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Impact of the COVID-19 pandemic on travel behavior in Istanbul: A panel data analysis.

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Keywords

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Author Contributions

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Abstract

The COVID-19 pandemic, which was reported in early January 2020 in China and spread rapidly around the globe, will certainly remain as one of the most impactful disruptive events of the 21st century. To contain the spread of the virus while awaiting a vaccine, countries applied different approaches from simply giving advice on personal hygiene and applying progressive measures to total lockdown. This paper aims to investigate the impacts of the pandemic on travel behavior in Istanbul,Turkey, through a longitudinal panel study conducted in three phases during the early stages of the epidemic and pandemic. The paper reflects the travel behavior evolution during the development of the outbreak resulting from residents' self- regulation and governmental measures, distinguishing travel for commute, Social/Recreational/Leisure (SRL), and shopping activities, as well as use of different travel modes based on various socio-economic characteristics. Due to the application of the social distancing of at least 1.5m, closure of numerous non-essential venues, encouraging teleworking and distance education, job losses and cancellation of all social gatherings in Istanbul between the second and third phase of our data collection, the transition in travel activity pattern and transport mobility appears to be quite extreme, particularly for commuting and SRL trips.

Keywords: COVID-19 pandemic; travel behavior, public transportation; teleworking; Istanbul.

1. Introduction

China reported detection of a pneumonia of an unknown cause to the Chinese Office of World Health Organization (WHO) on 31 December 2019 (Huang et al., 2020). To stop the spread, the Hubei Province and its capital city, Wuhan, the epicenter of the virus, were put into lockdown in

order to contain the virus. Despite the rapid spread of the virus in the Wuhan region, many political leaders around the globe disregarded the issue at early stages and only very few countries, such as South Korea, gave the necessary importance to the fight against the virus outbreak since the first day (Nieuwenhuijsen, 2020). However, on 11 March 2020, the COVID-19 outbreak was declared as a pandemic by WHO subsequent to the spread of the virus in other parts of the world such as Italy, Iran and North America (Afifi et al., 2020). As COVID-19 continues to spread further, it is crystal clear that COVID-19 is one of the most impactful events of the 21st century. It is believed by the economists that the impacts of the virus are so profound that they will lead to bankruptcy of many sectors, shut down of factories, and withdrawals or suspensions in long term investment in developing and developed countries (Fong et al., 2020). On the other hand, considering the limited medical interventions available to treat the virus and lack of a vaccine, most countries applied a variety of non-pharmaceutical interventions including various forms of lockdown, closure of universities/schools and non-essential workplaces, shifts to teleworking and distance education system, social distancing, postponing or cancelling events (i.e. sport events, political debates, festivals, etc.), restrictions on local, regional and international travel, and bans on people gatherings. All these factors left an indelible impression on many aspects of life from socio-economic to politics at a global scale. Beside the extensive medical investigations, many non-medical researchers also tried to reflect on the pandemic from various perspectives including but not limited to the impacts on business (Ritter and Pedersen, 2020), impacts on tourism (Yang, Zhang and Chen, 2020; Zenker and Kock, 2020), energy (Norouzi et al., 2020), and planning and decision making (Allam and Jones, 2020).

Alongside these non-medical efforts, this paper aims at scrutinizing the impacts of the COVID-19 pandemic on travel behavior in Istanbul, Turkey. Accordingly, we aim to capture the immediate

changes in Istanbulites' travel behavior as close to real time as possible since capturing behavior retrospectively might give rise to different forms of biases associated with remembering past behavior, particularly, behavioral changes. The major rationale behind this study is that the COVID-19 pandemic and the governmental policies aiming at containing the virus spread may have very large impacts on urban mobility, some of which could become structural. In comparison to rural areas, it is clear that the spread of COVID-19 is stronger in urban metropolitan cities (Raj, Velraj and Haghighat, 2020). On the other hand, a key role in the spread of the virus in megacities such as Istanbul is played by human mobility for various purposes and use of public transportation (Megahed and Ghoneim, 2020; Musselwhite, Avinery & Susilo, 2020). In response to the virus risk, individuals may change their mobility patterns. Within this context, the changes in travel behavior of the Istanbulites have been investigated in three different phases. During the first phase, the virus was only regarded in a blurred way in China and it was almost disregarded in Turkey. During the second phase, an outbreak of the virus was reported in the neighbor country, Iran, and some European countries particularly Italy. Thus, public sensitivity towards the virus started to be in the spotlight during this period. Finally, in the third phase the outbreak of the virus was officially reported in Istanbul and public sensitivity had reached its peak. More specifically, this paper investigates factors influencing the travel behavior of individuals distinguishing different trip purposes. In this regard, this paper, through unique three-wave panel data and based on a descriptive analysis, investigates the impacts of the COVID-19 pandemic and the measures taken by the government on travel behavior of individuals, distinguishing different trip purposes including home-work, Social/Recreational/Leisure (SRL) and shopping trips, in Istanbul, a megacity in the developing world. The findings are based on panel data from a sample of 144 Istanbul citizens. Interviewing the same cohort during the three phases (and their timing) is a *unique* feature of this study making

it stand out among other similar efforts assessing the impact of COVID-19 around the world in its very early stages.

2. Literature Review

Influencing the entire world, the COVID-19 pandemic has a disruptive impact on the way people live and move around, in cities and society as a whole. Subsequent to the halt in normal everyday life caused by the pandemic and based on the concerns on the hygiene and social distancing, many people favored the use of private cars over public transportation and other shared modes. On the other hand, for many years, there has been a debate on how to sustain urban mobility (Bertolini, le Clercq and Kapoen, 2005; Foltynova et al., 2020; Greene and Wegener, 1997; Shakibaei, Alpkokin and Gunduz, 2011) where many studies concluded that transportation decision-making should be more reflective of sustainability issues and quality of life in cities, since most cities in developing and developed countries are facing escalating motorization and mobility demands (Canitez, Alpkokin and Topuz-Kiremitci, 2020; Goldman and Gorham, 2006). However, apart from the increasing tendency to use private car, the pandemic has contributed to the recognition of the importance of the active mode of transportation (e.g. bicycle) (Budd and Ison, 2020; Zhang, 2020). In this context, early leadership came from the global south where Bogota, Colombia expanded its cycle network to alleviate the pressure on their public transportation (Nurse and Dunning, 2020). The global north also followed this trend and cities like New York, and Oakland in USA, and Milan, Paris, and Brussels in Europe took up non-motorized initiatives (Nurse and Dunning, 2020).

Focusing on the underlying literature, it is observed that a limited number of studies can be found on the interaction between viral outbreaks and mobility as a whole. Some of these studies evaluate the impact of the earlier viral outbreaks such as SARS and H1N1 pandemic on travel

behavior variation at urban (Kim et al. 2017), regional (Wen, Huimin and Kavanaugh, 2005) and international (Fenichel, Kuminoff, and Chowell, 2013; Liu, Moss, and Zhang, 2010) levels. The findings of these studies show remarkable decrease in travel and mobility during the pandemic period. However, these studies are limited to the short run in which the event takes place and do not explore the post-pandemic world. On the other hand, some studies focus on the role of mobility in the spread of the viruses (Pestre et al., 2011; Ruan, Wang, and Levin, 2006) where they report a positive relationship between mobility and the virus spread. This intuition has been discussed in a recent study conducted in early stages of the COVID-19 pandemic by Zhang, Zhang and Wang, 2020, where they found that there is a significant association between the number of COVID-19 positive cases in Chinese cities and the frequency of high speed rail services and flights from Wuhan.

At the time of writing this paper, the COVID-19 pandemic is still ongoing; thus, there is a limited, but growing number of studies on the impacts of the pandemic on the transportation sector – more specifically, travel behavior (e.g. Aloi et al., 2020; Beck and Hensher, 2020a, Beck and Hensher, 2020b; Beck, Hensher and Wei, 2020; de Haas, Faber and Hamersma, 2020; de Vos, 2020; Gutierrez, Miravet and Domenech, 2020; Hensher, 2020; Jenelius and Cebecauer, 2020; Lee and Lee, 2020; Molloy et al., 2020; Nurse and Dunning, 2020; Parady, Taniguchi and Takami, 2020; Shamshirpour et al., 2020; Tirachini and Cats, 2020). Table 1 presents some of the key findings of the impacts of the COVID-19 pandemic on travel behavior in different cities or countries. Given the transmission way of the SARS-Cov-2 (COVID-19) virus, physical distance emerged as one of the key strategies to mitigate the virus spread, thus, some form of mobility restrictions were inevitable. Within this context, some countries decided to take drastic measures such as the early lockdown in Wuhan, China, where some other countries like Japan relied

largely on requests for self-restriction including but not limited to teleworking and avoiding unnecessary travelling (Shaw, Kim and Hua, 2020). As given in Table 1, changes in travel behavior, apart from the perception of the risk posed by the pandemic on individuals and self-regulation, rely on governmental measures. Consequently, behavioral changes presented in this study and studies presented in the table might only reflect short term effects. In other words, long-lasting impacts of the pandemic on travel behavior should be evaluated in a post-COVID-19 world, which has not yet realized. However, past experiences have shown that disrupting impacts on travel behavior are only achievable during the period when the event takes place (Brewer and Hensher, 2001; Nguyen-Phuoc et al., 2018; Parkes, Jopson and Marsden, 2016).

3. Survey and Data Collection

A paper-based panel survey was conducted in Istanbul to focus on the dynamics of daily travel behavior and to evaluate the immediate changes in Istanbulites' travel behavior caused by the governmental measures and individuals' self-restriction due to the COVID-19 pandemic. Our three-phase longitudinal panel study was conducted between January 2020, when COVID-19 was an epidemic in China, and April 2020, when it had turned into a global pandemic. The phases of our study are as follows: phase 1: "total disregard of the virus in Turkey", phase 2: "raised sensitivity to the virus risk based on the experiences of Iran and Italy", and phase 3: "actual engagement with pandemic problems in the country". Figure 1 and Figure 2 illustrate the timeline over which the surveys were conducted and the measures taken by the government to contain the virus spread, respectively.

Table 1: A review of the impacts of the COVID-19 pandemic on travel behavior in different parts of the world.

Research	Study timeline (key dates in targeted region)	Region	Analyzing	Method	Key findings
Parady, Taniguchi and Takami (2020)	Wave 1: 1-8 Apr 2020 Wave 2: 16-23 Apr 2020 (first positive case on 24 Jan. in Tokyo and first death on 14 Feb. in mainland Japan. Initial request on cancelling or postponing large-scale events on 26 Feb. Request of 'stay at home' in Tokyo on 26 Mar.)	Kanto region including Tokyo (Japan)	Grocery shopping, other types of shopping, eating out, and leisure	Panel data, descriptive analysis and a discrete choice approach	Significant drop in activity levels. Severe reduction for leisure activities, eating out (alone and in group) and moderate reduction for grocery shopping.
Shamshiripour et al. (2020)	25 Apr-2 Jun 2020 (first positive case in Illinois on 24 Jan. First death in Illinois on 17 Mar. Closure of schools on 13 Mar. Closure of all restaurants and bars on 15 Mar. Cancelling all 50+ gatherings on 16 Mar. Statewide 'stay at home' order between 21 Mar – 7 Apr.; then extended till 30 Apr.)	Chicago (USA)	Teleworking, online shopping, airplane travel	SP-RP survey, Descriptive and statistical analysis	Significant increase in teleworking for 5 days a week during the pandemic. 65% growth in online grocery shopping (before and after the 'stay at home order'. Significant reduction in the 'future air travel' stated by the respondents
De Haas, Faber and Hamersma (2020)	27 Mar-4Apr 2020 (first positive case on 27 Feb. and first death on 6 Mar. in the Netherlands. Cancelling all events with 100+ participants and encouraging distance education on 12 Mar. Cancelation of all flights from Iran, Italy and China since 13 Mar. extension of all restrictions till 28 Apr.)	The Netherlands	Outdoor activities, work and education	Panel data, descriptive and statistical analysis	44% of workers started teleworking or increasing their level of teleworking. 55% and 68% reduction in amount of trips and distance travelled, respectively (during the pandemic compared to the fall 2019). Decrease of around 90% for trips by public transport. Significant increase in tendency to use active modes such as walking and bicycle and also private car.
Jenelius and Cebecauer (2020)	Mar - May 2020	Stockholm, Vastra Gotaland, Skane (Sweden)	Public transport ridership.	Data on ticket validations, sales and passenger counts	Highest decrease in use of public transport in Stockholm. Ridership significantly declined for rail and bus but more serious for rail. Shift from public transport to private car and to some extent to bicycle.

Table 1: Continued.

Research	Study timeline (key dates in targeted region)	Region	Analyzing	Method	Key findings
Beck and Hensher (2020a)	Last week of March 2020 and collected by 15 Apr. (first positive case on 25 Jan. and first death on 1 Mar. in Australia. Ban on large gatherings on 16 Mar. Further restrictions on 21 Mar. Beginning of lockdown on 23 Mar. Easter 'stay at home' on 5 Apr.)	Australia	Overall travel, travel by mode, travel by purpose, teleworking, shopping	SP-RP survey, Descriptive and statistical analysis	Biggest reduction in aggregate trip belongs to private car (drop from 17 trips a week to 8). Significant reduction in use of rail and bus. Almost a twofold increase in the number of those shifting to 5 days of teleworking. Highest drop for outdoor leisure activities.
Beck and Hensher (2020b)	23 May, 15 Jun 2020 (first positive case on 25 Jan. and first death on 1 Mar. in Australia. Ease of restriction in NSW, first round on 15 May, second round on 1 Jun. and third round on 1 Jul.	Australia	Overall travel, travel by mode, travel by purpose, teleworking, shopping	SP-RP survey, Descriptive and statistical analysis	Aggregate travel has increased by 50% since easing the restrictions, but still less than around 65% of that for before-pandemic days. Significant rebound for private car use. Alleviated concerns on use of public transport compared to the peak of outbreak but still far more than pre-Covid-19 days. Teleworking is continuing. A large increase in bicycle use.

Apart from governmental measures presented in Figure 2, the Istanbul Metropolitan Municipality re-planned many of its public transportation services including rail and road facilities such as ending metro services earlier at 21:00, halting the Nostalgic Tram and Funicular Istanbul services up to a further notice, and only accepting passengers as up to 50% of the facilities capacity as part of the coronavirus counter measures. It should be noted that Ramadan, Muslims' holy month started on 24 April in Turkey, and thus had no impact on the respondents' travel behavior in any of the phases.

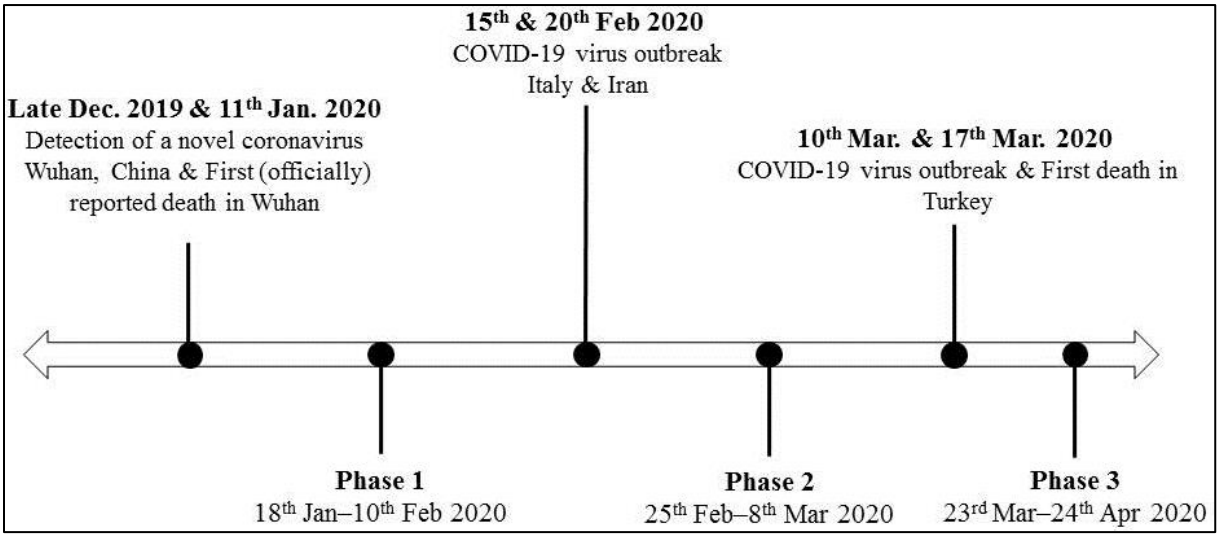

Figure 1: Data collection timeline.

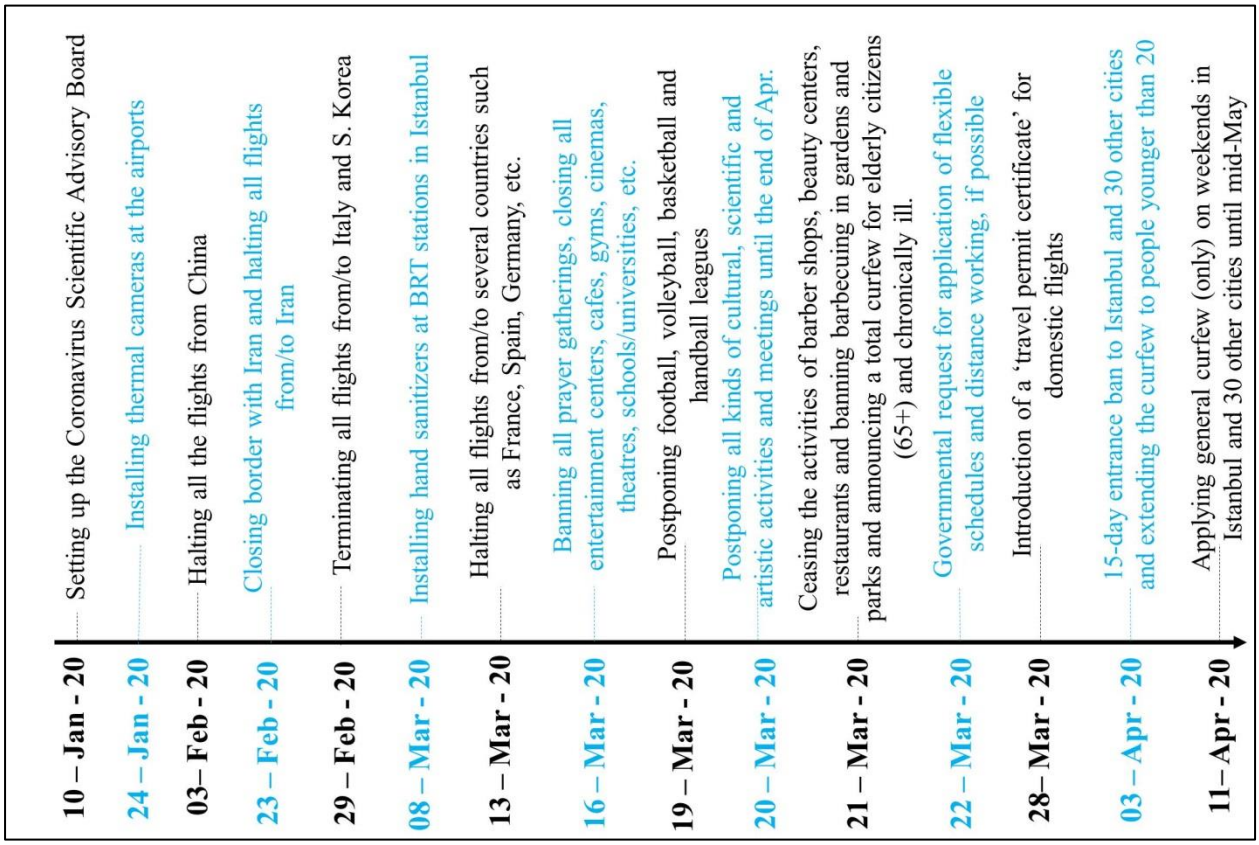

Figure 2: Key measures taken by the government in the initial stages of COVID-19.

Our surveys were structured to collect information in four major categories: 1- socio-demographic details such as gender, age, educational level, household size, as well as the

economic factors including occupation type, income and household income, car ownership and access to car in the household; 2- working conditions and an extensive set of questions about changes caused by the pandemic in issues such as commuting pattern and working system (e.g. shift to teleworking); 3- participation in social/recreational/leisure (SRL) activities as a whole including family visits, going to cinema, park, gym, joining sport, cultural and social events, and indoor/outdoor gatherings; 4- in-store and online shopping which covers grocery shopping as well as urgent needs (e.g. pharmacy). The major interest here is how people have changed their mobility for different trip purposes during various (early) stages of the pandemic, and to what extent. Transport modes and attitudes towards them are also emphasized here. To do this, survey questionnaires were distributed during different phases of the study, as shown in Figure 1. In order to make comparison between equal durations in different phases (with different phase durations – due to the unpredictable nature of the virus and its spread in different regions), the respondents were asked to report their activity patterns, frequencies and transportation modes during the same time span, per week (last week), in any specific phase. The 'snowball sampling' technique was used to collect data on respondents' travel behavior. The reason for selection of this sampling method was the lack of the access to a market research firm or online platforms. Indeed, the virus outbreak and imposed risks were incessantly, unpredictably and rapidly growing all around the world in the early stages and considering the tools available, the only viable means of data collection for this initial study was convenience sampling methods such as the snowball approach. The respondents were informed that the survey might be repeated in the future with regard to the worldwide progresses of the virus outbreak. In this context, a sample of 144 individuals who responded to all phases was produced. The descriptive statistics for the socio-demographic attributes are summarized in Figure 3.

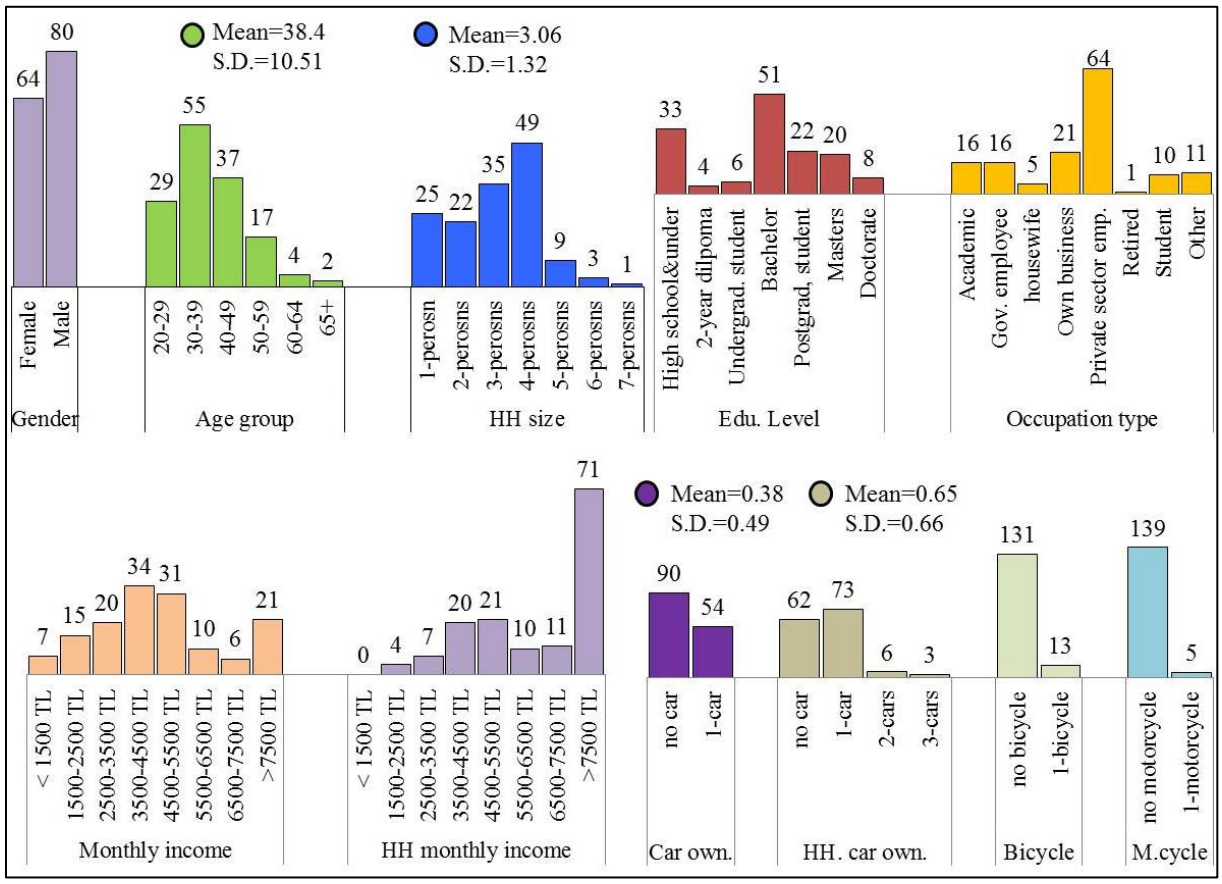

Figure 3: Descriptive statistics for the socio-demographic attributes.

Given the nature of the snowball sampling approach and also predominant concentration of the study on home-work trips, unemployed, less-educated, senior citizens (elderly) and retired individuals are under-presented in the sample. In other words, a sample size of $n = 144$ might not be fully representative of a megacity such as Istanbul, but it might be big enough to provide indications and insights of the key developments since we are using a panel data in which each phase had exactly the same respondents reporting the changes in their travel behavior – the scope of this study.

4. Case Study Findings

Inclusion of the panel study in this research has paved the way for a detailed exploration of longitudinal changes in travel behavior. This section initially reports on a brief overview of the

changes in commuting, SRL, and shopping activities, respondents' sensitivity to the threat and their concerns around the pandemic in transitions from phase 1 to phase 2 and similarly from phase 2 to phase 3. Figure 4 presents the changes in home-work, SRL and shopping activities where the term 'change' refers almost wholly to reductions in travel. Figure 5 shows the respondents' level of concern about the virus during different phases. The figures help demonstrate the importance of the sensitivity to the virus spread risk to make changes in mobility patterns. It is clear that in transition to phase 2 where the respondents' sensitivity was called by the virus outbreak in Iran and Italy, SRL activities experienced substantial weekly decline of almost 36% ($0.07 \times 0.70 + 0.93 \times 0.335$) compared to the first phase. This reduction was 3.4% and 2% for the number of days travelling to work and shopping frequencies, respectively. However, the major changes occurred in transition to phase 3 of the study where 64.5% of the respondents reported decline in the number of days travelling to work or university caused by switch to teleworking or distance education and working place closure, 77.8% reported significant reductions in SRL activities and 23.6% reported declines in weekly shopping activities. Each of the trip categories will be analyzed in detail in the following sub-sections.

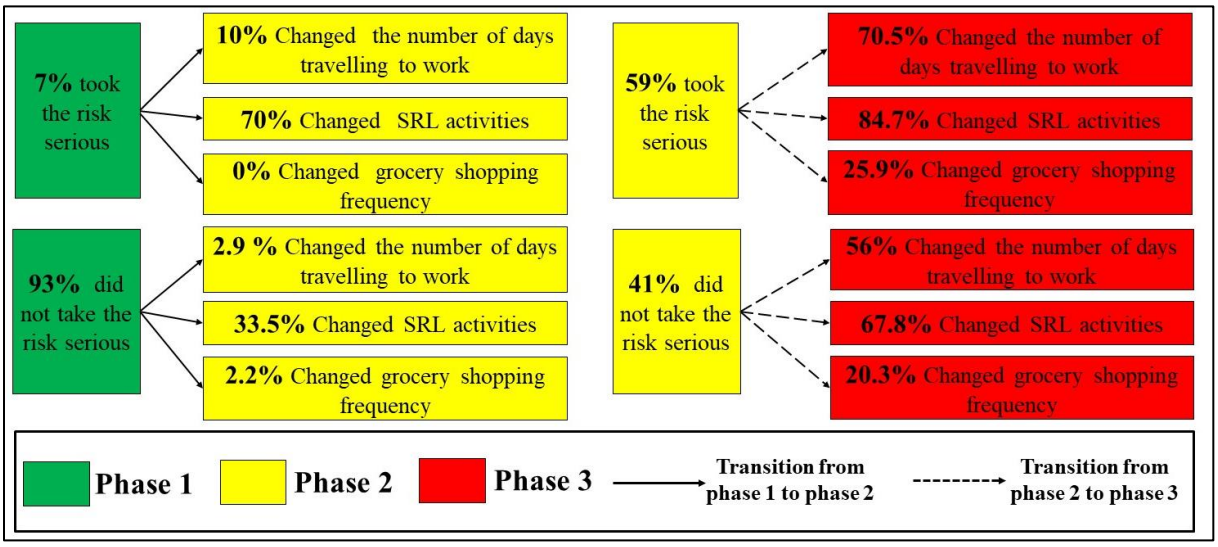

Figure 4: Activity change for different trips – phases 1-3.

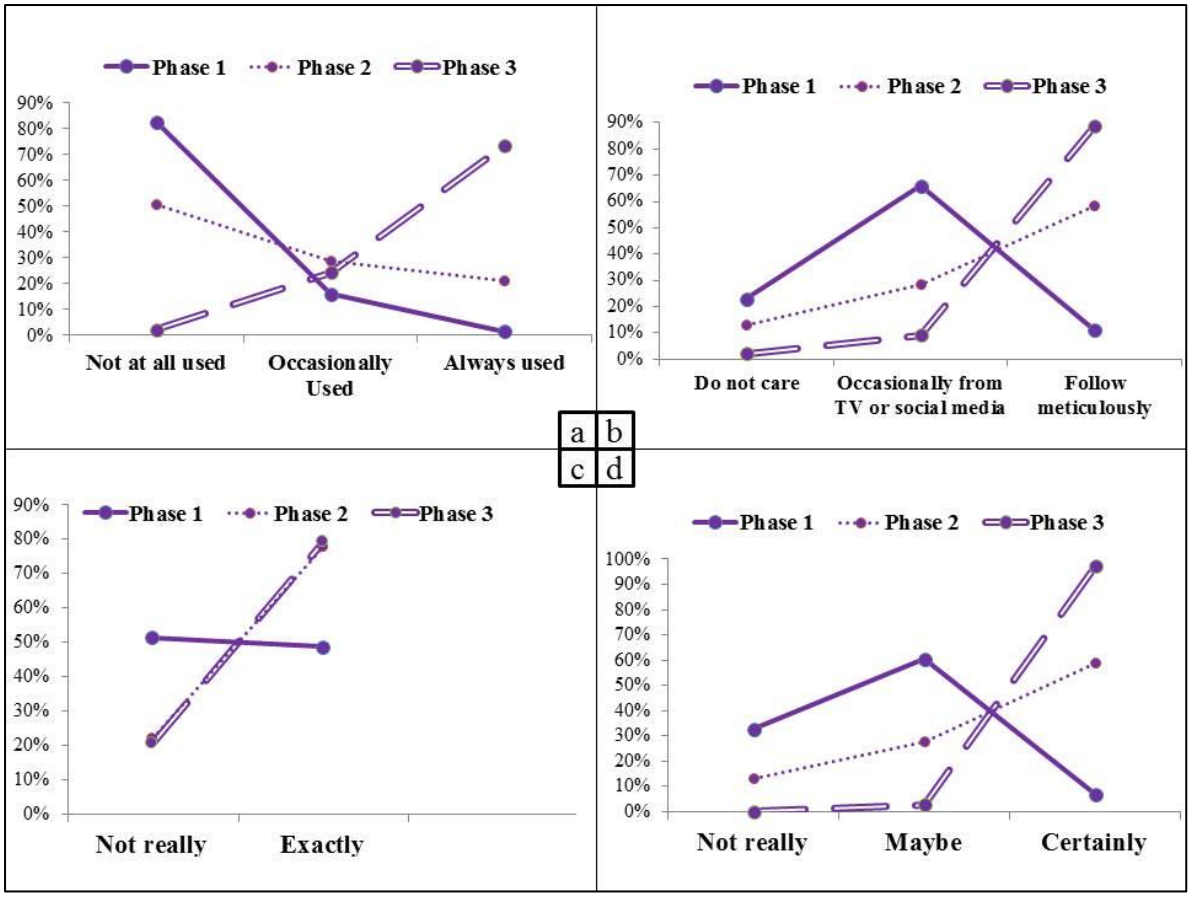

Figure 5: Respondents' level of concern about the virus outbreak during different phases a) using face mask in public spaces b) pursuing news about COVID-19 c) observing symptoms of the virus which are similar to flu and d) potential of the virus to threat countries all around the world.

4.1. Commute Trips (Work and University)

Given in Table 2 and Figure 6, the results from the respondents' phase 1 and phase 2 'number of days travelling to work' indicate that the outbreak of the virus in Iran and Italy did not result in significant decline of commute frequency in Istanbul. However, this reduction in transition from phase 2 to phase 3 is statistically significant. This significant decline might be explained by two major factors: First of all, the 3rd round of the study started on 23 March right after the outbreak of the Coronavirus in Turkey. Consequently, the individuals' sensitivity to the virus was in its peak. Furthermore, the most important factor behind this reduction was related to the preventative measures taken by the government. In this context, many professions and working places

including but not limited to the restaurants, barber shops, cafes, and entertainment places were obliged to cease their activities until a further notice. Almost all of the schools and universities shifted to distance education. Numerous firms initiated the process of teleworking. Elderly citizens (65+) and youngsters (20-) had to stay home caused by a governmental prohibition starting from late March.

Table 2: Exploring changes to commute and transport modes.

Variable	Mean			S.D.			t-stat			*p*-value		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1→2	Phase 2→3	Phase 1→3	Phase 1→2	Phase 2→3	Phase 1→3
Number of days travelling to work/university	5.15	5.09	2.97	1.29	1.40	2.54	1.80	11.77	11.97	.074	.000**	.000**
Walk	1.15	1.16	0.66	2.36	2.37	1.79	- 1.00	3.49	.319	.319	.000**	.000**
Cycle	0.12	0.12	0.08	0.82	0.82	0.65	-	1.18	1.18	-	.241	.241
Road public transport	1.72	1.60	0.66	2.48	2.44	1.75	1.61	5.92	6.34	.110	.000**	.000**
Rail	1.30	1.19	0.31	2.58	2.52	1.51	2.27	5.27	5.63	.025*	.000**	.000**
Private car	1.41	1.54	1.24	2.38	2.41	2.12	- 1.77	1.68	0.89	.079	.096	.376
Rideshare	0.82	0.76	0.52	1.96	1.92	1.55	1.38	2.53	2.93	.171	.013*	.004**

*Significant at $p < .05$; ** Significant at $p < .01$.

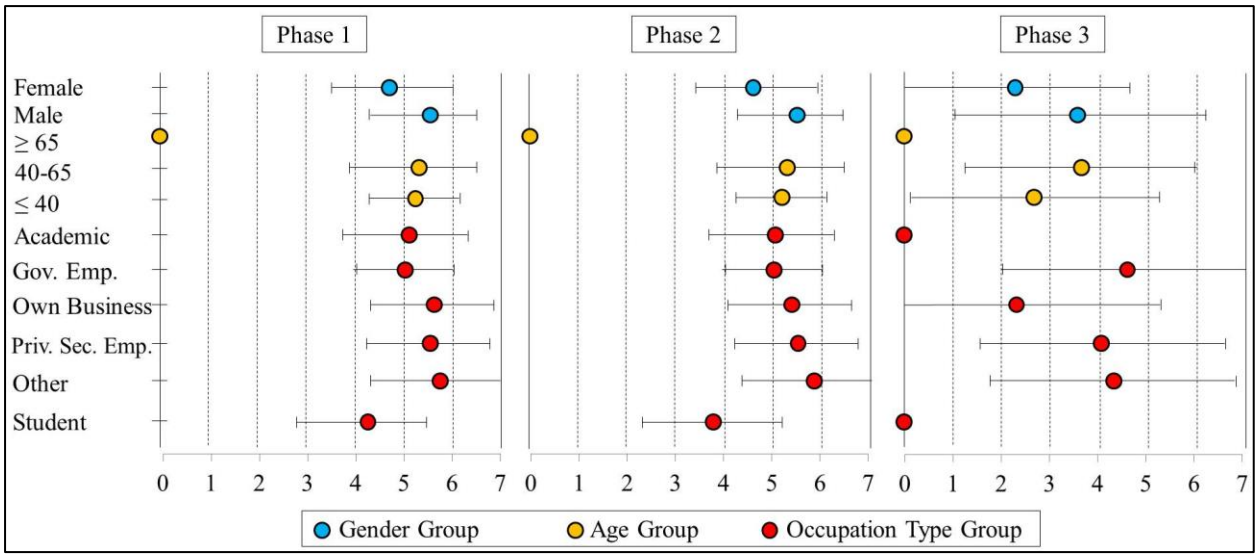

Figure 6: 'Number of days travelling to work/university' during different phases.

As is clear from Table 2 and Figure 7, when it comes to the transport modes during phase 1, it is observed that the highest mean for utilization while commuting to work belongs to the road

public transportation facilities including bus, BRT and minibus with average use of 1.72 times a week for 144 respondents. Private car follows with an average of 1.41. Rail facilities including metro, tram and light rail are in the 3rd place with average of 1.30. Walking (more than 15 min) is also a very common mode for home-work trips with 1.15 average. However, this is mainly due to the distance of the respondents' residential locations to the metro platforms and bus stations. In Istanbul, it is very common and acceptable for individuals to walk for 15-20 minutes to reach the public transportation facilities (particularly metro and BRT) with regard to the lower-rent of housing in such a distance compared to those in immediate proximity to such facilities. Rideshare is also a common mode with an average of 0.82. This is mainly due to the fact that almost all universities, schools and big companies have their own shuttle vehicles to the central nodes of the city. Furthermore, it was observed that some respondents routinely use carpool with their colleagues while commuting to their working places.

It was clearly observed that there is an increment in the number of those who have started to use private car instead of public transportation or those who have started to use the private car belonging to the other members of household during phases 2 and 3. However, distance education and teleworking have outweighed the mentioned fact during phase 3 where the number of those individuals starting to use private car during phase 3 was less than the decline in the number of those people shifting to distance education/teleworking who were used to use private car to commute during phases 1 and 2. Finally, it was observed that the mean use of aerial cable car, motorcycle, bicycle, taxi and ferry (0.00, 0.08, 0.12, 0.10, and 0.03 times a week, respectively) is negligible for the home-work trips of the respondents. It should also be mentioned that based on the symmetry of the round trips (home-work and work-home) all the values are for one-way home-work trips.

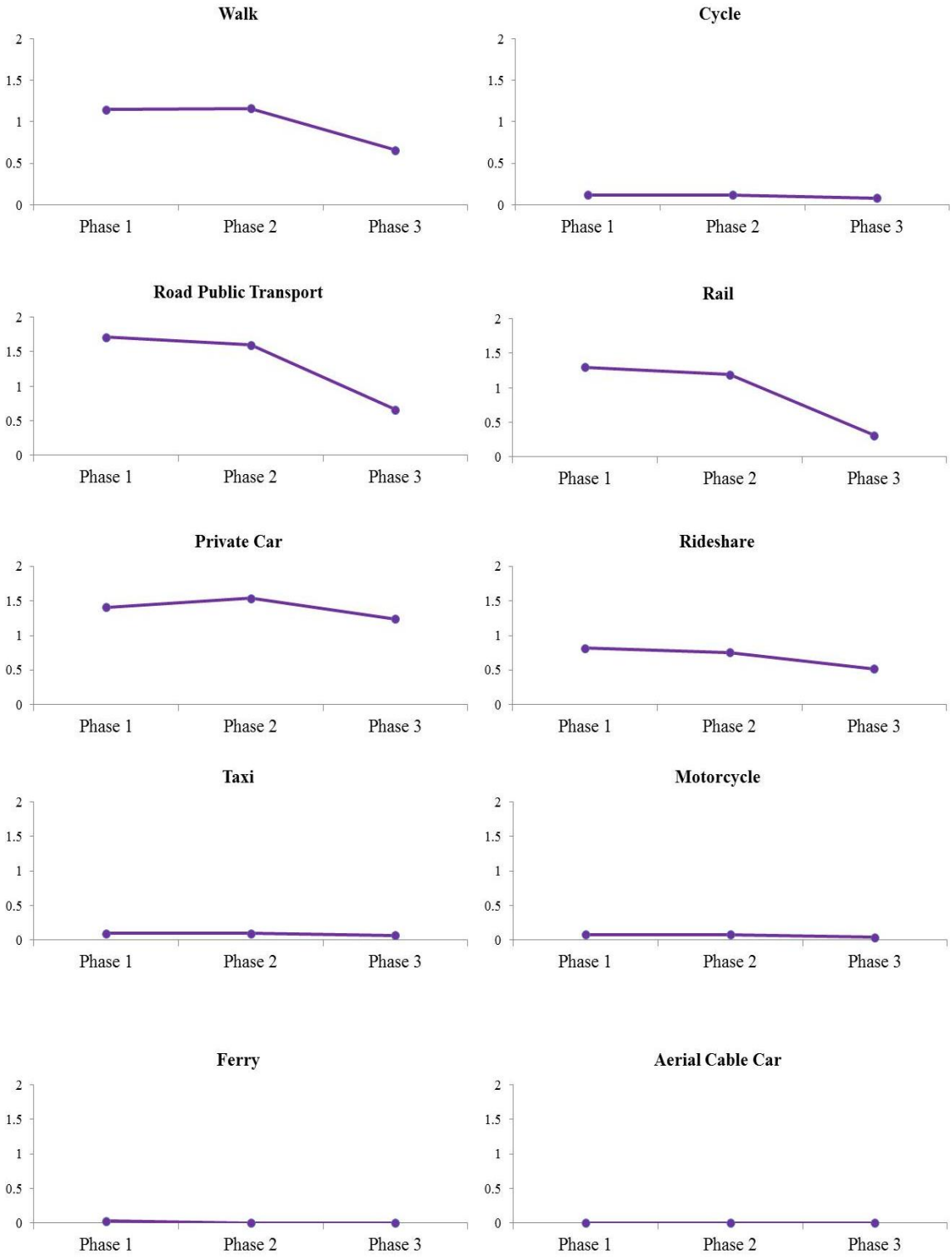

Figure 7: Reported average weekly commute trips by modes.

In analysis of the significance of the changes in use of each transport mode in transition from phase 1 to phase 2, it was observed that the only statistically significant reduction is related to the

rail facilities. All other modes of transport have not undergone a statistically significant change from phase 1 to the 2nd phase. In addition, private car is the only mode which has gained popularity for commute in transition from phase 1 to phase 2 and all other modes have experienced some kind of reduction.

As is shown in Table 2, walking, road public transportation, rail and rideshare modes have undergone statistically significant reductions in being used by the respondents for their home-work trips. Based on both empirical data and common sense, the major points triggering these reductions are the shifts to the teleworking/distance education system by numerous firms, universities, offices and other working places, closing the working places due to the governmental measures, and the respondents' increased tendency to use private car for their home-work trips. The increment in private car usage in transition from phase 1 to phase 2 can be associated to the respondents' sensitivity to the virus news coming from Iran and Italy. The changes in private car use from phase 2 to phase 3 are not statistically significant where there is a reduction in the overall use of private car in transition from phase 2 to phase 3.

Another interesting fact about the home-work trips is that in phase 1 a remarkable portion of car owners still preferred to use public transportation. In fact, fuel costs in Turkey are very high compared to the general income levels. Fuel costs fluctuate between 6.5 to 7 TL per liter (1 USD = 7.29 TL; as of 09.August.2020) where the minimum wage for 2020 is around 2300 TL and a remarkable portion of the nation are being paid based on the minimum wage approach. There are several toll roads in Istanbul. All passes from the European side of the city to the Asian side using Bosphorus Bridges and Eurasia Tunnel are upon payment. Thus, it is somehow costly to routinely use private car for home-work trips. However, during phase 2 and 3 of the study, all of the car owners have used their private car for home-work commutes, without even one exception.

This might be explained by the fact that individuals have prioritized health over economy. They have preferred not to take risks on public transportation. This may give us the opportunity to estimate people's value of health under pandemic situations.

It was observed that there was no relation between the 'number of days traveling to work' and gender, age, income level, car ownership and household size during any phases. Occupation type is the only factor which has significant relation with the number of working days during all three phases. A chi-square test of independence was performed to examine the relation between commuting days and occupation type where the relation between these variables were significant, $\chi^2\ (42, \mathrm{N} = 144) = 255.90, \mathrm{p} < .001;\ \chi^2\ (42, \mathrm{N} = 144) = 239.42, \mathrm{p} < .001;$ and $\chi^2\ (49, \mathrm{N} = 144) = 133.53, \mathrm{p} < .001$ for phases 1 to 3, respectively. To be more specific, with regard to the breakdown of the commuting days based on the occupation type during phase 1 of the study, it was clear that the significant difference was related to the private sector employees and government employees. Almost all of the government employees and academicians have worked 5 days a week. On the other hand, more than half of the private sector employees (38 out of 64 respondents) have worked 6 days a week since most private companies work half a day on Saturdays in Turkey. Besides, there was no part-time worker in public sector but a few members of private sector were part-time employees working 4 days or less a week during phase 1.

Business owners and students are among those with the highest flexibility in number of commuting days. There was no remarkable change in any occupation group's number of days travelling to work or university during phase 2 and working patterns were similar to the first phase. However, the changes during phase 3 were enormous. Commuting days of all of the academicians and students declined to zero due to the shift to the distance education system. The public sector with its limited application of shift work practice experienced minimum changes

compared to the private sector. Based on the mentioned shift work system, weekdays were divided into shifts during which workers in the same department would perform their duties on scheduled days to minimize contact. Approximately, one third of the private sector employees commuted 4 days or less during a week at 3rd period based on the shift to teleworking system or shift work. More than half of the business owners commuted less than 3 days a week which made them the most flexible group among all other occupation types. Figure 8 and Table 3 present the exploration of different transport modes used for commute based on socio-demographic characteristics.

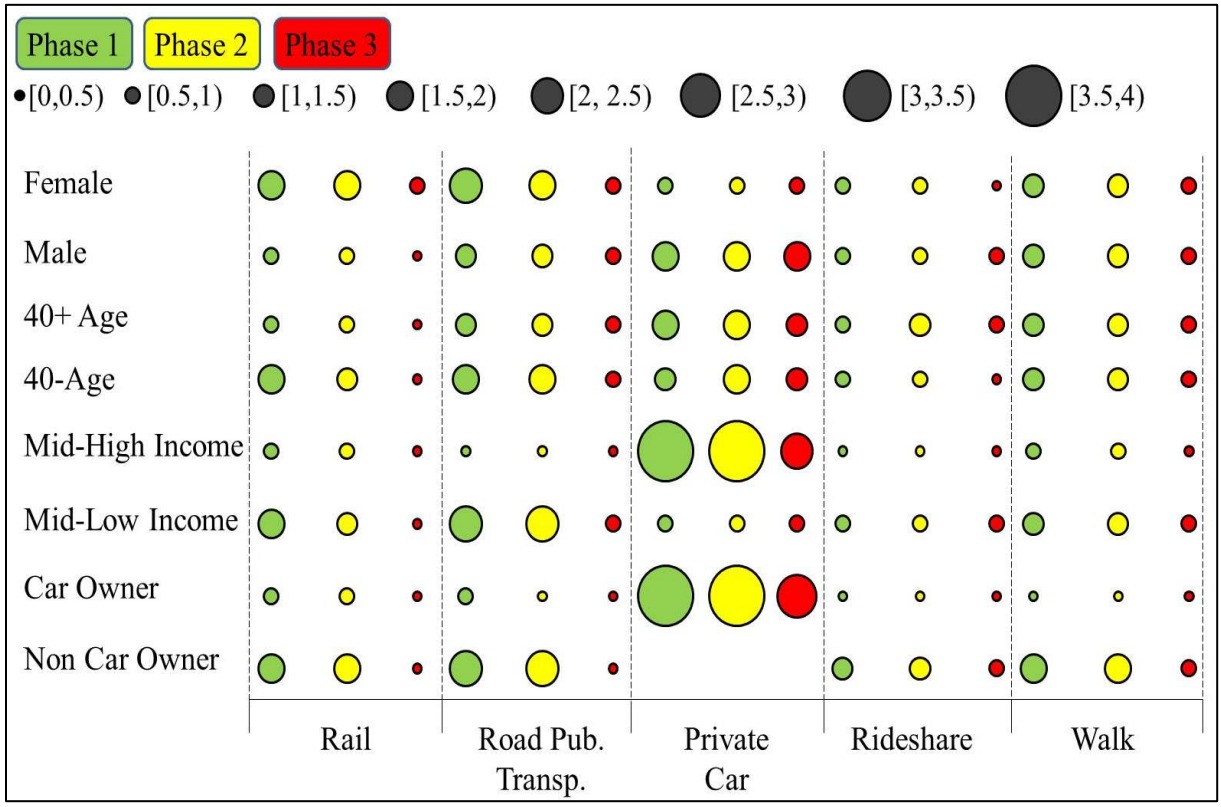

Figure 8: Average weekly use of different transport modes for commuting based on various socio-demographic groups.

Table 3: Exploring transport modes and socio-demographics for commute.

Variable	Mean			S.D.			t-stat			*p*-value		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Male private car use (MPCU) vs. Female private car Use (FPCU)	MPCU=1.90 FPCU=0.80	MPCU=1.98 FPCU=1.00	MPCU=1.73 FPCU=0.64	MPCU=2.63 FPCU=1.89	MPCU=2.60 FPCU=2.05	MPCU=2.32 FPCU=1.67	2.93	2.52	3.26	.004**	.013*	.001**
Female road public transport use (FRPTU) vs. Male road public transport Use (MRPTU)	FRPTU=2.05 MRPTU=1.45	FRPTU=1.89 MRPTU=1.38	FRPTU=0.78 MRPTU=0.56	FRPTU=2.48 MRPTU=2.46	FRPTU=2.44 MRPTU=2.42	FRPTU=1.89 MRPTU=1.64	1.44	2.16	0.73	.153	.208	.465
Female rail use (FRU) vs. Male rail Use (MRU)	FRU=1.88 MRU=0.84	FRU=1.72 MRU=0.78	FRU=0.56 MRU=0.10	FRU=3.05 MRU=2.03	FRU=3.01 MRU=1.96	FRU=2.11 MRU=0.70	2.34	2.17	1.68	.021*	.033*	.097
Older (40+) car use (OCU) vs. Younger (40-) car use (YCU)	OCU=1.88 YCU=1.07	OCU=1.85 YCU=1.32	OCU=1.50 YCU=1.06	OCU=2.61 YCU=2.16	OCU=2.57 YCU=2.29	OCU=2.22 YCU=2.03	1.97	2.17	1.22	.051	.205	.227
Younger (40-) rail use (YRU) vs. Older (40+) rail use (ORU)	YRU=1.76 ORU=0.65	YRU=1.58 ORU=0.65	YRU=0.44 ORU=0.12	YRU=2,93 ORU=1.82	YRU=2.86 ORU=1.82	YRU=1.88 ORU=0.69	2.80	2.39	1.44	.006**	.018*	.151
Mid-high income car use (MHICU) vs. Mid-low income car use (MLICU)	MHICU=3.51 MLICU=0.68	MHICU=3.59 MLICU=0.83	MHICU=2.41 MLICU=0.84	MHICU=2.66 MLICU=1.78	MHICU=2.58 MLICU=1.91	MHICU=2.36 MLICU=1.87	6.02	5.98	3.65	.000**	.000**	.000**

*Significant at $p < .05$; ** Significant at $p < .01$

When analyzing the use of private car for home-work trips, it was observed that there was a significant relation between gender and private car utilization during phase 1 where males used private car significantly more than females. During phase 2 females also started to use a private car more often to commute or other members of their household gave them a ride by the car belonging to the household. Nevertheless, males' use of private car for commuting during phase 2 is still significantly higher than that for females. Once again, males used private car significantly more than females for commuting during phase 3. It should also be mentioned that the application of teleworking system was significantly higher for females ($M = 1.36, SD = 1.85$) than males ($M = 0.76, SD = 1.49$); $t(120) = 2.10, p = .04$ during phase 3. In brief, the difference between utilization of private car for males and females is statistically significant during all phases where males use private car more than females to commute.

The income level had also a significant impact on private car utilization for home-work trips where the respondents belonging to the mid-high income group (more than 5500 TL/month) used private car more than the mid-low income respondents. During phase 1, mid-high income group used private car significantly more than mid-low income respondents for commuting. A similar pattern was also observed during phase 2 where mid-high income respondents used private car more than lower income group. This relation has declined during phase 3 where car owners of less than 5500TL group who were used to use public transportation for commuting have remarkably inclined to use private car. Anyway, the difference in private car use of mid-high and mid-low income groups is still statistically significant during phase 3 where higher income respondents used private car more than mid-low income respondents.

It was observed that females preferred rail facilities more than males for their home-work trips during all three phases. During phase 1, females used rail public transportation including metro,

tram and light rail significantly more than males. Again during phase 2, females used rail facilities more than males. This might be explained by the higher reliability and security of these facilities in comparison to road public transportation. During phase 3 females still used rail facilities more than males but not with a significant difference. A similar pattern is true for utilization of rail facilities and age. Younger respondents (under 40) used rail facilities more than elderly ones (40+) during phases 1, 2 and 3, where the differences were significant only for phases 1 an 2.

4.2. Social/Recreational/Leisure (SRL) Activities

As is clear from Table 4 and Figure 9, SRL activities of the respondents have undergone significant changes in transition to phases 2 and 3. The reductions of SRL activities are more salient compared to the commuting trips. In other words, in contrast to the home-work trips, the change in the frequency of social activities is statistically significant in transition from phase 1 to the second phase of the study where there was not yet any COVID-19 positive case reported in the country. This implies that the citizens have basically taken measures on their own, where the common feeling was that the virus definitely exists in the country given the presence of the frequent flights and passengers from numerous cities in Italy and Iran in an immediate recent time. In brief, as is presented in Table 4, the decline in SRL activity frequencies is statistically significant in both transitions from phase 1 to phase 2 and from phase 2 to phase 3. The table also presents the changes in utilization rank of different modes during three phases for SRL activities (where rank 1= not using at all, and rank 5= using most frequently).

Table 4: Exploring changes to SRL activities and transport modes.

Variable	Mean			S.D.			t-stat			*p*-value		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1→2	Phase 2→3	Phase 1→3	Phase 1→2	Phase 2→3	Phase 1→3
SRL activity frequency	2.50	1.71	0.25	1.90	1.69	0.48	7.43	11.05	14.31	.000**	.000**	.000**
Rail	2.52	1.81	1.06	1.79	1.57	0.47	6.26	5.90	9.94	.000**	.000**	.000**
Road public transportation	2.54	1.43	1.06	1.77	1.16	0.47	8.38	4.15	10.17	.000**	.000**	.000**
Ferry	1.40	1.03	1.00	0.93	0.20	0.00	5.14	1.64	5.13	.000**	.104	.000**
Private car	3.06	2.79	1.44	1.96	1.99	1.26	2.89	8.06	9.57	.004**	.000**	.000**
Rideshare	1.63	1.33	1.00	1.30	1.04	0.00	3.05	3.78	5.81	.003**	.000**	.000**
Taxi	1.25	1.15	1.00	0.78	0.74	0.00	1.77	2.37	3.85	.079	.019*	.000**
Aerial cable car	1.03	1.00	1.00	0.20	0.00	0.00	1.64	-	1.64	.103	-	.103
Walk	3.08	2.56	1.61	1.92	1.93	1.44	3.74	6.46	9.11	.000**	.000**	.000**

*Significant at $p < .05$; ** Significant at $p < .01$.

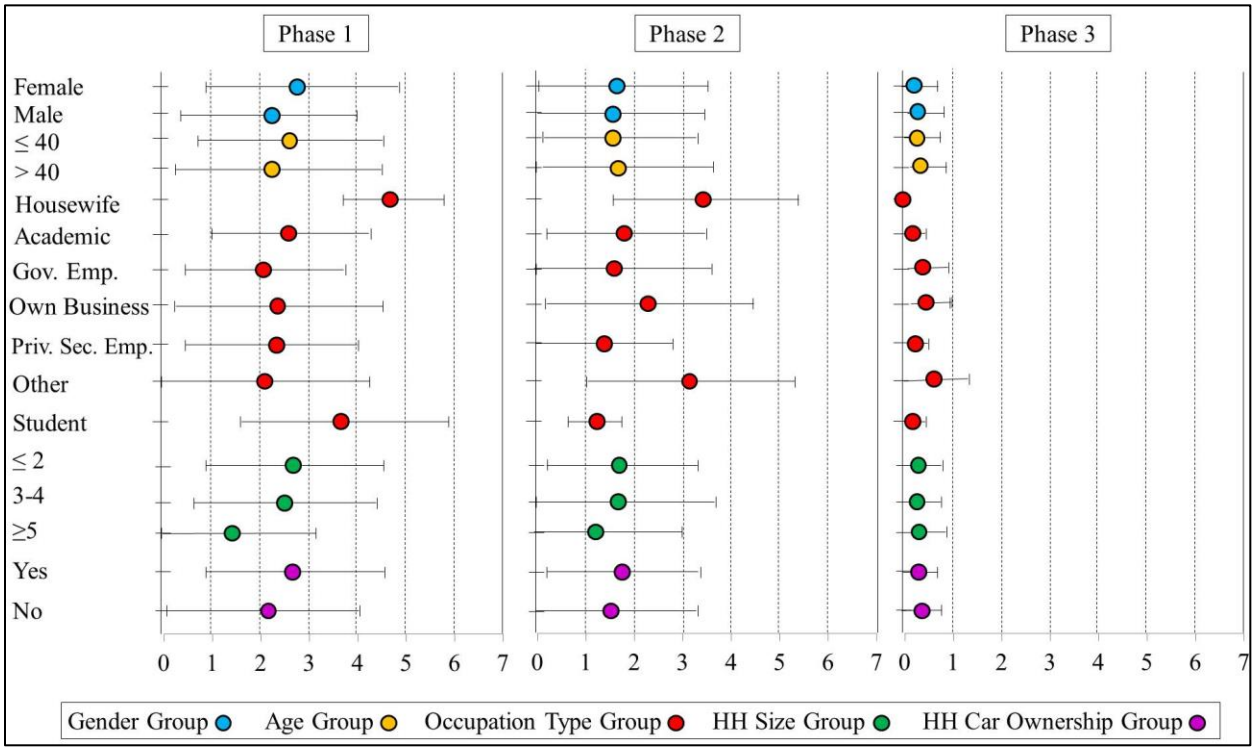

Figure 9: Changes in weekly SRL activity frequencies. Shown are frequencies of SRL activities during a week on "X" axis versus various socio-demographic attributes.

When it comes to the modes of transport, it is observed that private car and walking are the most common modes being used for SRL activities during phase1 with the average rank of 3.06 and 3.08, respectively. Road public transport including bus, BRT and minibus and rail facilities

follows the averages of 2.54 and 2.52 respectively. However, all modes have undergone a usage reduction during phase 2 (in transition from phase 1 to 2). These declines are statistically significant for all modes excluding taxi and aerial cable car from phase 1 to 2. It should also be noted that utilization of aerial cable car and taxi for SRL activities is negligible even during period 1 with an average rank of 1.03 and 1.25, respectively. Subsequently, all modes of transport except for ferry and aerial cable car have experienced statistically significant reductions in transition from phase 2 to phase 3. As for a general evaluation, all transport modes except for aerial cable car have undergone significant utilization decline for SRL purposes from phase 1 where there was no actual risk of the virus in the society to the 3rd phase where the outbreak of the virus in Istanbul and other Turkish cities was announced. Table 5 presents the relationship between different variables and the SRL activity frequency.

Table 5: Test of independence for SRL activity frequency and different variables.

Variable	Breakdown based on	χ^2			p-value		
		Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
SRL activity frequency	Gender	$(4, N = 144) = 6.46$	$(4, N = 144) = 0.65$	$(2, N = 144) = 3.08$	.167	.957	.214
SRL activity frequency	Age	$(40, N = 144) = 59.99$	$(40, N = 144) = 49.15$	$(20, N = 144) = 19.60$	.022*	.152	.483
SRL activity frequency	Occupation type	$(28, N = 144) = 42.99$	$(28, N = 144) = 40.80$	$(14, N = 144) = 21.86$	.035*	.056	.082
SRL activity frequency	Household size	$(24, N = 144) = 40.38$	$(24, N = 144) = 36.79$	$(12, N = 144) = 17.58$	.019*	.046*	.129
SRL activity frequency	Income level	$(28, N = 144) = 29.39$	$(28, N = 144) = 35.79$	$(14, N = 144) = 10.60$	.393	.148	.717
SRL activity frequency	Car ownership	$(4, N = 144) = 2.93$	$(4, N = 144) = 0.49$	$(2, N = 144) = 1.39$	.570	.974	.499
SRL activity frequency	Household car ownership	$(12, N = 144) = 30.33$	$(12, N = 144) = 21.26$	$(6, N = 144) = 16.50$	.002**	.047*	.011*

*Statistically significant at 95%; ** Statistically significant at 99%.

There was no relation between gender and SRL activity frequencies during all three phases of the study. This is somehow different for age where there is a relation between age and SRL activity

frequency during phase 1. However, during phases 2 and 3, this relation disappeared. With regard to the breakdown of the SRL activities based on age, it is observed that during phase 1, the younger respondents are remarkably more active which paves the way for formation of a relation between SRL activity frequency and age. During phases 2 and 3 though, the active role of younger respondents remarkably decreased. A pattern, analogous to the age, is also true for occupation type where there is a relationship between the SRL activity frequency and occupation type during phase 1. In other words, private sector employees, housewives and students were far more active. Similarly, these relations have been removed during phases 2 and 3 for the occupation type. This pattern for household size is even more interesting where the relationship between the SRL activity frequency and HH size in phases 1 and 2 vanishes during phase 3. During phase 1, the highest SRL activity is for those with household size of 1 and 4. Around half of both groups have SRL activity frequency of 3-5 times or more (high activity level) during a week. The most severe and significant reductions in SRL activities pertains to the transition from phase 1 to phase 2 for households of 1 to 4 members. There is no remarkable change for households of 5 and more members during the mentioned transition period. During phase 2, almost 80% of respondents of each group have performed SRL activities in a medium (1-2 times a week) to low (never or at most once a week) level. However, there is no case of high SRL activity frequency for any household size group during phase 3 where around 90% of the respondents have declared that they had no SRL activity or had activity of at most once a week. A key factor behind this fact might be the lockdown for 20- and 65+ individuals. Families with 20- members might have cancelled most of their SRL activities to stay home with their children. Family visits to 65+ individuals might have also faced the similar trend. When analyzing the SRL activity frequencies, no relation has been observed during any phases for income level and

car ownership (car directly being used by the respondent). However, during all three phases there is a relationship between car ownership in the household and SRL activity frequencies. This might be in parallel with the findings of the studies conducted by several researchers evaluating the interrelations between household car ownership, use of private car and role of life events such as changes in income and employment status, having children, and facing unpredicted events (Clarck, Chatterjee, and Melia, 2016; Klien and Smart, 2019).

Table 6 and Figure 10 present some insights to SRL activities and different variables. When analyzing the transport modes for SRL activities, it is clear that females normally use rail more than males. This difference in utilization of rail is statistically significant during phase 1 when there was no risk of the virus in Istanbul yet. However, although females use rail more than males during phases 2 and 3, the differences are not significant. In addition, utilization of road public transport is more commonplace among females compared to the males but the differences are not significant during any of the three phases. Private car utilization and walking frequencies for SRL activities during all three phases are higher for males but the differences are not significant.

The use of private car for SRL activities is more common for the respondents with higher income levels (more than 5500 TL/month) during phases 1 and 2. However, despite the higher value of the private car utilization of higher income respondents, the difference with lower income individuals is not significant during phase 3. This might be explained either by the general reductions in SRL activities or by the triggered tendency of lower income groups to use private car. During phases 1 and 2, individuals with lower income levels (less than 5500 TL/month) used rail facilities more than higher income respondents. However, the higher use of rail facilities during phase 3 by the lower income groups is not statistically significant. Similar to rail

facilities, lower income groups used road public transport more than higher income individuals during phase 1 where the difference is significant. However, this higher utilization is not statistically significant for phases 2 and 3 of the study.

It was observed that during phases 1 and 2, older respondents (over 40) have used private car more than younger ones for SRL purposes where the differences are not statistically significant. During phase 3, younger respondents have gotten ahead of elderly ones in private car utilization.

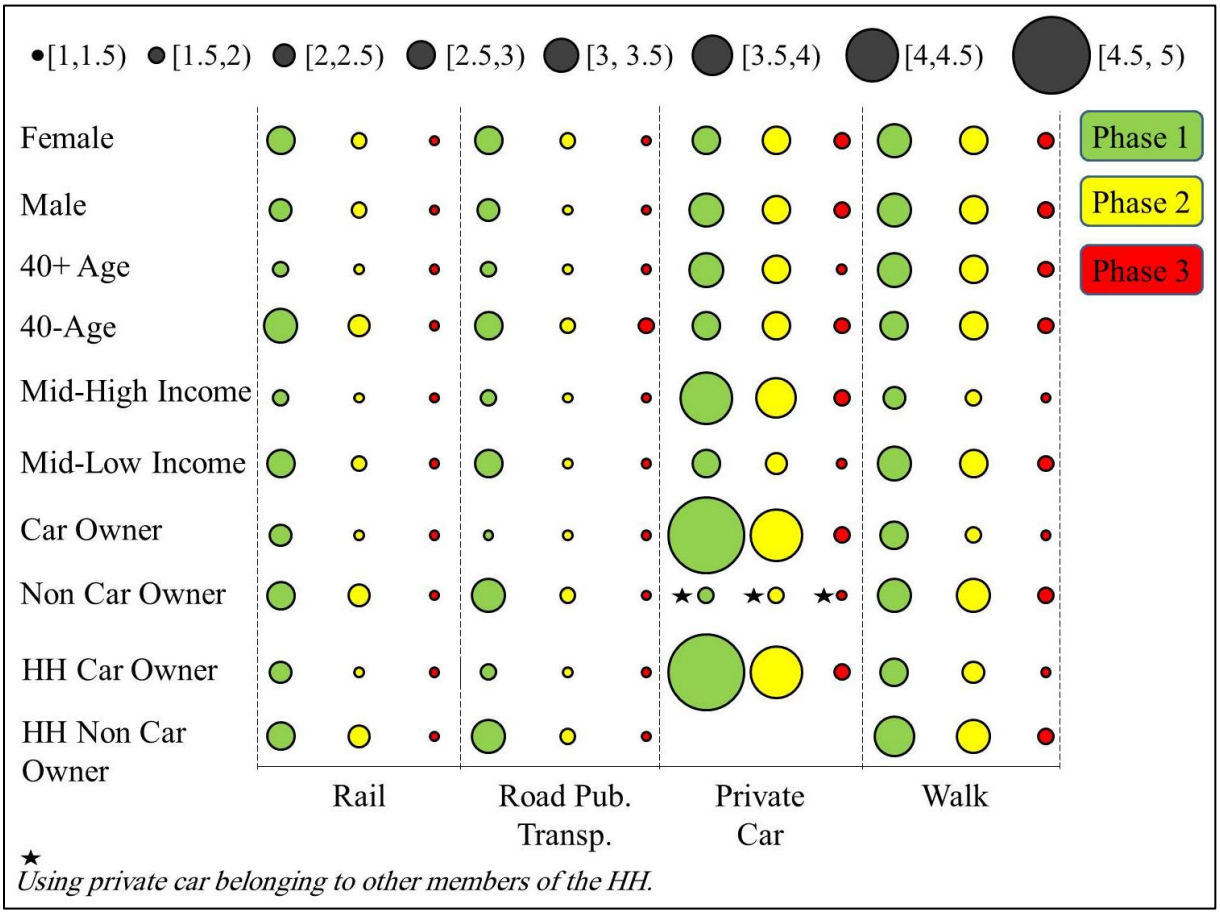

Figure 10: Average weekly utilization rank of different transport modes for SRL activities based on various socio-demographic groups (rank 1= not using at all, and rank 5= using most frequently).

Table 6: Testing the significance of the changes for transport modes' utilization rank for SRL activities based on socio-demographics.

Variable	Mean			S.D.			t-stat			*p*-value		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Female rail use (FRU) vs. Male rail use (MRU)	FRU=2.88 MRU=2.24	FRU=1.95 MRU=1.69	FRU=1.06 MRU=1.05	FRU=1.78 MRU=1.75	FRU=1.68 MRU=1.47	FRU=0.50 MRU=0.45	2.15	0.99	0.16	.033*	.322	.876
Female road public transportation use (FRT) vs. male road public transportation use (MRT)	FRT=2.84 MRT=2.30	FRT=1.52 MRT=1.36	FRT=1.13 MRT=1.00	FRT=1.77 MRT=1.75	FRT=1.26 MRT=1.08	FRT=0.70 MRT=0.00	1.85	0.77	1.43	.067	.442	.159
Female private car use (FCU) vs. Male private car use (MCU)	FCU=2.91 MCU=3.18	FCU=2.66 MCU=2.90	FCU=1.31 MCU=1.55	FCU=1.96 MCU=1.97	FCU=1.97 MCU=2.01	FCU=1.08 MCU=1.39	0.82	0.73	1.15	.415	.466	.250
Female walking (FW) vs. Male walking (MW)	FW=3.06 MW=3.10	FW=2.53 MW=2.58	FW=1.50 MW=1.70	FW=1.95 MW=1.91	FW=1.91 MW=1.95	FW=1.33 MW=1.53	0.12	0.14	0.84	.908	.893	.404
Mid-high income private car use (HCU) vs. Mid-low income (LCU)	HCU=4.46 LCU=2.57	HCU=3.92 LCU=2.40	HCU=1.65 LCU=1.37	HCU=1.30 LCU=1.92	HCU=1.80 LCU=1.91	HCU=1.49 LCU=1.17	6.67	4.35	1.02	.000**	.000**	.314
Mid-low income rail use (LRU.) vs. Mid-high income rail use (HRU.) for SRL activities	LRU=2.75 HRU=1.86	LRU=1.98 HRU=1.30	LRU=1.07 HRU=1.00	LRU=1.80 HRU=1.58	LRU=1.71 HRU=0.91	LRU=0.54 HRU=0.00	2.82	3.07	1.42	.006**	.003**	.158
Mid-low income road public transportation use (LRP) vs. Mid-high income road public transportation use (HRP) activities	LRP=2.85 HRP=1.65	LRP=1.49 HRP=1.27	LRP=1.07 HRP=1.00	LRP=1.78 HRP=1.40	LRP=1.23 HRP=0.93	LRP=0.54 HRP=0.00	4.18	1.11	1.42	.000**	.270	.158
Older people (40+) use of private car (OCU) is higher than younger people (40-) use of private car (YCU)	OCU=3.23 YCU=2.93	OCU=2.87 YCU=2.74	OCU=1.33 YCU=1.52	OCU=1.99 YCU=1.94	OCU=2.01 YCU=1.98	OCU=1.11 YCU=1.36	0.92	0.38	0.92	.361	.704	.358
Younger people (40-) rail use (YRU) vs. Older people rail use (ORU)	YRU=3.13 ORU=1.67	YRU=2.07 ORU=1.43	YRU=1.05 ORU=1.07	YRU=1.79 ORU=1.39	YRU=1.73 ORU=1.23	YRU=0.44 ORU=0.52	5.52	2.59	0.23	.000**	.011*	.817
Younger people (40-) road public transport use (YRP) vs. Older people road public transport use (ORP)	YRP=2.99 ORP=1.92	YRP=1.54 ORP=1.28	YRP=1.05 ORP=1.07	YRP=1.76 ORP=1.60	YRP=1.27 ORP=0.98	YRP=0.44 ORP=0.52	3.80	1.34	0.23	.000**	.181	.817
Non car owners' rail use (NRU) vs. Non car owners' road public transport use (NRP)	NRU=2.80 NRP=3.19	NRU=2.18 NRP=1.64	NRU=1.09 NRP=1.09	NRU=1.82 NRP=1.82	NRU=1.81 NRP=1.39	NRU=0.59 NRP=0.59	1.43	2.21	0.00	.154	.028*	1.000

*Significant at $p < .05$; ** Significant at $p < .01$

One probable factor behind this change might be the 20- lockdown during phase 3 where older members might have cancelled their SRL activities because of the case of their children. However, this difference during phase 3 is not statistically significant. Younger respondents (under 40) use rail facilities more than older ones for SRL purposes during phases 1 and 2 where the differences are significant. This trend has been reversed during phase 3 but the difference is not significant. Younger persons have used road public transport more than older respondents during phases 1 and 2 where the difference is significant only for phase 1. During phase 3 of the study, the trend has been changed where older ones have used road public transport more than younger respondents but the difference is not significant. Finally, non-car-owners have used road public transport more than rail facilities during phase 1 where the difference is not significant. The trend has faced a serious change during phase 2 where the utilization of rail for SRL activities has gained remarkable value compared to the road public transport and the difference is statistically significant. It should be mentioned that almost within any time span during day rail facilities are less crowded than road public transport, particularly BRT. Compared to the first phase, higher sensitivity of the respondents to the probability of the spread of the virus in Istanbul during phase 2 might be the major factor behind the individuals' higher tendency to use rail facilities. However, there is no difference in use of both modes during phase 3.

4.3. Shopping

As for the shopping activity within the scope of this paper, more in-depth experiences were collected for routine weekly-based grocery shopping. In fact, most Istanbulites cover their seasonal, event, etc. needs from numerous shopping malls located in different areas in the city. However, shopping malls are no longer just places to go to buy something and they are rather entertainment and community centers in Istanbul. In addition, district bazaars are being held in most neighborhoods of the city on special days on a regular basis each week. The focus of this

paper is on the weekly-based grocery shopping from local markets (supermarkets, etc.), district bazaar and online ordering. Furthermore, transport modes for shopping purposes have been analyzed in a more detailed manner for the 3rd phase of the study. As is clear from Table 7, the reduction in the frequency of grocery shopping (excluding online shopping) in transition from phase 1 to phase 2 is not statistically significant. However, the change is significant for the phase 2 to 3 transition. When it comes to the male-female grocery shopping frequency comparison, it is clear from Table 7 that during all three phases males are significantly more active than females.

Table 7: Changes in grocery shopping frequency during different phases.

Variable	Mean			S.D.			t-stat			p-value		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1→2	Phase 2→3	Phase 1→3	Phase 1→2	Phase 2→3	Phase 1→3
Grocery shopping frequency	1.23	1.18	1.05	1.10	1.00	0.96	1.26	2.08	2.43	.210	.039*	.016*
Female grocery shopping frequency	0.79	0.68	0.51	1.11	0.80	0.64	1.37	2.40	2.62	.176	.019*	.011*
Male grocery shopping frequency	1.57	1.58	1.48	0.97	0.97	0.96	-1.00	1.04	0.98	.320	.303	.332

*Significant at $p < .05$

The changes in males' shopping frequency are not statistically significant in the pre-to-post COVID-19 pandemic transition. In contrast, females have shown a noticeable reaction to the pandemic in transition to the 3rd phase and have significantly declined their grocery shopping activities (online shopping excluded). Generally speaking, the shopping frequency has been significantly dropped in the transition from pre-to-post virus outbreak in the city. During phase 3, all supermarkets, chain stores and district bazaars were urged to take strict governmental measures such as banning the entrance for persons without face masks and limitation of the customer presence to some minimal rates depending on the size of the place. Besides, all shopping malls were closed since late March (covering the period for the 3rd phase of this study).

Table 8 presents the changes in shopping manners with regard to the socio-demographic variables.

It was observed that gender and household size were the most important factors affecting the shopping frequencies of the respondents. In all phases, females are less active for grocery shopping than the males where the differences are statistically significant. When it comes to the household size, respondents with "HH size of ≤3" are more active for grocery shopping compared to those with "HH size of ≥4" during phases 1 and 2 of the study. The lower rate of shopping frequency for respondents belonging to bigger households might be explained by distribution of this activity among all members of their households (Chu et al., 2010). However, there is not a significant difference between shopping frequency of respondents with HH sizes of ≤ 3 and ≥4 during the 3rd phase. As a common sense, the key issue behind this fact might be associated to the general lockdown for 20- and 65+ individuals during phase 3. In other words, 20- and 65+ members belonging to bigger households have been deactivated during the 3rd phase and in consequence, other members had to undertake shopping activities on their own.

When analyzing the online shopping after the virus outbreak in Istanbul, it was observed that females have used online shopping significantly more than male respondents. Numerous chain stores and markets developed their online and on-call delivery services during phase 3. It was empirically observed that most of the single females and couples with HH size of 2 preferred to use online shopping applications during phase 3. A similar trend is true for online shopping and age. During phase 3, younger respondents' (40-) frequency of online shopping is significantly higher than older persons' (40+). In general, walking, online shopping and use of private car are the most commonly used means of mobility with average frequencies of 0.95, 0.68 and 0.31 times a week for the respondents.

Table 8: Exploring the changes in shopping during different phases based on socio-demographics.

Variable	Mean			S.D.			t-stat			p-value		
	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Males' grocery shopping frequency (MSF) vs. females' grocery shopping frequency (FSF)	MSF=1.57 FSF=0.79	MSF=1.57 FSF=0.68	MSF=1.48 FSF=0.51	MSF=0.97 FSF=1.11	MSF=0.97 FSF=0.80	MSF=0.96 FSF=0.64	4.46	6.12	7.22	.000**	.000**	.000**
Younger respondents' (40-) grocery shopping frequency (YSF) vs. older respondents' (40+) shopping frequency (OSF)	YSF=1.21 OSF=1.24	YSF=1.17 OSF=1.20	YSF=0.93 OSF=1.20	YSF=1.21 OSF=0.94	YSF=1.09 OSF=0.86	YSF=0.84 OSF=1.10	0.15	0.20	1.57	.879	.839	.119
HH≤3 shopping frequency (HSSF) vs. HH≥4 shopping frequency (HBSF)	HSSF=1.41 HBSF=0.98	HSSF=1.33 HBSF=0.98	HSSF=1.10 HBSF=0.97	HSSF=1.12 HBSF=1.04	HSSF=0.95 HBSF=1.04	HSSF=0.84 HBSF=1.10	2.35	2.05	0.81	.020*	.042*	.420
Females' online shopping frequency (FOS) vs. Males' online shopping (MOS)	-	-	FOS=1.02 MOS=0.41	-	-	FOS=1.16 MOS=0.85	-	-	3.47	-	-	.001**
Younger respondents' (40-) online shopping frequency (YOS) vs. older (40+) individuals online shopping (OOS)	-	-	YOS=0.96 OOS=0.28	-	-	YOS=1.13 OOS=0.74	-	-	4.36	-	-	.000**
HH≤3 Online shopping frequency HSOS vs. HH≥4 online shopping frequency (HBOS)	-	-	HSOS=0.91 HBOS=0.37	-	-	HSOS=1.16 HBOS=0.77	-	-	3.37	-	-	.001**
Mid-high income respondents' (5500 TL+) private car use frequency for shopping (HICUS) vs. mid-low income respondents car use for shopping (LICUS)	-	-	HICUS=0.45 LICUS=0.06	-	-	HICUS=0.64 LICUS=0.24	-	-	5.25	-	-	.000**
Mid-low income respondents' walking frequency for shopping (LIWS) vs. mid-high income respondents walking frequency for shopping (HIWS)	-	-	LIWS=0.60 HIWS=1.58	-	-	LIWS=0.81 HIWS=1.12	-	-	5.51	-	-	.000**
Non car owners' walking frequency for shopping (NWS) vs. car owners walking frequency for shopping (CWS)	-	-	NWS=1.40 CWS=0.61	-	-	NWS=1.14 CWS=0.83	-	-	4.64	-	-	.000**

*Significant at $p < .05$; ** Significant at $p < .01$

It was also observed that gender, household income and household car ownership are the parameters with significant impacts on walking-based grocery shopping during phase 3. Within this context, males walk for grocery shopping significantly more than females. Mid-low income households with monthly HH income of less than 5500 TL walk significantly more than the respondents belonging to the mid-high income groups. An analogous pattern is true for non-car-owning households where the members have to walk more than those of car-owning households for home-grocery shopping activity. The last two issues might be triggered by bulk purchases of high income and car-owning households.

5. Discussion of Policy Implications for Sustainable Urban Mobility

Having a widespread impact on people's lives, the COVID-19 pandemic continues to affect our way of life and behavior (by the time of writing this paper). These behavioral changes cover a vast range of subjects in cities and society as a whole, including urban mobility. Yuen et al. (2020) consider three stages of behavioral changes in response to the threats such as the COVID-19 pandemic: panic, adapt, and new normal. In this study, we aim to capture the immediate changes in Istanbulites' travel behavior as close to real time as possible.

In the early stages of the virus outbreak, some countries (e.g. China, Spain, and Italy) enforced nationwide or regional lockdowns and some others (e.g. the Netherlands, Japan, and Turkey) preferred to apply some forms of 'intelligent lockdown' requesting citizens to stay at home as much as possible. This resulted in less car traffic in cities and less traffic congestion and harmful emissions, reduced public transportation ridership, prioritization of teleworking and distance education, and triggering home-delivery of goods through online applications.

A remarkable drop in overall car use was reported in many cities around the world. In Australian cities, car use experienced a drop by over a third (35%) compared to the pre-COVID-19 period

(Beck and Hensher, 2020a). In the Netherlands, such a serious decline was not observed for use of car as a driver (limited decline of around 10%); however, the drop for car use as a passenger was almost 80% (de Haas, Faber and Haersma, 2020) which stems from the increased concerns on human contact. Other cities experienced a serious declines of over 80% (e.g. Milan, Rome, Barcelona, Madrid, Paris) and around 70% (e.g. Moscow, New York, London, Boston, Lisbon) in car traffic in March 2020 (Statistica, 2020). In our study, we also observed a decline of 29% and 53% in use of the private car during the "late March-late April" period for commuting and SRL activities, respectively. Less congestion on the roads, improved air quality and visibility in cities are among the benefits of this reduction in the use of private cars. However, the mentioned drop in all parts of the world is mainly associated with the governmental measures. In contrast, several studies advocate that cities in the post-COVID-19 period will experience congestion at levels not seen prior to the virus outbreak based on the increased sensitivity and human concern for social distancing and hygiene in public transportation (Beck and Hensher, 2020a; Beck and Hensher, 2020b; de Haas, Faber and Haersma, 2020). This study also indicates that private car will probably turn out to be a dominant mode of transport for commuting and SRL activities during 'back to the new normal era' in Istanbul. This implies that traffic congestion and air pollution will still remain as major urban problems within the foreseeable future. Transportation policy makers should be aware of these behavioral changes that potentially can lead to more CO_2 and local emission, and consider measures to counter such developments.

When discussing sustainability in urban mobility, a key factor is encouraging residents to use public transportation in cities. However, due to the virus outbreak, public transportation in many cities has been facing one of the greatest challenges of its history. In the Netherlands, the largest utilization decline among various modes of transportation is reported for public transportation:

more than 90% fewer trips compared to the same period in 2019 (de Haas, Faber and Haersma, 2020). Based on ticket validation data in Sweden in March to May 2020 period, public transportation ridership has experienced a decline of 60% and 40% in Stockholm and Vastra Gotaland, respectively (Jeneliuis and Cebecauer, 2020). A similar trend is reported in Budapest, Hungary, where public transportation ridership decreased by 80% (Bucsky, 2020). In Australia, the share of public transportation use for overall household trips fell from around 15% to 7% in the early days of the virus outbreak (Beck and Hensher, 2020a). A study conducted by Pawar et al. (2020) shows that in Indian cities, 5% of commuters shifted from public transportation to private modes of transportation between the virus outbreak and lockdown period. Falchetta and Noussan (2020) report serious declines of public transportation usage across European cities compared to the pre-COVID-19 period with overall drops of 90% in France and Italy, 70% in Germany, 85% in Spain and 75% in the UK (with some variations across cities). In our study, we observed that 5.6% of the commuters who were using public transportation during phase 1 of the study started to use private car during phase 2 and there was no shift to active modes of transportation such as cycling or walking. Shift to the private car was even more remarkable in the transition to phase 3. In phase 2 to phase 3 transition, 44% of those who were using public transportation during phase 2 shifted to teleworking or distance education; thus had no commuting trips. However, among the remaining 56% of the respondents, around 33% shifted to private car. This significant drop in public transportation ridership in cities around the globe is not implausible considering the fact that both governments and public transportation operators urged people to only use public transportation if highly necessary. However, a more important problem for the future of the public transportation and accordingly sustainable urban mobility is imposed by the concerns on hygiene and application of social distancing. In this study, 96.5% of the respondents marked public transportation as one of the major sources of the virus spread in

Istanbul which is in line with the findings of Bucsky (2020) and Shamshiripour et al. (2020). To cope with this perception, transportation policy should consider overt demonstrations of "deep-cleaning" by employing staff to provide visible cleaning when public transportation services are operational or by disinfecting seats and handholds when passengers alight. Furthermore, provision of sanitizer at stations and onboard services for passengers may also be beneficial. Finally, when facing similar public health threats, public transportation operators may take advantage of innovative technological solutions in provision of easier and more pleasant services. For instance, they may develop simple smart phone applications providing real-time information, sending alerts about whether it is a good time to use a specific service or not (simply via "red" or "green" indicator in the application).

The two basic modes of active transportation, walking and cycling may be the most promising modes for a sustainable urban mobility (Boulange et al., 2017; Meng et al., 2014). Apart from all the negative impacts of the COVID-19 pandemic on human life, encouraging people to use active modes of transportation in many parts of the world, the pandemic may offer an exceptional opportunity for transportation policy to enhance sustainability in urban environments. People in many regions without prominent cycling background such as New York (Teixeira and Lopes, 2020), Australia (Beck and Hensher, 2020b) and Bogota, Colombia (Nurse and Dunning, 2020) have turned to cycling to minimize their coronavirus exposure. Within this context, cities like Toronto and London have closed some roads to cars in order to allocate safer places to cyclists and pedestrians (the Conversation, 2020). However, we did not observe similar shifts to cycling in our case study, Istanbul. The major factors behind this might be the infrastructure limitations and the city's fabric. The city with its numerous downhill and uphill roads is not bicycle-friendly. On the other hand, due to the very large city size and warm and humid weather conditions during

summer and rainy weather during fall and winter, it might not be rational to anticipate high levels of cycling for standard long-distance commute trips and SRL activities. Based on the experiences of the cities like London and New York, urban policy in Istanbul should consider cycling as a major long term option for change that can be expected for at least short trips and transportation planners should provide safe facilities and infrastructure for cyclists. To do so, transport policy has to give careful thought to bicycle networks and e-bike services via regulations and investments.

All around the world, some forms of flexible working such as teleworking, flexible working start/finish times, and work shift systems have been applied to minimize human contact in response to the COVID-19 public health threat. A study conducted in Chicago shows that the number of those with no experience of teleworking has dropped from 71% to 37% in the pandemic period (Shamshiripour et al., 2020), while a very similar pattern is observable in Australia where the number of those with zero days of teleworking before the virus outbreak has declined from 71% to 39% (Beck and Hensher, 2020a). A panel study in the Netherlands indicates that around 54% of all workers telework at least a part of the week in the pandemic period (de Haas, Faber and Haersma, 2020). In this study, we also observe that 31% of the respondents have shifted to the teleworking system during the third phase of the study. Teleworking may be one of the behaviors that can last into the long term. Any action embedding a greater level of teleworking will be a sound investment in transportation needs and priorities for the sustainable mobility in the future. On the other hand, in megacities such as Istanbul with overloaded public transportation during morning and evening rush hours, authorities may communicate with decision makers in the public and private sectors to use staggered and flexible work start/finish time to avoid undesired crowd and human contact on facilities.

Finally, decision makers must have short to long-term plans for food stock, logistics, and freight at the time of similar disruptions. During early days of the virus outbreak in the country, serious difficulties were witnessed for grocery shopping, particularly for food and sanitary/cleaning supplies where people were trying to stock up on such household items. Learning from COVID-19 pandemic, Turkish authorities must guarantee the country's self-reliance on staple food and they should have early stage plans around inventory requirements and staffing. Besides, vulnerable society members such as disabled, elderly, and low income people must be treated as a form of positive discrimination.

Considering the reduced levels of commuting, SRL and shopping activities via most of the transport modes, it is proved that Istanbulites heed governmental request to 'stay at home' in short term in case of disrupting events such as the COVID-19 pandemic. However, policy makers should also bone up on economic dimensions of such disrupting events on citizens. 25.7% of the respondents reported that they have to work under any circumstances since they cannot live without their jobs and manage life even for a short period of several weeks due to financial issues. Almost 80% of these respondents are public transportation-dependent. Thus, it might be hard to fully contain the virus spread on public transportation without giving priority to hygiene and comfort attributes. This is even clearer for BRT and most of the bus services during the morning and evening rush hour in the city. Service levels and schedules must be revised at least until restrictions are eased to enforce social distancing.

6. Concluding Remarks and Suggestions for Future Studies

In this paper, we present the preliminary findings from a panel survey conducted in three progressive phases of the COVID-19 pandemic in its early stages in Istanbul, Turkey, between January and April 2020. During the first phase, the virus risk was disregarded in Istanbul while

the virus was a major risk only in China. Later on, outbreak of the virus in the neighbor country, Iran, and some European countries particularly Italy fueled fear into the Turkish society in the middle of February 2020. The second phase of the study started at this stage, as well. Finally, subsequent to the observation of the first COVID-19 positive case on 10 March and the first death on 17 March in Turkey, the country was sucked into a vortex of pandemic-originated problems. The third phase of this study commenced immediately after the first pandemic-caused death when the public perception was at the height of the sensitivity. Collection of data at the height of the governmental restrictions and public sensitivity may provide a useful reference position for the time we come out of the restrictions and when the life is back to the (new) normal. Furthermore, we can identify what changes in travel behavior might continue in the short term and long run by collecting data in the future. Our results provide insights across three main domains including commute, social/recreational/leisure (SRL) activities, and shopping and implications on public transportation, private car use, active modes of transportation, and flexible working system for policy makers.

our surveys covered a large number of behaviors and actual preferences around home-work trips, SRL activities, shopping, transport modes used for these purposes, and the respondents' reaction to the virus in different waves, so we are able to analyze the changes in individuals' travel behavior. Behavioral changes were triggered by both people's self-regulation and governmental measures to restrict travel and social contact and to "flatten the curve" in the short term. Our findings show that SRL activities are the only activity type which underwent significant decline in transition from phase 1 to the second phase. This implies that people strongly react to the public health threats such as the COVID-19 pandemic in its immediate stages and avoid unnecessary activities. However, in transition to the third phase of the study, all activities

including commuting, SRL and shopping experienced significant reductions. Decline of the utilization of all major public transportation modes including rail facilities, bus, BRT and minibus is underlined during post COVID-19 period in Istanbul where in contrast, tendency to use private car by Istanbulites is appreciated during the same period.

At the time of collecting data and writing this paper, urban travel in the context of COVID-19 were in nascent stages and behavioral changes and attitudes were in a stage of flux; thus, the findings of this study should be boosted by future researches in subsequent waves of the panel (including "back to the new normal", but potentially also a comeback of the virus) to provide insights for positive intervention before the formation of "bad mobility habits". In this regard, we will continue to track the changes in activity and mobility in the Turkish context. It would also be very beneficial to bring together the experiences from other megacities all around the world.

A preliminary study conducted by Currie et al. (2020), indicates that teleworking might be the only long term change that will emerge in a post-pandemic world. Therefore, dynamics of the shift to the teleworking and other forms of flexible working systems in Istanbul should be examined in future studies. In a megacity like Istanbul with traffic jams and crowding on public transportation during rush hours, staggered work hours may provide positive impacts on transport capacity and demand. This issue deserves more attention from policy makers and researchers.

On the other hand, more research is needed to address the prevalence of active modes of transportation. On aggregate, we did not detect any positive changes in the frequency of active modes such as cycling in the context of this study. However, the concept of teleworking might be tied up with such active modes. In other words, if people start to work from home, they would be more likely to focus on localized transport networks and active transport and this may become a new mobility pattern. Therefore, a study is needed to find out whether there might be a

relationship between the use of active transportation modes for different trip purposes and application of teleworking system in Istanbul.

Declaration of competing interest

None.

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