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Measuring changes in travel behavior pattern due to COVID-19 in a developing country: A case study of Pakistan

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ABSTRACT

Travel behavior has been affected around the world since the eruption of corona virus disease (COVID-19). Several industries including transportation industry have been hard hit by the pandemic. As the virus is transmitted through close contact with infected people, number of outdoor trips has reduced causing roads and public transport to be less crowded than before. In order to develop transport-related policies for the post COVID-19 world, it is necessary to explore how the pandemic has affected the travel behavior pattern. This study explored the influence of the COVID-19 pandemic on travel pattern and mode preferences in Pakistan using a questionnaire survey. The results showed significant shift in primary traveling purpose from work and studying to shopping during the pandemic. Number of trips performed for non-commuting purposes were also significantly different before and during the pandemic. A significant modal shift from motorbike to non-motorized modes of travel was found for distances less than 5 km. For longer distances, people shifted from public transport to private car. These findings suggest that past policies regarding different modes may be revisited in the post COVID-19 world. The statistical tests performed on the factors affecting mode choices indicated that the respondents put more priority on pandemic-related items such as infection concern, social distance, hand sanitizers' availability, and cleanliness, etc., during the pandemic. The findings of this study will certainly help in shaping up the policies for the post COVID-19 world especially in the developing countries.

1. Introduction

The eruption of the 2019 novel coronavirus causing COVID-19 has influenced travel behavior around the world. The first case of this virus was recorded on December 12, 2019 in Hebei, Wuhan, China. It was then labeled a global pandemic on March 11, 2020 (McCloskey and Heymann, 2020). A total number of 84.47 million people had been infected with 1.84 million (approximately 2.18%) fatalities around the world till January 06, 2021. The first case of COVID-19 infection in Pakistan was recorded on February 26, 2020 leading to 725,602 infections and 15,501 (2.13%) fatalities on April 13, 2021 (WHO, 2020).

The disease caused by the virus is very contagious and spreads through close contact with infected persons. In addition, epidemiologists reported that COVID-19 virus can live on hard surfaces from few hours to several days. Human corona viruses such as, SARS coronavirus, MERS coronavirus, or HCoV can live on metal, plastic, or glass (inanimate) surfaces for about 9 days at 30 °C and the duration of persistence reduces with increase in temperature (Kampf et al., 2020). Van Doremalen et al., 2020 and Wu et al. (2020) suggested that aerosol and surface stability of COVID-19 is similar to MERS, SARS, and HCoV. However, these viruses can be efficiently inactivated if the surfaces are disinfected and their spread can be limited by exercising basic hygiene guidelines issued by WHO such as; wearing a face mask, avoiding crowded places, and washing hands (WHO, 2020). Maintaining a social distance has been found to be an efficient strategy until a vaccine is developed.

After the outbreak of the COVID-19, the governments around the globe took unprecedented actions to contain the virus. Many countries; like France, Italy, UK, Iran, India, Saudi Arabia and Thailand implemented national lockdowns, limiting all non-essential traveling (de Haas et al. 2020). Likewise, Pakistan initiated nation-wide lockdown on April

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01, 2020, and extended it twice until May 09, 2020. The lockdown was eased in phases but some of the areas in mega cities with severe clusters remained under smart lockdown.

Travel behavior has been affected around the world since the eruption of the COVID-19 disease. It is more than a health crisis because several industries including transportation industry have been hard hit by the pandemic. As the virus is transmitted through close contact with infected people, number of outdoor trips have reduced causing roads and public transport to be less crowded than before. Besides other socio-economic impacts of this outbreak, this unique situation has compelled people to alter their daily lives drastically within a span of days and weeks (Musselwhite et al., 2020). Work and travel, the basic facets of daily lives, have changed radically due to this outbreak. In developing countries, like Pakistan, public transport (buses, wagons, metros, trains etc.) carries millions of people, often transporting passengers beyond their designated capacity with little or no consideration for hygiene and personal space. Moreover, maintaining a social distance (approx. 2 m) in public transportation seems a daunting task, which may affect mode choice behavior.

To develop transport-related policies for the post COVID-19 world, it is necessary to explore how the pandemic has affected the travel behavior pattern. This study aims to explore how COVID-19 affected the travel behavior in Punjab, the most populated province of Pakistan. It focuses on the changes in primary traveling purpose, mode choice and factors influencing mode choice before as well as during the COVID-19 pandemic. It also charts out new guidelines and policies for public and private stakeholders to address the mobility needs of individuals for current as well as future pandemics. The findings of this study will certainly help in shaping up the policies for post the COVID-19 world, especially in the developing countries.

The rest of the paper is organized as follows: Next section presents relevant studies. Section 3 presents the methodology. Section 4 presents the results and discussion. Important policy implications are presented in Section 5. Finally, Section 6 presents conclusions and recommendations for future works.

2. Literature review

The spread of infectious diseases has been found to affect travel behavior and vice versa. Mandatory lockdowns and the fear of getting infected generally reduce outdoor trips (Cahyanto et al., 2016; Kim et al., 2017). During the MERS outbreak in South Korea, trips to affected and other areas were reduced by about 14% and 9%, respectively. In addition, about 10% reduction in public transport trips was observed during the same outbreak. On the one hand, infectious diseases affect the travel behavior, while on the other hand, travel behavior can help predict the spread of infectious diseases. For example, a review of several studies suggested that highways, railways, and air transport propagate the spread of influenza and coronaviruses (Zhang et al., 2011; Browne et al., 2016). Hence, appropriate travel restrictions and social distancing measures can limit the spread of infectious diseases (Milne et al., 2008; Otsuki and Nishiura, 2016). Ibuka et al. (2010) also identified that the individual behaviors and perceptions are also significant predictors of adopted travel patterns such as staying at home and limited interaction during infectious diseases outbreak. Since there is a two-way relationship between spread of infectious diseases and travel behavior, the current ongoing phenomenon of COVID-19 outbreak is also being studied through two different lines of investigations with respect to its relationship with travel behavior. One strand of studies attempts to explore the effects of the COVID-19 pandemic on travel pattern (Litman, 2020; Bucsky, 2020; Ebenso & Otu 2020; de Haas et al., 2020) while the other strand of studies investigates the role of travel pattern in predicting the COVID-19 spread (such as Kraemer et al., 2020). Many recent studies of former type have found out significant changes in the travel behavior and mode preferences of the people across the globe due to the COVID-19 pandemic, while the latter strand of studies has also established an association between the mobility pattern and the COVID-19 spread. The authors of the emerging studies on the topic also categorized their work in the context of developed and developing countries (such as Mogaji, 2020) to look at the similarities and the variations of the results across different socioeconomic contexts.

The first direct influence of the COVID-19 pandemic on the travel pattern was the implementation of mobility restrictions, which has resulted in the disruption of livelihoods and social life of the people (Mogaji, 2020; Musselwhite et al., 2020; SLOCAT, 2020). Musselwhite et al. (2020) argue that the multifaceted dimensions of COVID-19 are affecting the travel pattern across the globe and that the associated changes may be long lasting in the post-COVID-19 world. The economic constraints posed by the COVID-19 might force the people to reduce the car usage frequency in favor of walking, cycling or cheaper public transport modes (Litman, 2020). However, predicting the future changes in the travel pattern is not that straight forward because people might switch from public transport to private cars due to safety and health woes (Stokell, 2020). It is more pertinent to those places which lack cycling and walking infrastructure, particularly in the developing world. The COVID-19 consequences have also brought the importance of walkable and car-independent accessible neighborhoods in the limelight. The overall travel trips, mainly the passenger transport trips have been reduced globally (EU, 2020; ITE, 2020; TUMI, 2020; UITP, 2020), but it is argued that this change will be temporary, and the pre-COVID-19 travel pattern will return as the direct effects of COVID-19 on the economy will fade away (Litman, 2020).

West et al. (2020) identified human behavior as the central element for the transmission of the COVID-19 virus. Wilder-Smith et al. (2020) argued on the important role of the overall societal response and top-down measurements to contain the coronavirus disease. A growing number of emerging studies are also providing an evidence on the influence of travel behavior on the transmission of COVID-19 globally. Kraemer et al. (2020) found a correlation between the human mobility pattern and COVID-19 spread in China. However, after the imposition of control measures and travel restrictions, the analysis of the travel data showed an insignificant correlation between the two variables under consideration. Peeri et al. (2020) also presented the similar results and found the massive movements of people to and from Wuhan during the Chinese New Year celebrations as one of the main reasons behind the COVID-19 propagation. Zhang et al. (2020) also confirmed the positive role of high-speed trains and air flights in spreading the COVID-19 cases across Chinese cities.

Various travel modes have their merits and demerits over each other with respect to the risks associated with COVID-19 spread. Public transport and active traveling modes have been advocated much in the recent decades as means of sustainable mobility. However, social distancing, which is an agreed upon precautionary measure against COVID-19, is in conflict with the principle of public transportation (Musselwhite et al., 2020). For instance, an association has been reported between acute respiratory infection (ARI) and the use of buses and tram lines (Troko et al., 2011). Public transportation modes offer a closed environment for the riders to remain either seated or standing for a considerable time nearby each other., thus they greatly increase the risks of infectious diseases spread (Edelson and Phypers, 2011). However, Musselwhite et al. (2020), by referring the works of Williams et al. (2010) and Cooley et al. (2011), do not advocate the idea of suspension of mass public transport vehicles during the pandemic as a countermeasure to the containment of coronavirus related infectious diseases, as to them, household exposure poses a much greater risk for the spread of such infectious diseases. Also, Peeri et al. (2020) reported inadequate risk assessment and limited reporting of virus cases in China as the main reason behind the rapid spread of COVID-19. Though, they also reported on the significant role of increased accessibility of Wuhan and associated travel pattern observed by the Chinese in spreading the virus. Nonetheless, public transportation can still be safely used during the COVID-19 pandemic by adhering to precautionary measures by its users

(APTA, 2020), although an entirely risk-free environment for traveling will not be possible (EU, 2020). The precautionary measures with respect to public transport use, which are being highly prioritized are physical distancing, avoiding congestion and crowding, disinfection of public transport vehicles and transit hubs, and availability of sanitizers in all public transport vehicles and hubs (EU, 2020; Transit Center, 2020). Evidence emerging from Japan and France suggests the effectiveness of the adopted precautionary measures in relation to public transit use during the pandemic, as none of the spotted COVID-19 clusters could be traced to the public transits in both countries (O'Sullivan, 2020).

Whereas the active traveling modes of cycling and walking have been associated with many health-related advantages (Hamer and Chider, 2008; Reinhardt-Rutland, 2011). Recently, cycling and walking have been regarded as socially compatible with the social distancing protocols by many researchers in an open letter to the UK government (Woodcock et al., 2020). Extending the pavements and bicycle paths for active traveling has already been thought out as one of the urban mobility way-forward options in many of the member states of the European Union (EU, 2020). Many local level initiatives taken across the globe also support the adoption of walking and cycling interventions more often during the COVID-19 pandemic (PBIS, 2020). Most of the developed world countries and municipalities (examples are UK, Madrid, Lisbon, Bordeaux, Athens, and many more) have put in place the transport related programs promoting the use of e-scooters, cycling, and walking in response to the COVID-19 pandemic (POLIS, 2020).

The COVID-19 pandemic is a global event which has affected numerous aspects of daily lives. There is a lack of enough empirical evidence on how this pandemic has affected travel behavior in developing countries. This research study fills the gap by exploring how COVID-19 pandemic is influencing travel behaviours and mode preferences in developing countries such as Pakistan. It also aims at outlining new transport policies considering the travel behavior changes due to the pandemic. It offers new insights and practical implications for both public and private policy makers and stakeholders to navigate through these precarious times and chart new pathways for individual travel behaviours.

3. Methods

3.1. Survey design and sampling strategy

The questionnaire was prepared carefully to measure the travel pattern both before and during the COVID-19 pandemic. The objectives of the study and the instructions to fill the questionnaire were provided to the respondents to obtain reliable responses. The questionnaire was pre-tested by the experts belonging to the relevant research area and the recommendations were incorporated to ensure the clarity and understanding of each statement to the respondents. Face-to-face interviews were not possible due to the social distancing requirements and the partial lockdown in the country. Therefore, an online questionnaire was distributed to the target population through emails, social media websites and personal contacts. The responses were received from Lahore, Faisalabad, and Rawalpindi, three major cities of the most populated province of Pakistan, Punjab. These three cities are the most populated cities in the Punjab province and have similar socio-economic characteristics. The survey was run for a period of about three weeks from May 09 to 31, 2020. Six hundred and seventy-one (671) responses were received during this period. It should be noted that the lockdown was lifted on May 09 in Pakistan and only few areas were under smart lockdown after May 09. The timeline of COVID-19, cumulative number of cases and associated deaths in Pakistan (OurWorldinData, 2020) are shown in Fig. 1. It also shows the data provided by Punjab Safe Cities Authority (PSCA) about changes in traffic levels at various major roads in Lahore, Punjab, Pakistan. The term lockdown means the complete nationwide lockdown implemented by the government, whereas smart lockdown means partial lockdown which was implemented in certain areas containing clusters of the COVID-19 cases after the complete lockdown had been lifted.

3.2. Survey instrument

The questionnaire had three distinct sections: (1) socio-economic and demographic characteristics (SEDs), (2) travel pattern before as well as during the COVID-19 pandemic, and (3) the factors influencing mode preferences before as well as during the COVID-19 pandemic. SEDs consisted of age, age, monthly household income, education level, cycle ownership, motorbike ownership, car ownership, and employment status. Section 2 contained questions about primary traveling purpose, the main reason for which people travel, before as well as during the COVID-19 pandemic. It also contained questions about traveling frequency for non-commuting trips and preferred mode for short as well as long distances before and during the COVID-19 pandemic. Section 3 consisted of 5-point Likert type items representing factors that may influence mode preferences before and during the COVID-19 pandemic. Since the virus spreads primarily through close contact with infected people or by getting in contact with an infected surface, it is hypothesized that people will pay more attention to pandemic-related items while choosing a transport mode. For example, comfort and convenience might not be as important as infection concern and maintaining social distance during the pandemic. Therefore, factors, which may affect mode choice during the pandemic, were identified and respondents were asked to place a priority on each factor while choosing a transport mode.

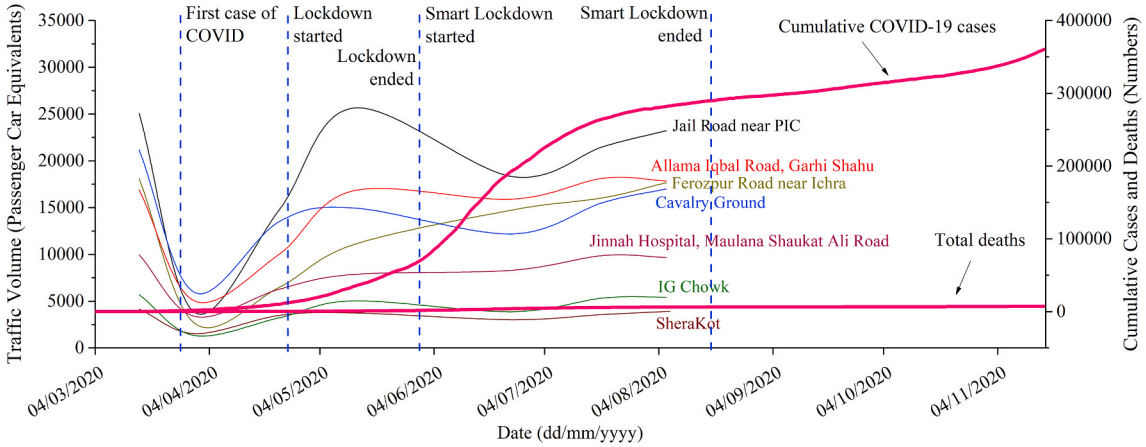

Fig. 1. COVID-19 timeline, cumulative cases and deaths in Pakistan, and traffic levels at various major roads in Lahore, Punjab, Pakistan.

3.3. Analysis methods

Since nonparametric tests require fewer assumptions as compared to parametric equivalents, can be conducted on ordinal, and are relatively easy to comprehend (Gibbons and Chakraborti, 2014), therefore, they were used in this study. Nonparametric tests may have lower power as compared to their counterparts, however, the power loss will be relatively small if the data follows a normal distribution and meets all other assumptions (Kitchen, 2009). It is suggested that nonparametric tests be used instead of parametric tests if there is no experimental evidence about the distribution of the errors. The data collected through Section 2 and 3 of the questionnaire consisted of repeated measurements, which require special considerations during the statistical analysis. SPSS v. 20 was used for all the statistical analyses.

3.3.1. Statistical analyses on repeated measurements

McNemar-Bowker test was applied on the repeated measurements of nominal data e.g., primary traveling purpose before and during the pandemic. It is a nonparametric test with more than *2* levels for each nominal variable which can be presented in a $k \times k$ contingency matrix. Moreover, McNemar's tests were carried out as post-hoc tests to determine the levels of nominal variables which differed significantly. The McNemar test is used to find out if there are differences on a binary dependent variable between two paired groups. In order to reduce type I errors while carrying out multiple hypothesis testing, Bonferroni correction was used, which is calculated as α/n, where α and n represent the significance level and the number of tests to be conducted, respectively.

To compare the ordinal repeated measurements under two different conditions, such as number of non-commuting trips made before and during the COVID-19 pandemic, a non-parametric alternative of the paired *t*-test known as Wilcoxon signed rank test was used.

3.3.2. Statistical analyses on independent measurements

The Mann-Whitney *U* test can be used to compare differences between two independent groups. It is a non-parametric alternative to the two-sample *t*-test and does not require the dependent variable to be continuous and normally distributed. Hence, Mann-Whitney *U* test was carried out on the independent groups when the dependent variables were ordinal, e.g., effect of gender on the number of outdoor trips done for non-commuting purposes. The correlations between continuous/ordinal variables e.g., monthly household income and number of non-commuting trips was determined using Spearman Correlation.

3.3.3. Analysis on the factors influencing mode preferences

Section 3 of the questionnaire consisted of items affecting mode preferences. These items represent certain underlying variables. Exploratory factor analysis (EFA) is a technique to find out those underlying variables also called factors. Hence, EFA was conducted on the items influencing mode preferences during the COVID-19 pandemic to extract the underlying factor. Once the underlying factor was discovered, the factor scores were computed to represent the relative standing of each respondent. Regression factor scores were computed and used for further statistical analyses in this study.

4. Results and discussion

4.1. Socio-economic demographics of the respondents

Socio-economic demographics of 671 respondents, whose complete responses were received during a time span of about three weeks, are shown in Table 1. Most respondents were male (73.3%), with age bracket of 18–30 years (65.9%) and education level of master's and above (52.2%). Some groups such as male, young and those with higher education have a higher share in the collected sample and may produce bias in the results and derived findings. However, it should be noted that the share of working women is quite less in the population due to cultural and religious constraints. Hence, the share of female respondents makes a good representation of the women population whose travel behavior was likely impacted by the pandemic. Similarly, the higher percentage of young and highly educated respondents may imply that young and educated people are more active on social media as compared to the less educated and older respondents i.e., 46–60 years old (3.3%) and more than 60 years old (0.9%). Nonetheless, the results and findings obtained from the collected sample would provide useful insight into the effects of the pandemic on the travel pattern, particularly for younger and well-educated people in a developing country.

Table 1
SEDs of the respondents.

Items	Description	%
Gender	Male	73.3
	Female	26.7
Age	18–30	65.9
	31–45	30.0
	46–60	3.3
	Above 60	0.9
Education level	High schooling	.4
	College	2.5
	Bachelors	44.9
	Masters and above	52.2
Occupation	Student	37.0
	Business	4.0
	Government employee	24.9
	Private employee	28.8
	Others	5.4
Income level (PKR)	Less than 25,000	5.8
	25,000–50,000	23.0
	50,001–100,000	28.2
	More than 100,000	28.2
	Prefer not to say	14.9
Car Ownership	Yes	42.9
	No	57.1
Motorcycle Ownership	Yes	51.1
	No	48.9
Bicycle Ownership	Yes	12.8
	No	87.2

4.2. Travel pattern before and during covid-19 pandemic

4.2.1. Primary purpose of traveling

In this study, primary traveling purpose is defined as the most important cause for which people travel during their everyday life. These may be the trips over which people have very little or no control. For instance, people may reduce their trips for other purposes, but they might be compelled to make trips for some primary reasons. People may have different primary purposes of traveling; some might travel primarily for work while others may travel primarily for education etc. The primary purpose of traveling might vary based on the circumstances e.g., during a pandemic.

About 55% of the respondents declared that their primary traveling purpose was work before the pandemic; whereas a reduced percentage i.e., 51% declared that their primary of purpose of traveling was work during the pandemic (Fig. 2). It could be explained by the fact that work from home gained popularity during the pandemic. Similarly, the percentage of respondents declaring education as primary purpose also reduced from 30% before the pandemic to 22% during the pandemic, which was expected since many educational institutes either switched completely or partially to online education. About 10% of the respondents declared shopping as their primary traveling purpose during the pandemic, whereas only about 4% of the respondents declared it as their primary purpose before the pandemic.

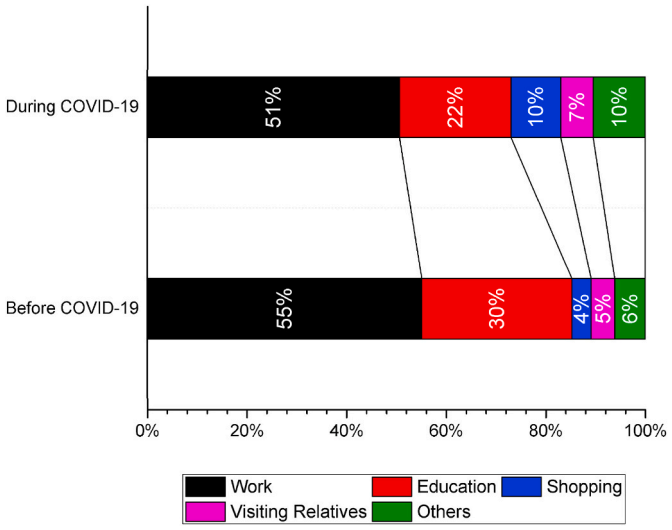

Fig. 2. Distribution of primary traveling purpose before and during COVID-19 pandemic.

"Visiting relatives" and "others" were put together into a category named "others" for further analyses. The results of the McNemar-Bowker test indicated significant variation between primary traveling purpose before and during COVID-19 pandemic ($\chi 2$ (6) = 40.389, p = 0.000). The cross-tabulation table and McNemar post-hoc test results are shown in Fig. 3. α and n for Bonferroni correction were set as 0.05 and 6, respectively. The results indicated that the primary traveling purpose significantly shifted from work and study trips to shopping trips during the pandemic. However, expected count in 1 cell (25%) was less than 5 in both cases, therefore, the results should be interpreted with caution. Also, there was a significant change from study trips to other trips. The reduction in work and study trips is associated with the work-from-home and online education policies (de Haas et al., 2020).

Although study trips reduced during the pandemic, they still represent a considerable portion of the total trips (i.e., 22%). It could be attributed to the fact that this survey was conducted soon after the lockdown was over implying that educational institutions had gradually started their operations. Even during the lockdown, students living in certain areas did not have access to the internet. Therefore, they had to travel to nearby places to get internet access in order to join the online classes. These trips may also represent a considerable portion of the study trips during the pandemic.

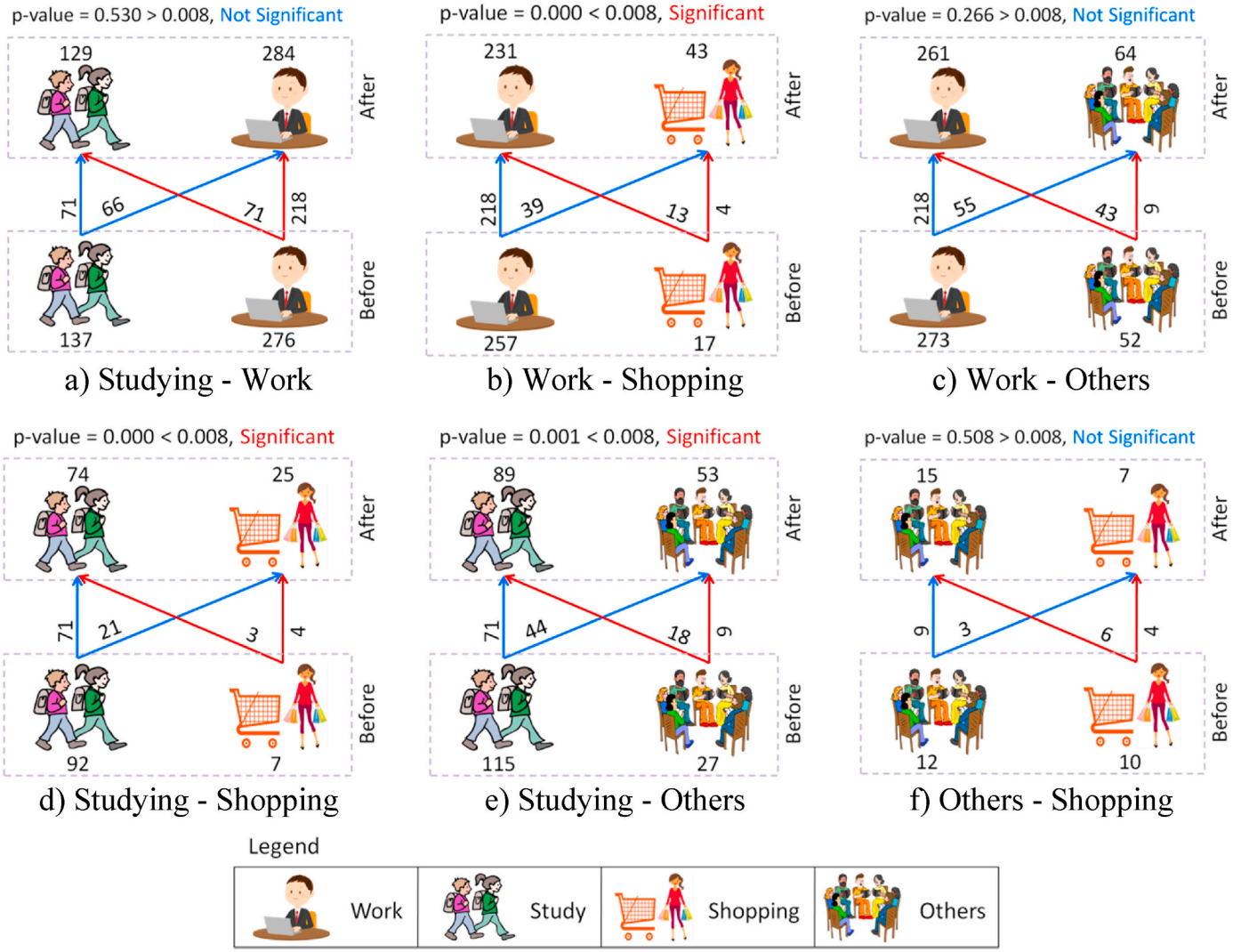

Fig. 3. Change in primary traveling purpose before and during COVID-19.

4.2.2. Frequency of non-commuting trips

Non-commuting trips, unlike commuting trips e.g., work or education trips, are those trips which are not done on daily basis. These may include shopping, social, recreational, and other trips. Fig. 4 shows that traveling frequency for non-commuting trips reduced during the COVID-19 pandemic. About 31% of the respondents did not travel at all during the pandemic. The results of the Wilcoxon signed ranks test pointed out statistically significant differences in number of non-commuting trips carried out before and during the pandemic (Z = −14.037, p = 0.000). Similar findings have been reported in other parts of the world (Landry et al., 2021).

Mann-Whitney *U* test was applied to assess the impacts of SEDs on the number of non-commuting trips. Certain categories of socio-demographic variables were combined together due to low percentage of respondents in those categories. For example, all the responses with age above 30 years were combined into a single category entitled "above 30 years"; undergraduate and below education levels were combined into a category entitled "Undergrad and below"; and businessman, government employee and private employee were combined together to form a new category entitled "Employed". The results of Mann Whitney *U* test are shown in Table 2.

Males undertook significantly more non-commuting trips than females before and during the pandemic. A reason could be that the financial responsibility of a household is generally considered to lie on men in Pakistan. In addition, women are often discouraged from traveling outside under the pretext of defending them from sexual abuse (Rizvi et al., 2014). People in the above 30 years old age group made significantly more non-commuting trips before and during the pandemic as compared to the younger age group. It could be because those above 30 years of age are likely to be married and have more social responsibilities.

Employed people undertook significantly more non-commuting trips relative to students during the pandemic, however, this difference was non-significant before the pandemic. A possible reason for this is the fact that age is likely to be correlated with employment status as well as social responsibilities. Those in the above 30 years old age are likely to be employed, married, and have more social responsibilities. In addition, the likelihood of having children increases with age which, in turn, have been found to promote car use (Ye et al., 2018).

Car owners made significantly more non-commuting trips before and during the pandemic than those who did not own a car. Existing evidence suggests that car ownership is associated with number of outdoor trips (Sillaparcharn, 2007). However, motorbike and bicycle ownership had no significant effect on number of trips made.

A very weak but significant correlation was found between number of non-commuting trips and monthly household income before the pandemic ($r_s = 0.102$, $p = 0.008$). An even weaker but significant correlation was found between number of non-commuting trips and monthly household income during the pandemic ($r_s = 0.078$, $p = 0.043$).

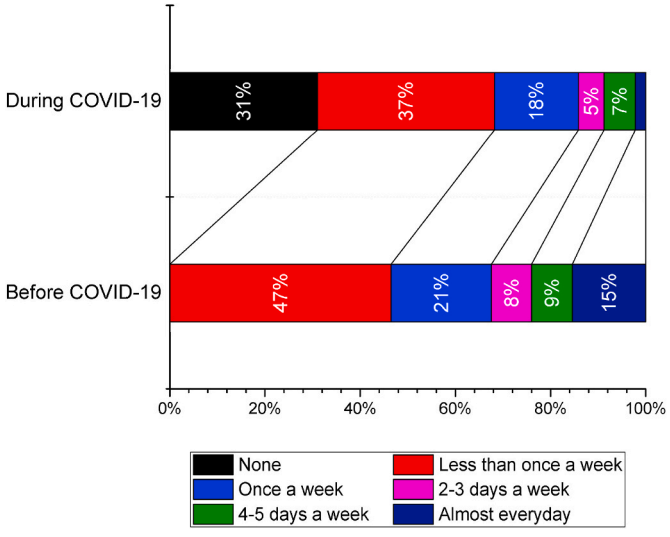

Fig. 4. Frequency of non-commuting trips before and during COVID-19 pandemic.

4.2.3. Preferred mode for shorter distances (<5 km)

The distribution of mode choices for shorter distances is shown in Fig. 5. Public transport, office/campus transport and taxi/rickshaw were put together into a category entitled "Public Transport" for further analyses because they had to follow similar instructions from the relevant authorities during the pandemic. Similarly, walking and bicycling were put together into a new class entitled "Non-motorized". McNemar-Bowker test indicated that mode choices were significantly different for short distances (<5 km) before and during the COVID-19 pandemic ($\chi 2\ (6) = 14.055$, $p < 0.05$). Post-hoc McNemar tests were conducted to determine how modal shift took place for short distances. The cross-tabulation table and McNemar test results are shown in Fig. 6.

The shift from public transport to private car was non-significant. The reason could be the fact that people might think that a close contact with other people for few minutes might not be that dangerous. Moreover, public transport use is not quite common among car owners in Pakistan. Therefore, no significant shift was observed due to the pandemic. The respondents significantly shifted from motorbike to non-motorized modes of travel which is a good sign. It could be because trips for shopping significantly increased which are likely to be made to the nearby shops. Hagberg and Holmberg (2017) also found that shoppers tend to use non-motorized mode of travel for short distance shopping trips. A study conducted in Shenyang, China also reported that shorter travel distances are important for low-carbon modes (e.g., walking and bicycling) (Li et al., 2018).

4.2.4. Preferred mode for longer distances (>5 km)

The distribution of mode choices for longer distances is shown in Fig. 7. Public transport, office/campus transport and taxi/rickshaw were put together into a category entitled "Public Transport" for further analyses. As expected, very few respondents chose bicycle or walking mode for distances longer than 5 km. Therefore, walking and bicycling were omitted from the statistical analysis. McNemar-Bowker test indicated no significant difference between mode choice for longer distances (>5 km) before and during the COVID-19 pandemic ($\chi^2\ (3) = 7.743$, $p > 0.05$). However, post-hoc McNemar test indicated that a significant modal shift took place from public transport to private car (Fig. 8) because post-hoc tests are more focused and have more power to detect significant differences.

The shift from public transport to private car was significant, which could be attributed to the fact that inter-provincial and inter-city transport was mostly banned during the pandemic. Secondly, people may not feel safe in public transport due to close contact with other people for several minutes or hours as opposed to travel for shorter distances where the contact is only for few minutes. Existing evidence suggests that people are likely to prefer their health over economy. For example, a panel study conducted in Istanbul, Turkey reported that car owners preferred to travel by their cars owing to the fear of infection during the pandemic (Shakibaei et al., 2021). The total number of trips may have decreased during the pandemic; however, the proportion of private car use increased especially for longer distances.

The modal shift from public transport to motorbike was non-significant. It could be explained by the fact that riding a motorbike for longer distances is not convenient, especially during summers when this survey was conducted.

Table 2
Effects of SEDs on the frequency of non-commuting trips (results of Mann Whitney *U* Test).

Item	Group	Before COVID-19			During COVID-19		
		Mean Ranks	U	P	Mean Ranks	U	p
Gender	Male	354.95	34710.5	0.000	359.60	32421	0.000
	Female	283.91			271.12		
Age	18–30	321.65	44268	0.003	319.19	43178	0.001
	Above 30	363.69			368.45		
Education	Undergrad & below	146.63	2722.5	0.418	137.75	2545	0.223
	Masters & above	161.96			162.54		
Profession	Student	302.99	44266.5	0.067	296.9	42755.5	0.015
	Employed	327.62			331.52		
Car ownership	Yes	367.27	46147	0.000	371.27	44994	0.000
	No	312.49			309.48		
Motorbike ownership	Yes	345.85	52872	0.136	347.53	52296	0.098
	No	325.7			323.94		
Bicycle ownership	Yes	353.84	23620.5	0.312	360.58	23041	0.186
	No	333.38			332.39		

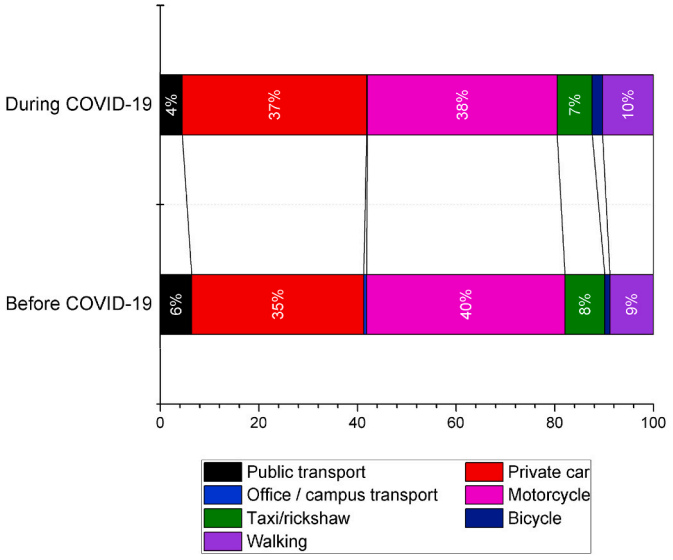

Fig. 5. Mode choices for shorter distances before and during COVID-19 pandemic.

4.3. Factors influencing mode preferences before and during the COVID-19 pandemic

There are several factors that influence mode choice under normal circumstances e.g., travel time, cost, and comfort etc. However, additional factors may come into play during a pandemic such as infection concern, social distance, and hand sanitizer availability in the bus etc. The distribution of responses for several factors influencing mode preferences before as well as during the pandemic are shown in Figs. 9 and 10, respectively.

As expected, most of the respondents put more priority on the pandemic-related items while choosing a mode during the pandemic. The mean and standard deviation of the priorities for each item are shown in Table 3. Mean of the priority placed on each item showed that the respondents put the most priority on cleanliness followed by infection concern during the pandemic. However, they placed the most priority on comfort followed by safety and security before the pandemic. The least mean priority was placed on comfort during the pandemic and hand sanitizer's availability in public transport vehicles before the pandemic.

In order to determine how people placed priorities on different factors before and during the pandemic, Wilcoxon Signed Rank tests were conducted. The results, as shown in Table 4, indicated that people put higher priority on safety and security, social distance, cleanliness, infection concern, hand sanitizers' availability, waiting for less congested vehicle and paying for less congested vehicle during the pandemic. Interestingly, personal social status still plays a role in mode choice during the pandemic. It is to be noted that there was no significant difference between priority placed on comfort before and during the pandemic. Hence, certain factors, which are important for mode choice during normal everyday life, may not be as important during a pandemic. On the other hand, certain pandemic-related factors for mode choice might be non-existent during normal everyday life, however, they may become the most important factors during a pandemic.

4.3.1. Exploratory factor analysis (EFA) on the items influencing mode preferences during the COVID-19 pandemic

EFA (with principal axis factoring) on the items influencing mode preferences during the COVID-19 pandemic produced a single factor based on the eigenvalues criteria (eigenvalues > 1). This underlying factor accounted for about 61.962% of the total variance. The factor loadings are presented in Table 5 (factor loading cut-off value $= 0.40$). The sampling adequacy was satisfactory (Kaiser-Meyer-Olkin measure $= 0.991$); the determinant of the matrix was 0.001; and Bartlett's test of sphericity was significant (0.000). Cronbach's alpha was also satisfactory (i.e., >0.7).

The regression approach was used to calculate the factor scores, which were subsequently used for determining the impacts of SEDs on the underlying factor influencing mode preferences during the pandemic.

4.3.2. Effects of SEDs on the underlying factor influencing mode preferences during the COVID-19 pandemic

Mann-Whitney *U* test was carried out to determine the effects of SEDs on the underlying factor influencing mode choice during the pandemic (Table 6). Females placed more priority on the pandemic-related items relative to the males during the pandemic. Females have been found to perceive more risk of the pandemic as compared to males (Dryhurst et al., 2020; Rana et al., 2021). Those who did not own a motorbike or a bicycle put significantly more priority on the items associated with the pandemic. A probable explanation is that such users are likely to use public transport, therefore, they might be more worried about the pandemic-related items. A weak significant correlation was found between the underlying factor and monthly household income ($r_s = 0.078$, $p = 0.046$).

5. Policy implications

5.1. Shopping as primary purpose of traveling

About 10% respondents declared that their primary traveling

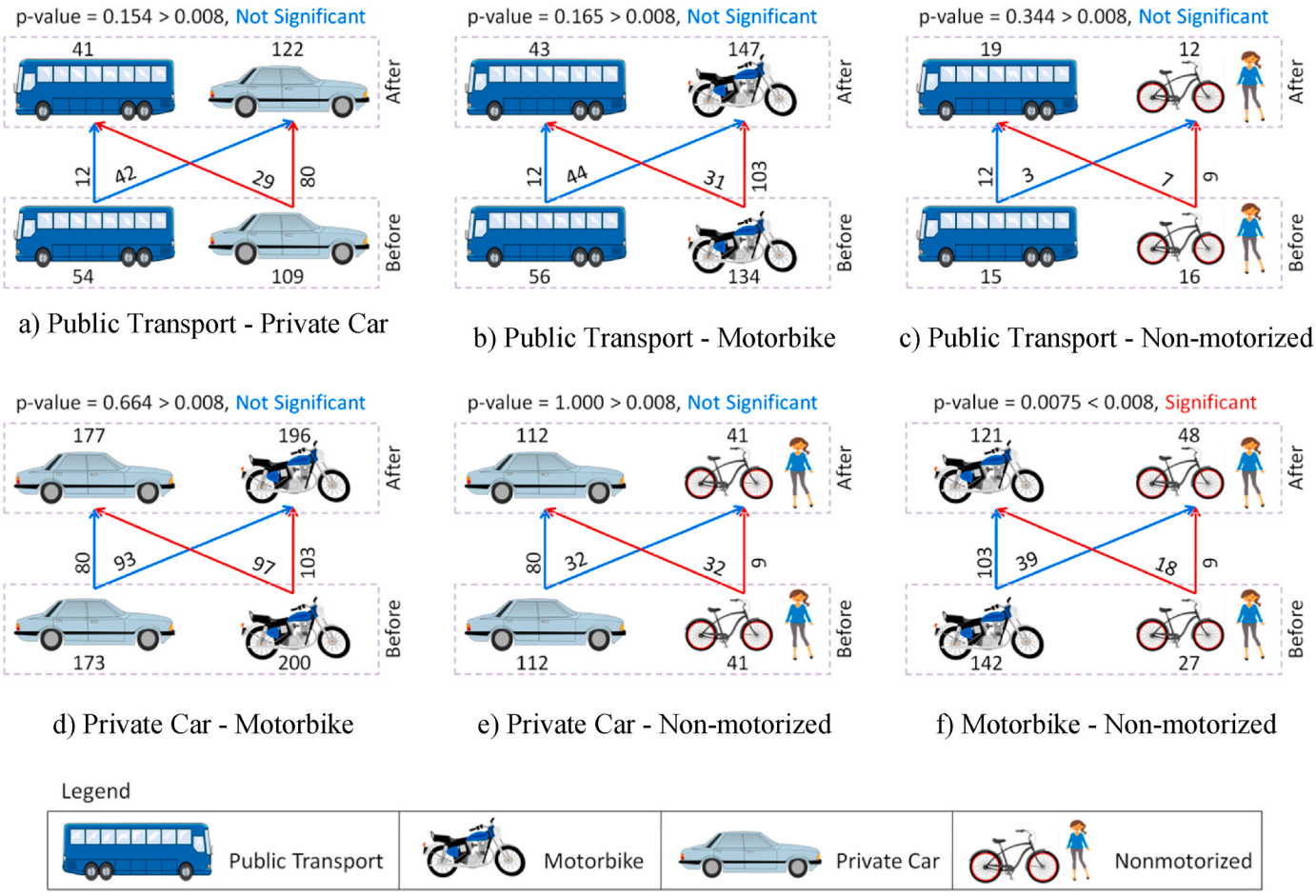

Fig. 6. Mode shift for short distances due to COVID-19 (results of McNemar test).

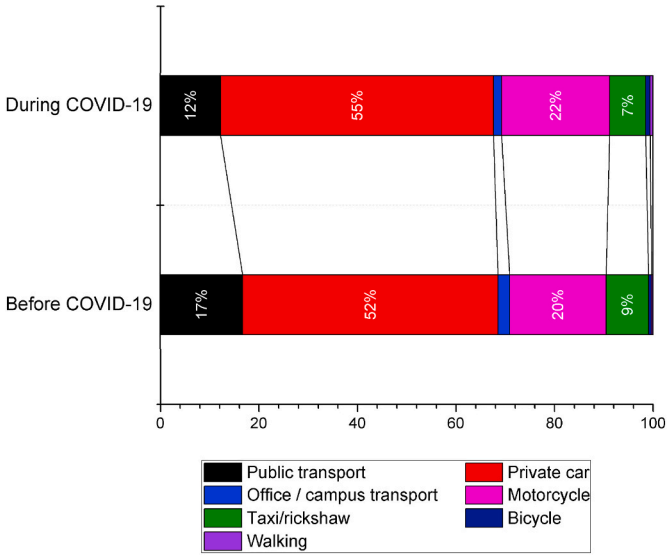

Fig. 7. Mode choices for longer distances before and during COVID-19 pandemic.

purpose was shopping during the pandemic, whereas only 4% stated that their primary purpose was shopping before the pandemic. Further, statistical analysis indicated a significant shift in primary traveling purpose from work and study to shopping. Therefore, shopping trips require special attention in the post COVID-19 world. For instance, Bawa and Ghosh (1999) reported that larger families tend to undertake more grocery trips because they have more needs. This is worrying in the perspective of the COVID-19 pandemic because close relatives in Pakistan generally live together in a joint family system implying that they are likely to make more trips and are at a greater risk of spreading the virus to more people (Tian et al., 2020). Moreover, Bawa and Ghosh (1999) reported that people older than 55 make more grocery trips, which is consistent with the finding of this study that people above 30 years of age make more non-commuting trips. Whereas current data on fatality rates suggests that older people are more likely to be affected by the virus (Liu et al., 2020). In addition, consumers may combine their trips for several purposes in order to reduce their shopping trip frequency during the pandemic as they do in their normal daily lives to optimize their time spent on shopping (Leszczyc et al., 2004). Hence, consumers may be attracted by supermarkets with large variety of items in order to reduce their trip frequency during the pandemic. Although, supermarkets and stores around the world have taken measures such as limiting the number of people in the stores at a time, maintaining social distance between the consumers and other necessary precautions, panic-buying was also observed during the pandemic (Nicola et al., 2020) which can lead to undesirable results. Moreover, lack of awareness among Pakistani consumers especially due to the low literacy rate may contribute to the transmission of the virus.

A sudden increase in online shopping has been observed due to the pandemic (Ozili and Arun, 2020) and it has the potential to reduce the outdoor shopping trips. Convenience and accessibility offered by the online shopping have been found to be the distinct characteristics which attract consumers to shop electronically (Wolfinbarger and Gilly, 2001; Jarvenpaa and Todd, 1997; Burke, 1997). Lack of mobility such as an

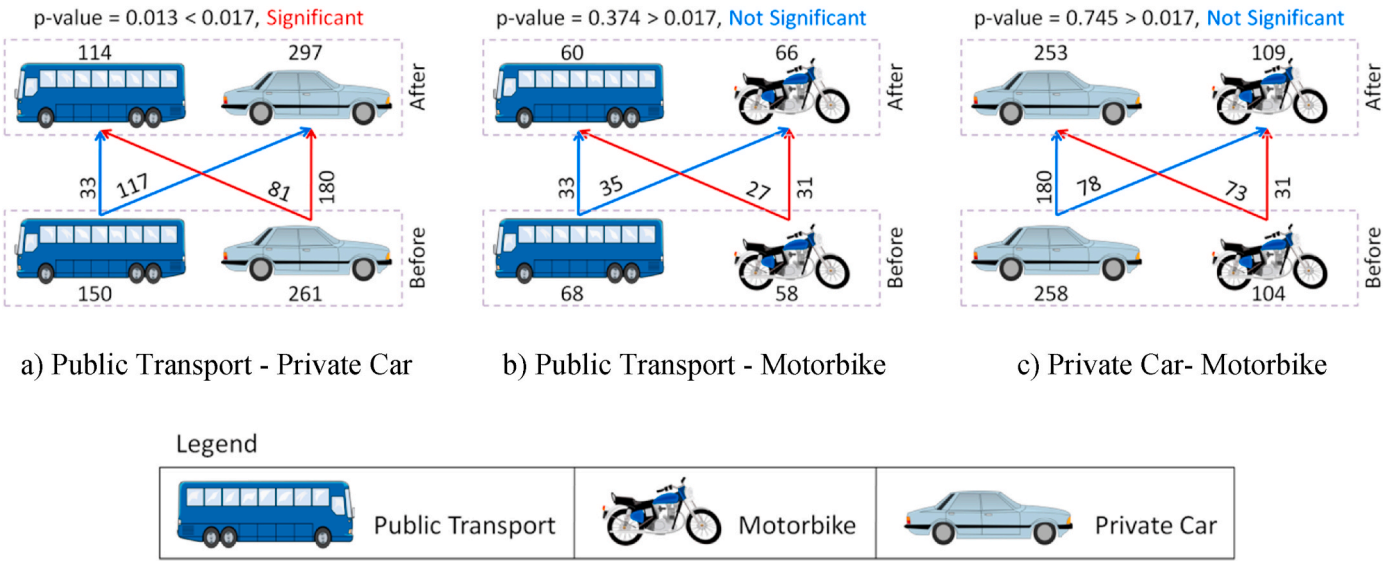

Fig. 8. Mode shift for long distances due to COVID-19 (results of McNemar test).

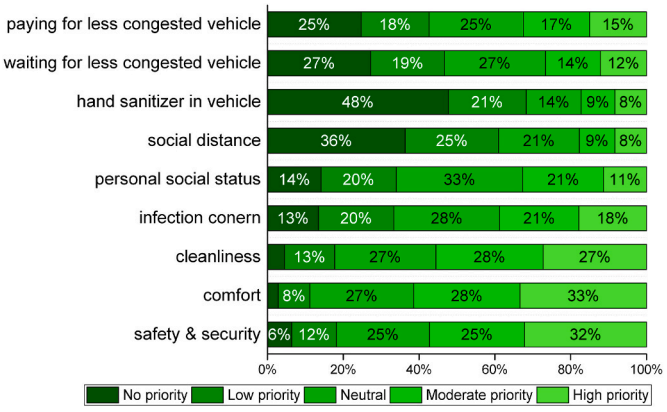

Fig. 9. Distribution of responses for the factors influencing mode preferences before the pandemic.

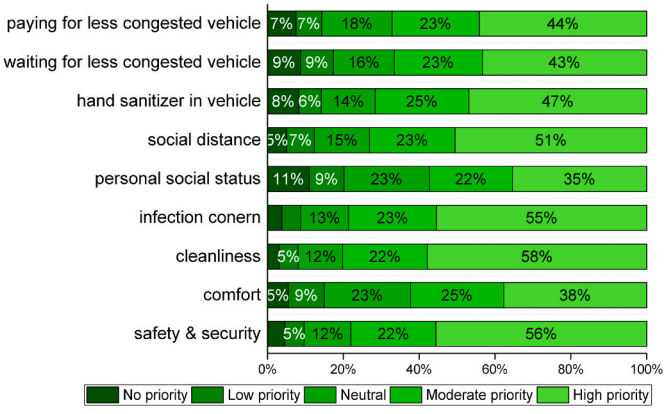

Fig. 10. Distribution of responses for the factors influencing mode preferences during the pandemic.

illness, absence of transport or other factors can also give rise to online shopping (y Monsuwé et al., 2004). Hence, consumers have more reasons during the pandemic to conveniently shop online due to mobility constraints such as self-isolation, social distancing, and unavailability of transport etc. However, there are certain factors that hinder online

Table 3
Mean and standard deviation of user rating for each item affecting mode choice.

Items	Before COVID-19		During COVID-19	
	Mean	Std. Deviation	Mean	Std. Deviation
Safety and security	3.65	1.222	4.20	1.114
Comfort	3.81	1.078	3.80	1.199
Cleanliness	3.61	1.149	4.28	1.044
Infection concern	3.10	1.286	4.22	1.079
Personal social status	2.96	1.196	3.63	1.333
Social distance	2.29	1.274	4.07	1.175
Hand sanitizer in vehicle	2.10	1.313	3.97	1.256
Waiting for less congested vehicle	2.65	1.341	3.84	1.307
Paying for less congested vehicle	2.80	1.381	3.90	1.253

Table 4
Factors influencing mode preferences before and during the COVID-19 pandemic (Wilcoxon Signed Rank test results).

Item	Group	Z	Asymp. Sig. (2-tailed)
Safety and security	Before and After COVID-19	−10.469	.000
Comfort		-.023	.982
Cleanliness		−13.171	.000
Infection concern		−15.990	.000
Personal social status		−10.979	.000
Social distance		−18.049	.000
Hand sanitizer in vehicle		−18.281	.000
Waiting for less congested vehicle		−15.214	.000
Paying for less congested vehicle		−14.460	.000

shopping especially in the developing countries such as social and technical factors, lack of trust and affection, overpricing, lack of variety, security risks, and limited internet access etc. (Alam et al., 2016; Bigdeli et al., 2009; Abbad et al., 2011; Mateen et al., 2018; Nazir et al., 2012; Lawrence and Tar, 2010). Lack of awareness among people is also an obstacle to the adoption of online shopping. An initiative about providing latest information to the farmers through smart phones was undertaken by the government of Pakistan. However, majority of the farmers did not even know how to use the smart phones for accessing the

Table 5
Exploratory factor analysis of the items influencing mode preferences.

Items	Factor 1
Social distance	.882
Cleanliness	.878
Infection concern	.855
Safety & security	.820
Hand sanitizers in vehicles	.795
Paying for less congested vehicle	.783
Waiting for less congested vehicle	.780
Comfort	.627
Personal social status	.613
% of variance explained	**61.962**
Cronbach's alpha	**0.931**

Table 6
Effect of SEDs on the underlying factor influencing mode preferences during the COVID-19 pandemic.

Item	Group	During COVID-19		
		Mean Ranks	U	p
Gender	Male	307.97	32558	0.000
	Female	382.51		
Age	18–30	328.47	47646	0.929
	Above 30	327.08		
Education	Undergrad & below	185.37	2292	0.176
	Masters & above	156.24		
Profession	Student	302.20	43904	0.350
	Employed	315.92		
Car ownership	Yes	326.92	52197	0.899
	No	328.81		
Motorbike ownership	Yes	303.16	45245	0.001
	No	354.16		
Bicycle ownership	Yes	280.14	19765.5	0.013
	No	334.94		

relevant information (Khan et al., 2019). Furthermore, English language of the online shopping websites can also be a barrier. Nationwide policies about teaching English language and relevant courses to young students to raise awareness regarding e-commerce and related security issues can increase awareness about and trust in e-commerce (Abbad et al., 2011). In addition, the government should aim at increasing internet access. Government of Punjab, the most populated province of Pakistan, provided free Wi-Fi hotspot service at several public places but the coverage is still limited to few major cities.

Online shopping websites and e-vendors should overcome these shortcomings and challenges in order to attract the consumers. This could be achieved by maintaining quality, reducing risk factor and delivery costs, and adding testimonials, ratings, and reviews from the previous consumers regarding the product quality and services to convince the consumers and build trust (Abrar et al., 2017; Yousaf et al., 2012). Entry of famous international brands such as Amazon into the Pakistani e-commerce industry may also increase the competition and bring about positive changes. Application of other alternatives such as OSaaS: Online Shopping as a Service could be explored to solve some of the problems such as low literacy rate, communication barrier and limited or no internet access etc. (Khan et al., 2016). An advantage of OSaaS particularly useful during the pandemic is that customers can place their orders to the cloud service center in their local language using cell phones.

5.2. Non-motorized/active modes for shorter distances

The results of the current study showed that there was a significant shift from motorbike to walking and bicycling for shorter distances (<5 km) during the pandemic. In addition, McNemar test showed that bicycle use was significantly higher during COVID-19 pandemic ($p < 0.001$). However, the overall share of active modes as well as bicycle ownership (12.8%) is still low. The analysis on the factors affecting mode choice showed that people prefer modes with low infection chances and more social distance etc. Walking and cycling possess these attributes. In addition, there are less vehicles on the roads due to the pandemic (Parr, 2020) providing a good opportunity to shift to non-motorized modes of travel. Less motorized traffic during the pandemic may also develop a sense of safety among the bicyclists and pedestrians. Furthermore, there was a significant shift from work and study trips to shopping trips. Use of private car for shopping can be further reduced and active modes can be encouraged if distances between homes and stores are reduced (Jiao, 2011). This study also found that people still pay attention to their personal social status while choosing a mode which indicates less use of non-motorized modes, especially bicycles. In order to change the perception about non-motorized transport and promote its use, a consistent effort at community or government level is needed (Buehler et al., 2016).

As the world progresses towards promoting the active modes of travel (i.e., walking and cycling), the planners in Pakistan focus on ensuring smooth traffic flow for private cars (Haque, 2015). Construction of flyovers and wide roads have discouraged pedestrians and bicyclists in big Pakistani cities. A study about walkability in Asian cities indicated that 41% of the respondents believe that the facilities for pedestrians in their cities are either bad or very bad (Leather, 2011). Furthermore, 67% of the respondents would shift from walking to motorized modes if the walking environments do not improve. Bicycle trips have been declining in Pakistan due to inadequate cycling infrastructure. A survey conducted in Lahore, Pakistan found cultural issues and gender to be the main barriers to biking followed by other hindrances related to the environment and infrastructure (Aslam et al., 2018).

These findings suggest that a developing country like Pakistan, which mainly focused on car travel in the past, should now focus on non-motorized modes of travel. The relevant authorities can properly utilize this opportunity and maintain the share of active modes even after the pandemic is over. Pucher et al. (2010) presented a review of the policies aimed at promoting bicycling and suggested that a comprehensive approach is better than uncoordinated individual measures to promote bicycling. Winters et al. (2017) suggest convenient, safe, and well-connected bicycling and walking infrastructure for promoting active travel. They also classified the policies in four broad categories: society-level policies, city-level policies, route-level policies, and individual-oriented policies. Considering the current situation under the pandemic, where there is less motorized traffic and the financial situation is not encouraging, it is recommended that individual-oriented policies be the top priority for short term planning in order to further increase the share of active modes. Individual-oriented policies are informational and educational policies targeting individuals or population groups and, may prove to be useful in motivating people to use active modes of travel during the pandemic.

5.3. Planning for shorter commuting times

This study indicates that less people traveled for work and study during the pandemic, however, the percentage is still substantial. People need to travel for various reasons during a pandemic while maintaining social distance and adopting other necessary precautions. In addition, essential workers need to commute even during a lockdown. This study also found that people shifted from public transport to private car for longer distances during the pandemic. Major cities of Pakistan have seen ill-planned growth over the years. Moreover, facilities, shopping, and health etc., are generally separated by long distances (Qasim et al., 2013). Although these ideas seem workable under lockdown and social distancing protocols, such urban planning policies force people to travel long distances for work, education and other purposes and private car

use is encouraged particularly during a pandemic.

The urban planning policies in Pakistan have two major negative consequences. Firstly, there will be, arguably, higher chances of disease spread if public transport is used because active modes are not suitable for longer distances. Secondly, people may shift from public transport to private car for longer distances, as found in this study, resulting in negative environmental impacts. By the late 20th century, the smart urbanism policies to make cities smaller and compact began to be implemented (Batty, 2020). Various other policies such as reducing car use, transit-oriented-development and road pricing etc. were also implemented at several places around the world. One of the objectives was to promote healthier and environment friendly modes of transport. Hence, the compact city idea, aside from being popular owing to its other advantages during normal life, seems plausible under pandemic situations. Although pandemics do not happen very often, future urban planning policies oriented towards the core idea of compact cities may prove to be beneficial in terms of shorter commuting distances which can be covered by non-motorized modes of travel in shorter times.

5.4. Long term impacts on public transport

Since public transport is the worst affected mode of travel during the COVID-19 pandemic, the evolving situation of the pandemic indicates three possible long term scenarios: 1. people avoid the use of public transport altogether and it may never recover, 2. people prefer active modes and private car over public transport in the long term. 3. people start using public transport as soon as fear of the pandemic and the pandemic itself go away.

Certain initial studies favored the first scenario indicating that public transport may not recover any time soon. For example, at the end of June 2020, the use of general traffic and shared bikes reached around 85%, while public transport had risen to only about 60% of the use in the previous reference period in Spain (Orro et al., 2020). However, the experience from the past pandemics and the current prevailing situation indicates that the first scenario seems improbable.

The results of this study and the studies conducted, when pandemic had spread widely, supported the second scenario indicating that people may prefer active modes and private transport over public transport. For example, Conway et al. (2020) reported that many respondents are planning to walk and ride bicycle more than before (Conway et al., 2020). Furthermore, walking and private car use increased and public transport use declined in two cities in Italy (Moslem et al., 2020).

However, multiple studies have recently begun to report the evidence for the third scenario. For instance, Przybylowski et al. (2021) reported that 75% of the public transport users in the city of Gdańsk, in Poland plan to restart using the public transport once the pandemic is over. People are returning to public transport in China, however, no COVID-19 clusters have been found to be associated with public transport (Shen et al., 2020). Hence, it is recommended that transport authorities focus on improving the perceptions about public transport system during the pandemic to attract the users in the long term. Furthermore, Beliaev et al. (2020) recommended using financial incentives to recover public transport in the long term while keeping in view the users' preferences. Finally, the extent to which public transport recovers also depends on the work-from-home policies, which may affect the long term travel behavior (Beck and Hensher, 2020). Yet public transport may still remain to be a need of the society because there are certain sectors which require morvement from homes to work such as manufacturing, construction, and many service-related jobs. Policies to attract people towards pubic transport are beneficial for the society, however, these policies must be developed and implemented while keeping in view the ethical considerations. For example, public transport may, arguably, propagate the spread of the virus. Hence, any policies aimed at reviving public transport must be based on users' preferences.

6. Conclusions

This study explored the effects of the COVID-19 pandemic on travel patterns and mode preferences in a sample from three cities of province Punjab of Pakistan. A questionnaire was administered online to collect the data about demographics, primary travel behavior, mode choice and factors influencing the mode preferences before and during the pandemic. The statistical analyses indicated differences between primary traveling purpose before and during the pandemic. The results indicated that less people traveled for work and study during the pandemic as compared to the before-pandemic situation. However, more people traveled for shopping during the pandemic. Number of trips performed for non-commuting purposes were found to be significantly different before and during the pandemic. Males undertook significantly more non-commuting trips as compared to females during the pandemic. Those above 30 years old and car owners made significantly more non-commuting trips during the pandemic. Monthly household income was found to be positively correlated with number of non-commuting trips before and during the pandemic.

Mode choice was significantly different before and during the pandemic for shorter distances (<5 km). Public transport use reduced, whereas private car use increased during the pandemic. However, the shift between public transport and private car was not significant for shorter distances. There was a significant modal shift from motorbike to bicycling and walking. Mode choice was also found to be significantly different for longer distances (>5 km) before and during the pandemic and the shift from public transport to private car was also statistically significant.

The respondents also placed priorities on different factors influencing the mode preferences before as well as during the COVID-19 pandemic. Mean of the user rating for each factor indicated that the respondents placed the most priority on cleanliness followed by infection concern during the pandemic. However, they placed the most priority on comfort followed by safety and security before the pandemic. Least priority was placed on comfort during the pandemic and hand sanitizer availability in vehicle before the pandemic. EFA on the factors influencing mode preferences during the pandemic yielded an underlying factor. Statistical analysis indicated that females put higher priority on the pandemic-related items relative to the males during the pandemic. Those who did not own a motorbike, or a bicycle put significantly more priority on the pandemic-related items. Monthly household income was found to have a very weak positive correlation with the underlying factor.

Based on the results of this study, policy implications regarding shopping as a primary purpose of traveling, mode choice for shorter distances, shorter commuting times, and long-term impact on public transport are also presented. This study had some limitations. The sample was not representative mainly in terms of education level. The number of respondents for age groups above 45 years old was very small probably owing to their less familiarity with online tools and social media. In addition, people may have some discrepancies while reporting their travel behavior few months before the virus emerged. Since the pandemic is still going on, further studies on this topic may target cross-city and cross-country comparisons to better understand the transferability of the findings of this study.

This study is based on the findings from a questionnaire study conducted in one country. Yet it is hypothesized that the findings reported here might be applicable to other societies with similar socio-demographic and economic characteristics, and wherever similar travel patterns and mode choices persist (e.g., the cities in the South Asian countries i.e., India, Bangladesh, Afghanistan, and Sri Lanka). There could be some similarities with the cities of the developed countries, however, caution is advised while transferring these findings to such cities and further comparative studies are recommended. Since the sample is skewed towards male, younger and more educated people, the findings should be applied to populations with similar characteristics.

The results presented here might not be applicable to cities where transport modes are different. In addition, the scale of the pandemic should also be considered while generalizing the results of this study.

Author statement

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tranpol.2021.04.023.

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