds for the explanatory independent variables. The findings of the binary logistic models for commute trips before and during COVID-19 revealed that two independent variables: male gender and public transport use are significantly correlated to paratransit use for commute purposes, with no change in significance level during and before COVID-19. While the significance level of two independent variables, household car ownership, changed from being highly significant with paratransit use for commute purposes before COVID-19 to marginally significant during COVID-19, the evaluation of the quality of buses and minibuses changed from being highly significant before COVID-19 to not significant correlations with paratransit use during COVID-19. The findings of the model confirm the inverse relationship between male gender and paratransit use for commute purposes both before and during COVID-19, as the odds of using paratransit for commuting purposes changed from 53% less odds before COVID-19 to 63% less odds during COVID-19 as the male gender increases. Similarly, each additional car owned by the household corresponds with a substantially higher probability of not using paratransit modes of commuting (27%) during COVID-19. However, this number has since fallen to 25% during COVID-19. On the other hand, each increase in public transportation use corresponds with a higher likelihood of using paratransit modes of transportation for commuting purposes (29%) before COVID-19, with no change during COVID-19.

4.4 Paratransit use at the city level

To answer the third research question, a Chi-square test of independence was conducted to explore how the paratransit use in the four cities of Cairo, Alexandria, Beirut, and Jounieh changed during COVID-19.

Tab. 8 shows the results of the Chi-square test of independence, which shows the levels of paratransit use for non-commute trips in the cities are highly significantly different ($P<0.001$). The higher levels of paratransit have probably caused this difference use both before and after the pandemic in Alexandria, where the choice of paratransit is higher than the other three cities (Tab.3). In Alexandria, 12.5% of the respondents used paratransit as a dominant mode before COVID-19, which this figure was 1.4% in Cairo, 0.9% in Beirut, and

3.1% in Jounieh. Paratransit use changed to 9.2%, 1%, 0.7%, and 1.9%, respectively. Likewise, the levels of paratransit use for commute trips in Alexandria were 9.2%, higher than the other three cities (1.5%, 1.5%, and 3.2% in Cairo, Beirut, and Jounieh). These figures were weakened to 6.6%, 1%, 0.9%, and 3.1% during the pandemic.

The results of the PRE-analysis reveal a weak or moderate correlation between city and paratransit use. In other words, the paratransit use changes by changing the city with different strengths for the correlations as the Phi values (as a PRE-measure) represent the strength of the correlation between city and paratransit use where the phi value 20-40% considered as a moderate strength correlation and the Phi values less than 20% considered weak correlation. The test findings confirm a moderate correlation between city and paratransit use for non-commute purposes before COVID-19, which has changed during COVID-19 to a weak strength correlation with city. While the other two variables, paratransit use for commute purposes during and before COVID-19, show a weak strength correlation with the city.

Variable	Pearson X^2 value	df	Two-sided P	Phi
Paratransit use for non-commute purposes during COVID-19	120.33	3	<0.001	0.191
Paratransit use for non-commute purposes before COVID-19	155.08	3	<0.001	0.217
Paratransit use for commute purposes during COVID-19	61.95	3	<0.001	0.137
Paratransit use for commuting purposes before COVID-19	82.16	3	<0.001	0.158

Tab.8 The results of the Chi-square test of independence and Phi values for paratransit use versus city

5. Discussion

The novel coronavirus, COVID-19, has radically transformed travel behavior in urban areas throughout the world. A rapidly rising demand for transport alongside a lack of government response has led to the emergence of a Paratransit mobility sector that works alongside formal mobility systems. This study examined the correlation between independent variables and paratransit transportation use as dependent variables in Egypt and Lebanon before and during COVID-19. The results demonstrate some notable findings that contribute to this understanding. It will also shed light on some findings that need further investigation. One of the findings compared the results of binary logistic models for non-commute or commute trips before and after COVID-19 to see how the correlations changed during COVID-19 by comparing the significance levels and odds for the explanatory independent variables. Non-commute or commute trips during and before COVID-19 indicate that three independent variables: household car ownership, public transport use, and evaluation of the quality of buses and minibuses, are significantly correlated to non-commute paratransit use with no change in significance level before and during COVID-19. The use of private cars instead of transportation increased, and transportation decreased in general during COVID-19. Several studies supporting this finding were carried out in the US (Wilbur et al., 2023; Sevi & Shook, 2022), Germany (Eisenmann et al., 2021), The Netherlands (Chen et al., 2022), Istanbul (Aydin et al., 2022), Switzerland (Molloy et al., 2021), and in various countries around the world (Möllers et al., 2022; De Vos, 2020; X. Chen et al., 2021; Paul et al., 2022; Abdullah et al., 2020).

Additionally, this manuscript's findings confirm the inverse relationship between paratransit use for non-commute or commute travel and male gender both before and during COVID-19. The percentage of males using paratransit modes of transportation changed from 34% before COVID-19 to 54% during COVID-19 for non-commute travel. It changed from 53% before COVID-19 to 63% less during COVID-19 for commuting travel. These results align with travel survey studies conducted in the Netherlands and King County, Washington, USA (Eisenmann et al., 2021).

When comparing the results, each subsequent increase in household size correlates with a significantly higher likelihood of using paratransit modes of transportation for non-commute purposes (15%) before COVID-19. This ratio has been reduced to 11% during COVID-19, which aligns with studies (X. Chen et al., 2021; Molloy et al., 2021).

In the four case-study cities of this study, statistical assessments of paratransit use before and during COVID-19 have identified that presenting these results can assist policymakers in better planning and defining objectives in sustainable transportation and mobility plans. The study highlights the significant difference between the cities in the levels of paratransit use for non-commute trips before Corona, where the choice of paratransit is 12.5% in Alexandria,1.4% in Cairo, 0.9% in Beirut, and 3.1% in Jounieh. Paratransit use changed to 9.2%, 1%, 0.7%, and 1.9%, respectively, during COVID-19. The level of paratransit use for commute trips in Alexandria was 9.2%, higher than the other three cities (1.5%, 1.5%, and 3.2% in Cairo, Beirut, and Jounieh). These figures were weakened to 6.6%, 1%, 0.9%, and 3.1% during the pandemic. It confirms previous findings of a decrease in paratransit use during COVID-19.

Hegazy (2022) explains in his study that one of the reasons for the significant difference between Cairo and Alexandria is that public investments in transportation are focused on the Greater Cairo region, where new types of transportation are diversified. A further explanation is that paratransit is a mode of transportation that can adjust to each place's particular geographic, social, cultural, and economic circumstances, providing greater accessibility for the most marginalized members of society. In cities like Alexandria, paratransit is one of the few viable modes of transportation that can serve inner neighborhoods due to its versatility and relatively simple navigation of minor, uneven roadways, and the road network context (Abdelrahman, 2020; Masoumi, 2019; Shaheen et al., 2023).

Due to political, geographical, and sectarian power dynamics in Beirut, Lebanon, private efforts in paratransit services rose to prominence due to the failure of state-led transport policies. Furthermore, due to the high ownership of cars in Lebanon (Beirut and Jounieh), the choice of paratransit has declined (Chalak et al., 2016; Samaha & Mohtar, 2020).

As the data in Jounieh was gathered earlier in the fall of 2021, the same data was subsequently gathered for a further three months, from November 2022 to January 2023, in Cairo and Beirut; the numbers may not match. Data gathered during the summer months in Jounieh matches the months of Egypt's academic year. Therefore, data collection should occur at several seasons of the year to precisely reflect the true behavior of the commuters. Additionally, a longer duration for the data collection method yields a larger sample size, improving the predictive power of commuter behavior. Additionally, most people who collected the data were employees and students at private universities. 90% of study participants from middle-class to affluent families may represent only a tiny portion of the population. Given that when gathering data, students might not appropriately consider the significance of diversity and social inclusion. This assumption was raised by examining the variables related to household income, size, and number of cars owned. The political climate in every nation presented another challenge for data collection. The unease among street people resulted in some students being harassed by other passengers. Additionally, authorities wanted certain study conductors to confirm that their research was legitimate to their colleagues.

Due to currency fluctuations between Egypt, Lebanon, and the Euro, questions about expenses and income were eventually dropped from the survey. Since the Egyptian pound is the sole currency, the values collected were expressed in Egyptian pounds. It was not confirmed if all the values collected from Lebanon were in US dollars or if any responses were given in Lebanese money. The collected data raised these questions, as well as how the numbers demonstrated a significant difference between Beirut and Jounieh. This rendered all the model's income and expense statistics.

We advise decision-makers, trailblazers, and the transportation industry to use the results and conduct more research to confirm the importance of the criteria. Informal public transit options, or paratransit, are a crucial

component that improves the quality of life in cities on social, economic, and environmental fronts. To maintain accuracy and save time, it is advised that future research have a larger sample size and access to big government data. This will enable the researchers to use more potent parametric tools to analyze data, which will have higher precision in the commuter behavior forecast.

6. Conclusion

The study clarified the concept of paratransit at the beginning, then explored, evaluated, and drew conclusions from the data regarding the study's viability and potential benefits. It also concludes the vision of developed countries for this type of transportation and its negatives. Then it discussed why it spread in developing countries, especially Egypt and Lebanon. It described how COVID-19 has affected the world. Four binary logistic models were developed to examine how the correlations of using paratransit for commuting and non-commuting purposes changed during the pandemic to understand better its impact and the differences between the pre- and post-epidemic periods. The study concludes that COVID-19 has drastically changed how people commute in cities across the globe. During COVID-19, the usage of private vehicles as a form of transportation increased while the use of public transportation fell. A family's likelihood of utilizing paratransit also rose with the size of the family. The research validated the distinction between the Egyptian cities of Cairo and Alexandria and the Lebanese cities of Beirut and Jounieh concerning their dependence on paratransit.

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