

UNIVERSITY OF BAHRAIN

College of Engineering

Department of Civil Engineering



MODELING CROSS-COUNTRY EFFECTS OF COVID-19 ON OVERALL TRAFFIC AND TRAVEL BEHAVIORS

A Thesis submitted in partial fulfilment of the requirements for the Master's
Degree in Civil Engineering

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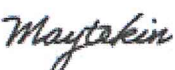
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Abstract

This study examines the impact of the COVID-19 pandemic on traffic and transportation in Bahrain, India, Pakistan, and European countries (mostly Belgium and Italy). The findings indicate significant changes in travel behavior and a substantial reduction in overall trips during the pandemic. Respondents varied in their out-of-home activities, with Europe showing a preference for continuing such activities. The study highlights the need for effective policies and strategies to address the challenges posed by the pandemic and provides valuable insights for future pandemic preparedness. Furthermore, the study explores the long-term effects on travel behavior, transportation preferences, and hygiene measures, emphasizing the importance of adapting transportation systems. A questionnaire link was initiated and distributed to gather people's experiences in the targeted regions and statistical tests are used to distinguish the differences between before compared to during COVID-19 situation. In addition, minitab software is used to anticipate the total number of trips based on selected parameters and among different models. In this context and by measuring different aspects of the data, it is noticed that overall trips are reduced significantly and fuel saving percentage confirms this argument. However, the trips related to groceries resulted to minimal to zero differences in all the targeted regions as they are necessities. The regressions models also indicate some of the factors that have strong influence on the total number of trips like occupational status, distance from home to shopping locations, predominant travel mode for shopping, frequency of out-of-home activities, and preference on performing out-of-home activities.

Dedication

My thesis is dedicated to BAHRAIN, my nation, which deserves all of our time and effort to maintain Bahrain foremost in all sectors. I also dedicate this thesis to my parents, family, friends, and anybody else that believes in me and will always be by my side while I pursue my dreams.

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Glossary

COVID-19	Corona Virus of 2019
ICT	information and communication technology
WHO	World Health Organization
USD	United States Dollars
UNICEF	United Nations Children's Fund
USA	United States Associations
BART	The Bay Area's largest transportation system
GPS	Global Positioning System
PAPQ	Perceived Air Pollution Quantity
PTSD	Post-Traumatic Stress Disorder
KSA	Kingdom of Saudi Arabia
EU	The European Union
BHD	Bahraini Dinars
EUR	Euro
BTPC	Bahrain Public Transport Company

Chapter 1

Introduction

- 1.0 Introduction
- 1.1 Research Problem
- 1.2 Research Questions
- 1.3 Research Objectives
- 1.4 Research Significance
- 1.5 The study's Setting.

1.0 Introduction

The “coronavirus 2 severe acute respiratory syndrome” causes Coronavirus disease 2019, which is also known as COVID-19 and SARS-CoV-2. The first known case of this virus was detected in Wuhan, China, in December 2019 (Page, Hinshaw, & McKay, 2021). The disease quickly spread over the world, resulting in the COVID-19 pandemic. On 11th of March 2020, World Health Organization (WHO) announced COVID-19 as an international pandemic against which all of the countries have to employ the necessary procedure and health measures to contain the situation and flatten the curve (Infected cases Vs Time) in order for the health sector to be stable throughout the epidemic period and control the cases accordingly.

Following the COVID-19 outbreak, governments throughout the world made exceptional measures to suppress the virus. Many nations, including France, Italy, the United Kingdom, Iran, India, Saudi Arabia, and Thailand, enforced national curfews, banning all non-essential movement (de Haas et al. 2020). Similarly, Pakistan imposed a national lockdown on April 1, 2020, and prolonged it twice till May 9, 2020. Although the lockdown was gradually decreased, several regions in megacities with severe clusters remained under smart lockdown (Abdullah, Ali, Hussain, Aslam, & Javid, 2021).

The COVID-19 pandemic has benefitted and harmed several industries. The epidemic might have helped e-commerce, information and communication technology (ICT), food production, and retail. Many studies have looked at how e-commerce and ICT affect behavioral changes in activity and related travel (or activity-travel behavior changes), notably the possibility for substituting out-of-home activities with virtual-based tasks like e-learning, telework, and online buying (Irawan, Belgiawan, Joewono, & Bastariant, 2021).

During the early stages of the COVID-19 epidemic in Saudi Arabia, approximately one-fourth of the general population sampled reported medium to significant mental trauma (Sun, Wandelt, Zheng, & Zhang, 2021).

Further to the information provided above, this study is aiming to study the impact of the outbreak on the traffic and transportation sector where studies have shown several effects when it comes to public transportation, grocery shopping, work from home guidelines,

etc., all of which would have a substantial effect on the transportation and traffic sector all over the world (Shamshiripour, Rahimi, Shabanpour, & Mohammadian, 2020)

1.1 Research Problem

This study is aiming to capture the zone-zone activities, impacts of the confinement + curfews on the transportation activities and comparing the status before the outbreak and during the declaration and application of the appropriate control measures. Statistical analysis was applied in order to get a detailed description on how COVID-19 exactly affected some regions (Bahrain, Europe (mostly Belgium and Italy / 54% and 11% respectively), Pakistan and India). Due to the critical situation, it is important to come up with a result that would give a comprehensive idea about the transportation sector as victim to the outbreak and declaring an international pandemic by WHO.

1.2 Research Questions

- What aspects of the transportation sector are affected by the pandemic?
- How have the travel patterns changed due to the restrictions implemented for COVID-19?
- How do the impacts differ in different countries and regions?
- What changes could be sustained in the future after the restrictions are lifted?

1.3 Research Objectives

- 1) To study and compare different countries' situations regarding covid-19 effects on different travel
- 2) To study the effects of policies regarding the pandemic on travel frequencies for different activities
- 3) To foresee the long-term impacts of COVID-19 restrictions

1.4 Research Significance

The Research is very vital to come up with a detailed study that would identify vulnerabilities in different aspects of traffic and transportation affected by travel restrictions. Research would help countries in getting a clear picture of how transportation has been impacted by COVID-19 in different parts of the world. This may be used as historical data if similar cases occur in the future. This research will also enable the administrations to formulate/update transport policies considering the changes that would be sustained in this sector.

Chapter 2

Theoretical Framework and Literature Review

2.0 Introduction

2.1 COVID-19 Pandemic Effect on Mobility and Public Transportation

2.2 Air Pollution Perception

2.3 General Effects of COVID-19 on Various Aspects

2.0 Introduction

The COVID-19 was discovered in China (Most likely in Wuhan and precisely in an enormous market aimed to sell live animals) in December 2019 (Worobey, et al., 2022) . Viruses can be transmitted through direct contacts with infected people (Droplets). Some theories also state that transmission could be through physical contact with contaminated surfaces (Hindson, 2020) . By pointing out the effects on children, the COVID-19 epidemic has been particularly devastating for youngsters. In comparison to adults, the epidemic has consumed a far larger portion of their life, and the loss of in-person learning and favorite activities with friends has been painful. As we look forward to a future beyond the COVID-19 epidemic, many adults and children may find it difficult to let go of dread and uncertainty which may accordingly cause them anxiety, stress and introversion (UNICEF, 2021).

By the end of March 2020, global road travel declined by more than half compared to the same time in 2019. When compared to the same period in 2019, flight activity was about 75% lower by mid-April 2020 (IEA 2020). The drop in passenger transport demand is due to a combination of government limitations and society anxieties of contracting and spreading COVID-19 when utilizing mass transportation modes (Wielechowski, Czech, & Grzeda, 2020).

On a general view, COVID-19 pandemic has affected the whole world dramatically in different aspects. To decrease the impact of the virus, many control measures have been conducted including social distancing, work at home policy, etc.

One of the aspects that has been affected significantly is global transportation and mobility. An enormous reduction has occurred to traffic volumes and relevant economic activities. Accordingly, a significant reduction in oil demand occurred that resulted in a major drop in price to USD 11.57 on 21st of April, 2021. Increase in infection from 0 to 0.0003% has resulted in mobility reduction by 2.31% while stay at home policy reduced mobility by 7.87%. Metropolitan cities in the USA were affected dramatically when it came to transit ridership and traffic volumes, which decreased by 94% and 72%, respectively. Furthermore, when comparing 2020 with 2021, New York experienced 35 percent lower traffic during COVID-19 outbreak. The research could be used to look at

the consequences of the COVID-19 pandemic or any other similar event on mobility at the country level (Rahman, et al., 2021)

2.1 COVID-19 Pandemic Effect on Mobility and Public Transportation

2.1.1 Saudi Arabia:

In Saudi Arabia, till the study period in 2021, 281,456 cases were identified and almost 3000 deaths were reported as a result of adverse symptoms due to COVID-19. This study focuses specifically on Riyadh and Jeddah as both are major cities within the country. Figure 2.1 and Figure 2.2 basically show the variations with respect to new cases and mobility responses within Riyadh (Figure 2.1) and Jeddah (Figure 2.2). As shown in figures 2.1 and 2.2, rapid increase was observed in the cases since the discovery of the first case, 2 March, 2020. As a countermeasure, countries applied various curfews to control the cases and flatten the curve (as illustrated in the below figures). As a result, curfew had apparent effects on mobility.

These two cities. Residential trips increased in a noticeable manner (30%). On the other hand, transit trips have decreased dramatically (70%) due to fear of people getting infected and (Rahman, et al., 2021). “Those percentages shown are up to the study period (2021) and not reflecting the current situation”.

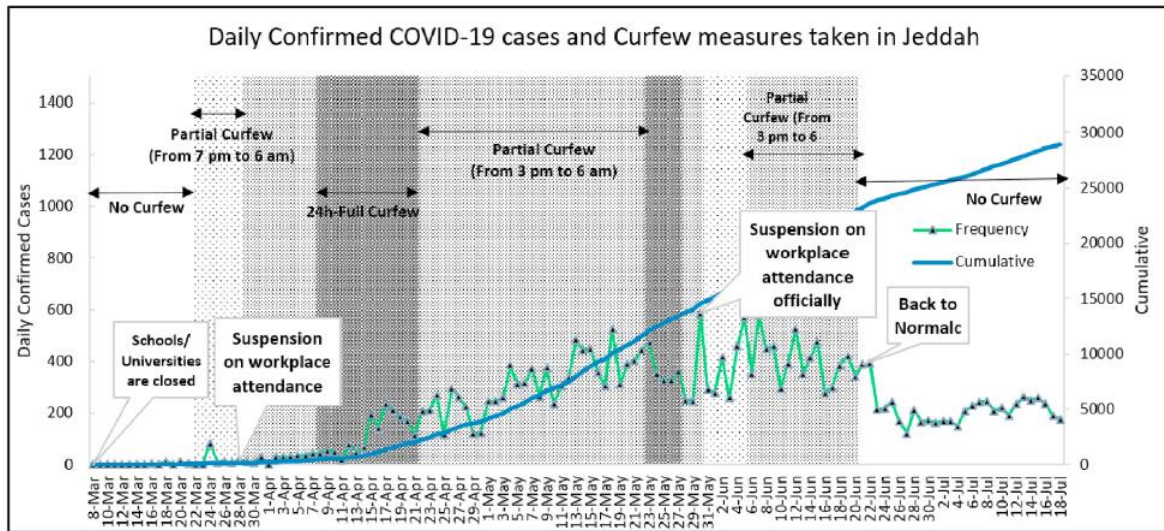


Figure 2.1: Daily Confirmed Cases in Riyadh (Rahman, et al., 2021)

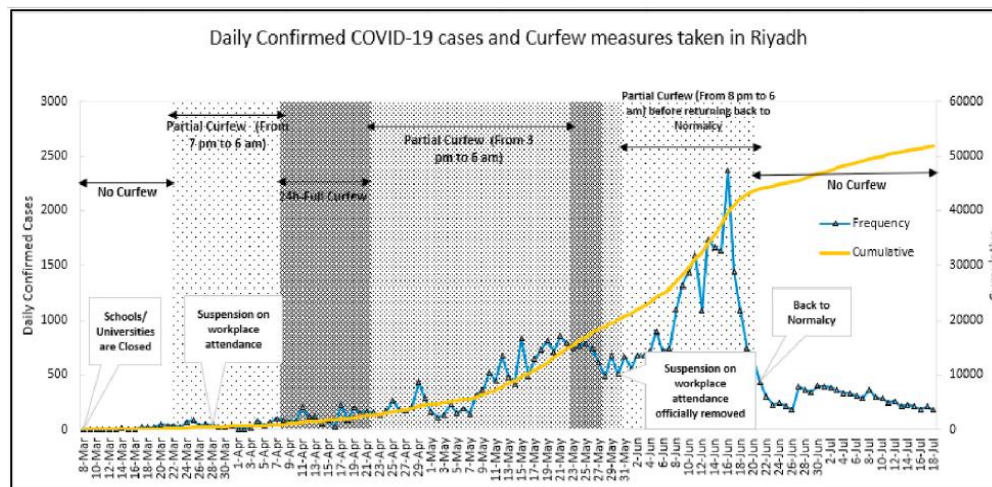


Figure 2.2: Daily Confirmed Cases in Riyadh (Rahman, et al., 2021)

2.1.2 Aviation Movement in Canada (from December 2019 to April 2020)

Table 2.1 : Monthly Aviation Movement in Canada (Abu-Rayash & Dincer, 2020)

	19-Dec	20-Jan	20-Feb	20-Mar	20-Apr	Average	% Decrease
Total Civil Movements	301,273	293,256	336,921	283,797	90,393	310,483	-71%
Commercial movements	208,941	203,544	212,563	179,577	49,376	208,349	-76%
Private and other movements	15,167	13,722	17,992	17,341	14,629	15,627	-6%
Local	77,165	75,990	106,366	86,879	26,388	86,507	-69%

movements							
Total Military movements	1,095	1,363	1,651	1,366	1,001	1,370	-27%
military movements	955	1,115	1,269	1,116	893	1,113	-20%
military local movements	140	248	382	250	108	257	-58%

As shown in Table 2.1 above, a dramatic reduction in Aviation mobility occurred in the shown period from 19-Dec, 2019 till April, 2020. Total Aviation civil movement reduced around 71% while 69% reduction was noticed in the military movements.

2.1.3 San Francisco

A brief description of San Francisco situation as from the beginning of the outbreak till the date of the referenced research (8th April 2020) shows that 17 bus routes of the city were kept open, out of total 68 routes that were available before the pandemic. Those 17 routes were aimed to serve workers that are vital and cannot stay at home while doing their work remotely. Since citizens were told to stay in their homes to prevent the spread of the coronavirus illness COVID-19, the city lost an estimated \$1 million every week. It was declared on March 26 ,2020 that its train and light rail lines will be closed and replaced with buses. BART, the Bay Area's largest transportation system, was losing an estimated \$57 million per month in sales taxes, tolls, advertising income, and parking fees due to a reduction in attendance (Canales , 2020).

2.1.4 Case Study in the City of Santander:

City of Santander, located in north Spanish coast which has a total population of nearly 180,000 people, out of which approximately 70% of them are employed (Aloi, et al., 2020).

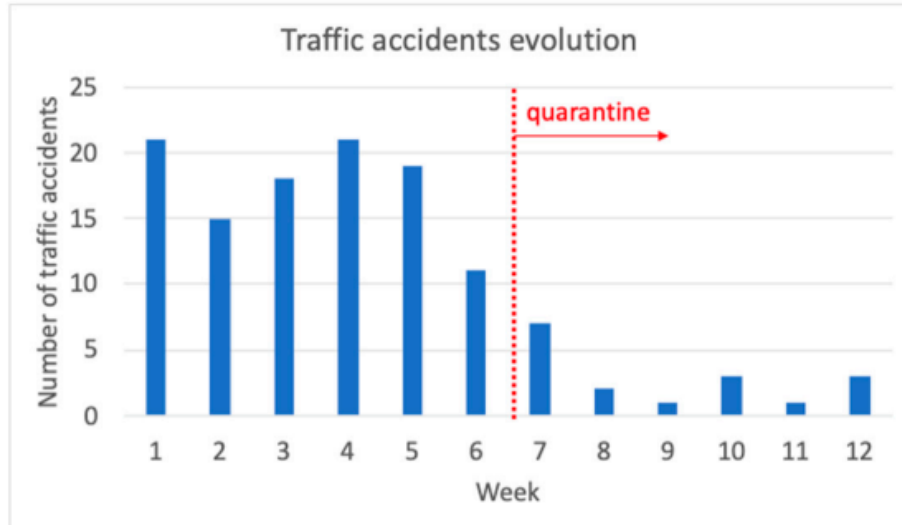


Figure 2.3: Number of traffic accidents per week (Aloi, et al., 2020)

As an overall review of the city of Santander in Spain on its traffic flow before and during the quarantine, it is noticed and as per figure 2.3 above that number of traffic decreased dramatically from 105 accidents to 17 (-83.8%). This study was performed during the quarantine declared by the government and compared with one month and half before quarantine. Figure 2.3 gives a clear indication that number of traffic experienced a noticeable decrease during the peak of COVID-19 outbreak and accordingly number of traffic reduced exponentially (Aloi, et al., 2020).

2.1.5 Australia (Household and Activities)

The poll, which was conducted in the last week of March 2020, requested respondents to submit details on their job status before the COVID-19 outbreak as well as thereafter, including their capacity to work from home and instances of doing so. Respondents were then asked to consider their household's weekly travel activities in early March 2020, prior to the emergence of COVID-19 as a serious public health issue. The survey started on March 30th, one day after Australia's most draconian social distance limits went into force. At this stage, 78 percent of respondent families had made modifications to their weekly household travel (females were more likely to say they had), while 15% had made no modifications and had no plans to make any (lower-income families were more likely to have made no changes), while 7% intended to make changes (men were more

likely to disclose planned changes). 32% of households, that had previously altered, planned to make greater adjustments in the future. (J. Beck & A. Hensher, 2020).

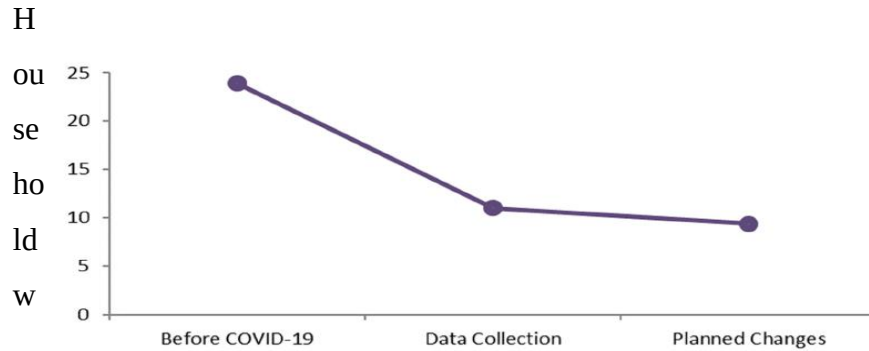


Figure 2.4: Impact of COVID-19 on reported household weekly trips (J. Beck & A. Hensher, 2020).

Figure 2.4 above shows the drivers willingness of car usage before COVID-19, during the data collection of the survey (table 2.2) and the planned changes in the future which itself indicates a dramatic reduction in car usage (J. Beck & A. Hensher, 2020).

Table 2.2: Overview of survey sample (J. Beck & A. Hensher, 2020)

Sample characteristics	Statistical Figures of the sample	Country	Percentage
-	-	New South Wales	22%
Female	52%	Australian Capital Territory	2%
Age	46.3 ($\sigma = 17.5$)	Victoria	28%
Income	\$ 92,826.00 ($\sigma = \$58,896.00$)	Queensland	22%
Have Children	32%	South Australia	11%
Number of Children	1.8 ($\sigma = 0.8$)	Western Australia	11%
Age of Children	11.2 ($\sigma = 0.8$)	Northern Territory	1%
-	-	Tasmania	2%

2.1.6 City of Budapest

In the city of Budapest, data were collected to measure the impact on various modes of transportation because of COVID-19 outbreak throughout the city. A study was done which aimed to demonstrate the effects on modes of transportation with respect to usage and overall popularity (post-pandemic situation). On the basis that modes of transportations can be affected by different factors such as fares, car ownership, salaries, etc., it was very predictable these factors have been influenced so badly during the pandemic outbreak which accordingly led to drastic impacts on the modes of transport by different factors (Bucsky, 2020). Data with respect to mode transport usage were collected on six bases.

- 1- Road Transport (Using GPS tracking applications)
- 2- Public Transport
- 3- Pedestrian Transport
- 4- Cycling
- 5- Bike sharing system.
- 6- Further ridesharing systems

Data was collected from the 9th week of 2020 till week number 14, including the days in March. The city of Budapest used its 2017 year as a baseline in order to compare the effects on modes in the COVID crisis compared to 2017 as the ideal year for transportation and overall prosperousness. Three scenarios have been used (Lower Estimate, Middle estimate and higher estimate) to evaluate the effects on modes of traffic (specifically in weeks 12 and 13 of the 2020 year). Figure 2.5 shows the difference of situations on the studied modes in 2017 (as a baseline and as a pre-virus situation and weeks 12 and 13 since they indicate the worst situation during the year (2020) and during March, specifically). For pedestrian traffic, 50% reduction was observed (compared to the baseline year). Mobility has a steep reduction of around 51%, 57% and 64% (Lower estimate, middle estimate and higher estimate respectively). The daily trips reduced from 10.1 million to 4.3 million when compared to baseline year (2017) (Bucsky, 2020).

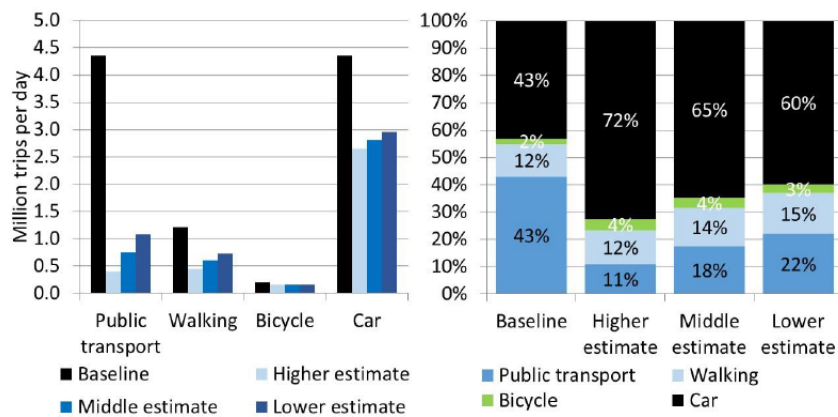


Figure 2.5: Average trips by mode of transport and modal share in the second half of March 2020 (Bucsky, 2020).

2.1.7 Poland

The COVID-19 issue has wreaked havoc on all modes of transportation, both public and private, on a national and worldwide scale. From January to June 2020, Figure 2.8 depicts the monthly numbers of people transported by public transportation in Poland. Since the COVID-19 pandemic breakout in March 2020, a significant drop in passenger transit in Poland was observed. In contrast to January 2020, the overall number of passengers using public transportation had decreased by 77 percent by the end of April. Air passenger transportation grew less popular as a result of government limitations. Nearly 21 million passengers were transported by public transportation in Poland in June 2020 as a result of subsequent stages of restriction easing, increasing by 38.6 percent from May (Figure 2.6) (Wielechowski, Czech, & Grzeda, 2020).

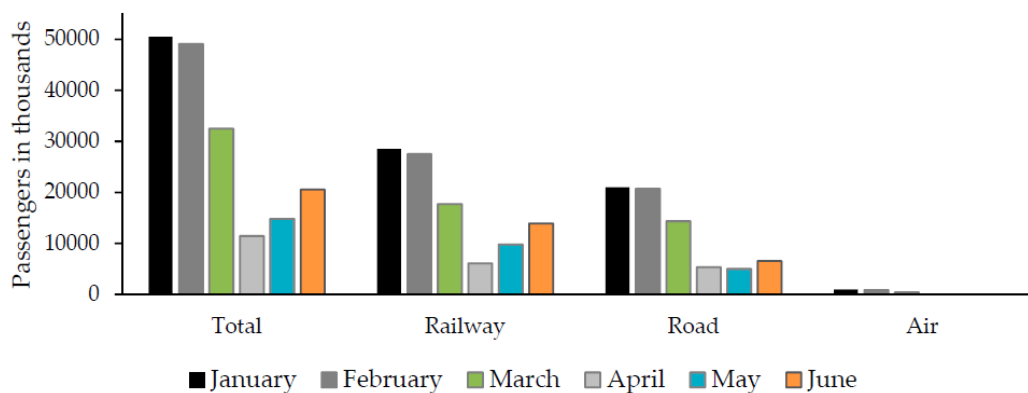


Figure 2.6: Passenger transport in Poland from January to June 2020 by means of transport, in 1000 persons (Sas, 2022)

2.1.8 Netherlands:

Netherlands travel behavior was impacted in different aspects because of COVID-19 pandemic (Haas, Faber, & Hamersma, 2020). This study presented results regarding people's experiences since coronavirus crisis in terms of outdoor activities, work and education, personal travel patterns. When it comes to outdoor activities, figure 2.7 below illustrates that people in general acted less active. Highest percentages of "Less often" lay on Grocery Shopping and Volunteering.

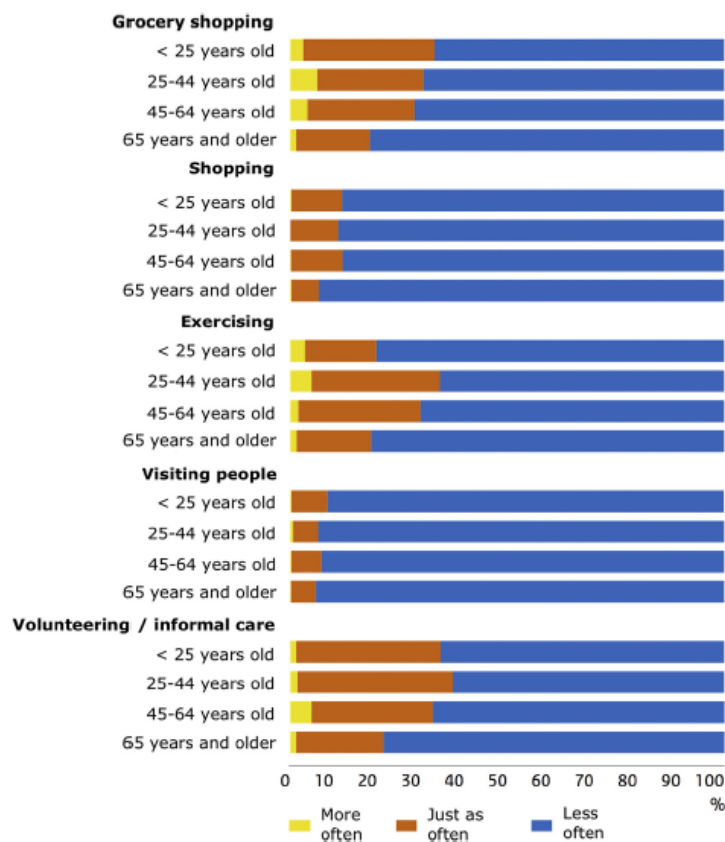


Figure 2.7: Change in outdoor activities since coronavirus crisis, per age group (Haas, Faber, & Hamersma, 2020).

Since there has been a noticeable increase in working from home percentage, figure 2.8 below shows a summarized analysis based on data collected by the study where most of population, aimed in the study, show an overall self-satisfaction working from home.

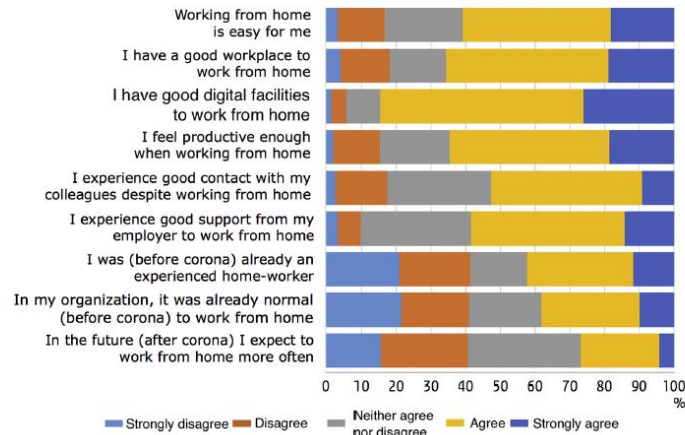


Figure 2.8: Experience with working from home (Haas, Faber, & Hamersma, 2020)

Results showed that there was a significant increase in walking and overall sport activities as well as grocery shopping, while significant decrease on other leisure when compared to before covid and the situation at the time of the study.

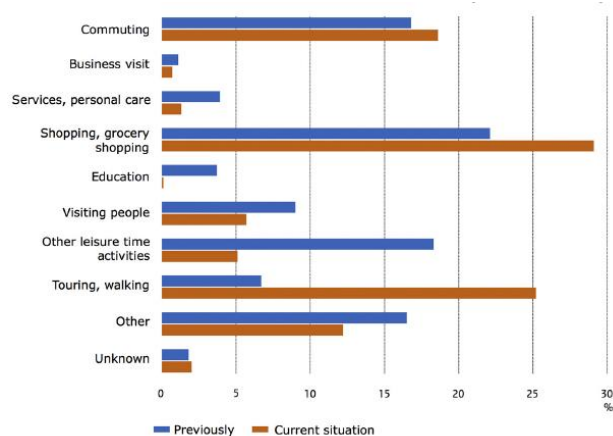


Figure 2.9: Share of trip motives in number of trips. (Haas, Faber, & Hamersma, 2020)

2.1.9 Sweden

A study by (Jenelius & Cebecauer, 2020) conducted on the major cities in Sweden (Stockholm, Västra Götaland and Skåne). Among these cities, Stockholm was hit the most between March and May, 2020, as shown in figure 2.10 below.

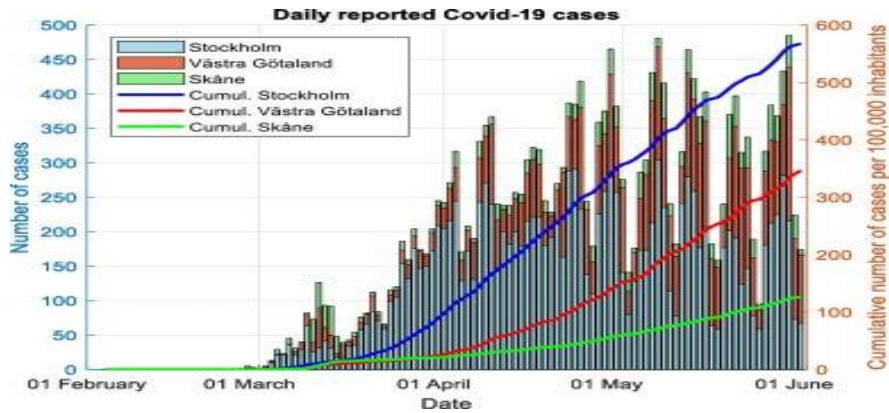


Figure 2.10: Daily number of reported cases (bars) among the major cities – COVID-19 in Sweden (Jenelius & Cebecauer, 2020)

Figure 2.10 depicts the relative change in the total daily number of journeys for the three areas Stockholm, Västra Götaland, and Skåne. Bus journeys from Stockholm were removed. Ridership began to decline in all areas in early March 2020, but at varying rates. On the same day, the Swedish Public Health Agency raised the risk rating of COVID-19 spread in Sweden from "low" to "moderate." Ridership fell precipitously on 10 March 2020, when the Public Health Agency raised the danger rating to "extremely high." Ridership in Stockholm and Skåne dropped dramatically in the first few days, reaching 60% reductions. Västra Götaland experienced a slower drop, with a maximum loss of almost 40%.

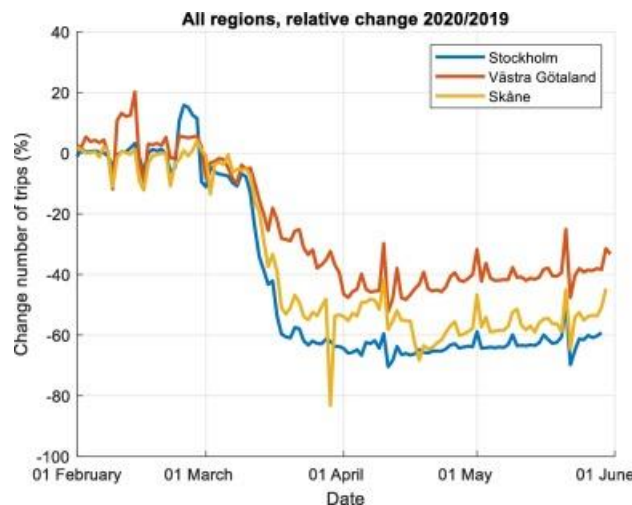


Figure 2.11: All regions, daily number of trips, relative change 2020 from the baseline 2019. (Jenelius & Cebecauer, 2020)

2.2 Air Pollution Perception

As proposed by (Lou, et al., 2021), this study aimed to capture the effects of the outbreak on individuals when it comes to air pollution perception among individuals in 10 different countries (Australia, Brazil, China, Ghana, India, Iran, Italy, Norway, South Africa and the USA) before and after the outbreak of COVID-19. In this context, an online survey was distributed in May 2020 which allowed for a cross-sectional study regarding the overall air quality perception before and after declaration of the pandemic. The study is aimed to focus on middle-educated people holding at least a bachelor's degree. Also, survey was administrated in a way to be equally distributed in terms of gender (50.9% male and 48.9% female) (Lou, et al., 2021). Results are shown in comparison to the middle-class individuals which gave an overall fair awareness to air quality before the pandemic according to (Bickerstaff & Walker, 2001). Comparisons were done on the Likert Scale from 1 to 7. Where 1 represents “extremely low pollution” and 7 “extremely high pollution”. Overall, study has shown on the “Likert Scale” a median of 4.08 and Standard deviation of 1.61 before the outbreak and a median of 2.84 and Standard deviation of 1.28 after the outbreak where it shows a better air quality recognized by the population after the declaration of the pandemic (Lou, et al., 2021). Figure 2.12 below shows a rough comparison on the 10 countries mentioned in terms of pollution recognized before and after, where in general people noticed a dramatic reduction in air pollution after the pandemic being declared.

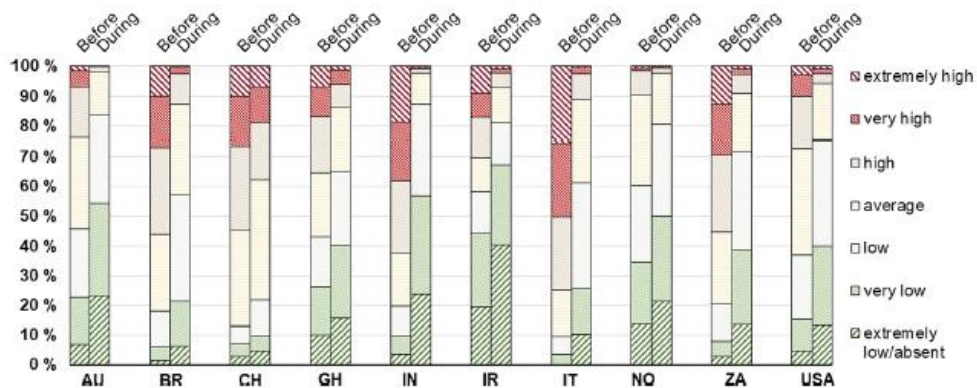


Figure 2.12: Perceived Air Pollution Quantity (PAPQ) before and during (Lou, et al., 2021).

According to another study by (Barbieri, et al., 2020), survey was conducted regarding two aspects, “How do you regard the amount of air pollution before the epidemic?” and “How do you regard the amount of air pollution during the restrictions?”. The respondents' opinions were expressed on a 7-point Likert scale ranging from "very low/absent air pollution to extremely high air pollution." Figures 2.13 (a) and (b) show the replies received before and during the implementation of the COVID-19 limitations, respectively (Barbieri, et al., 2020).

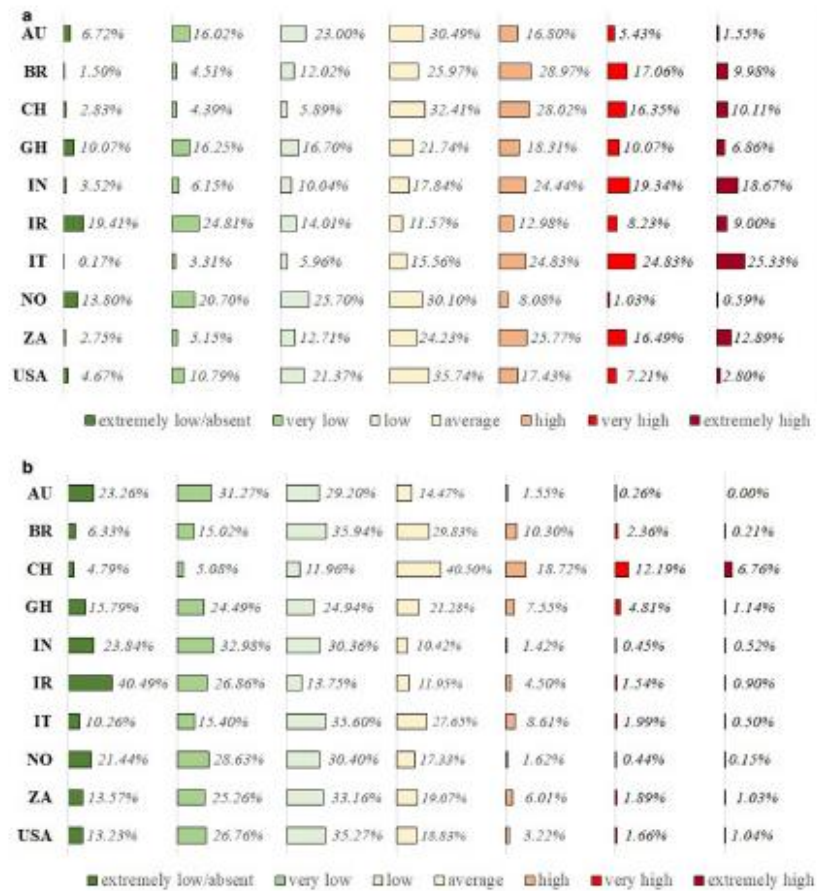


Figure 2.13: Perceived Amount of Air Pollution Before (a) And During (b) (Barbieri, et al., 2020).

The results on both studies are almost identical. As shown in figure 2.13 above, people think more positively in respect to recognized/perceived air quality after the pandemic declaration. Percentage of people among the studied countries who think that pollution is extremely low, very low and low, occupy the highest percentages compared to the situation before the pandemic (Barbieri, et al., 2020).

2.3 General Effects of COVID-19 on Various Aspects

2.3.1 Psychological Impact

According to a study by Passavanti et al. (2020), an online survey was created. The online survey was administered in seven countries (Australia, China, Ecuador, Iran, Italy, Norway and the United States), and numerous issues were investigated; hence, the questionnaire was divided into three basic sections: (1) socio-demographic information, (2) leisure time use, and (3) use of information media and technology. The poll focuses on COVID-19 understanding, coping strategies, and psychological impact. Study is built on cross-sectional method and survey was distributed in the period between 17-04-2020 to 30-04-2020. By summing up, it is obvious to note that between 60% to 80% of the sample reflects an anxiety level from mild to severe as an adverse effect resulted from the counter measures associated with COVID-19. 17% to 36% illustrates levels ranging from moderate to severe (Figure 2.14 and 2.15). 70% of the population experienced an adverse effect of Post-Traumatic Stress Disorder (PTSD) from medium to sever (figure 2.16)

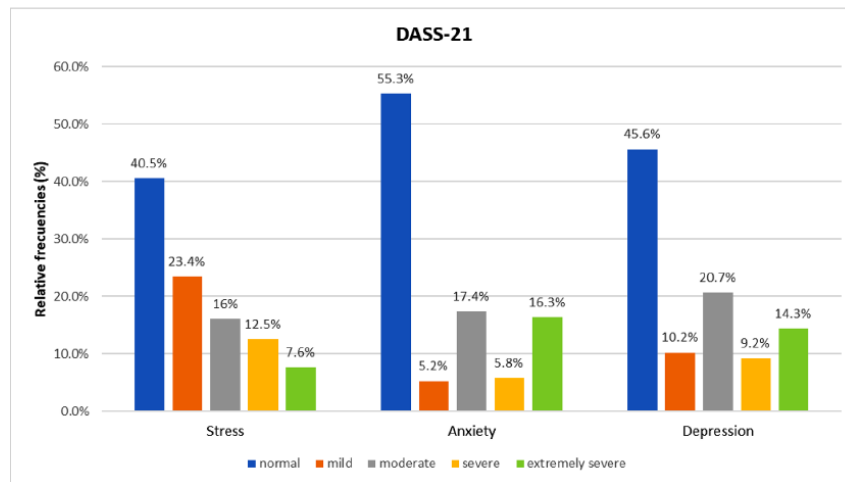


Figure 2.14: Relative frequencies of DASS-21 scales in the sample. (Passavanti, et al., 2020)

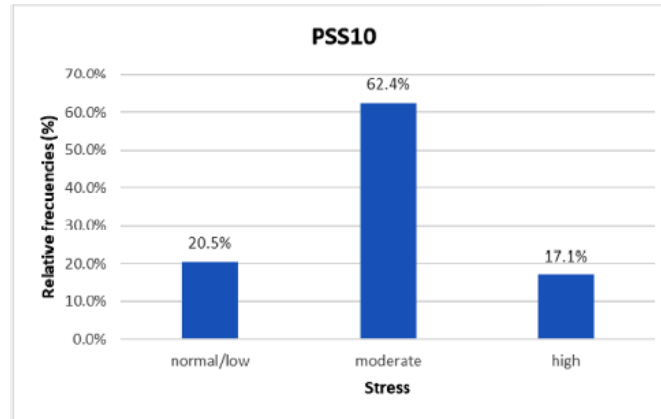


Figure 2.15: Relative frequencies of PSS10 scale in the sample. (Passavanti, et al., 2020)

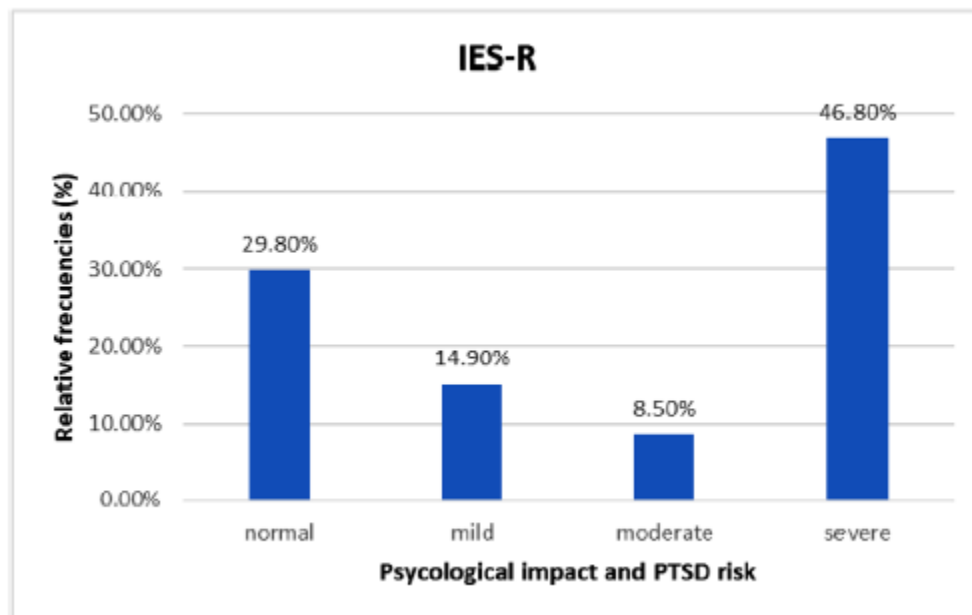


Figure 2.16: Relative frequencies of IES-R scale in the sample. (Passavanti, et al., 2020)

2.3.2 COVID-19 Effects on Road Safety

A study by (Ktrakazas, Michelaraki, Sekadakis, & Yannis, 2020) is aimed to assess the developed applications on driving behaviors namely in Greece and Kingdom of Saudi Arabia (KSA) as they are developing applications to contain the virus. It was indicated that 6-11% increase in speed occurred as a result of the lockdown during 2020 (especially March and April) while that led accordingly to an increase in the harsh breaking events of about 12%. Mobile phone usage increased by 42%. However, on the bright side,

accidents in Greece reduced 41% during the mentioned period (Katrakazas, Michelaraki, Sekadakis, & Yannis, 2020).

2.3.3 COVID-19 Effects on Education

This epidemic has had an impact on and will continue to have an impact on the delivery of knowledge and skills at all levels of education. While many children and adults will most likely adjust for the disruption in traditional educational offerings by adapting to new modalities, others may suffer. The growing gap for people whose families are unable to absorb the instruction and supervision of education required for in-home schooling, due to a lack of time and abilities, is not currently addressed. Those already at a disadvantage due to socioeconomic status, language, or special needs are disproportionately affected by the COVID-19 pandemic school closures and will have the most difficult time adjusting (Hoofman & Secord, 2021). (This study was done in 2021 and those findings may be varied at the current time)

Chapter 3: Methods and Procedure

3.0 Introduction

3.1 Research Approach

3.2 Data Collection

3.3 Brief Information regarding the data

3.4 Analysis Criteria

3.5 Data Analysis Method

3.6 Regression Model

3.7 Introduction to Z-test for Comparing two samples.

3.8 Introduction to Chi-Square Test

3.0 Introduction

Travel behavior data was collected for different countries of the world including Bahrain, Saudi Arabia, India, Pakistan and EU (mostly Belgium and Italy). Countries with the coordination of researchers from various countries. This available data was utilized for analysis of this research. The results of the analysis were used to identify changes in future travel demand and devising preparedness strategies for transport sector.

3.1 Research Approach

Available data for various countries was utilized in the purpose of getting different statistical parameters (Mean, Standard deviation, median, etc.) as well as conducting some statistical tests to observe the differences between the two situations (Before and During COVID-19). These parameters can be used to get a comprehensive conclusion on the effect of COVID -19 for the studied regions. As a result, Minitab Software was used to generate a regression model that gives a more detailed conclusion on effects of different aspects on the total number of trips.

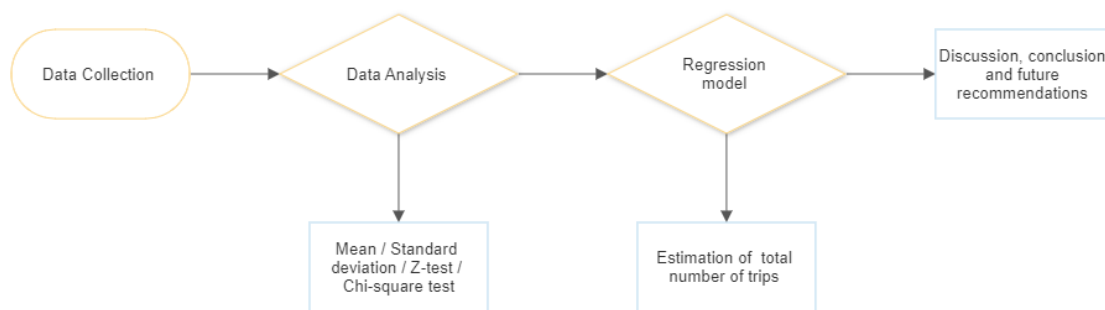


Figure 3.1 : Methodology Flow Chart

3.2 Data Collection

A team of researchers, organized by Hasselt University, was employed to collect data from the respective countries including Bahrain, Saudi Arabia, India, Pakistan and EU countries. Survey monkey was used for designing and distributing the survey. The survey link was distributed online using social media and research platforms. This effort was

carried out in 2021 and it took 3 months (January to March) to gather the data. All the gathered data is elaborated in Appendix A.

3.3 Brief Information Regarding the Data

- Questions are 57 questions ranging from Socio-Demographic aspects to Travel Activities including groceries, work/education, recreational, etc. (For more details refer to appendix A)

Table 3.1: Brief overview on the data collected

Regions				
-	Bahrain	Europe	Pakistan	India
Sample size	183	93	315	499
Total	1,090			

3.4 Analysis Criteria

Not all questions are selected in the analysis. This is due that some questions do not have enough responses which accordingly would have significant effect on the accuracy of the analysis. Following criteria is used conducting the analysis:

- * Questions with less than 30 responses are excluded (Johnson, Miller, & Freund, 2019).
- * Comparison is done using before – after situations (For questions with adequate responses).
- * Regression model is built to construct a model on future circumstances.

3.5 Data Analysis Methods

Data was analyzed in different aspects using descriptive statistics. Following statistical terminologies are going to be used in this regard:

- Mean: The sum of a set of numbers divided by the number of numbers in the set (Jacobs, 1982).

$$\text{mean} = \left(\frac{1}{n}\right) * \sum_{i=1}^n a_i \frac{a_1+a_2+\dots+a_n}{n} \quad 3.1$$

- Standard Deviation: A set of numbers' standard deviation is a measure of their variation or dispersion. A low standard deviation indicates that the set's values are close to the mean (also known as the anticipated value), whereas a large standard deviation indicates that the values are spread out throughout a wider range (Bland & Altman, 1996).

$$\sigma = \sqrt{\sum \frac{(x_i - \mu)^2}{N}} \quad 3.2$$

x_i = each value from the population

μ = the population mean

N = the size of the population

σ = population standard deviation

- Median: The median is the value that separates the upper and lower halves of a data sample, population, or probability distribution in statistics and probability theory. It is sometimes referred to as “the middle” value in a data collection. The main difference between the median and the mean in summarizing data is that the median is not deviated by a tiny fraction of exceptionally large or small values, and so offers a better reflection of a “typical” value (Loveday, 2016).

Median can be calculated as below:

$$\left[\begin{array}{l} x \left(\frac{n}{2} \right), \text{ if } n \text{ is even} \\ \frac{x \left(\frac{n-1}{2} \right) + x \left(\frac{n+1}{2} \right)}{2}, \text{ if } n \text{ is odd} \end{array} \right] \quad 3.3$$

x = ordered list of values (ascending or descending order)

n = number of values in data set

- Standard error: The standard error (SE) of a statistic (usually a parameter estimate) is the sample distribution's standard deviation or an approximation of that standard deviation (Altman & Bland, 2005).

$$SE = \frac{\sigma}{\sqrt{n}} \quad 3.4$$

σ = population standard deviation

n = number of values in data set

- Sample Variance: The sample variance, s^2 , is used to calculate the variability of a sample. A sample is a small set of elements chosen from a larger population (Loveday, 2016).

$$s^2 = \frac{\sum(x_i - \bar{x})^2}{n-1} \quad 3.5$$

s^2 = sample variance

x_i = the value of the one observation

$\bar{x}$ = the mean value of all observations

n = number of values in data set

3.6 Regression Model:

Multiple regression is a statistical model that allows to explore the relationship between a dependent variable and multiple independent variables. It is commonly used in social sciences, business, and economics to analyze the impact of various factors on a particular outcome. The model seeks to estimate the strength and direction of the relationship between the dependent variable and each independent variable, while controlling for the effects of other independent variables. The resulting equation can be used to predict the value of the dependent variable based on the values of the independent variables (Cohen, J, Cohen, P, West, S. G, & Aiken, L. S, 2003).

3.6.1 R Squared

R-squared, also known as the coefficient of determination, is a statistical measure that represents the proportion of the variance in the dependent variable that is explained by the independent variables in a multiple regression model. It is a measure of how well the model fits the data.

The equation for R-squared in a multiple regression model is:

$$R\text{-squared} = 1 - (SS_{\text{res}} / SS_{\text{tot}}) \quad 3.6$$

Where SS_{res} is the sum of squares of the residuals (the differences between the observed values and the predicted values), and SS_{tot} is the total sum of squares (the differences between the observed values and the mean of the dependent variable).

In other words, R-squared measures the proportion of the total variation in the dependent variable that is explained by the independent variables in the model. A value of 1 indicates that all of the variation in the dependent variable is explained by the independent variables, while a value of 0 indicates that none of the variation is explained by the model. Typically, higher values of R-squared indicate a better fit of the model to the data. However, it is important to note that R-squared should not be used as the sole criterion for evaluating the goodness of fit of a model, as it has its limitations (Cohen, J, Cohen, P, West, S. G, & Aiken, L. S, 2003).

3.6.2 Mallow Cp

Mallow's C_p is a statistical measure used to evaluate the quality of fit of a multiple regression model. It is similar to adjusted R-squared, but takes into account the number of predictors in the model. Mallow's C_p compares the mean squared error of the model to the mean squared error of a model with only the intercept term.

The equation for Mallow's C_p is:

$$C_p = (SS(E_p) / MSE) - (n - 2p) \quad 3.7$$

where SSE_p is the sum of squared errors for the model with p predictors, MSE is the mean squared error of the full model, n is the total number of observations, and p is the number of predictors in the model.

In general, smaller values of Mallow's C_p indicate a better fit of the model. A value of C_p close to p indicates that the model is a good fit, while values greater than p suggest that the model may be overfitting the data. It is important to note that Mallow's C_p is only one of several measures that can be used to evaluate the quality of a multiple regression model, and should be used in conjunction with other measures such as adjusted R-squared and residual plots (Hair, J. F, Black, W. C., Babin, B. J, & Anderson, R. E., 2010).

3.6.3 F-Value

The F value in multiple regression is a statistical test that assesses the overall significance of the regression model. It is a ratio of the variance explained by the regression model to the residual variance, and it is used to determine whether the regression model provides a better fit to the data than a null model with no predictor variables.

The F value is calculated as:

$$F = (SSR / p) / (SSE / (n - p - 1)) \quad 3.8$$

where SSR is the sum of squares due to regression, SSE is the sum of squares due to error, p is the number of predictor variables in the model, and n is the sample size.

SSR represents the amount of variation in the dependent variable that is explained by the regression model, while SSE represents the amount of variation that is not explained by the model. The degrees of freedom for SSR are equal to the number of predictor variables in the model, while the degrees of freedom for SSE are equal to the sample size minus the number of predictor variables minus one.

The F value is compared to the F distribution with p degrees of freedom for the numerator and n - p - 1 degrees of freedom for the denominator. If the F value is greater than the critical value from the F distribution at the desired level of significance (typically 0.05), then the regression model is considered to be statistically significant and provides a better fit to the data than a null model with no predictor variables.

In summary, the F value in multiple regression is a statistical test that assesses the overall significance of the regression model, and it is calculated using the equation $F = (SSR / p) / (SSE / (n - p - 1))$ (Fox, 2016).

3.6.4 R Squared Adjusted and Predicted

R-squared adjusted is a modified version of R-squared that takes into account the number of predictor variables in a multiple regression model. It is calculated using the following equation:

$$R\text{-squared adjusted} = 1 - [(1 - R\text{-squared}) * (n - 1) / (n - k - 1)] \quad 3.9$$

where R-squared is the regular coefficient of determination, n is the sample size, and k is the number of predictor variables in the model. R-squared adjusted penalizes the model

for including additional predictor variables that do not significantly contribute to explaining the variation in the dependent variable.

Predicted values in a multiple regression model are the values of the dependent variable that are estimated by the model for a given set of values of the predictor variables. The equation for predicting Y based on a set of predictor variables $X_1, X_2, \dots, X_k$ is:

$$Y_{\text{predicted}} = b_0 + b_1X_1 + b_2X_2 + \dots + b_kX_k \quad \mathbf{3.10}$$

where $Y_{\text{predicted}}$ is the predicted value of the dependent variable, b_0 is the intercept, and $b_1, b_2, \dots, b_k$ are the regression coefficients for the predictor variables.

In summary, R-squared adjusted is a modified version of R-squared that adjusts for the number of predictor variables in a multiple regression model, and predicted values in a multiple regression model are the values of the dependent variable that are estimated by the model for a given set of values of the predictor variables (Kutner, et al.).

3.7 Introduction to Z-test for Comparing two samples

Z- test is mainly used to compare two samples in order to decide whether to accept the difference in mean between the two targeted groups. α of 0.05 is assumed throughout the analysis (which means if the probability is less than 5%, the hypothesis is rejected) (Johnson, Miller, & Freund, 2019).

The null hypothesis: $H_0: \mu_1 - \mu_2 = \delta_0$ (constant)

δ_0 is assumed to be zero and accordingly the null hypothesis is $H_0: \mu_1 = \mu_2$

The alternative hypothesis $H_1: \mu_1 \neq \mu_2$.

3.7.1 Z-test procedure

1- Assumption of the null and alternative hypothesis (as explained above)

2- finding z_{critical} from the z-table (table 3.2 and 3.3) by taking $\alpha/2$. Given α 0.05.

3- finding z_{stat} as per below equation (Johnson, Miller, & Freund, 2019):

$$z = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad \mathbf{3.1}$$

4- specifying the rejection region as illustrated in the figure below:

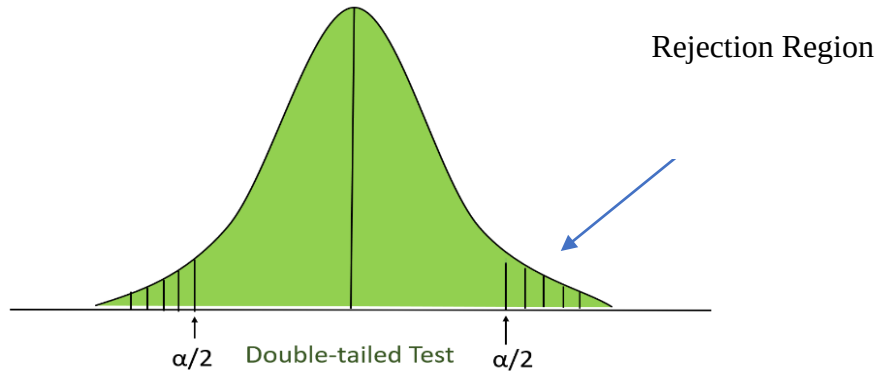


Figure 3.2: Double-tailed Z-Test

5- if z_{stat} does not fall within the rejection region, hypothesis is accepted. On the other hand, if it does fall within the rejection region, then the hypothesis is rejected. (As shown in figure 3.2 above).

3.8 Introduction to Chi-Square Test

Chi-square test is used to observe the difference to the expected value (Named as frequency) (Moore & Notz, 2021).

3.8.1 Chi-Square Test Procedure

- 1- Null hypothesis H_0 equal frequencies, H_1 unequal frequencies.
- 2- Degree of freedom (df) = $n-1$.
- 3- From chi-square table (table 3.4), critical value can be obtained.
- 4- Calculated Chi-square value as per below equation (Moore & Notz, 2021).

$$\chi^2 = \sum \frac{(\text{observed value} - \text{Expected value})^2}{\text{Expected Value}} \quad 3.2$$



Two-tailed Chi-Square test (5% significance)

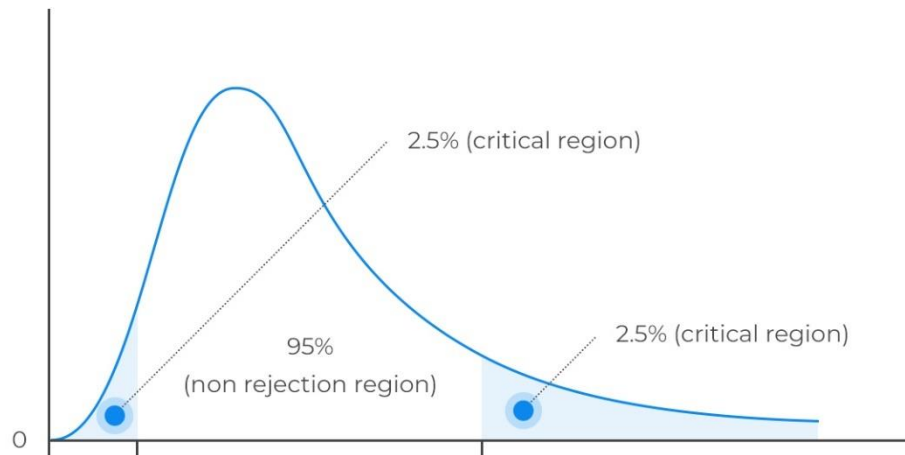


Figure 3.3: Two Tailed Chi Square Test (Forjan, 2019)

- 5- If X_c^2 falls within the rejection region, then the hypothesis is rejected or else it would be accepted (as shown in figure 3.3).

Table 3.2: Positive Z-table

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
+0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
+0.1	.53983	.54380	.54776	.55172	.55567	.55966	.56360	.56749	.57142	.57535
+0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
+0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
+0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
+0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
+0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
+0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
+0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
+0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
+1	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
+1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
+1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
+1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91308	.91466	.91621	.91774
+1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
+1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
+1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
+1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
+1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
+1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
+2	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
+2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
+2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
+2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
+2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
+2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
+2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
+2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
+2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
+2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
+3	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
+3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
+3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
+3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
+3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
+3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
+3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
+3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
+3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
+3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997
+4	.99997	.99997	.99997	.99997	.99997	.99997	.99998	.99998	.99998	.99998

Table 3.3: Negative Z-table

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
-0	.50000	.49601	.49202	.48803	.48405	.48006	.47608	.47210	.46812	.46414
-0.1	.46017	.45620	.45224	.44828	.44433	.44034	.43640	.43251	.42858	.42465
-0.2	.42074	.41683	.41294	.40905	.40517	.40129	.39743	.39358	.38974	.38591
-0.3	.38209	.37828	.37448	.37070	.36693	.36317	.35942	.35569	.35197	.34827
-0.4	.34458	.34090	.33724	.33360	.32997	.32636	.32276	.31918	.31561	.31207
-0.5	.30854	.30503	.30153	.29806	.29460	.29116	.28774	.28434	.28096	.27760
-0.6	.27425	.27093	.26763	.26435	.26109	.25785	.25463	.25143	.24825	.24510
-0.7	.24196	.23885	.23576	.23270	.22965	.22663	.22363	.22065	.21770	.21476
-0.8	.21186	.20897	.20611	.20327	.20045	.19766	.19489	.19215	.18943	.18673
-0.9	.18406	.18141	.17879	.17619	.17361	.17106	.16853	.16602	.16354	.16109
-1	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786
-1.1	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
-1.2	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08692	.08534	.08379	.08226
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-2	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.3	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-3	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-4	.00003	.00003	.00003	.00003	.00003	.00003	.00002	.00002	.00002	.00002

Table 3.4: Chi-Square Distribution Table

Percentage Points of the Chi-Square Distribution									
Degrees of Freedom	Probability of a larger value of χ^2								
	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	0.554	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09
6	0.872	1.635	2.204	3.455	5.348	7.84	10.64	12.59	16.81
7	1.239	2.167	2.833	4.255	6.346	9.04	12.02	14.07	18.48
8	1.647	2.733	3.490	5.071	7.344	10.22	13.36	15.51	20.09
9	2.088	3.325	4.168	5.899	8.343	11.39	14.68	16.92	21.67
10	2.558	3.940	4.865	6.737	9.342	12.55	15.99	18.31	23.21
11	3.053	4.575	5.578	7.584	10.341	13.70	17.28	19.68	24.72
12	3.571	5.226	6.304	8.438	11.340	14.85	18.55	21.03	26.22
13	4.107	5.892	7.042	9.299	12.340	15.98	19.81	22.36	27.69
14	4.660	6.571	7.790	10.165	13.339	17.12	21.06	23.68	29.14
15	5.229	7.261	8.547	11.037	14.339	18.25	22.31	25.00	30.58
16	5.812	7.962	9.312	11.912	15.338	19.37	23.54	26.30	32.00
17	6.408	8.672	10.085	12.792	16.338	20.49	24.77	27.59	33.41
18	7.015	9.390	10.865	13.675	17.338	21.60	25.99	28.87	34.80
19	7.633	10.117	11.651	14.562	18.338	22.72	27.20	30.14	36.19
20	8.260	10.851	12.443	15.452	19.337	23.83	28.41	31.41	37.57
22	9.542	12.338	14.041	17.240	21.337	26.04	30.81	33.92	40.29
24	10.856	13.848	15.659	19.037	23.337	28.24	33.20	36.42	42.98
26	12.198	15.379	17.292	20.843	25.336	30.43	35.56	38.89	45.64
28	13.565	16.928	18.939	22.657	27.336	32.62	37.92	41.34	48.28
30	14.953	18.493	20.599	24.478	29.336	34.80	40.26	43.77	50.89
40	22.164	26.509	29.051	33.660	39.335	45.62	51.80	55.76	63.69
50	27.707	34.764	37.689	42.942	49.335	56.33	63.17	67.50	76.15
60	37.485	43.188	46.459	52.294	59.335	66.98	74.40	79.08	88.38

Chapter 4 (Analysis and Results)

4.1 Introduction

4.2 Statistical Analysis

4.2.1 Total Responses Analysis

4.2.2 Comparison between Regions

4.2.3 Before COVID-19 and During COVID-19 Analysis

4.2.3.1 Bahrain

4.2.3.2 Europe

4.2.3.3 India

4.2.3.4 Pakistan

4.1 Introduction

This chapter mainly elaborates more on the data collected. Statistical results are illustrated, and fair comparison is made between the targeted regions in terms of activities, transportation and some basic questions (age, language, etc.). In the same context, regression model is created for future reference on similar situations.

4.2 Statistical Analysis

Recalling the conditions of selection as stated in chapter 3, questions must at least 30 responses or else the whole question is deemed inaccurate and excluded. This is basically aiming to reflect accurate statistical analysis and do not show any bias in data. Some questions are excluded from the analysis due to low number of responses (less than 30) as this is a stipulated criteria when it comes to statistical analysis / discussions (as explained in chapter 3). Questions which are excluded Q10, Q23-26, Q64-66, Q68-82, Q87.

4.2.1 Total Responses Overview

The analysis of total responses in the document shows that questions 1 to 23 have the highest number of responses, indicating their suitability for statistical analysis. The response rate remains consistently high for most questions, with over 500 responses. However, questions 24 to 26 show a reduction in responses below 250. Similarly, questions 45 to 67 have a lower response rate, affecting the statistical accuracy, except for questions 51-53, 60, and 67. Questions 68 to 82 have a significant decrease in responses, indicating lower accuracy, while questions 83 to 87 show a higher response rate with a substantial reduction in question 87.

4.2.2 Comparison between Regions

4.2.2.1 Section I: Questions About Socio-Demographic Aspects

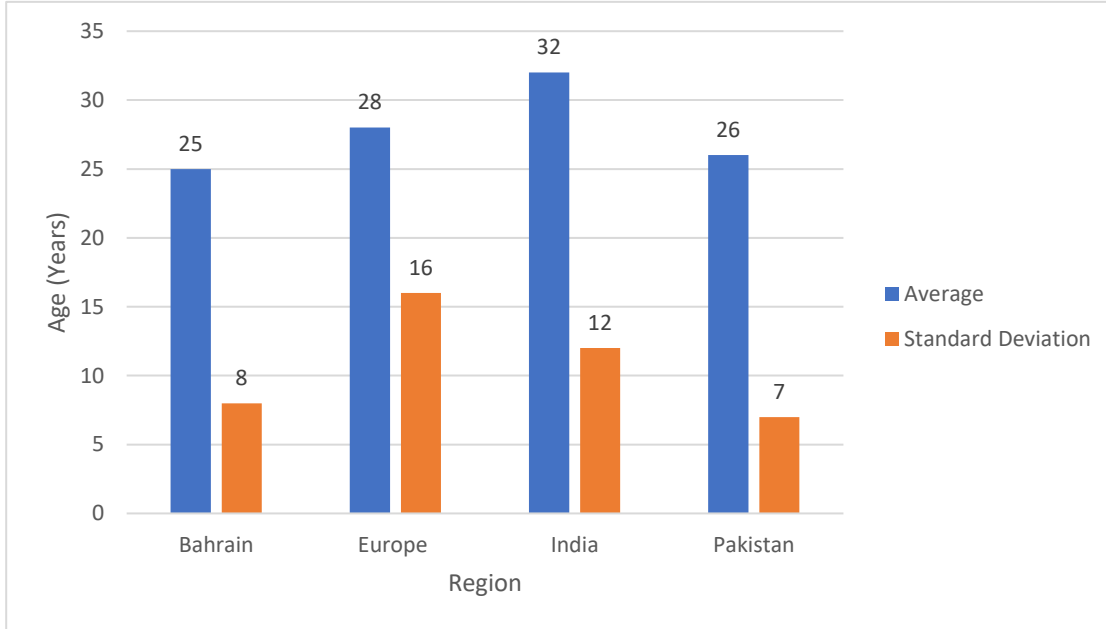


Figure 4.1: Age

As Shown in figure 4.1, average between each country is very close to each other with a standard deviation (difference to the mean) ranging from 7-16. Average in India is the maximum comparing with other targeted regions (32) while Bahrain illustrates the Lowest average of 25 years.

Table 4.1: Gender

Region	Male / Female (%)
Bahrain	47 / 53
Europe	54 / 46
India	52 / 48
Pakistan	80 / 20

As shown in table 4.1 above, all the countries show almost equally distributed data for gender. However, Pakistan includes a data of 80% Male and only 20% Female.

Table 4.2: List of Countries (Rough Comparison)

Region	From the studied region / other regions (%)
Bahrain	88 / 12
Europe	97 / 3
India	96 / 4
Pakistan	96 / 4

As it is very obvious from table 4.2 above, all the countries show greater percentage on their own Countries. Europe shows 97% of the responses under the region of Europe (the maximum) while Bahrain shows 88% of the responses are living in Bahrain (the minimum).

Table 4.3: Nationality (Rough Comparison)

Region	Region Nationality / other nationalities (%)
Bahrain	70 / 30
Europe	57 / 43
India	98.5 / 1.5
Pakistan	98 / 2

As demonstrated in table 4.3 above, each region illustrates greater percentage of responses under its own nationality except for Europe which shows approximately equally distributed data.

Table 4.4: Occupation Status before COVID-19

Region	Major occupation of the studied region
Bahrain	Student (63%)
Europe	Employed for wages (46%)
India	Employed for wages (52%)
Pakistan	Student (43%)

Table 4.4 above shows that each region has different results. Majority of the data for Bahrain, and Pakistan are Student, 63% and 43% respectively. Majority of the data for Europe and India are Employed for Wages, which are 46% and 52% respectively.

Table 4.5: Highest Degree of Education

Region	Major percentage (before COVID-19)	Major percentage (during COVID-19)
Bahrain	Student (63%)	Student (63%)
Europe	Employed for wages (46%)	Employed for wages (46%)
India	Employed for wages (52%)	Employed for wages (52%)
Pakistan	Student (43%)	Student (43%)

Table 4.5 above indicates Answers show differences when compared to situation before COVID (Q6).

Bahrain: Before COVID the majority was attending physically high school while during the questionnaire period people shifted to online education.

Europe: Most of the respondents were studying master's degree while during the questionnaire period most of them were working from home (41%)

India: Most respondents showed no change to the previous situation – 31%

Pakistan: Most respondents shifted to online education (29%) while previously most of them were attending physically (44%).

Table 4.6: Household gross income

Region	Overall Average. Bahrain (Bahraini Dinar), Europe (Euros), India / Pakistan (Rupees)	Overall Standard Deviation
Bahrain	BHD 1,020 (Equivalent to USD 2,706)	811 (USD 2,152)
Europe	EUR 3,062.50 (Equivalent to USD 3,364)	2673 (USD 2,936)
India	Indian Rupee 57,762 (Equivalent to USD 694)	34324 (USD 412)
Pakistan	Pakistan Rupee 113,431 (Equivalent to USD 1,363)	81651 (USD 981)

As clearly explained in table 4.6 above, the highest household average income among all the responses was in Europe (USD 3,364) while the lowest was in India (USD 694) comparing to the other targeted regions.

Table 4.7: family setup

Region	Major percentage
Bahrain	Couple with children (37%)
Europe	Single adult without children (32%)
India	Couple with children (38%)
Pakistan	Joint Family (44%)

As clearly shown in table 4.7 above, Majority of results in Bahrain, Europe, India and Pakistan are Couple with Children (37%), Single Adult without children (32%), Couple with Children (38%) and Joint Family (44%) respectively.

4.2.2.1.1 Demographic Characteristics of Respondents

The data presented above indicates a notable disparity in household income among the respondents in Bahrain, Europe, Pakistan, and India. It is evident that a significant majority of respondents in Bahrain and Europe have household incomes surpassing the overall average. Conversely, a substantial proportion of respondents in Pakistan and India fall within or below the overall average, which stands at USD 1,388 in Pakistan and USD 707 in India. Furthermore, the educational background of the respondents varies across regions. The majority of respondents in Europe and India possess collegiate or academic qualifications, while in Bahrain and Pakistan, a significant portion have completed high school education. However, it is noteworthy that educational attainment, as a percentage of the total respondents, does not exhibit a bias towards any particular group, with each category representing 50% or less of the total for each region. Most of respondents are local citizens except for Europe (50% / 50%) and almost equally distributed when it comes to gender. As per figure 4.1, respondents are youths (maximum average is 32 years old in India).

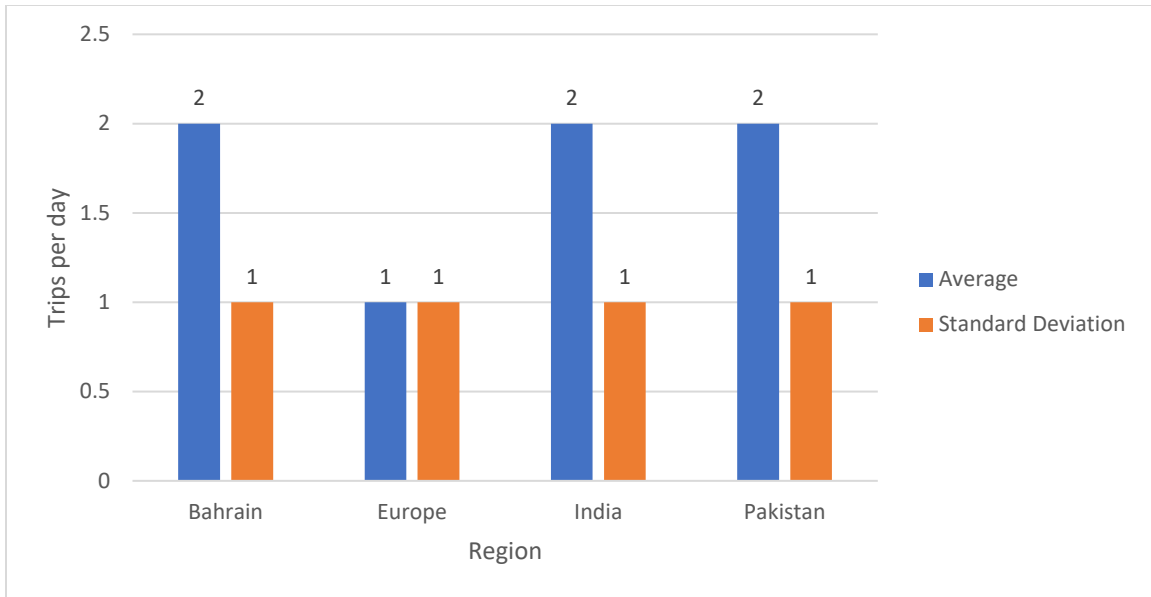


Figure 4.2: Number of cars/motorbikes in house

As indicated in figure 4.2 above, countries show close results as all the regions show an average of 2 cars/ motorbikes in each house except for Europe which shows only 1 car/motor bike in each house. All the regions show a standard deviation of 1.

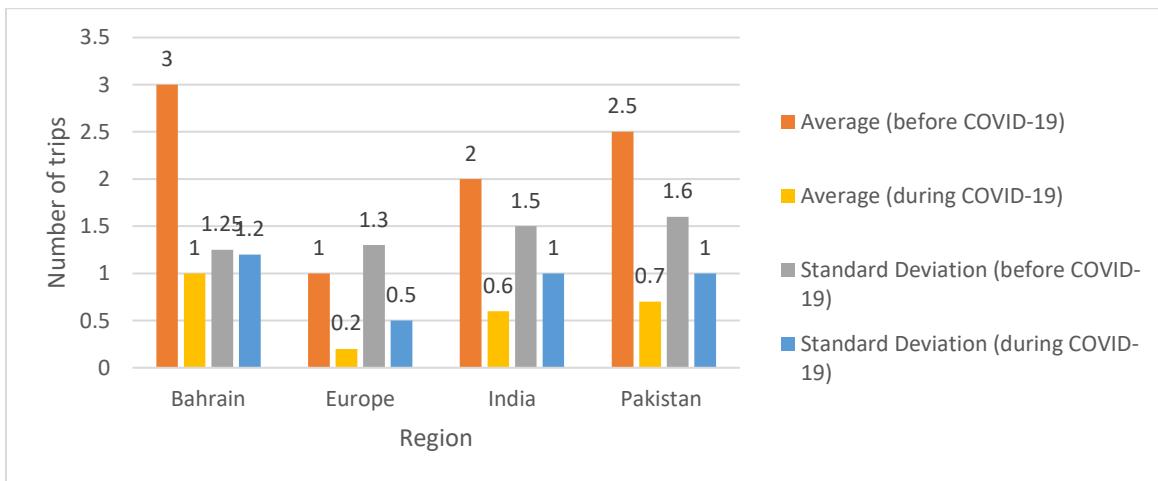


Figure 4.3: trips performed via car/car-pooling/motorcycle/taxi/uber on an average per day.

According to figure 4.3, the number of trips has reduced more than 50% of the average number before COVID-19. This indicates that people were cautious not to be infected and were insisting heavily to reduce their trips to the minimum.

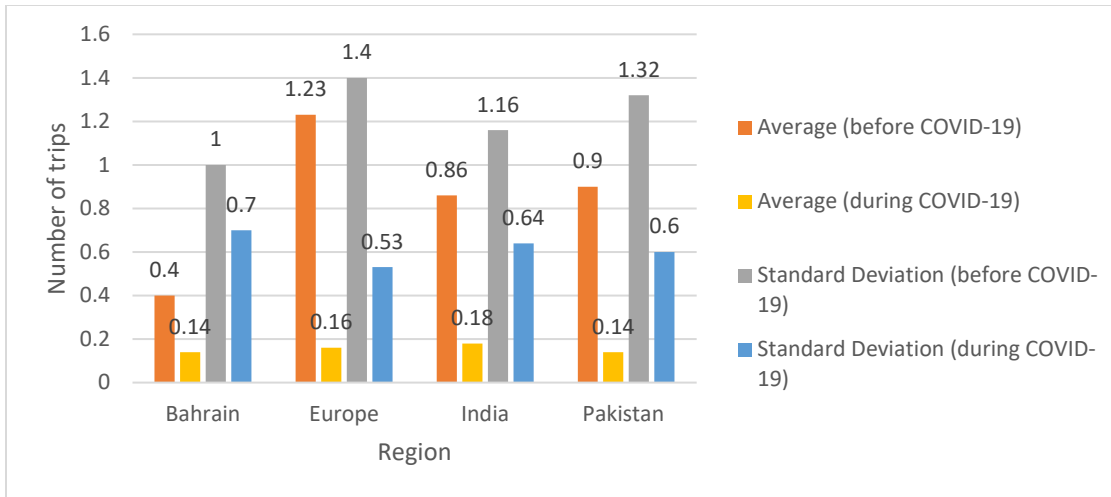


Figure 4.4: trips performed via bus/train/metro on an average per day - Overall Comparison

Referring to figure 4.4, people reduced their trips to almost 0 during the outbreak as they were avoiding contact with the public and assembly areas. Public Transport in Bahrain is managed by Bahrain Public Transport Company (BPTC) (appointed by Ministry of Transportation and Communication). The Corporation has invested a significant amount in the new network, mostly as a result of a three-pronged strategy focused on safety, connectivity, and technology. To ensure that the new public transportation model offers the highest in safety and customer service standards, BPTC has used a combination of internationally renowned safety programs, intensive driver up-skilling schemes, and a fleet of technologically advanced vehicles. This has increased reach, connectivity, accessibility, and delivered an improved travel experience (BPTC, n.d.). according to recent statistics by ministry of transportation, average monthly ridership is around 30,384 for buses (Telecommunication, 2023).

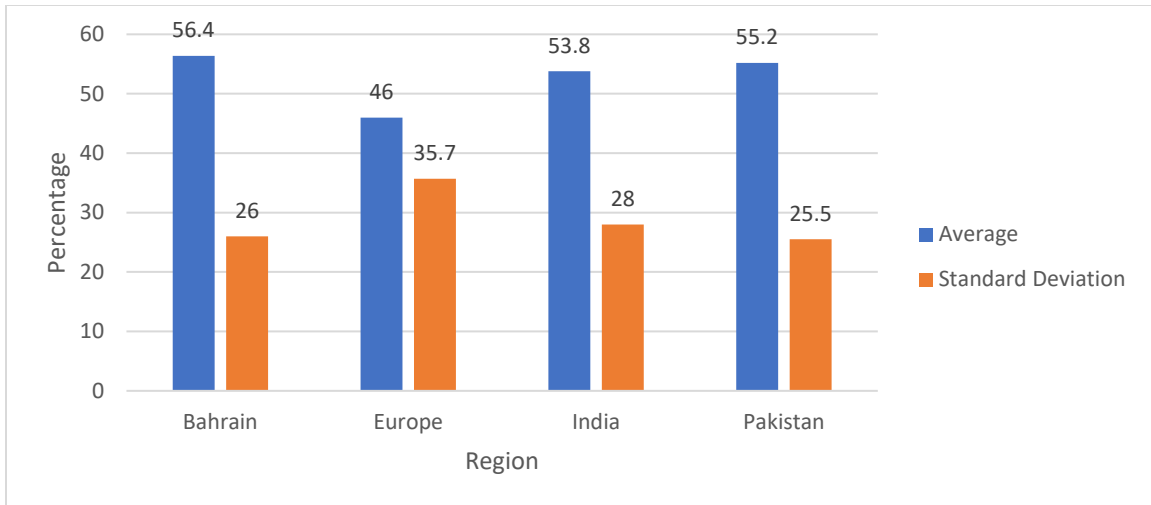


Figure 4.5: Fuel Consumption Saving During the Pandemic when compared to normal situation- Overall Comparison

Figure 4.5 shows the targeted regions experienced almost 50% reduction in average with a standard deviation ranging from 25.5% to 35.7%. huge reduction in fuel consumption of around 50% gives a clear indication of reduced number of trips during the pandemic due to taking the required protective measures and precautionary actions during the outbreak.

4.2.2.2 Section II: Questions about respondents' household activity travel routine

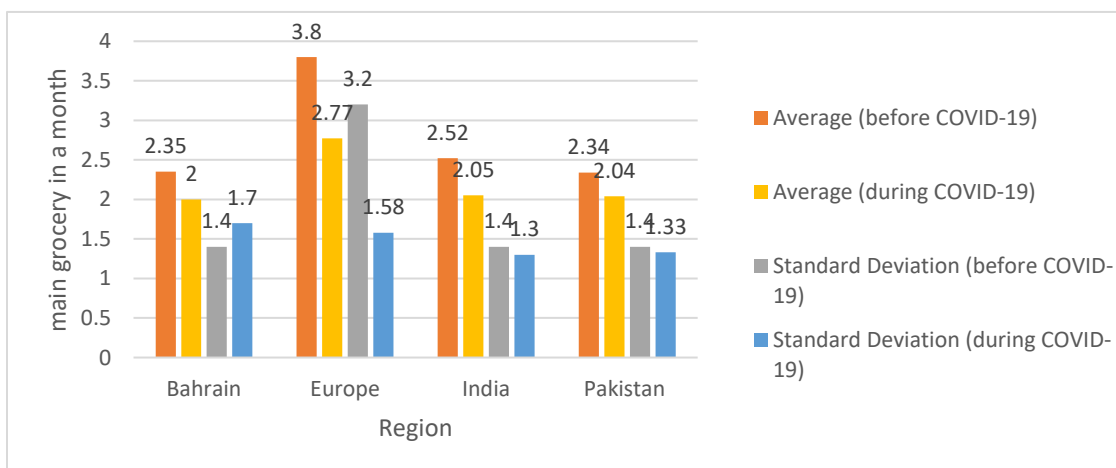


Figure 4.6: Grocery in a month - main grocery

As per figure 4.6, no noticeable difference is spotted as groceries are considered as necessities. People tended to perform main grocery with slight reduction due to the restrictions and outbreak situations. However, the difference is negligible.

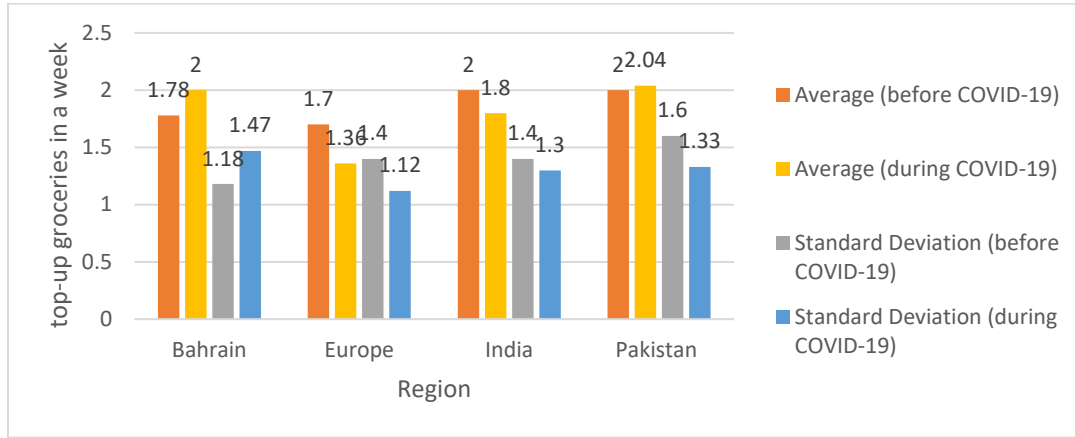


Figure 4.7: Grocery in a week - top-up grocery

Figure 4.7 illustrates that there is an absence of significant variation when it comes to top-up groceries, which are considered essential items. People generally continued to engage in their top-up grocery shopping activities, albeit with a slight decrease in response to the imposed restrictions and the prevailing outbreak circumstances. Nonetheless, the observed difference is minimal and has minimal impact.

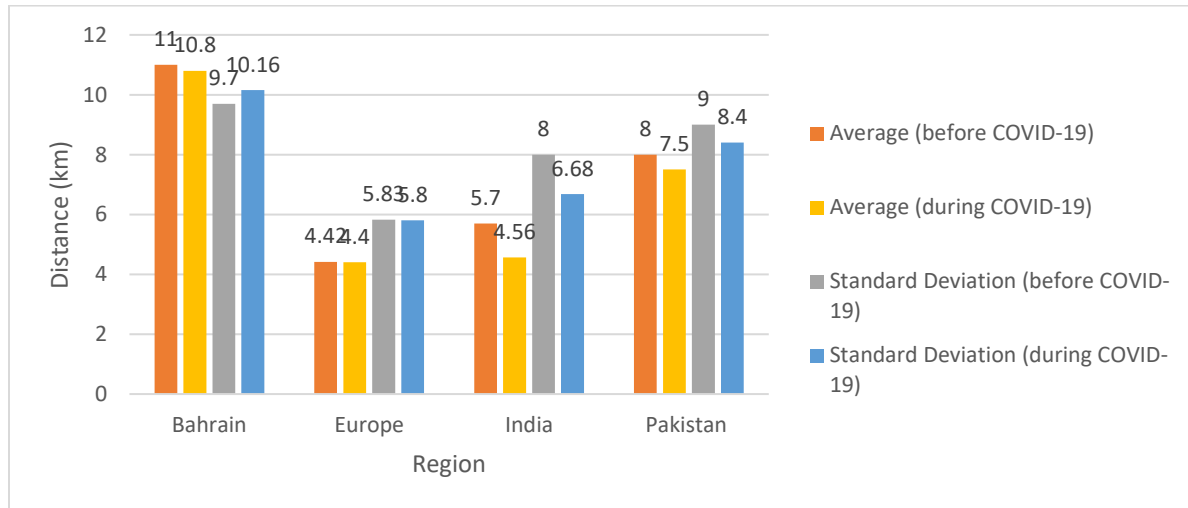


Figure 4.8: Approximate distance from home to shopping location in kilometers – before and during COVID-19 - main grocery.

Referring to figure 4.8, approximate distance from home to shopping locations are approximately the same before and during COVID-19 which indicates that respondents did not tend to relocate during the pandemic.

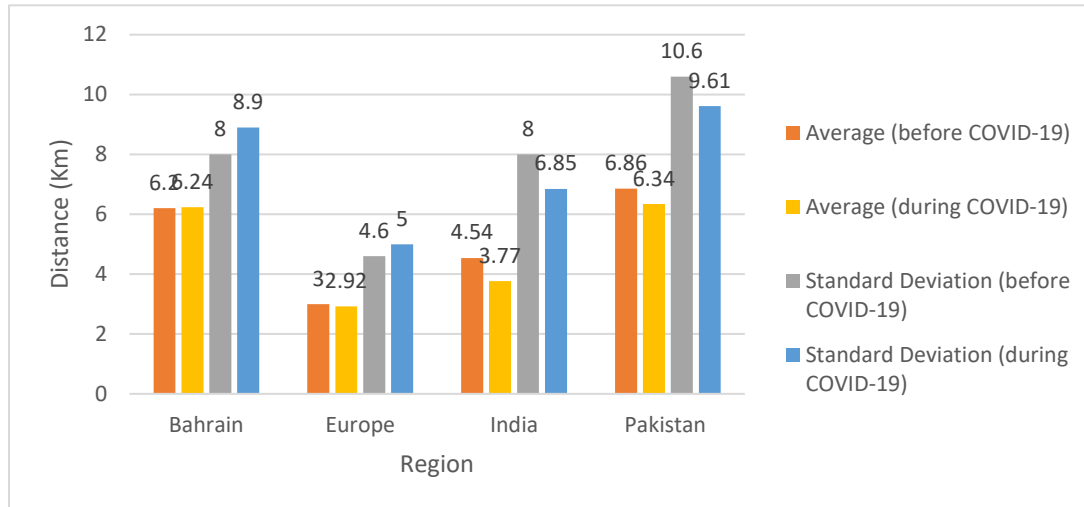


Figure 4.9: Approximate distance from home to shopping location in kilometers – before and during COVID-19 - top-up grocery.

Referring to figures 4.9, approximate distance from home to shopping locations are approximately the same before and during COVID-19 which indicates that respondents did not tend to relocate during the pandemic.

Table 4.8: Travel mode for shopping activities. - Before COVID-19 - Main Grocery

Region	Major percentage
Bahrain	Car (88%)
Europe	Walking / Cycling (51%)
India	Walking / Cycling (26.83%)
Pakistan	Car (47%)

Table 4.8 illustrates that majority of respondents in Bahrain were using car before COVID-19 (88%). Walking/Cycling in Europe and India of 51% and 26.83% respectively. 47% of respondents were using car in Pakistan. Although, a percentage below 50% does not show a dominance, but this is the highest proportion for a single mode among the respondents from Pakistan.

Table 4.9: Travel mode for shopping activities. - During COVID-19 - Main Grocery

Region	Major percentage
Bahrain	Car (86%)
Europe	Walking/cycling (50%)
India	Two-wheeler (40.84%)
Pakistan	Car (47%)

As illustrated in table 4.9 above, majority of respondents in Bahrain were using car during COVID-19 (86%). Walking/Cycling in Europe (50%) and Two-wheeler in India (40.84%). 47% of respondents were using car in Pakistan.

Table 4.10: Travel mode (shopping activities). Before COVID-19 (Top-Up Grocery)

Region	Major percentage
Bahrain	Car (76%)
Europe	Walking / Cycling (74%)
India	Walking / Cycling (41.16%)
Pakistan	Car (36%)

Table 4.10 illustrates that majority of respondents in Bahrain were using car before COVID-19 (76%). Walking/Cycling in Europe and India of 74% and 41.16% respectively. 36% of respondents were using car in Pakistan.

Table 4.11: Predominant Travel mode for shopping activities. - Top-up Grocery

Region	Major percentage
Bahrain	Car (74%)
Europe	Walking/cycling (71%)
India	Walking/cycling (45.36%)
Pakistan	Car (32%)

As shown in table 4.11 above, majority of respondents in Bahrain were using car during COVID-19 (74%). Walking/Cycling in Europe and India of 71% and 45.36% respectively. 32% of respondents were using car in Pakistan.

Comparison between before and during COVID-19:

Table 4.8, 4.9, 4.10 and 4.11 simply elaborate on the usage of the travel mode that is most utilized in each country. We can simply notice and regardless of the number of trips, that the preferred travel mode approximately remained the same before and during COVID-19 which indicates that the outbreak did not affect people's choice in this regard. Coming Questions show the preferred companion (Alone, with family, with friends) in performing main grocery and top-up grocery:

- 1 (preferred)
- 2 (moderate)
- 3 (not preferred)

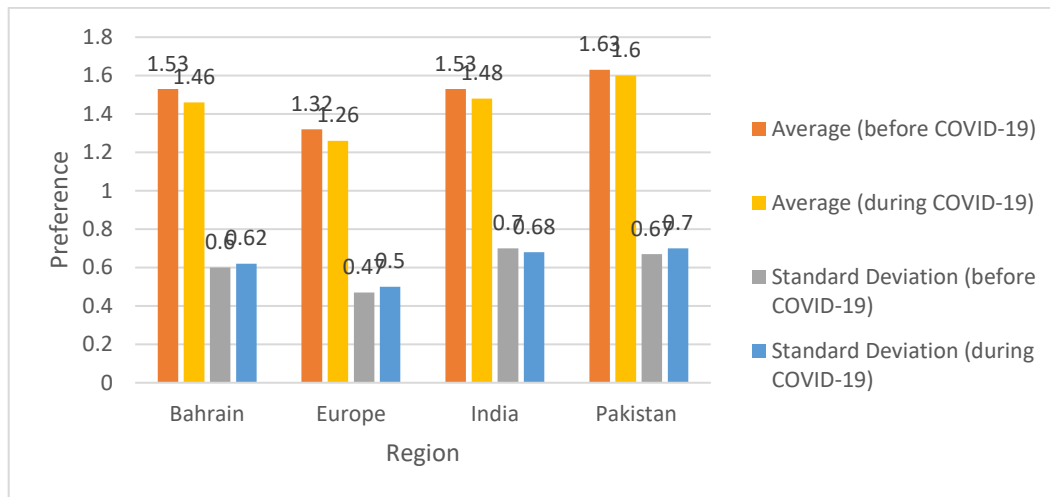


Figure 4.10: performed trips for main grocery –Rank from 1 to 3. - Alone - Overall Comparison

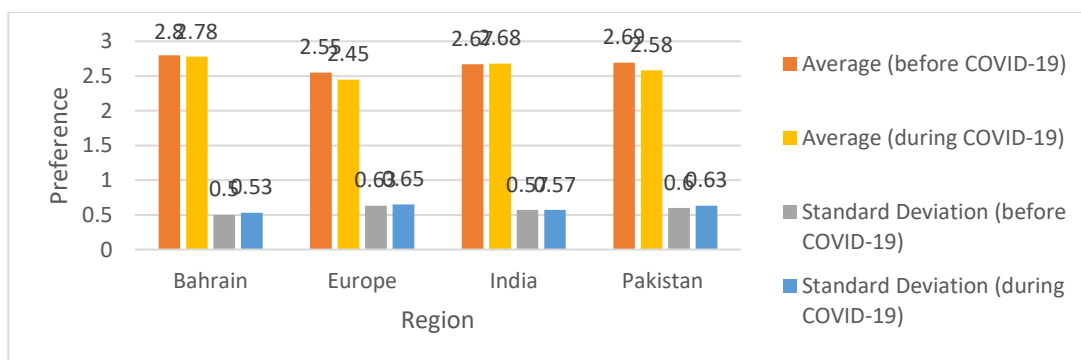


Figure 4.11: performed trips for main grocery – Rank from 1 to 3. - With family - Overall Comparison

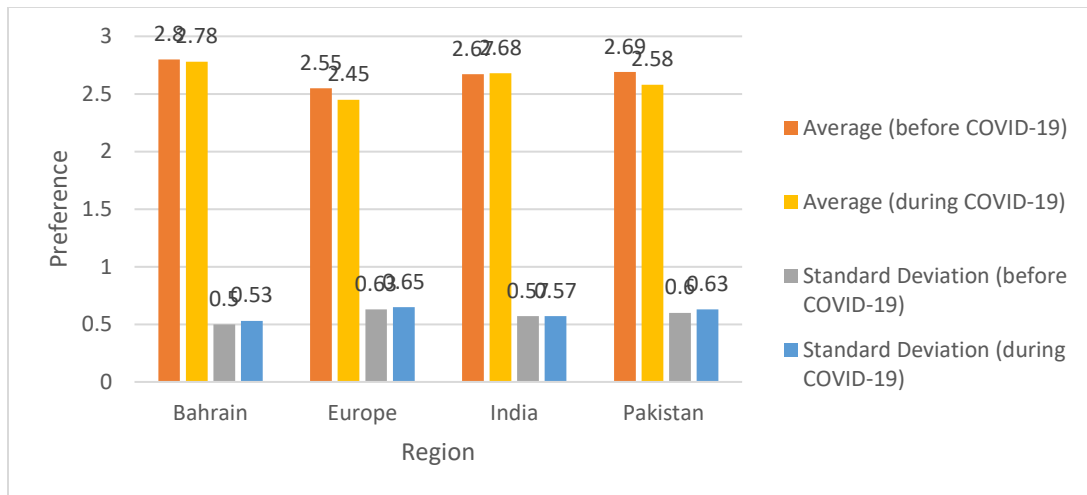


Figure 4.12: performed trips for main grocery – Rank from 1 to 3. - With friends - Overall Comparison

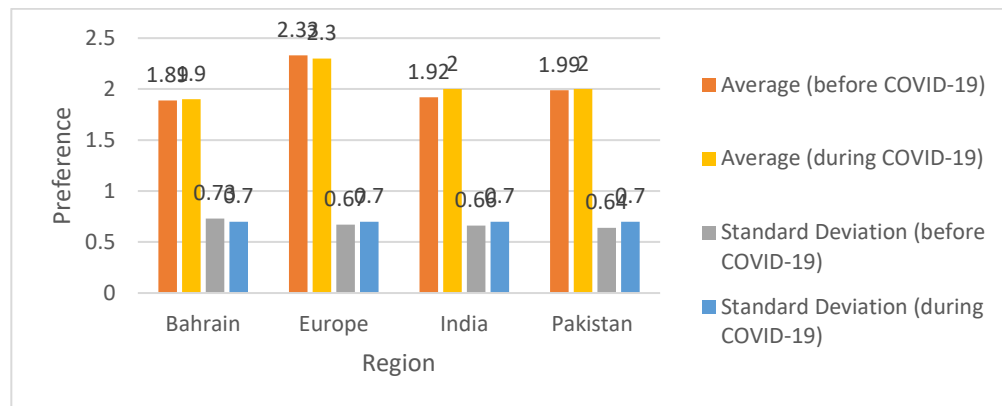


Figure 4.13: performed trips for top-up grocery - Rank from 1 to 3 - with family.

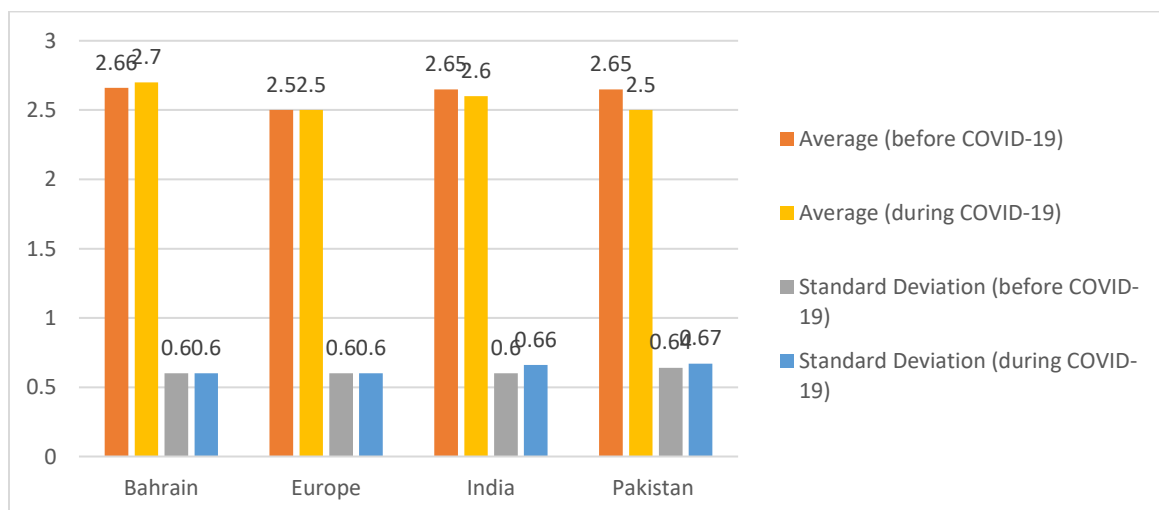


Figure 4.14 : Performed trips for top-up grocery –Rank from 1 to 3 - with friends

Comparison between before and during COVID-19:

Figures from 4.10 to 4.14 clearly prove that people's preferred companion did not change during the pandemic when compared to normal situation. Regardless of the number of trips, people's preference remained the same in this regard.

Table 4.12: Online Shopping During COVID-19

Region	Major percentage
Bahrain	1-2 times a month & Never (62%)
Europe	1-2 times a month (41%)
India	Never (52%)
Pakistan	Never (50%)

Table 4.12 above shows that most respondents in Bahrain were performing online shopping during COVID-19 either 1-2 times a month or Never (total of 62%). On the other targeted regions similar results were concluded (majority ranging from 41% to 52%). In this context, seems that people tend to online shopping but not on top priority. This may be due to people's mentality not being into online shopping as it was not viral in the very beginning of the pandemic.

Table 4.13: Whether or no grocery has changed as a result of COVID-19 Outbreak

Region	Yes / No (%)
Bahrain	26 / 74
Europe	26 / 74
India	52 / 48
Pakistan	42 / 58

Table 4.13 shows that Bahrain and Europe most of the respondents did not change their shopping place for grocery because of the outbreak. However, India and Pakistan show that almost half of the respondents changed their shopping location as a counter measure. This basically gives an indication of the overall situation as people may tend to change their grocery due to finding it more congested compared to other groceries. On the other hand, people may find that their grocery is somehow safe and perhaps safer than other groceries.

Table 4.14: Whether performing out-of-home activities before COVID-19

Region	Yes / No (%)
Bahrain	59 / 41
Europe	78 / 22
India	63 / 37
Pakistan	67 / 33

As shown in table 4.14 above, most of the respondents among all regions were performing out of home activities with a biggest percentage in Europe (78%) and smallest percentage in Bahrain (59%). This could be due to the difference in weather conditions wherein, Bahrain has generally hot climate for most part of the year while European countries have more favorable weather in this context.

Table 4.15: Whether performing out-of-home activities during COVID-19

Region	Yes / No (%)
Bahrain	31 / 69
Europe	69 / 31
India	21 / 79
Pakistan	25 / 75

Table 4.15 shows that in most regions, most respondents were not performing any out-of-home activities during COVID-19 except Europe which majority of 69% were performing out-of-home.

Comparison between before and during COVID-19:

Tables 4.14 and 4.15 clearly show that people tended not to perform out-of-home activities during the pandemic in order to avoid infection. The majority of respondents in Europe did not change their preference when it comes to out-of-home activities as almost the same allocation remained the same even during the pandemic. This is because that people in Europe did not find that such activities are considered as causes of infections. Instead, they found it as an approach to boost immunity.

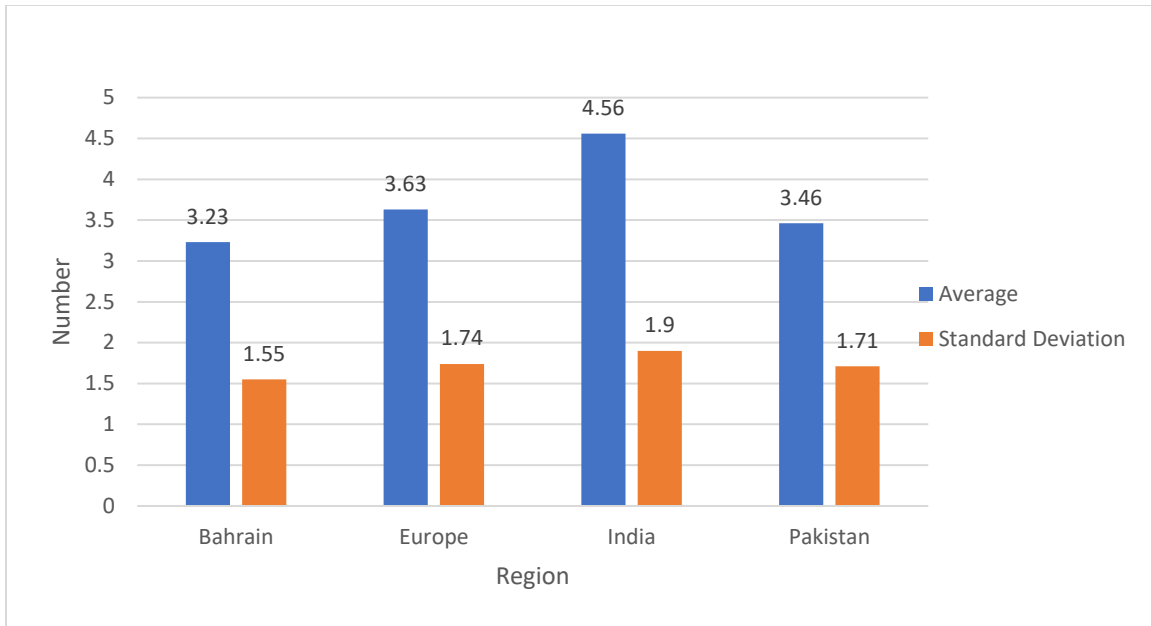


Figure 4.15: Times of performing out-of-home activities in a week before COVID-19

Figure 4.15 above explains that India's respondents were performing out of home activities the most (almost 5 times a week) while all the other regions show almost the same number of times performing out of home activities before the pandemic (3-4 times a week). Standard deviation ranges from 1.55 to 1.9.

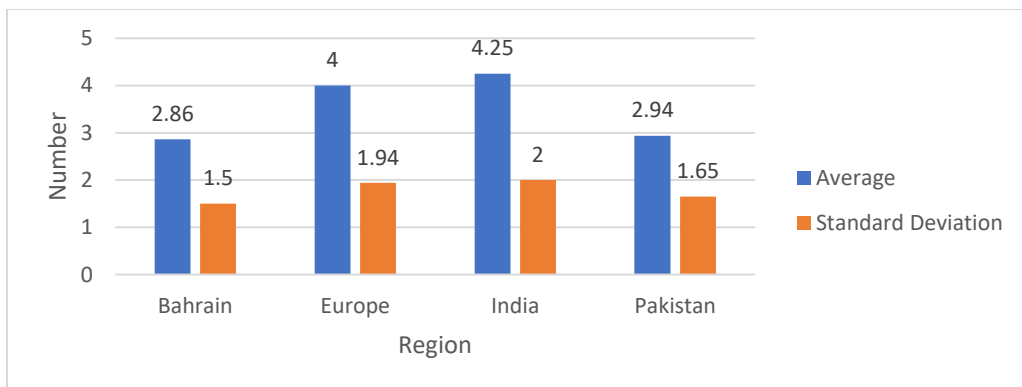


Figure 4.16: Times of performing out-of-home activities in a week during COVID-19

As shown in figure 4.16 above, respondents from India & Europe were performing out of home activities the most during the pandemic (almost 4 times a week) while all the other regions show almost the same number of times performing out of home activities during the pandemic (approximately 3 times a week). Standard deviation ranges from 1.5 to 2 for all regions.

Comparison between before and during COVID-19:

Figures 4.15 and 4.16 give a clear indication of the awareness/compliance level to the COVID-19 restrictions in different regions as number of times out-of-home activities performed reduced during the pandemic.

Table 4.16: Type of out-of-home activities performed before COVID-19.

Region	Major percentage
Bahrain	Walking (51%)
Europe	Walking (25%)
India	Walking (63%)
Pakistan	Walking (58%)

As clearly stated in table 4.16 above, majority among all the targeted regions were performing walking. The lowest in Europe (25%) and the highest in India (63%).

Table 4.17: Out-of-home physical activities performed during COVID-19

Region	Major percentage
Bahrain	Walking (37%)
Europe	Walking (25%)
India	Walking (66%)
Pakistan	Walking (73%)

Table 4.17 above shows most respondents among all regions were performing walking with the lowest in Europe (25%) and the highest in Pakistan (73%).

Comparison between before and during COVID-19:

Tables 4.16 and 4.17 indicate that people preferred out-of-home activities did not change even during the pandemic. People who continued performing out-of-home activities continued performing the same type of activity. This indicates that the pandemic had no effect on people's preferences in this regard.

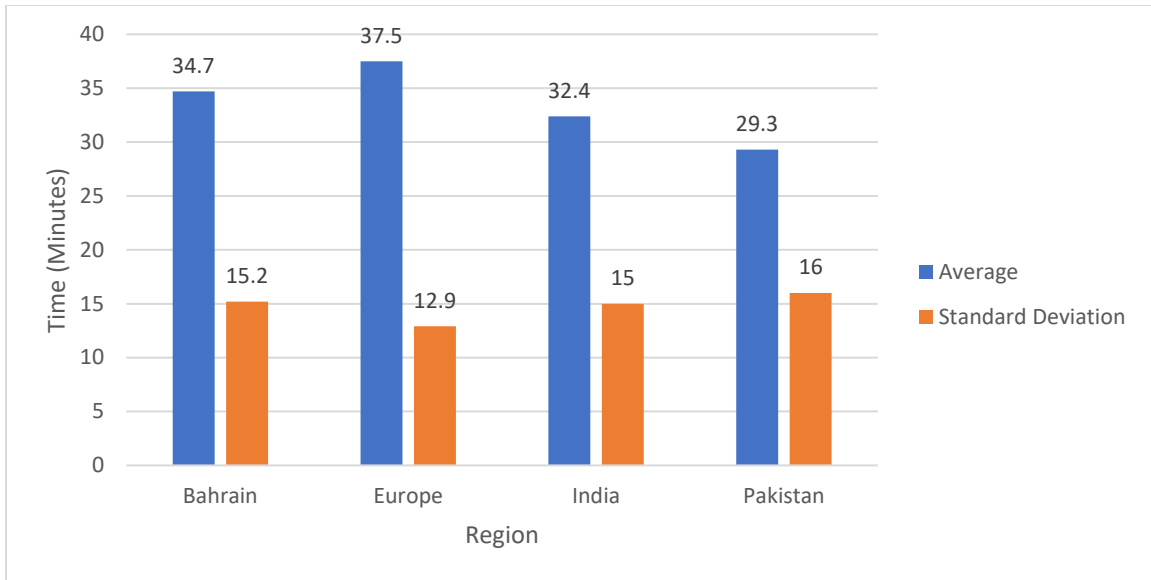


Figure 4.17: Average time spent to perform out-of-home physical activities in minutes per day

Figure 4.17 indicates that the respondents among the targeted regions were performing between 30 – 40 minutes per day, on average, with standard deviation ranging from 12.9 to 16.

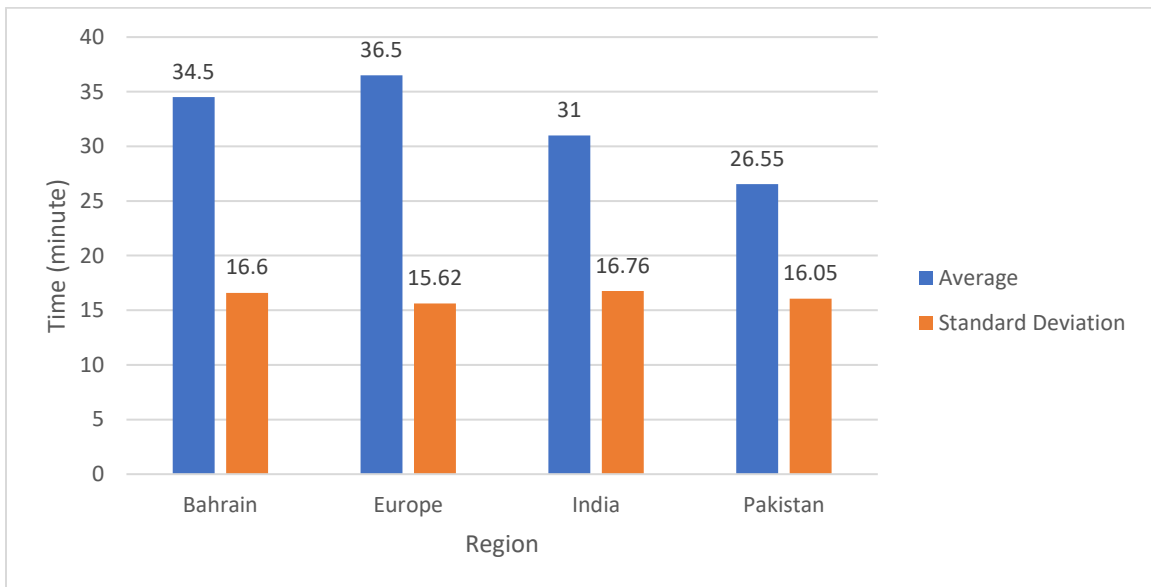


Figure 4.18: Average time spent to perform out-of-home physical activities in minutes per day (During COVID-19)

As shown in figure 4.18 above, all the respondents among the targeted regions were performing between 30 – 40 minutes per day except, for Pakistan (26 minutes), with standard deviation ranging from 15.62 to 16.76.

Comparison between before and during COVID-19:

It was noticed that most respondents preferred not to perform out-of-home activities during the outbreak. However, and as per figures 4.17 and 4.18, people who continued performing the activities during the pandemic tended to perform them with approximately the same time as they were before COVID-19.

Table 4.18: Opinion about road congestion during COVID-19

Region	Major percentage
Bahrain	Strongly Agree (55%)
Europe	Strongly Agree (83%)
India	Strongly Agree (78%)
Pakistan	Strongly Agree (67%)

Table 4.18 above illustrates that all the regions, most respondents strongly agree with the statement that traffic congestion during COVID-19 got reduced which is obvious due to the substantial reduction in traffic, increase in number of people working from home, etc.

Table 4.19: Opinion about lower crashes during COVID-19

Region	Major percentage
Bahrain	Somewhat Agree (45%)
Europe	Strongly Agree (45%)
India	Strongly Agree (61%)
Pakistan	Strongly Agree (59%)

As displayed in table 4.19 above, Majority of respondents from almost all the regions strongly agree that the roads have become safer, except for Bahrain which agree to a lesser extent. More investigations should be done on the trends of road safety during the pandemic.

Table 4.20: Opinion on “driving behaviors were less reckless during the pandemic.”

Region	Major percentage
Bahrain	Somewhat Agree (30%)
Europe	Neither agree nor disagree (34%)
India	Strongly Agree (59%)
Pakistan	Strongly Agree (51%)

As clearly shown in table 4.20 above, majority of respondents from India and Pakistan agree with the statement (59% and 51% respectively). However, majority of respondents in Bahrain somewhat agree with the statement and in Europe they neither agree nor disagree (30% and 34% respectively).

Table 4.21: Opinion on “working from home increases productivity.”

Region	Major percentage
Bahrain	Neither agree nor disagree (34%)
Europe	Neither agree nor disagree (31%)
India	Neither agree nor disagree (27%)
Pakistan	Neither agree nor disagree (26%)

As illustrated in table 4.21 above, all the regions the majority of respondents neither agree nor disagree with the statement. Other opinions are approximately close in percentages (number of corresponding responses).

4.2.3 Detailed Analysis on each region (Before – During situations)

Important Notes:

- In chi-square test, rejection of the null hypothesis means that the number of responses is not equal. Responses might be scattered or biased towards a certain direction. Acceptance of the null hypothesis means that responses are almost equally distributed (equal frequency) – 5% error is allowed ($\alpha=0.05$).
- In Z-test, rejection of the null hypothesis means that the average / mean between two groups (before and during COVID-19 situations) are not equal or not even close to each other. Acceptance of the null hypothesis means that the mean between two situations (before and during COVID-19) are the same based on 5% error ($\alpha=0.05$)

4.2.3.1 Bahrain

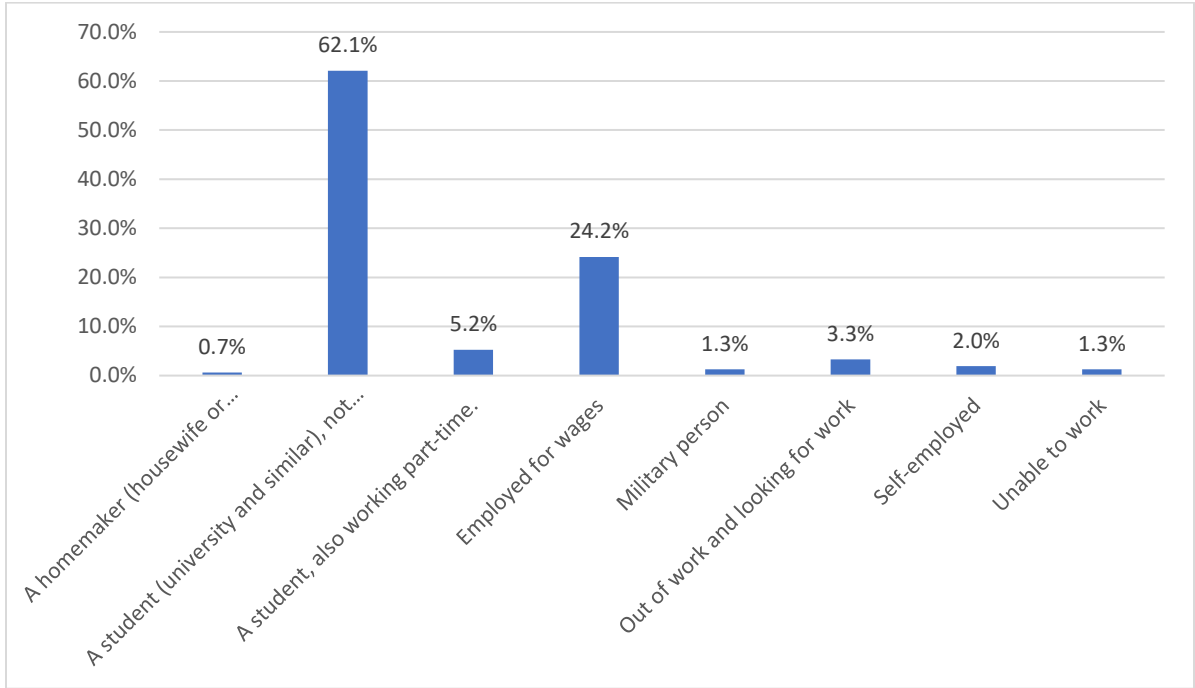


Figure 4.19: Occupational Status Before COVID-19 / Bahrain

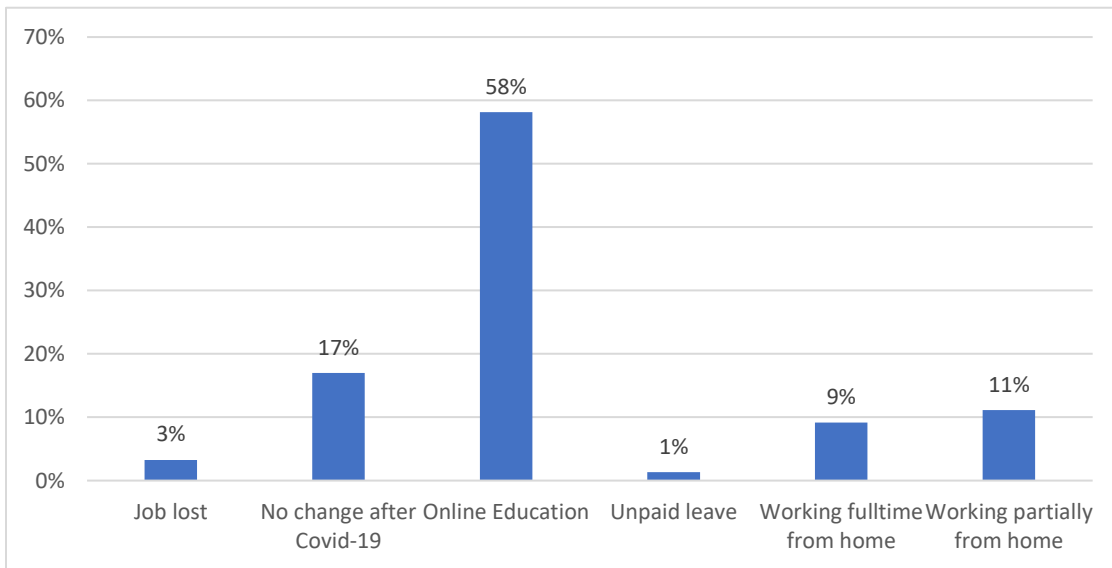


Figure 4.20: Occupational Status During COVID-19 / Bahrain

As shown in figures 4.19 and 4.20 above, occupation status before COVID-19 shows that most of the respondents were students (62%) and a considerable percentage were employees (24%). On the other hand, during COVID-19, most of the respondents shifted to online education during the outbreak.

Table 4.22: Chi Square Test - (Occupation Status Before COVID-19, Bahrain)

Occupation Before COVID-19	Observed Value	Expected Value
A homemaker (housewife or househusband)	1	19
A student (university and similar), not working.	95	19
A student, also working part-time.	8	19
Employed for wages	37	19
Military person	2	19
Out of work and looking for work	5	19
Self-employed	3	19
Unable to work	2	19

$$Xc^2_{critical} = 14.07$$

$$Xc^2_{Stat} = 396.07$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, the null hypothesis of equal frequencies is rejected

Table 4.23: Chi Square Test - (Occupation Status During COVID-19, Bahrain)

Occupation Before COVID-19	Observed Value	Expected Value
Job lost	5	44
No change during Covid-19	26	44
Online Education	89	44
Unpaid leave	2	44
Working fulltime from home	14	44
Working partially from home	17	44

$$Xc^2_{critical} = 11.07$$

$$Xc^2_{Stat} = 164.7$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, the null hypothesis of equal frequencies is rejected

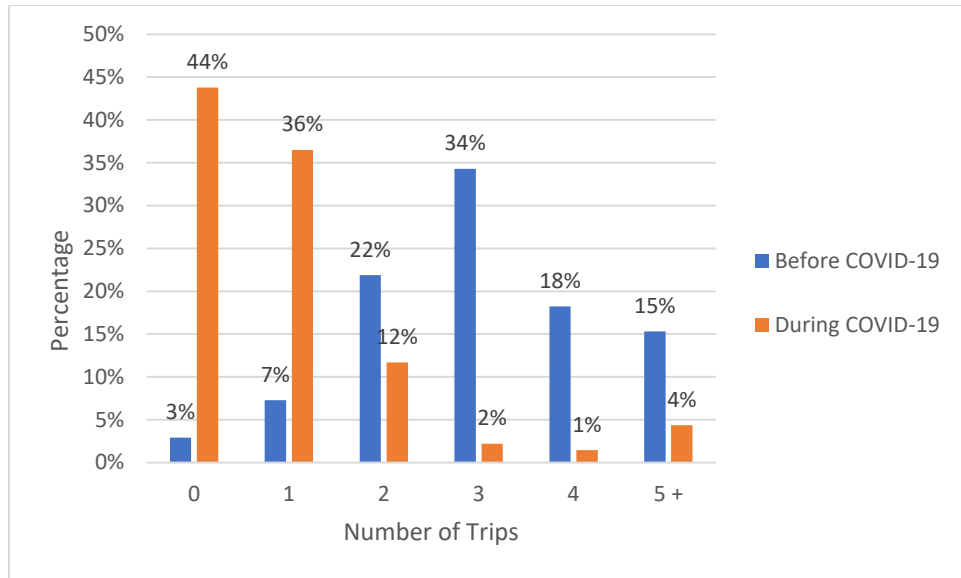


Figure 4.21: Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day, Bahrain.

As illustrated above in figure 4.21, most of the respondents were performing 3 trips on average before the virus outbreak. However, considerable percentages are distributed performing 2,4,5+ trips on average. The least were performing 0 to 1 trip on average (10%).

Table 4.24: Trips/day via car/carpooling/motorcycle/taxi/Uber - Z Test - Bahrain

Statistical Category	Before COVID-19	During COVID-19
Mean	3.04	0.94
Known Variance	1.58	1.22
Observations	137	137
Hypothesized Mean Difference	0	
z	14.65	
z Critical two-tail	1.96	

As shown in figure 4.24 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis is rejected.

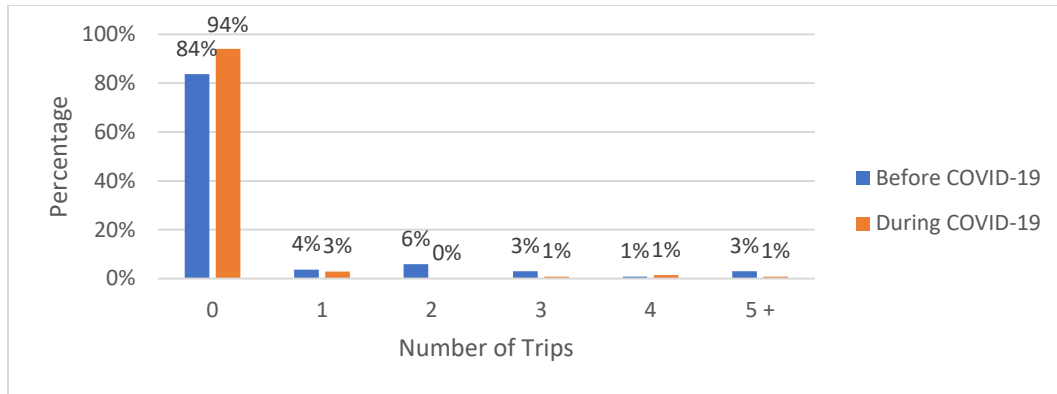


Figure 4.22: Trips performed via bus/train/metro on an average per day, Bahrain

It is clearly shown in figure 4.22 above that most of the respondents did not perform activities using bus/train/metro (84% and 94% before and during COVID-19 respectively).

Table 4.25: Trips/day via bus/train/metro - Z Test - Bahrain

Statistical category	Before COVID-19	During COVID-19
Mean	0.42	0.15
Known Variance	1.23	0.50
Observations	135	136
Hypothesized Mean Difference	0	
z	2.43	
z Critical two-tail	1.96	

As shown in table 4.25 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis is rejected.

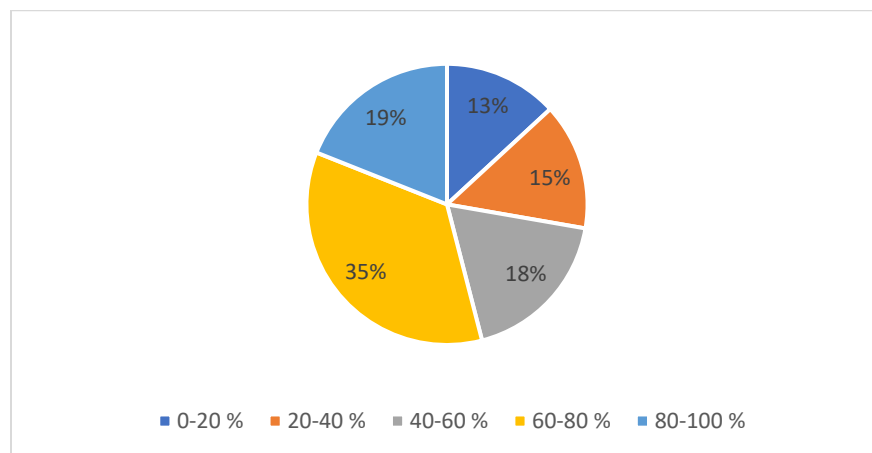


Figure 4.23: Fuel Saving percentage During the Pandemic when compared to normal situation – Bahrain.

As shown in figure 4.23 above, most of the sample (35%) were saving around 60-80%. Only 13% stated that they were saving only 0-20%. Other categories are almost equally distributed.

Table 4.26: Fuel saving (during Covid - 19) - Chi-Square analysis - Bahrain.

Fuel Consumption	Actual Number of responses	Expected Number of responses
0-20 %	18	27
20-40 %	20	27
40-60 %	25	27
60-80 %	48	27
80-100 %	26	27

$$Xc^2_{critical} = 20.99$$

$$Xc^2_{Stat} = 9.48$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, the null hypothesis of equal frequencies is rejected

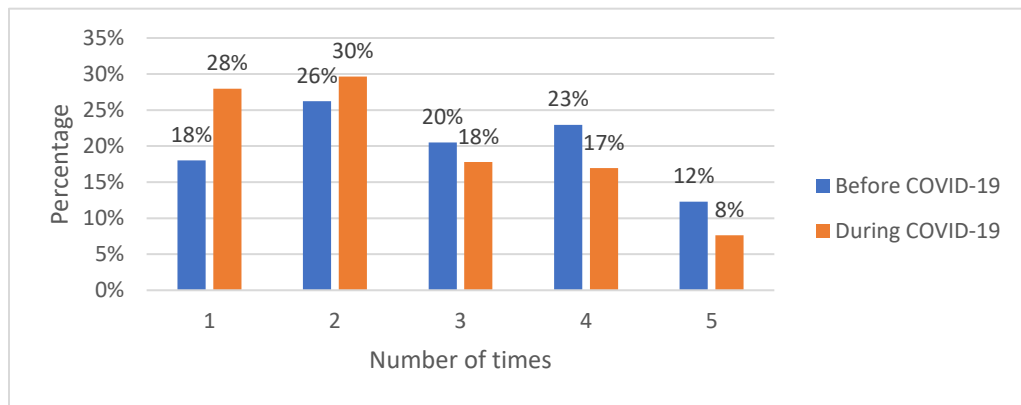


Figure 4.24: Number of times the main grocery in a month, Bahrain

As shown in figure 4.24 above, there are some slight differences between before COVID-19 and during COVID-19 in respect to number of times. Majority of respondents before and during COVID-19 were performing main grocery 2 times in a month (26% and 30% respectively). On the other hand, the lowest percentage for respondents that were

performing main grocery 5 times in a month for both situations (before and during COVID-19) – 12% and 8% respectively.

Table 4.27: Number of monthly grocery trips - Z Test - Bahrain

Statistical Category	Before COVID-19	During COVID-19
Mean	2.85	2.47
Known Variance	1.70	1.62
Observations	122	118
Hypothesized Mean Difference	0	
z	2.32	
z Critical two-tail	1.96	

As Shown in figure 4.27 above, since $z > z_{\text{critical}}$, then the null hypothesis is rejected.

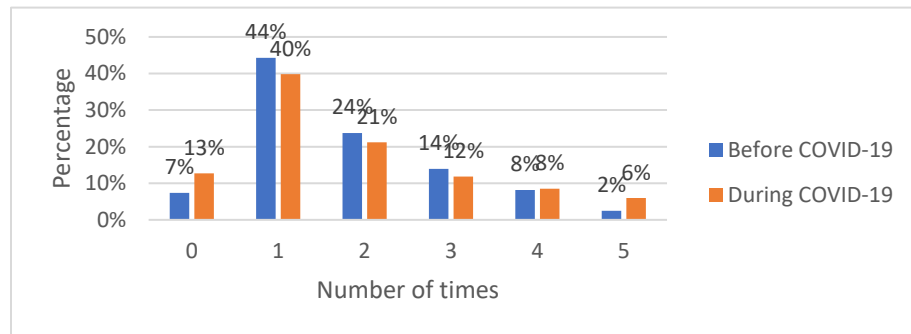


Figure 4.25: Number of times top-up grocery in a week , Bahrain

Results and percentages almost similar with slight differences before and during COVID-19 as shown in figure 4.25. The biggest percentage for respondents that were performing top up grocery once in a week (44% before COVID-19 and 40% during COVID-19). On the other hand, the smallest percentage for respondents that were performing 5 times top up grocery in a week (2% before COVID-19 and 6% during COVID-19).

Table 4.28: Weekly top-up grocery trips - Z Test - Bahrain

Statistical Category	Before COVID-19	During COVID-19
Mean	1.79	1.81
Known Variance	1.39	1.88
Observations	122	118
Hypothesized Mean Difference	0	
z	-0.16	
z Critical two-tail	1.96	

As shown in table 4.28 above, $+ z_{\text{critical}} \leq z \leq - z_{\text{critical}}$ and hence the hypothesis of equal mean is accepted.

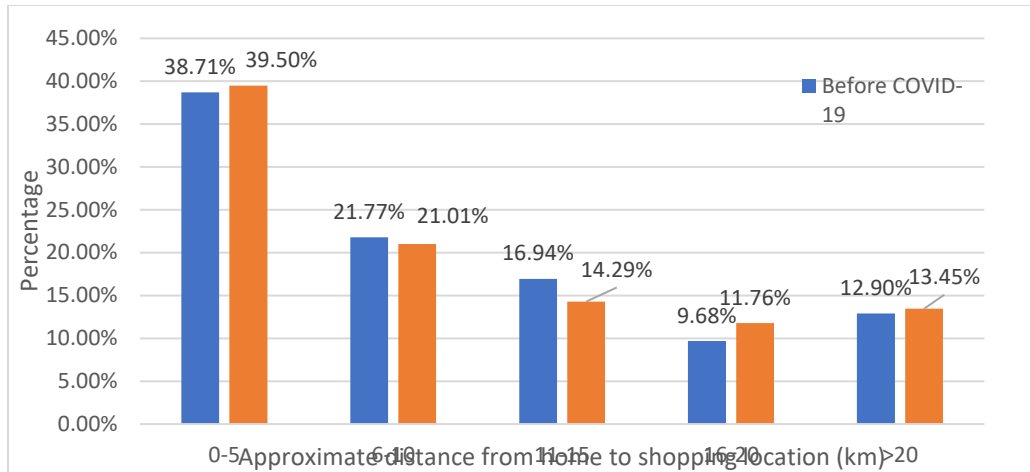


Figure 4.26: Approximate distance from home to shopping location in kilometers. - Main Grocery – Bahrain

Figure 4.26 above clearly shows similar results before and during the outbreak on the distances between respondents' home to the nearest main grocery. The highest percentage for respondents that their distance was between 0-5 km (38.71% and 39.50% before and during COVID-19 respectively). The lowest percentage for respondents their distance was between 16-20 km (9.68% and 11.76% before and during COVID-19 respectively).

Table 4.29: Home-to- main grocery distance (km) - Bahrain - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	10.99	10.82
Known Variance	93.70	103.22
Observations	124	119
Hypothesized Mean Difference	0	
z	0.14	
z Critical two-tail	1.96	

As shown in table 4.29 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

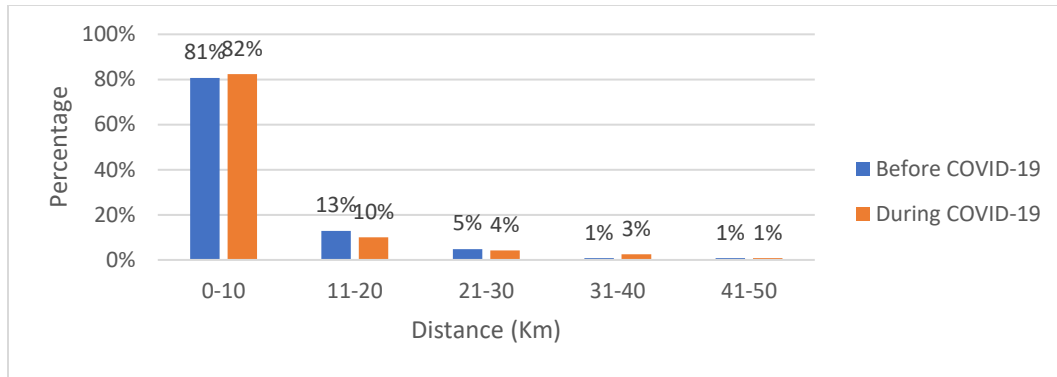


Figure 4.27: Approximate distance from home to shopping location in kilometers. - Top-up Grocery – (Bahrain)

Figure 4.27 above illustrates that results are approximately identical when it comes to distance between home to shopping location (top-up grocery) with the highest percentage on distance that ranges between 0 to 10 km (81% before COVID-19 and 82% during COVID-19). The residual percentage (approx. 9% before and during COVID-19) on the distance higher than or equal 11km.

Table 4.30: Home-to- top up grocery distance (km) - Bahrain - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	6.21	6.24
Known Variance	64.46	79.40
Observations	124	119
Hypothesized Mean Difference	0	
z	-0.02	
z Critical two-tail	1.96	

As shown in table 4.30 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

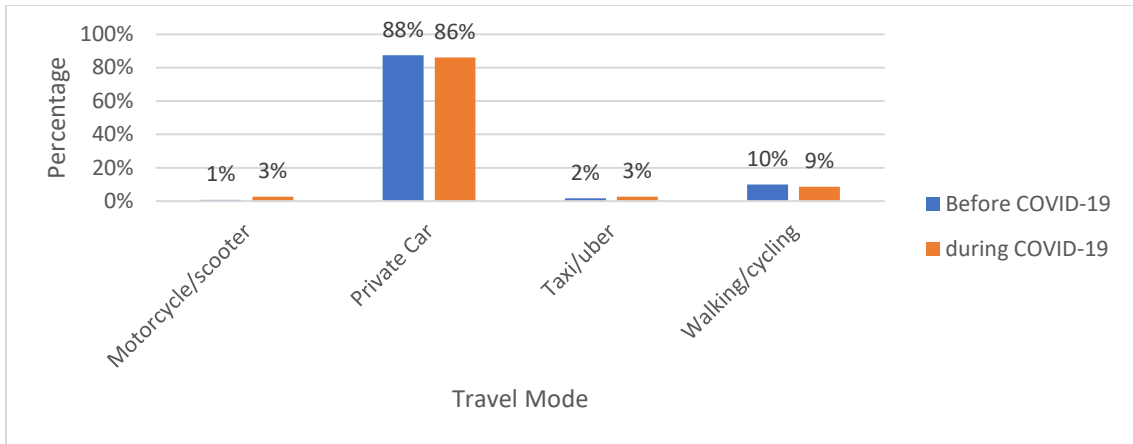


Figure 4.28: Predominant Travel mode for shopping activities – Main Grocery (Bahrain)

Figure 4.28 above shows the dominance on respondents that were using private car as a preferable travel mode to nearest main grocery (88% and 86% before and during COVID-19 respectively).

Table 4.31: Bahrain: Travel mode vs. grocery shopping (pre-COVID) Chi-Square.

Travel mode	Actual Number of responses	Expected Number of responses
Motorcycle/scooter	1	30
Private Car	105	30
Taxi/uber	2	30
Walking/cycling	12	30

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 252$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.32: Bahrain: Travel mode vs. grocery shopping (during-COVID) Chi-Square.

Travel mode	Actual Number of responses	Expected Number of responses
Motorcycle/scooter	3	29
Private Car	99	29
Taxi/uber	3	29
Walking/cycling	10	29

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 230$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

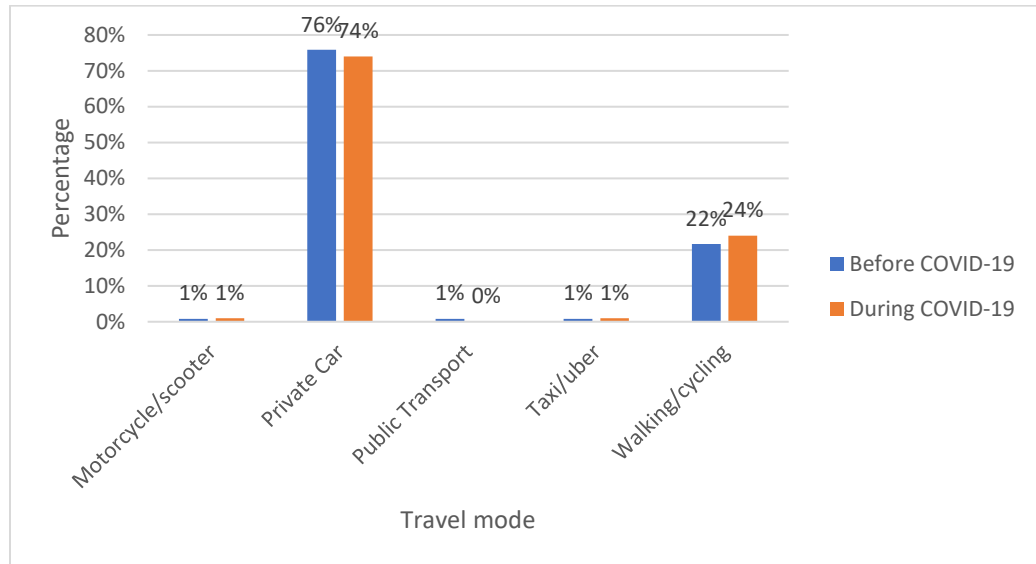


Figure 4.29: Predominant Travel mode for shopping activities - Top-up Grocery (Bahrain)

Figure 4.29 above demonstrates that majority of respondents were using their private car as a travel mode to top-up grocery (76% before COVID-19 and 74% during COVID-19). However, a considerable percentage of respondents were traveling to nearest top-up grocery by walking/cycling (22% and 24% before and during COVID-19 respectively).

Table 4.33: Bahrain: Travel mode vs. top-up Grocery (pre-COVID) - Chi-Square

Travel mode	Actual Number of responses	Expected Number of responses
Motorcycle/scooter	1	24
Private Car	91	24
Public Transport	1	24
Taxi/uber	1	24
Walking/cycling	26	24

$$Xc^2_{critical} = 9.49$$

$$Xc^2_{stat} = 253.33$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.34: Bahrain: Travel mode vs. top-up Grocery (during-COVID) - Chi-Square

Travel mode	Actual Number of responses	Expected Number of responses
Motorcycle/scooter	1	26
Private Car	77	26
Taxi/uber	1	26
Walking/cycling	25	26

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 148.15$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

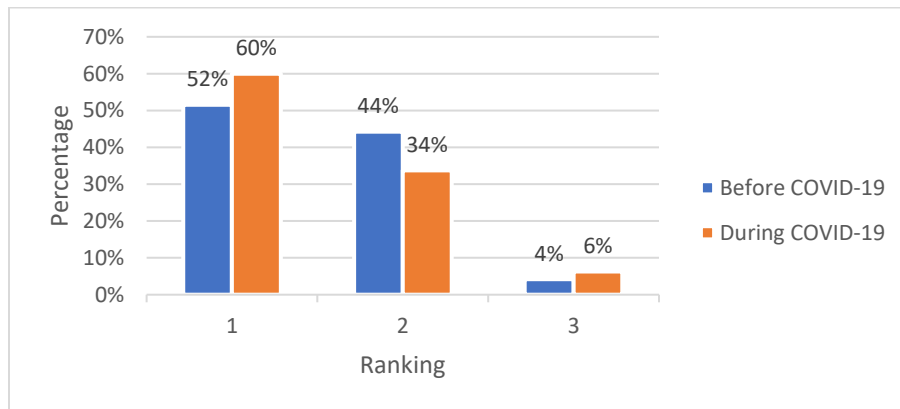


Figure 4.30: Alone – Main Grocery (Bahrain) – (Rank from 1 – 3)

Figure 4.30 above shows that before COVID-19, 52% of respondents ranked 1 (preferred) being alone doing the main grocery activities, 44% ranked 2 (fair) and 4% ranked 3 (not preferred). On the other hand, as the figure also indicates, during COVID-19, 60% of respondents ranked 1 (preferable) being alone doing the main grocery activities, 34% ranked 2 (moderate) and 6% ranked 3 (not preferred). As clearly indicated, there is no substantial difference between the two situations (before and during COVID-19)

Table 4.35: Alone – Main Grocery (Bahrain) – (Rank from 1 – 3) - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	1.53	1.46
Known Variance	0.34	0.38
Observations	95	80
Hypothesized Mean Difference	0	
z	0.70	
z Critical two-tail	1.96	

As shown in table 4.35 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

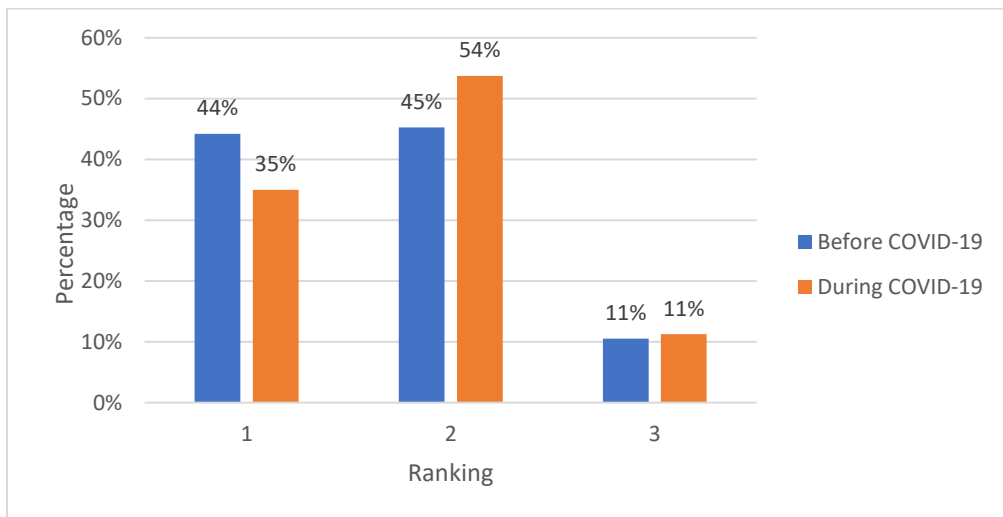


Figure 4.31: With family – Main Grocery (Bahrain) – (Rank from 1 – 3)

Figure 4.31 above shows that before COVID-19, 44% of respondents ranked 1 (preferable) being with family doing the main grocery activities, 45% ranked 2 (moderate) and 11% ranked 3 (not preferred). On the other hand, as the figure also indicates, during COVID-19, 35% of respondents ranked 1 (preferable) being with family doing the main grocery activities, 54% ranked 2 (moderate) and 11% ranked 3 (not preferred). As clearly indicated, there is no substantial difference between the two situations (before and during COVID-19).

Table 4.36: With family – Main Grocery (Bahrain) – (Rank from 1 – 3) - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	1.66	1.76
Known Variance	0.44	0.41
Observations	95	80
Hypothesized Mean Difference	0	
z	-1.01	
z Critical two-tail	1.96	

As shown in table 4.36 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

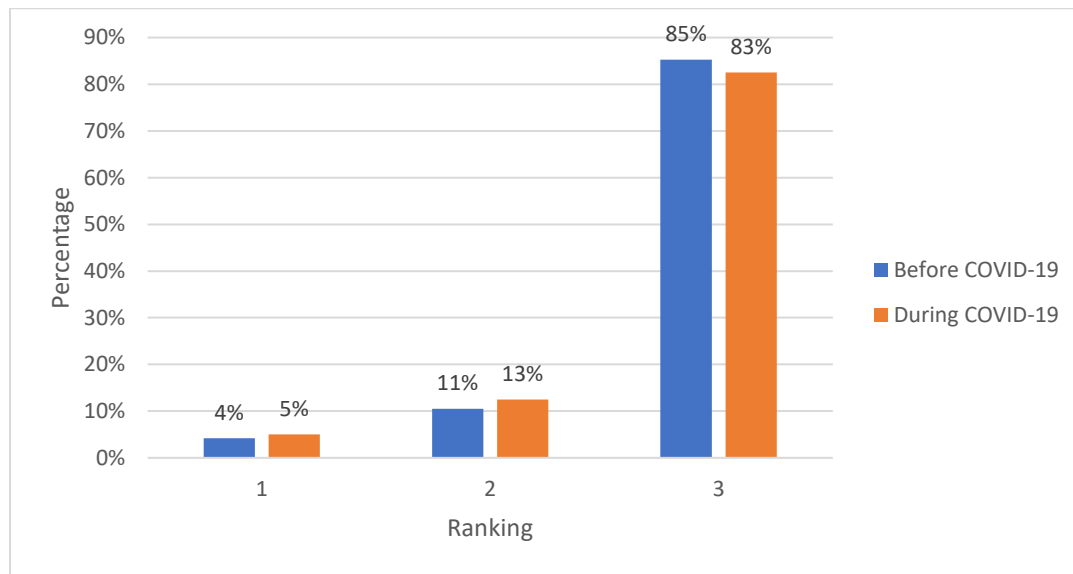


Figure 4.32: With friends – Main Grocery (Bahrain) – (Rank from 1 – 3)

Figure 4.32 above shows that before COVID-19, 4% of respondents ranked 1 (preferable) being with friends doing the main grocery activities, 11% ranked 2 (moderate) and 85% ranked 3 (not preferred). On the other hand, as the figure also indicates, during COVID-19, 5% of respondents ranked 1 (preferable) being with friends doing the main grocery activities, 13% ranked 2 (moderate) and 83% ranked 3 (not preferred). As clearly indicated, there is no substantial difference between the two situations (before and during COVID-19 (almost the same))

Table 4.37: With friends – Main Grocery (Bahrain) – (Rank from 1 – 3) - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	2.81	2.78
Known Variance	0.24	0.28
Observations	95	80
Hypothesized Mean Difference	0	
z	0.46	
z Critical two-tail	1.96	

As shown in table 4.37 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

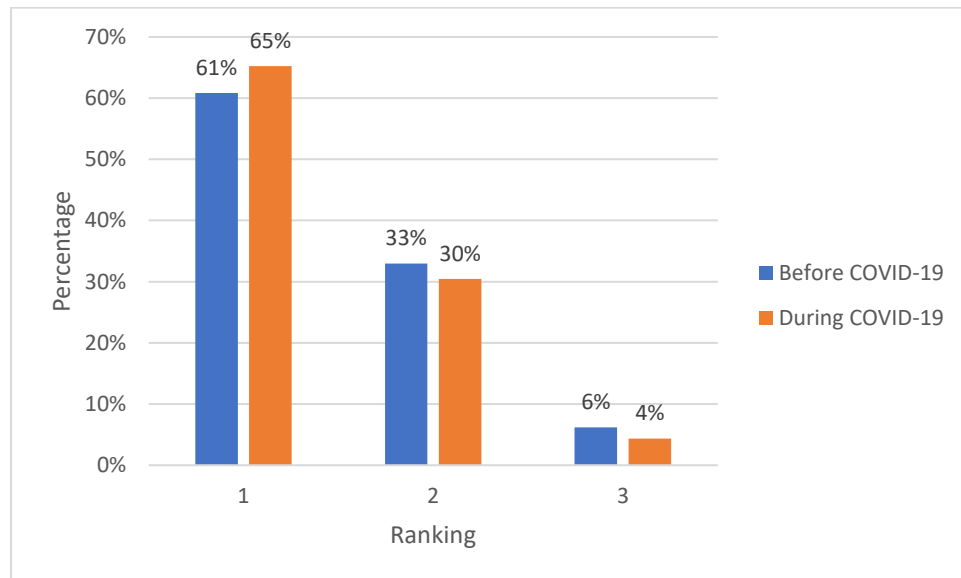
**Figure 4.33: Alone – Top-up Grocery (Bahrain) – (Rank from 1 – 3)**

Figure 4.33 above shows that before COVID-19, 61% of respondents ranked 1 (preferred) being alone doing the top-up grocery activities, 33% ranked 2 (moderate) and 6% ranked 3 (not preferred). On the other hand, as the figure also indicates, during COVID-19, 65% of respondents ranked 1 (preferable) being alone doing the top-up grocery activities, 30% ranked 2 (moderate) and 4% ranked 3 (not preferred).

Table 4.38: Alone – Top-up Grocery (Bahrain) – (Rank from 1 – 3) - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	1.45	1.39
Known Variance	0.38	0.33
Observations	97	69
Hypothesized Mean Difference	0	
z	0.67	
z Critical two-tail	1.96	

As shown in table 4.38 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

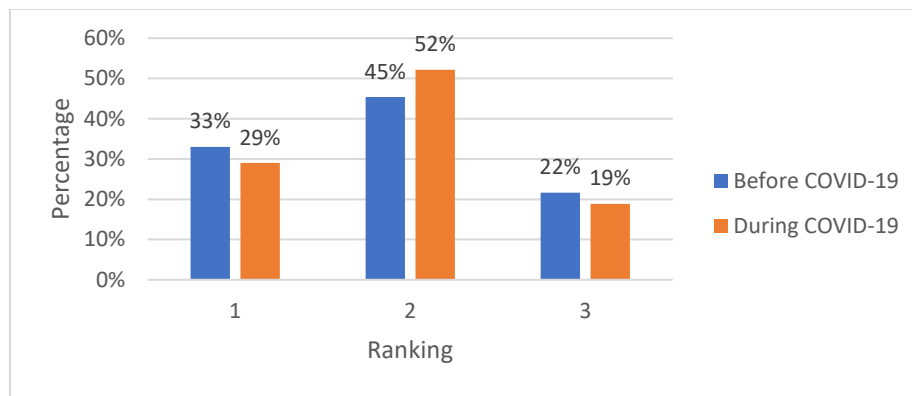
**Figure 4.34: With family – Top-up Grocery (Bahrain) – (Rank from 1 – 3)**

Figure 4.34 above shows that before COVID-19, 33% of respondents ranked 1 (preferable) being with family doing the top-up grocery activities, 45% ranked 2 (moderate) and 22% ranked 3 (not preferred). On the other hand, as the figure also indicates, during COVID-19, 29% of respondents ranked 1 (preferable) being with family doing the top-up grocery activities, 52% ranked 2 (moderate) and 19% ranked 3 (not preferred).

Table 4.39: With family – Top-up Grocery (Bahrain) – (Rank from 1 – 3) - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	1.89	1.90
Known Variance	0.54	0.47
Observations	97	69
Hypothesized Mean Difference	0	
z	-0.11	
z Critical two-tail	1.96	

As shown in table 4.39 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

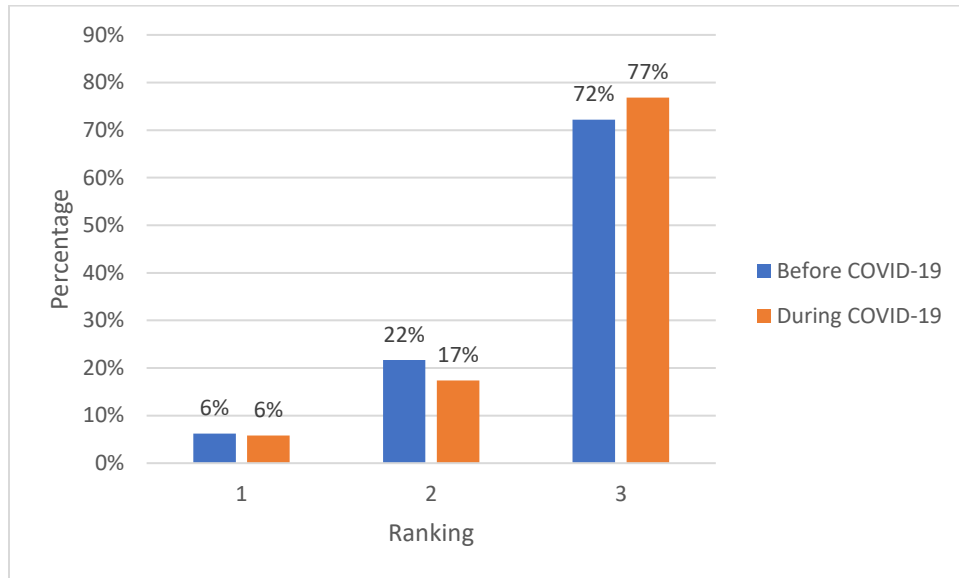


Figure 4.35: With friends – Top-up Grocery (Bahrain) – (Rank from 1 – 3)

Figure 4.35 above shows that before COVID-19, 6% of respondents ranked 1 (preferable) being with friends doing the top-up grocery activities, 22% ranked 2 (moderate) and 72% ranked 3 (not preferred). On the other hand, as the figure also indicates, during COVID-19, 6% of respondents ranked 1 (preferable) being with friends doing the top-up grocery activities, 17% ranked 2 (moderate) and 77% ranked 3 (not preferred).

Table 4.40: With friends – Top-up Grocery (Bahrain) – (Rank from 1 – 3) - Z test

Statistical Category	Before COVID-19	During COVID-19
Mean	2.66	2.71
Known Variance	0.35	0.33
Observations	97	69
Hypothesized Mean Difference	0	
z	-0.55	
z Critical two-tail	1.96	

As shown in table 4.40 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

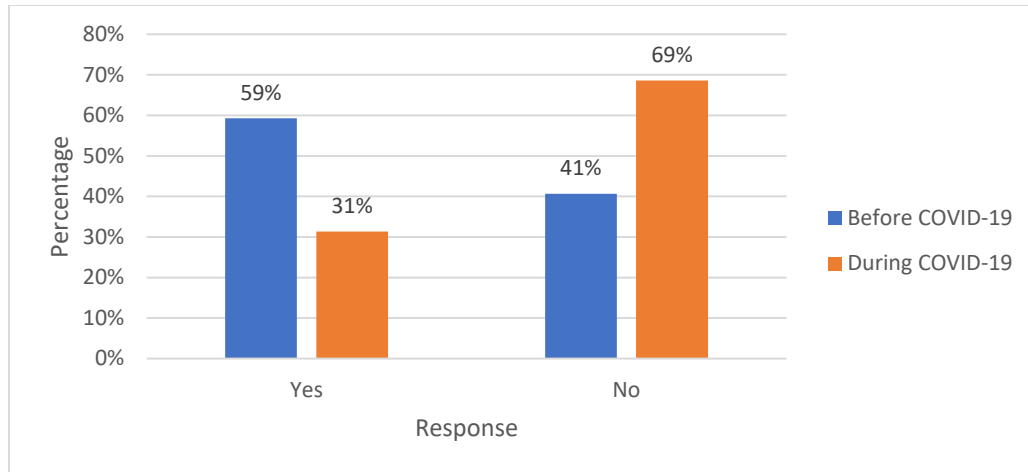


Figure 4.36: Whether performing out-of-home activities, Bahrain

As clearly shown in figure 4.36 above, the majority of respondents were performing out-of-home activities before COVID-19 with a dominant percentage of 59%. In contrast, majority were not performing any out-of-home activities during the outbreak with a dominant percentage of 69%

Table 4.41: Chi-Square Test: Out-of-home activities pre-COVID-19 (Bahrain).

Answer	Actual Number of responses	Expected number of responses
Yes	70	59
No	48	59

$$Xc^2_{critical} = 3.841$$

$$Xc^2_{stat} = 4.101$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.42 : Chi-Square Test: Out-of-home activities during-COVID-19 (Bahrain).

Answer	Actual Number of responses	Expected number of responses
Yes	37	59
No	81	59

$$Xc^2_{stat} = 16.4$$

$$Xc^2_{critical} = 4.101$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

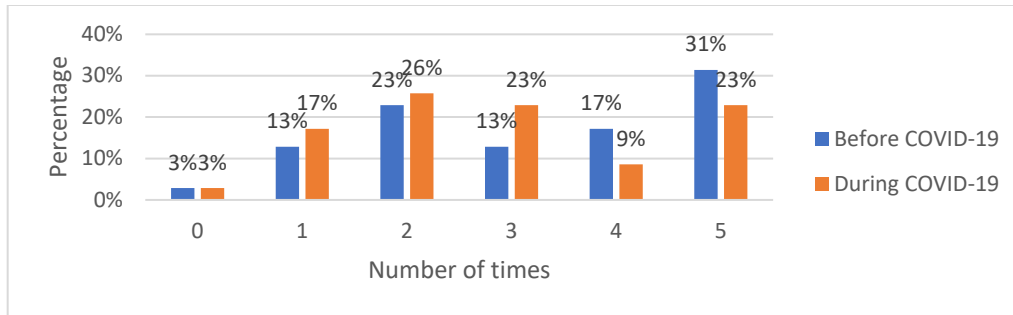


Figure 4.37: Times of performing out-of-home activities in a week , Bahrain

Figure 4.37 shows close results in number of times that out-of-home activities were performed. The highest variance (between the two situations – before and during COVID-19) for respondents that were performing out-of-home activities 3 times a week (13% and 23% before and during COVID-19 respectively). Understandably, 3% respondents who were not performing out of home activities, continued in the same manner.

Table 4.43 : Times of performing out-of-home activities in a week - Z test (Bahrain)

Statistical Category	Before COVID-19	During COVID-19
Mean	3.23	2.86
Known Variance	2.41	2.24
Observations	70	35
Hypothesized Mean Difference	0	
z	1.18	
z Critical two-tail	1.96	

As shown in table 4.43 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

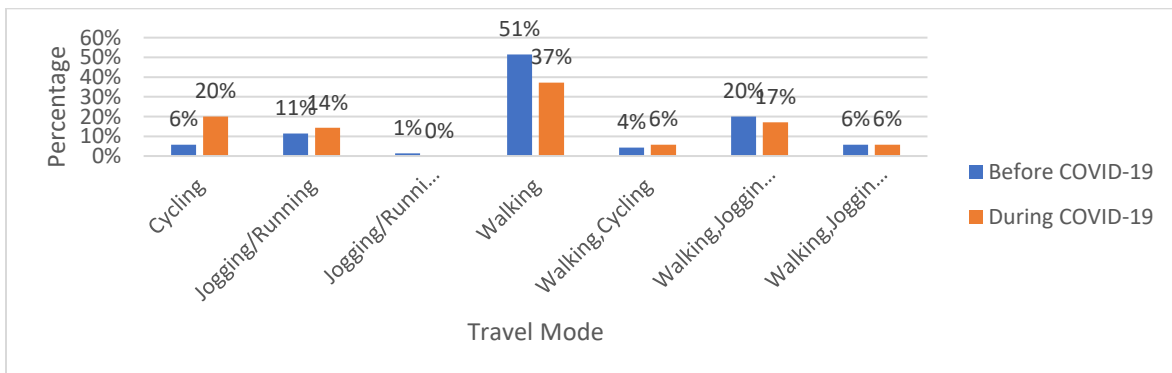


Figure 4.38: Normally performed out-of-home activities – Bahrain

Figure 4.38 above shows that majority of respondents were choosing walking as an out-of-activity among all other types (51% and 37% before and during COVID-19 respectively). The lowest percentage was for performing Jogging/Running, Cycling as a chosen activity (1% and 0% before and during COVID-19 respectively).

Table 4.44 : Out-of-home activities (Before COVID-19) – Bahrain - Chi Square Test

Out-of-home activity	Actual number of responses	Expected number of responses
Cycling	4	10
Jogging/Running	8	10
Jogging/Running, Cycling	1	10
Walking	36	10
Walking, Cycling	3	10
Walking, Jogging/Running	14	10
Walking, Jogging/Running, Cycling	4	10

$$Xc^2stat = 89.8$$

$$Xc^2critical = 12.59$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

Table 4.45 : Out-of-home activities (during COVID-19) – Bahrain – Chi Square Test

Out-of-home activity	Actual number of responses	Expected number of responses
Cycling	7	5
Jogging/Running	5	5
Jogging/Running, Cycling	0	5
Walking	13	5
Walking, Cycling	2	5
Walking, Jogging/Running	6	5
Walking, Jogging/Running, Cycling	2	5

$$Xc^2stat = 22.4$$

$$Xc^2critical = 12.59$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

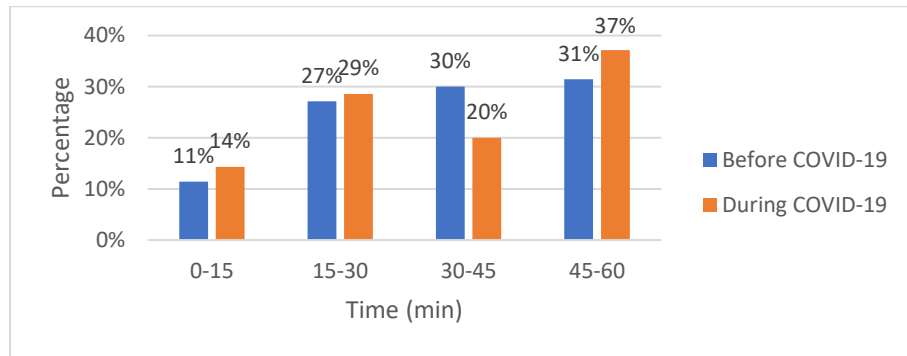


Figure 4.39: Average time spent to perform out-of-home physical activities in minutes per day – Bahrain.

Close results are shown in Figure 4.39. The respondents who were spending 30-45 minutes in out-of-home activity per day have greatest difference between the two situations—before and during COVID-19, which is 30% and 20%, respectively. The lowest difference or variation was for those who were spending 15-30 minutes in out-of-home activities per day, which was 11% and 14% before and during COVID-19, respectively.

Table 4.46: Out-of-home physical activities in minutes per day - Bahrain (Z test)

Statistical Category	Before COVID-19	During COVID-19
Mean	34.71	34.50
Known Variance	230.17	275.29
Observations	70	35
Hypothesized Mean Difference	0	
z	0.064	
z Critical two-tail	1.96	

As shown in table 4.46 above, $+ z\ critical \leq z \leq - z\ critical$ and hence the hypothesis of equal mean is accepted.

Table 4.47: Summary - Bahrain

Subject	Before COVID-19	During COVID-19
Occupational Status	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Trips Performed via bus/train/metro on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Fuel saving percentage as compared to normal situation	The null hypothesis of equal frequencies is rejected	
Number of times the main grocery in a month was performed	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Number of times top-up grocery in a week was performed	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers. - Main Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers - Top-up Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Predominant Travel mode for shopping activities - Main Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Predominant Travel mode for shopping activities - Top-up Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Alone – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With family – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With friends – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	

Alone – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With family – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With friends – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Whether or not performing out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Times of performing out-of-home activities in a week	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Normally performed out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Average time spent to perform out-of-home physical activities in minutes per day	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	

Table 4.47 above summarizes the findings of all the questionnaire questions on responses that are larger than 30. The aim of performing the statistical tests is to show the variance (difference) between the two targeted situations (before and during COVID-19). All the questions that are tested using the chi-square test reject the null hypothesis of equal frequencies (which means that there are noticeable differences between the studied categories of each tested question). On the other hand, questions that are tested using the Z-test show close mean (before and during COVID-19) depending on tolerance of 5%. All the ranking questions regarding the preferred companions show that the null hypothesis of equal mean is accepted (preference was not affected by the outbreak of the virus). In contrast, some questions reject the null hypothesis of equal mean (questions related to average usage of a certain mode choice + average number of times main grocery was performed before and during COVID-19).

4.2.3.2 Europe

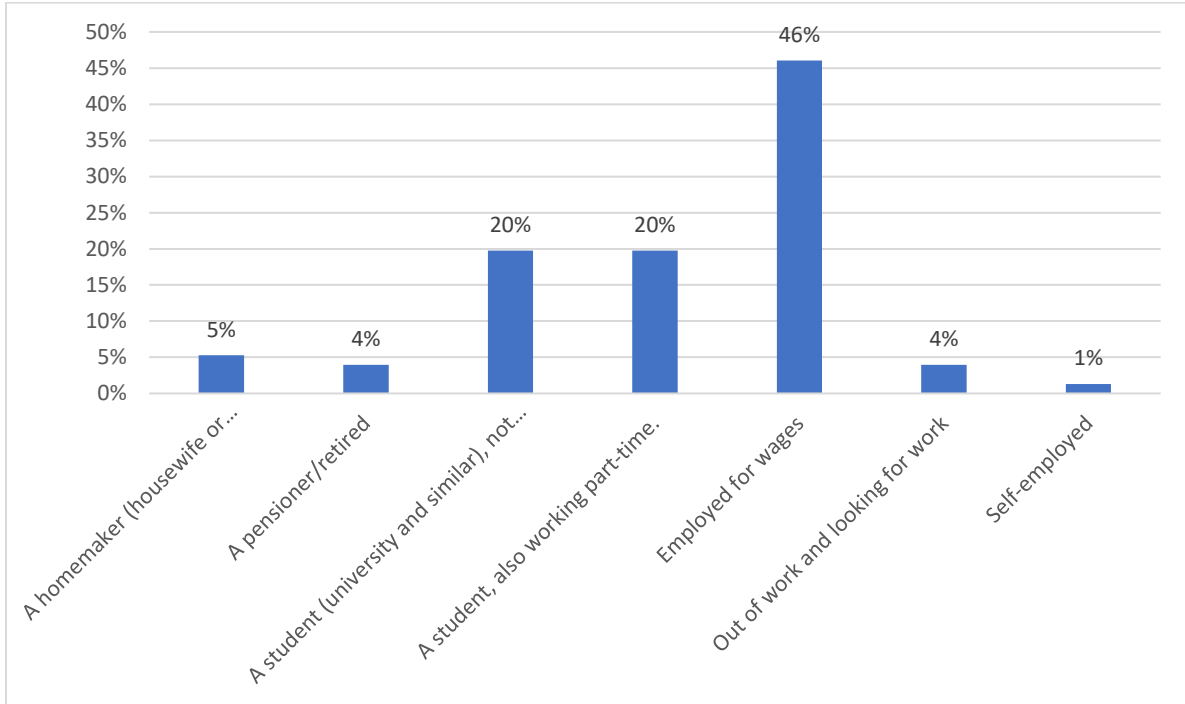


Figure 4.40: Occupational Status before COVID-19 / Europe

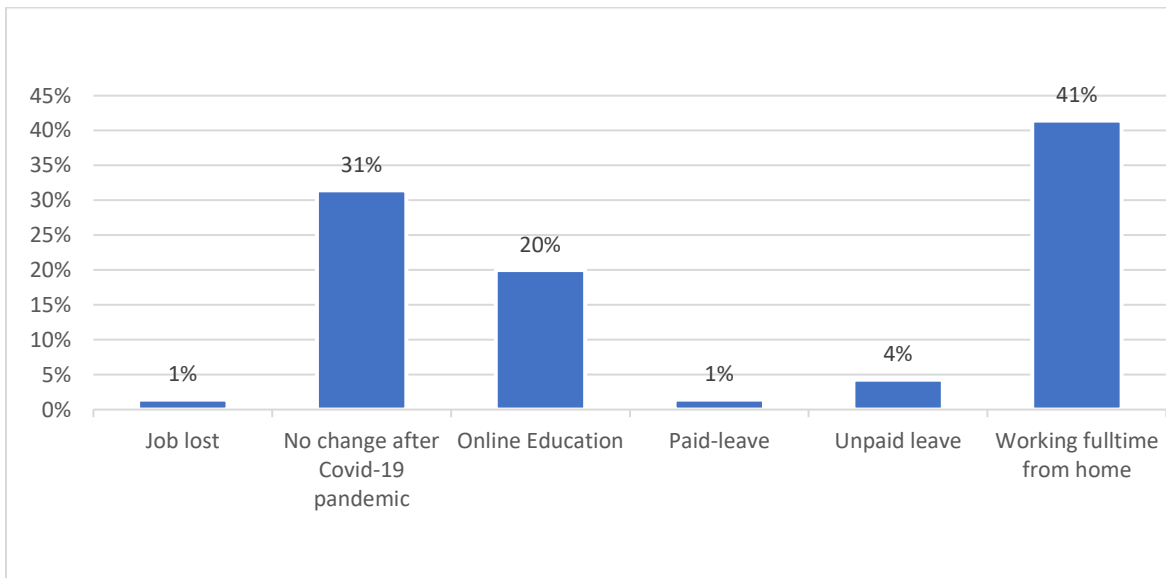


Figure 4.41: Occupational Status during COVID-19 / Europe

As clearly demonstrated in figures 4.40 and 4.41 above, most respondents shifted from being an ordinary employee (employed for wages – 46%) to working full time from home (41%). However, a considerable percentage experienced no change during the outbreak (may include no change in their studying situation, work, their own business, etc.).

Table 4.48: Chi Square Test - (Occupation Status before COVID-19, Europe)

Occupational Status	Actual number of responses	Expected number of responses
A homemaker (housewife or househusband)	4	11
A pensioner/retired	3	11
A student (university and similar), not working.	15	11
A student, also working part-time.	15	11
Employed for wages	35	11
Out of work and looking for work	3	11
Self-employed	1	11

$$Xc^2_{critical} = 12.59$$

$$Xc^2_{stat} = 81.5$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.49: Chi Square Test - (Occupation Status during COVID-19, Europe)

Occupational Status	Actual number of responses	Expected number of responses
Job lost	1	12
No change during Covid-19 pandemic	22	12
Online Education	14	12
Paid-leave	1	12
Unpaid leave	3	12
Working fulltime from home	29	12

$$Xc^2_{critical} = 11.07$$

$$Xc^2_{stat} = 61.31$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

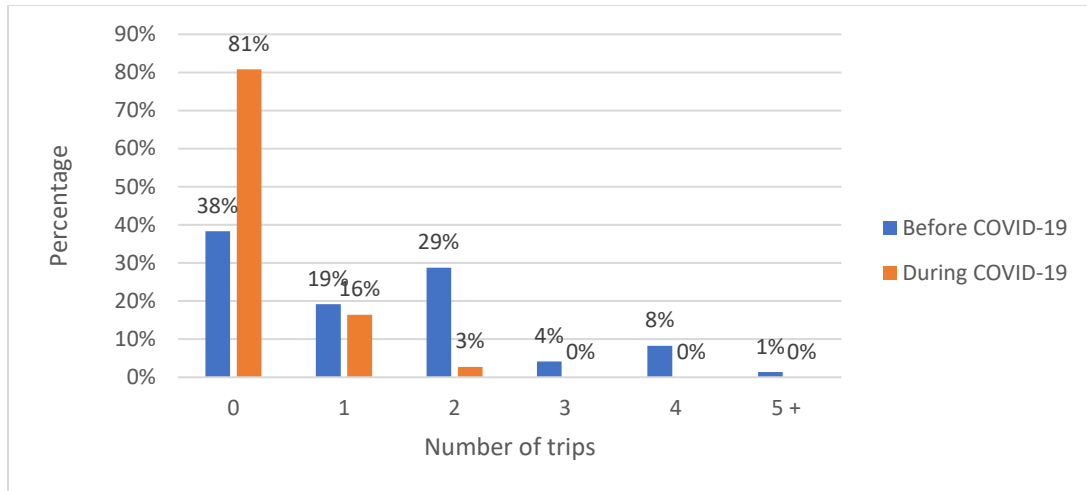


Figure 4.42: Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day, Europe.

Figure 4.42 above clearly indicates the substantial increase in the percentage of responses performing 0 trips via car/carpooling from 38% (before COVID-19) to 81% (During COVID-19) (more than double). This is clearly due that responses wanted to protect themselves by eliminating any kind of trips during the outbreak (staying at home).

Table 4.50: Trips/day via car/carpooling/motorcycle/taxi/Uber - Z Test - Europe

Statistical category	Before COVID-19	During COVID-19
Mean	1.29	0.22
Known Variance	1.74	0.23
Observations	73	73
Hypothesized Mean Difference	0	
z	6.51	
z Critical two-tail	1.96	

As shown in table 4.50 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

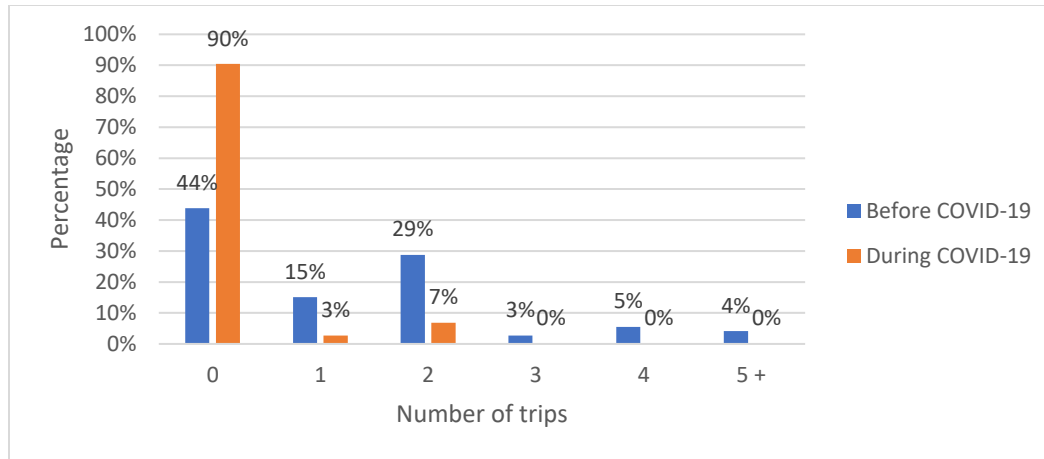


Figure 4.43: Trips performed via bus/train/metro on an average per day, Europe.

As demonstrated in figure 4.43 above, before COVID-19, most respondents were not performing any trips via bus/train/metro/ (44%). However, a considerable percentage were performing at least 1 trip per day (total of 56%). On the other hand, during COVID-19, there was a substantial increase in the number of respondents that were performing 0 trips via the mentioned mode (90%) which gives a clear indication that people at that time were conservative not to be infected and were avoiding places where people used to assemble + strict governmental precautionary steps Taken.

Table 4.51: Trips/day via bus/train/metro - Z Test - Europe

Occupational Status	Before COVID-19	During COVID-19
Mean	1.23	0.16
Known Variance	1.96	0.28
Observations	73	73
Hypothesized Mean Difference	0	
z	6.10	
z Critical two-tail	1.96	

As shown in table 4.51 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

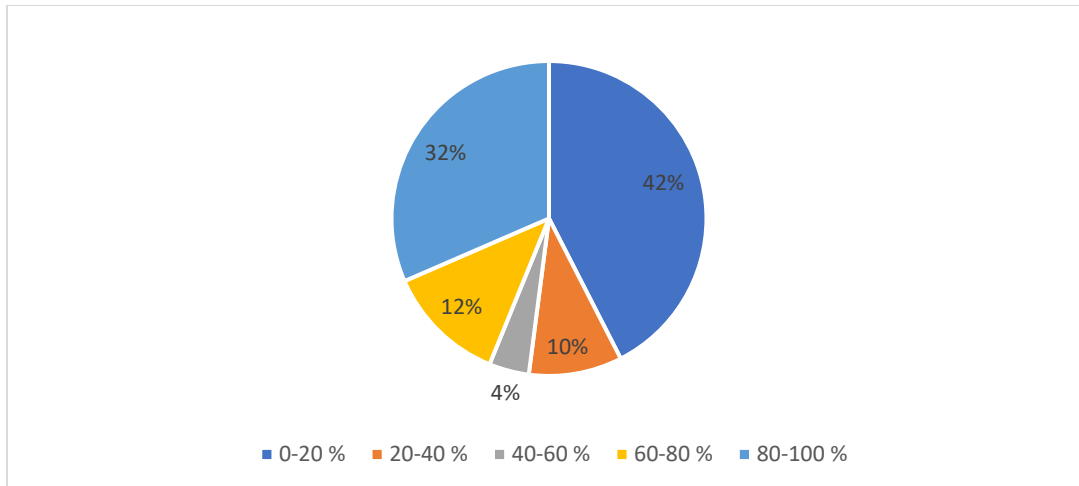


Figure 4.44: Fuel Saving percentage During the Pandemic when compared to normal situation – Europe.

As illustrated in figure 4.44 above, the majority of the sample (32% + 42% = 74%) were saving around 60-100%. Only 26% stated that they were saving only 0-60%. This gives a clear explanation that number of trips reduced substantially during the outbreak.

Table 4.52: Fuel saving (during Covid - 19) - Chi-Square analysis - Europe.

Reduction percentage range	Actual number of responses	Expected number of responses
0-20 %	31	15
20-40 %	7	15
40-60 %	3	15
60-80 %	9	15
80-100 %	23	15

$$Xc^2_{critical} = 9.45$$

$$Xc^2_{stat} = 38.57$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

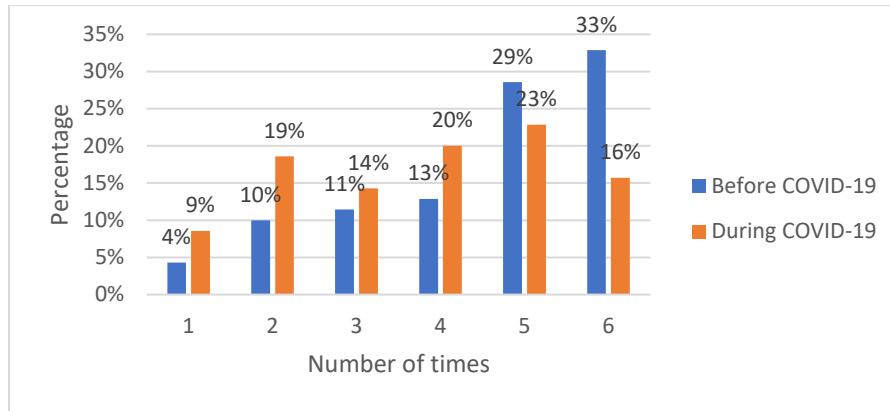


Figure 4.45: Number of times the main grocery in a month was performed – Europe.

Generally, and as shown in figure 4.45 above, majority of respondents were performing the main grocery 5-6 times a month before COVID-19 (total of 62%) +. On the other hand, the majority of respondents were performing the main grocery 4 to 5 times a month (49%) and the residual percentage is almost equally distributed with the lowest being 1 time per month and the highest of 2 times a month.

Table 4.53: Number of monthly main grocery trips - Z Test - Europe

Statistical category	Before COVID-19	During COVID-19
Mean	3.81	2.77
Known Variance	10.15	2.50
Observations	70	70
Hypothesized Mean Difference	0	
z	2.45	
z Critical two-tail	1.96	

As shown in table 4.53 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

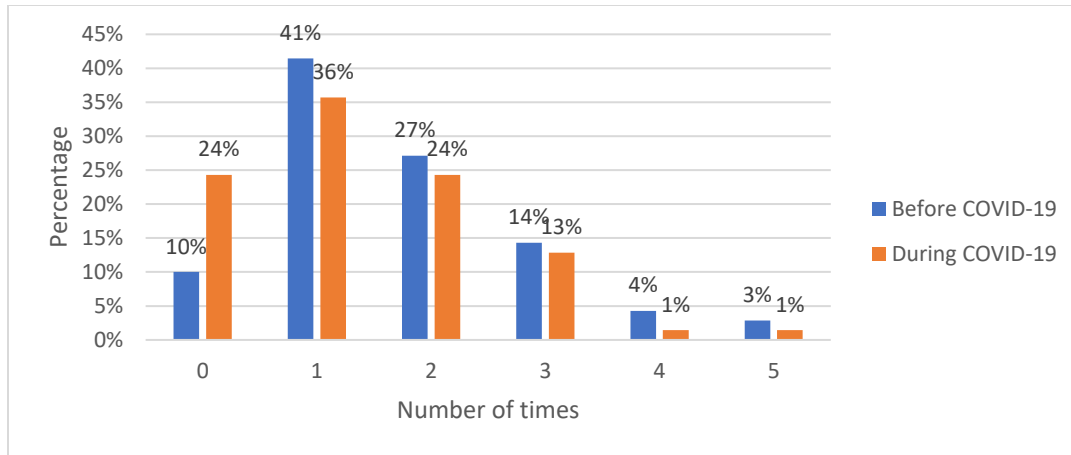


Figure 4.46: Number of times top-up grocery in a week was performed – Europe

Figure 4.46 above gives clear idea that was no significant difference when it comes to comparing the number of times of performing top-up grocery per week. However, it is obvious that number of respondents that were performing 0 top-up grocery per week during COVID-19 is double comparing it to before COVID-19 situation (most probably this is because of the virus outbreak and the precautions taken by staying at home).

Table 4.54: Weekly top-up grocery trips - Z Test – Europe

Statistical category	Before COVID-19	During COVID-19
Mean	1.70	1.36
Known Variance	1.31	1.25
Observations	70	70
Hypothesized Mean Difference	0	
z	1.79	
z Critical two-tail	1.96	

As shown in table 4.54 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

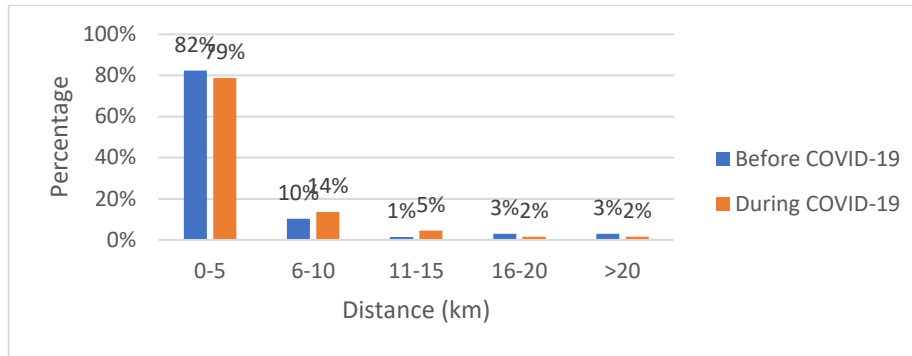


Figure 4.47: Approximate distance to the main grocery – Europe

As shown in figure 4.47 above, there was almost no difference to the distance of main grocery in which the respondents were performing (majority of respondents their approximate distances of main grocery were ranging from 0-5 km – 82% before COVID-19 and 79% during COVID-19). This gives an indication that most of respondents did not relocate or change the main grocery in which they used to go.

Table 4.55: Home-to- main grocery distance (km) - Europe - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	4.43	4.39
Known Variance	34.07	33.50
Observations	68	66
Hypothesized Mean Difference	0	
z	0.03	
z Critical two-tail	1.96	

As shown in table 4.55 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

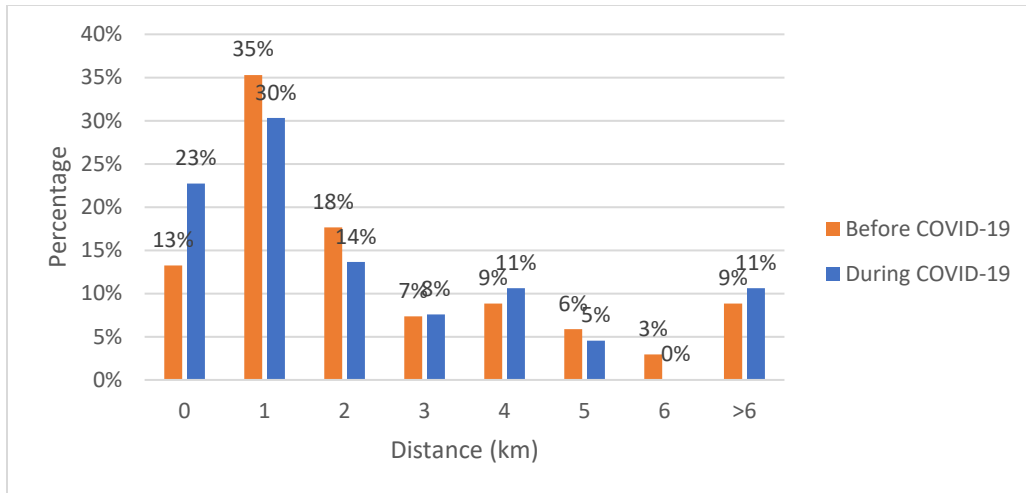


Figure 4.48: Approximate distance from home to shopping location in kilometers. – Top-up Grocery – Europe

As indicated in figure 4.48 above, close observations when comparing the distances of the intended top-up grocery of the respondents (Highest percentage for respondents that their intended top-up grocery was located 1 km away – 35% before COVID-19 and 30% during COVID-19). In contrast, lowest percentage for respondents that their intended to was located 6km away – 3% before COVID-19 and 0% during COVID-19)

Table 4.56: Home-to- top up grocery distance (km) - Europe - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	3.01	2.92
Known Variance	20.82	24.96
Observations	68	66
Hypothesized Mean Difference	0	
z	0.11	
z Critical two-tail	1.96	

As shown in table 4.56 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

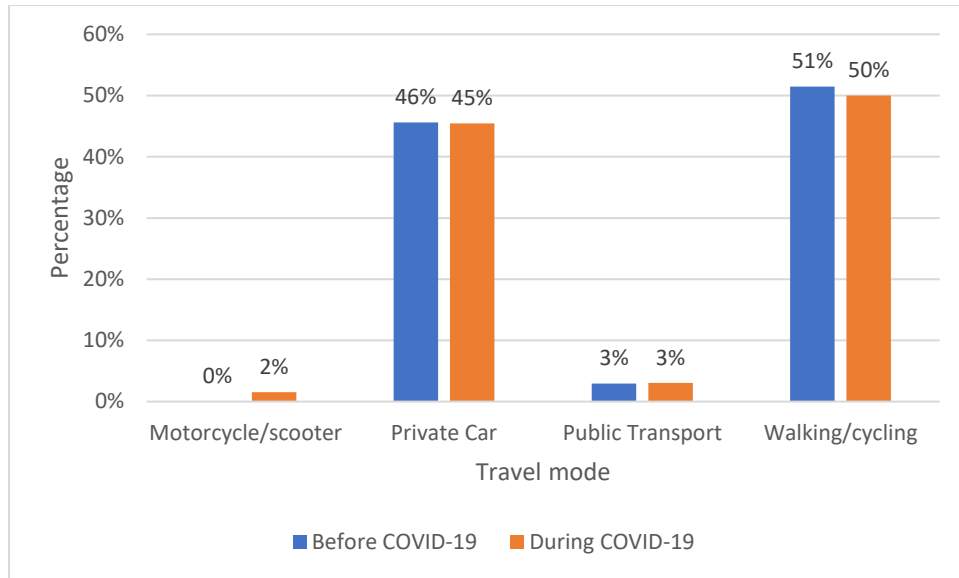


Figure 4.49: Predominant Travel mode for shopping activities - Main Grocery (Europe)

As shown in figure 4.49 above, Private Car and Walking/Cycling take the dominance (97% before COVID-19 and 95% during COVID-19). Accordingly, there is no change in the preferred travel mode when it comes to main grocery whether before during the outbreak.

Table 4.57: Europe: Travel mode vs. grocery shopping (pre-COVID) Chi-Square.

Travel mode	Actual number of responses	Expected number of responses
Motorcycle/scooter	0	17
Private Car	31	17
Public Transport	2	17
Walking/cycling	35	17

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 60.82$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.58: Europe: Travel mode vs. grocery shopping (during-COVID) Chi-Square.

Travel mode	Actual number of responses	Expected number of responses
Motorcycle/scooter	1	17
Private Car	30	17
Public Transport	2	17
Walking/cycling	33	17

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 54.85$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

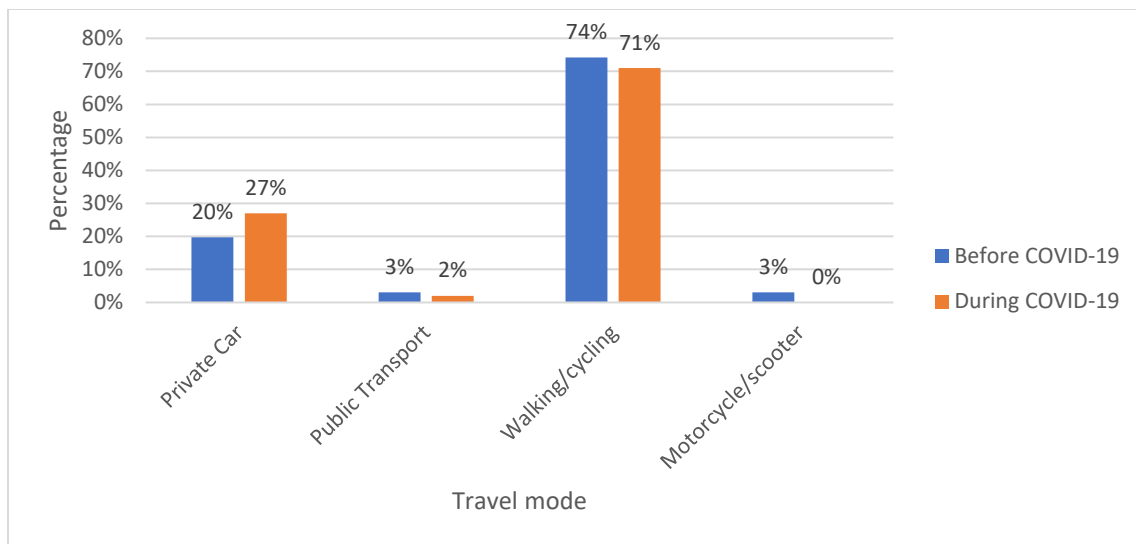


Figure 4.50: Predominant Travel mode for shopping activities - Top-up Grocery (Europe)

Figure 4.50 clearly indicates that the majority of respondents were using walking/cycling as a travel mode when performing top-up grocery in both situations (Before and during COVID-19 – 74% and 71% respectively). Nearly quarter of the respondents were using their private car for performing top-up grocery (20% before COVID-19 and 27% during COVID-19).

Table 4.59: Europe: Travel mode vs. top-up Grocery (pre-COVID) - Chi-Square

Travel mode	Actual number of responses	Expected number of responses
Private Car	13	17
Public Transport	2	17
Walking/cycling	49	17
Motorcycle/scooter	2	17

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 90.24$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.60: Europe: Travel mode vs. top-up Grocery (during-COVID) - Chi-Square

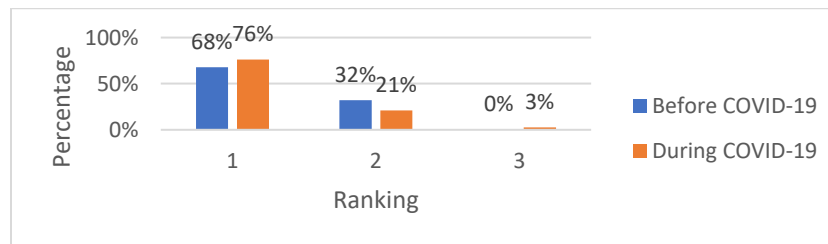
Travel mode	Actual number of responses	Expected number of responses
Private Car	17	16
Public Transport	1	16
Walking/cycling	44	16
Motorcycle/scooter	0	16

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 81.61$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

**Figure 4.51: Alone – Main Grocery (Europe) – (Rank from 1 – 3)**

As explained in figure 4.51 above, most respondents considered being alone as the preferred choice (68% before COVID-19 and 76% During COVID-19). Slight increment emphasizes the idea the people were more conservative not to be in close physical connections with the public.

Table 4.61: Alone – Main Grocery (Europe) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.32	1.26
Known Variance	0.22	0.25
Observations	56	38
Hypothesized Mean Difference	0	
z	0.57	
z Critical two-tail	1.96	

As shown in table 4.61 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

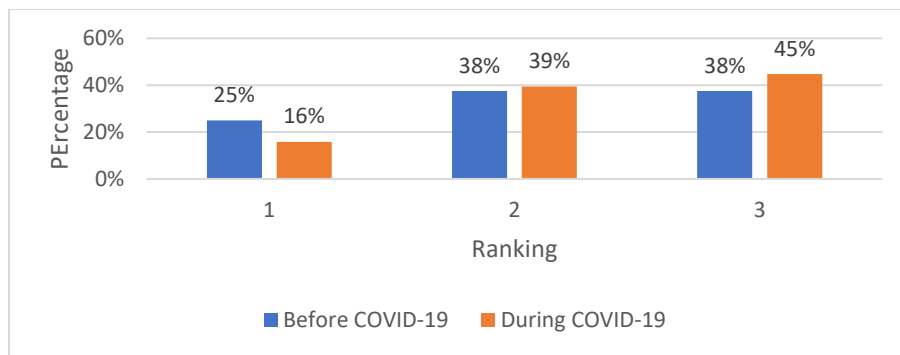
**Figure 4.52: With family – Main Grocery (Europe) - (Rank from 1 – 3)**

Figure 4.52 clearly shows that preference when it comes to being with family in performing the main grocery is approximately equally distributed between 1 (most preferred), 2 (moderate) and 3(not preferred) with almost no difference between before and during COVID-19 situations. Most respondents lay in 2 and 3 choices (from moderate to not preferred).

Table 4.62: With family – Main Grocery (Europe) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.13	2.29
Known Variance	0.62	0.54
Observations	56	38
Hypothesized Mean Difference	0	
z	-1.04	
z Critical two-tail	1.96	

As shown in table 4.62 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

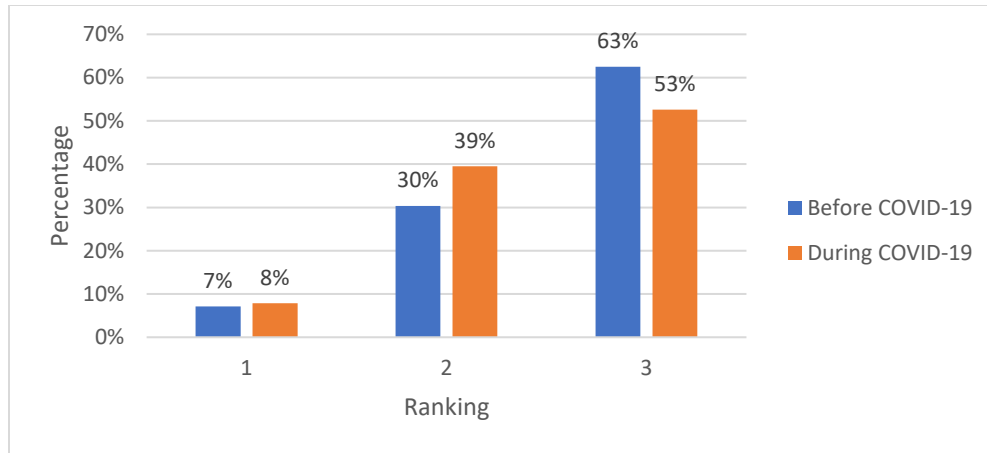


Figure 4.53: With friends – Main Grocery (Europe) – (Rank from 1 – 3)

Figure 4.53 indicates that most respondents did not prefer being with friends in performing their main grocery (Rank 3) (63% before COVID-19 and 53% During COVID-19). However, a considerable percentage were moderate (Rank 2) (30% before COVID-19 and 39% during COVID-19). It is very noticeable that their preference was not impacted by the outbreak.

Table 4.63: With friends – Main Grocery (Europe) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.55	2.45
Known Variance	0.40	0.42
Observations	56	38
Hypothesized Mean Difference	0	
z	0.79	
z Critical two-tail	1.96	

As shown in table 4.63 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

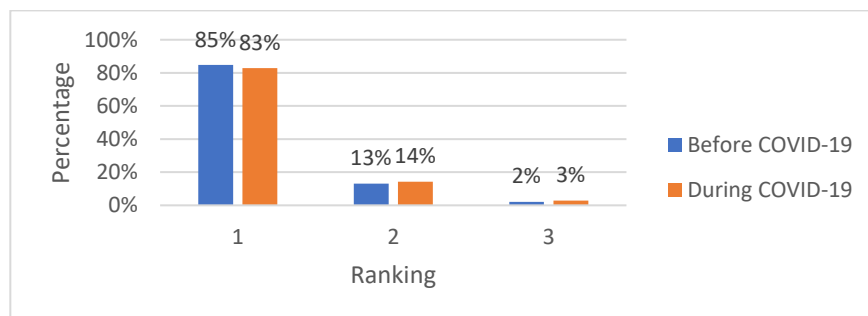


Figure 4.54: Alone – Top-up Grocery (Europe) – (Rank from 1 – 3)

Figure 4.54 above shows clear demonstration that most of respondents preferred being alone (Rank 1) (85% before COVID-19 and 83% during COVID-19) in performing top-up grocery. This is mainly due that top-up groceries are usually close in distance and no need for a companion.

Table 4.64: Alone – Top-up Grocery (Europe) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.173913043	1.2
Known Variance	0.19	0.22
Observations	46	35
Hypothesized Mean Difference	0	
z	-0.25	
z Critical two-tail	1.96	

As shown in table 4.64 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

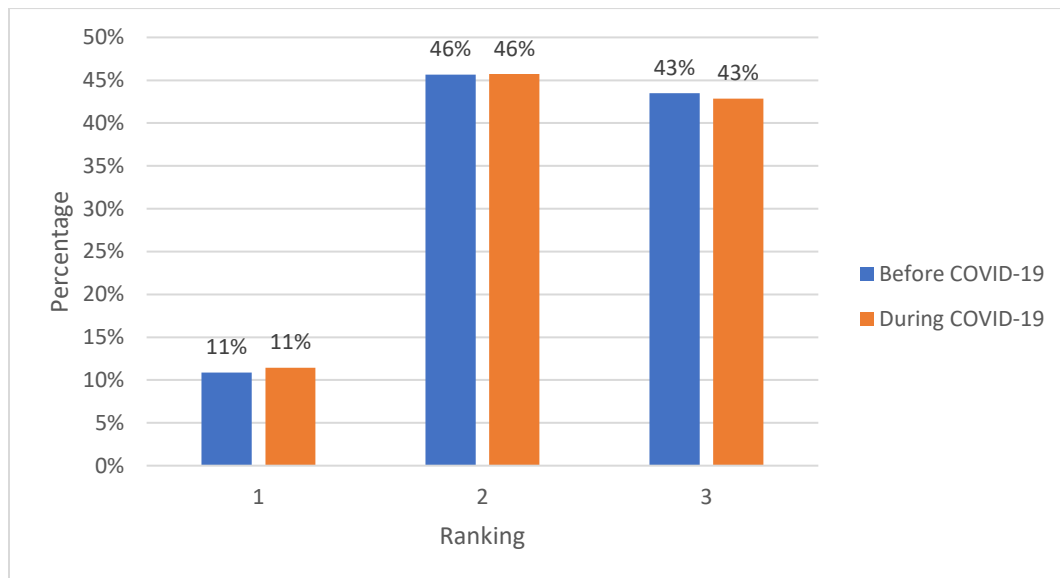


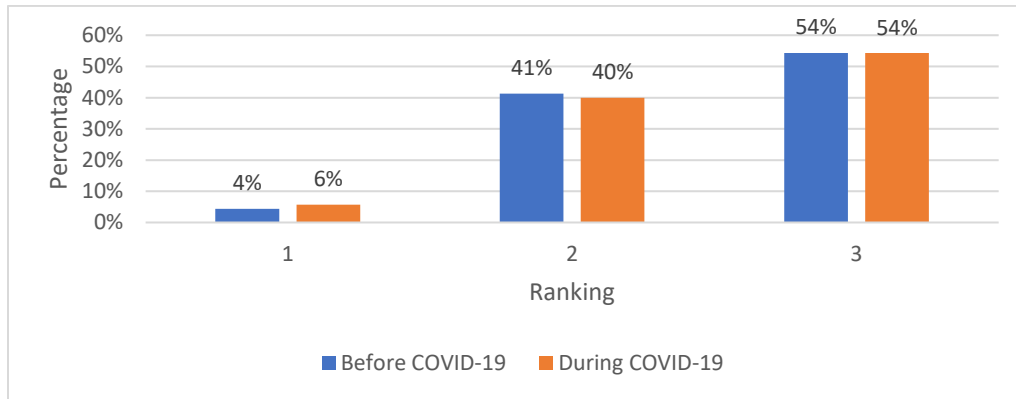
Figure 4.55: With family – Top-up Grocery (Europe) – (Rank from 1 – 3)

As shown in figure 4.55 above most respondents were either moderate (Rank 2) or did not prefer (Rank 3) being with family in performing the top-up grocery (total of 89% before and during COVID-19). Almost no difference in the respondents' preferences between the two situations.

Table 4.65: With family – Top-up Grocery (Europe) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.33	2.31
Known Variance	0.45	0.46
Observations	46	35
Hypothesized Mean Difference	0	
z	0.08	
z Critical two-tail	1.96	

As shown in table 4.65 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

**Figure 4.56: With friends – Top-up Grocery (Europe) – (Rank from 1 – 3)**

As shown in figure 4.56 above, most respondents did not prefer performing the top-up grocery with friends (54% before and during COVID-19). Considerable percentage ranked 2 (fair or moderate) being with friends to perform top-up grocery and the least for the respondents that ranked 1 (preferred being with friends to perform top-up grocery – 4% before COVID-19 and 6% during COVID-19).

Table 4.66: With friends – Top-up Grocery (Europe) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.50	2.49
Known Variance	0.34	0.37
Observations	46	35
Hypothesized Mean Difference	0	
z	0.11	
z Critical two-tail	1.96	

As shown in table 4.66 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

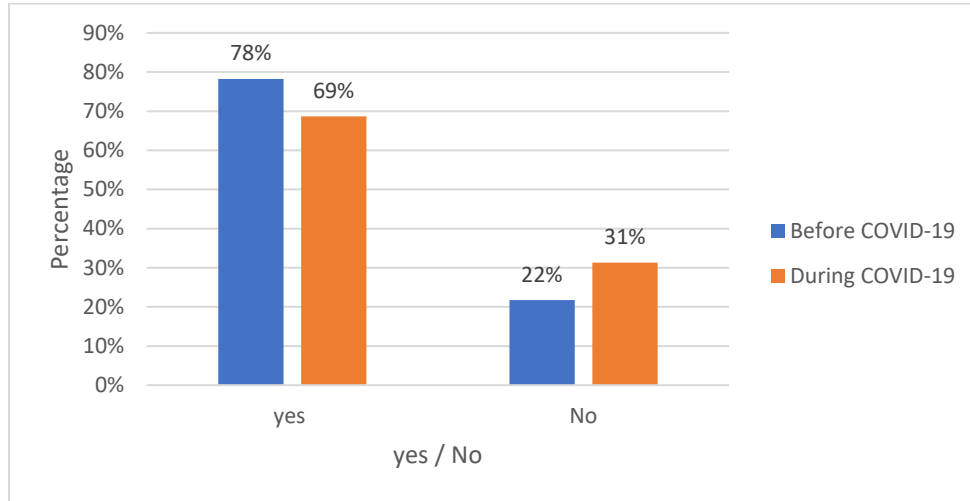


Figure 4.57: Percentages of whether or not performing physical activities– Europe.

Figure 4.57 above clearly demonstrates a slight difference between both situations (Before and During COVID-19) in respect to performing out-of-home activities (22% were not performing any out-of-home activities before COVID-19 and 31% during COVID-19). In contrast, 78% were performing the out-of-home activities before COVID-19 and 69% during COVID-19. This slight decrease in percentage of respondents performing out-of-home activities is possibly due to being more cautious with the precautionary measures against infection.

Table 4.67: Chi-Square Test: Out-of-home activities pre-COVID-19 (Europe).

Respondent answer	Actual number of responses	Expected number of responses
yes	54	35
no	15	35

$$Xc^2_{critical} = 3.84$$

$$Xc^2_{stat} = 22.04$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.68: Chi-Square Test: Out-of-home activities during-COVID-19 (Europe).

Respondent answer	Actual number of responses	Expected number of responses
yes	46	34
no	21	34

$$Xc^2_{critical} = 3.84$$

$$Xc^2_{stat} = 9.32$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

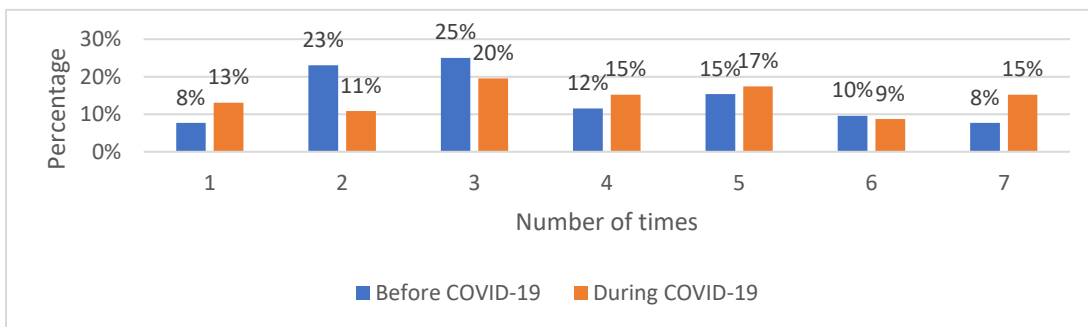


Figure 4.58: Times of performing out-of-home activities in a week– Europe.

As demonstrated in figure 4.58 above, people were performing out-of-home activities 1,2,3,4,5,6 and 7 times in a week almost with the same proportions from the sample. The highest percentage for people performing 3 times a week (25% before COVID-19 and 20% during COVID-19) and the lowest for people performing 1 time a week before COVID-19 (8%) and 6 times a week during COVID-19 (9%).

Table 4.69: Times of performing out-of-home activities in a week - Z test (Europe)

Statistical category	Before COVID-19	During COVID-19
Mean	3.635	4.00
Known Variance	3.02	3.78
Observations	52	46
Hypothesized Mean Difference	0	
z	-0.98	
z Critical two-tail	1.96	

As shown in table 4.69 above, $+z_{critical} \leq z \leq -z_{critical}$ and hence the hypothesis of equal mean is accepted.

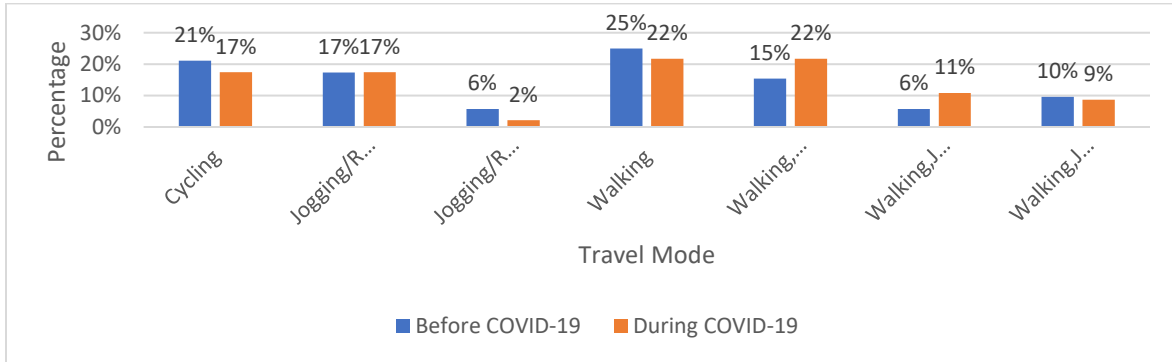


Figure 4.59: Normally performed out-of-home activities) – Europe.

As shown in figure 4.59 above, the majority were performing either walking or cycling or both walking and cycling (total 61% before COVID-19 and 56% during COVID-19). The lowest percentage is for people that were performing jogging/running (6% before COVID-19 and 2% during COVID-19). No noticeable substantial differences between the two situations as people tend to use the favored way of out-of-home activities.

Table 4.70: Out-of-home activities (Before COVID-19) – Europe - Chi Square Test

Out-of-home activity	Actual Number of responses	Expected Number of responses
Cycling	11	7
Jogging/Running	9	7
Jogging/Running,Cycling	3	7
Walking	13	7
Walking,Cycling	8	7
Walking,Jogging/Running	3	7
Walking,Jogging/Running,Cycling	5	7

$$Xc^2_{critical} = 12.59$$

$$Xc^2_{stat} = 12.35$$

Since Xc^2_{stat}

$< Xc^2_{critical}$, then the null hypothesis of equal frequencies is Accepted

Table 4.71: Out-of-home activities (during COVID-19) – Europe – Chi Square Test

Out-of-home activity	Actual Number of responses	Expected Number of responses
Cycling	8	7
Jogging/Running	8	7
Jogging/Running,Cycling	1	7
Walking	10	7
Walking,Cycling	10	7
Walking,Jogging/Running	5	7
Walking,Jogging/Running,Cycling	4	7

$$Xc^2_{critical} = 12.59$$

$$Xc^2_{stat} = 10.30$$

Since Xc^2_{stat}

$< Xc^2_{critical}$, then the null hypothesis of equal frequencies is Accepted

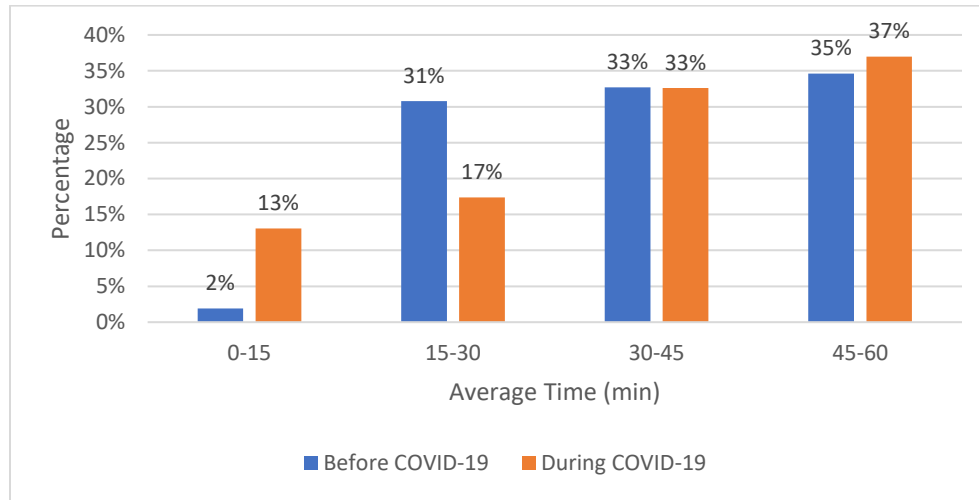


Figure 4.60: Average time spent to perform out-of-home physical activities in minutes per day– Europe.

As indicated in figure 4.60 above, proportions are almost equally distributed between 15-30 minutes, 30-45 minutes and 45-60 minutes before COVID-19. The lowest for respondents that were performing out-of-home activities 0-15 minutes per day (2%). in contrast, during COVID-19, small difference between (30-45 minutes per day) and (45-60 minutes per day) – 33% and 37% respectively. During COVID-19, the lowest

percentage for respondents that were performing out-of-home activities 0-30 minutes a day (30% in total).

Table 4.72: Out-of-home physical activities in minutes per day - Europe (Z test)

Statistical category	Before COVID-19	During COVID-19
Mean	37.5	36.52
Known Variance	167.65	244.02
Observations	52	46
Hypothesized Mean Difference	0	
z	0.33	
z Critical two-tail	1.96	

As shown in table 4.72 above, $+ z_{critical} \leq z \leq - z_{critical}$ and hence the hypothesis of equal mean is accepted.

Table 4.73: Summary - Europe

Subject	Before COVID-19	During COVID-19
Occupational Status	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Trips Performed via bus/train/metro on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Fuel saving percentage as compared to normal situation	The null hypothesis of equal frequencies is rejected	
Number of times the main grocery in a month was performed	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Number of times top-up grocery in a week was performed	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers. - Main Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	

Approximate distance from home to shopping location in kilometers - Top-up Grocery	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
Predominant Travel mode for shopping activities - Main Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Predominant Travel mode for shopping activities - Top-up Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Alone – Main Grocery (Rank from 1 – 3)	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
With family – Main Grocery (Rank from 1 – 3)	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
With friends – Main Grocery (Rank from 1 – 3)	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
Alone – Top-up Grocery (Rank from 1 – 3)	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
With family – Top-up Grocery (Rank from 1 – 3)	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
With friends – Top-up Grocery (Rank from 1 – 3)	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
Whether or not performing out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Times of performing out-of-home activities in a week	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	
Normally performed out-of-home activities	The null hypothesis of equal frequencies is accepted	The null hypothesis of equal frequencies is accepted
Average time spent to perform out-of-home physical activities in minutes per day	Since $+z_{\text{critical}} \leq z \leq -z_{\text{critical}}$, the hypothesis of equal mean is accepted.	

The results of all the questionnaire questions on replies bigger than 30 are summarized in Table 4.73 above. To demonstrate the variance (difference) between the two specified circumstances, statistical tests are carried out (before and during COVID-19). The chi-square test disproves the null hypothesis of equal frequency for each of the examined questions (which means that there are noticeable differences between the studied categories of each tested question) – except question regarding the performed out-of-home activities which actually validates the null hypothesis of equal frequencies between ways of performing out-of-home activities. On the other hand, based on a tolerance of 5%, questions assessed using the Z-test indicate close means (both before and during COVID-19). Regarding the chosen companions, all ranking questions demonstrate that the null hypothesis of equal mean is confirmed (preference was not affected by the outbreak of the virus).

4.2.3.3 India

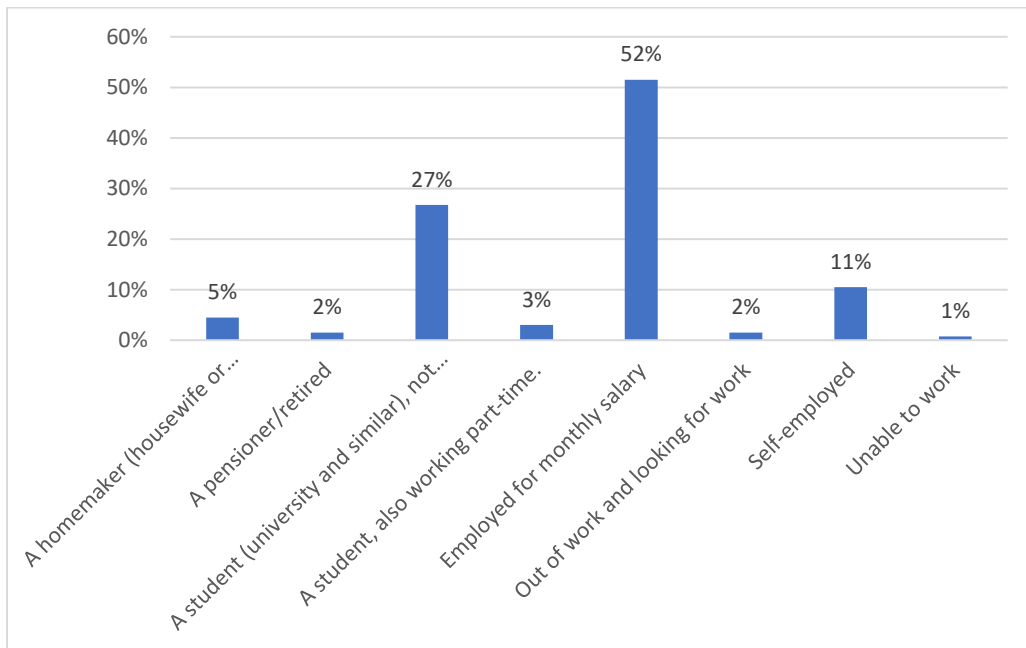


Figure 4. 61: Occupational Status Before COVID-19 / India

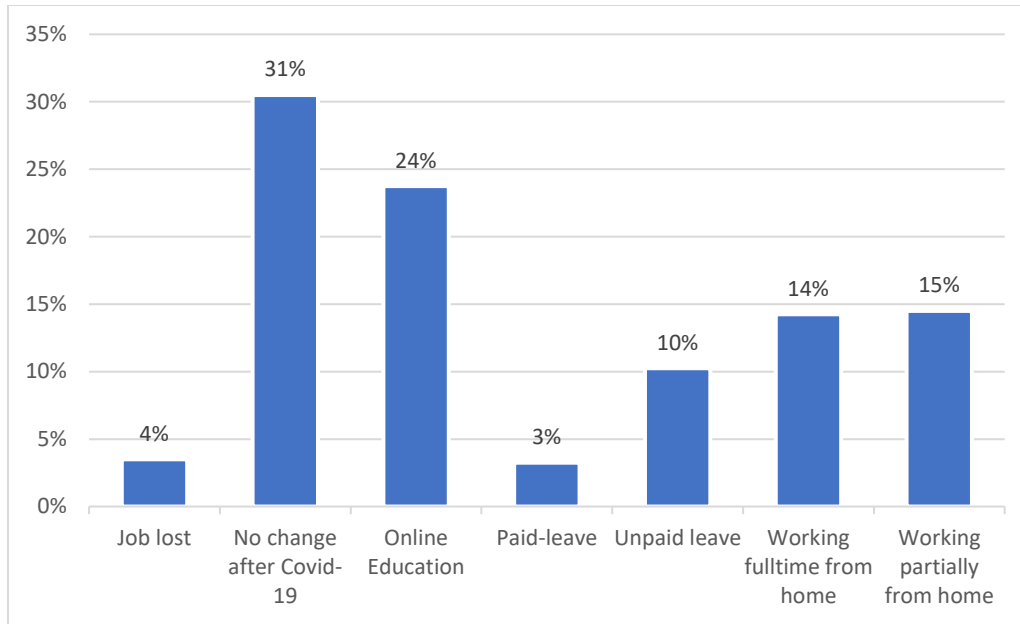


Figure 4.62: Occupational Status during COVID-19 / India

Figures 4.61 and 4.62 above show the difference in occupational status before and during COVID-19. The majority of respondents were employees before COVID-19 (52%). Considerable percentage were university students (27%). In contrast, during COVID-19, most respondents either did not experience any change or shifted to online education (31% and 24% respectively). In the context of during COVID-19 situation, it is noticeable that people also were experiencing work from home either partially (15%) or fully (14%).

Table 4.74: Chi Square Test - (Occupation Status before COVID-19, India)

Occupational Status	Actual number of responses	Expected number of responses
A homemaker (housewife or househusband)	18	50
A pensioner/retired	6	50
A student (university and similar), not working.	107	50
A student, also working part-time.	12	50
Employed for monthly salary	206	50
Out of work and looking for work	6	50
Self-employed	42	50
Unable to work	3	50

$$Xc^2_{critical} = 14.07$$

$$Xc^2stat = 723.96$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

Table 4.75: Chi Square Test - (Occupation Status during COVID-19, India)

Occupational Status	Actual number of responses	Expected number of responses
Job lost	14	57
No change during Covid-19	122	57
Online Education	95	57
Paid-leave	13	57
Unpaid leave	41	57
Working fulltime from home	57	57
Working partially from home	58	57

$$Xc^2critical = 12.59$$

$$Xc^2stat = 169.94$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

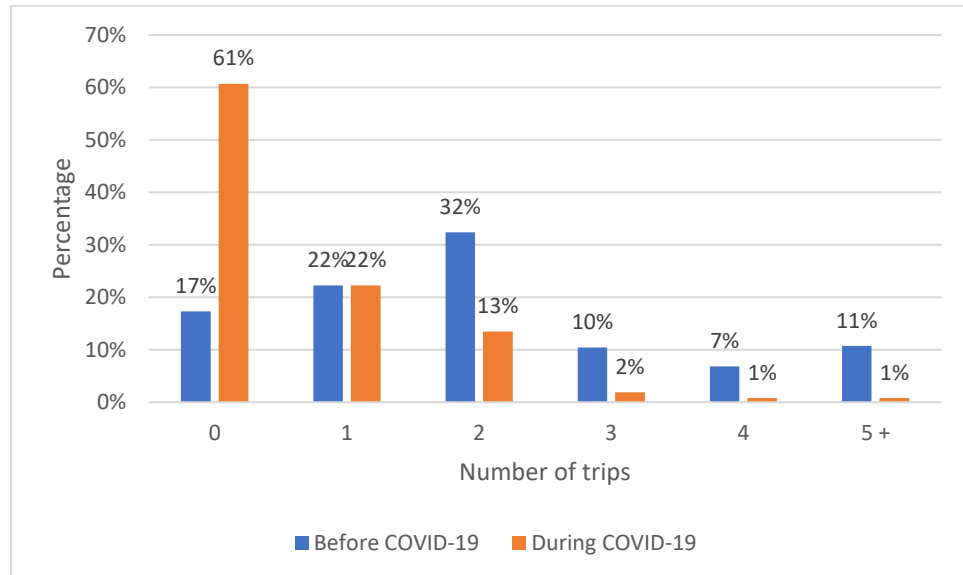


Figure 4.63: Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day, India.

Figure 4.63 above clearly demonstrates no noticeable variances (differences) between number of trips before COVID-19 situation with the largest percentage of 32% (for respondents that were performing 2 trips per day) and the lowest of 7% (for respondents that were performing 4 trips per day). On the other hand, majority respondents tended not to perform any trip during the pandemic via car/carpooling /motorcycle/taxi/uber (61%). The reason of this that most probably people preferred staying at home as a proactive precautionary action.

Table 4.76: Trips/day via car/carpooling/motorcycle/taxi/Uber - Z Test - India

Statistical category	Before COVID-19	During COVID-19
Mean	1.99	0.624
Known Variance	2.26	0.89
Observations	364	364
Hypothesized Mean Difference	0	
z	14.74	
z Critical two-tail	1.96	

As shown in table 4.76 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

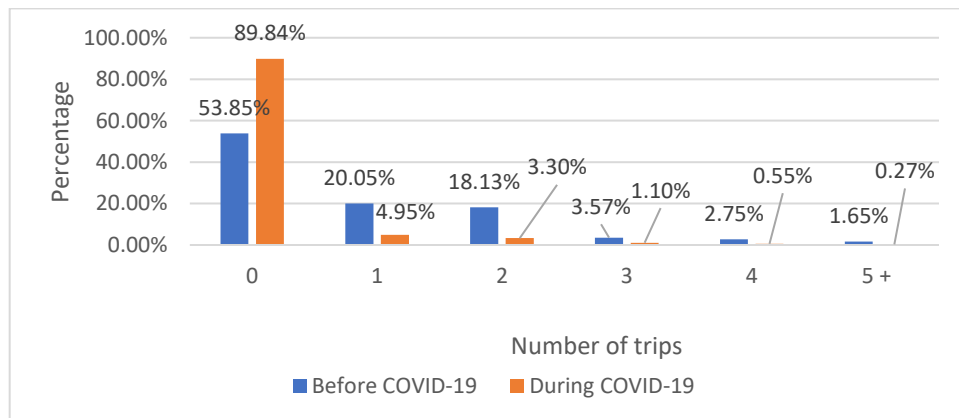


Figure 4.64: Trips performed via bus/train/metro on an average per day , India.

Figure 4.64 above indicates that majority of population are not choosing bus/train/metro as a travel mode (54% did not perform any trip via bus/train/metro on an average per day). However, this percentage increased substantially during COVID-19 (90%). The most likely explanation for this is that many chose to stay at home as a preventative measure and avoid stations where people assemble.

Table 4.77: Trips/day via bus/train/metro - Z Test - India

Statistical category	Before COVID-19	During COVID-19
Mean	0.86	0.18
Known Variance	1.36	0.40
Observations	364	364
Hypothesized Mean Difference	0	
z	9.75	
z Critical two-tail	1.96	

As shown in table 4.77 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

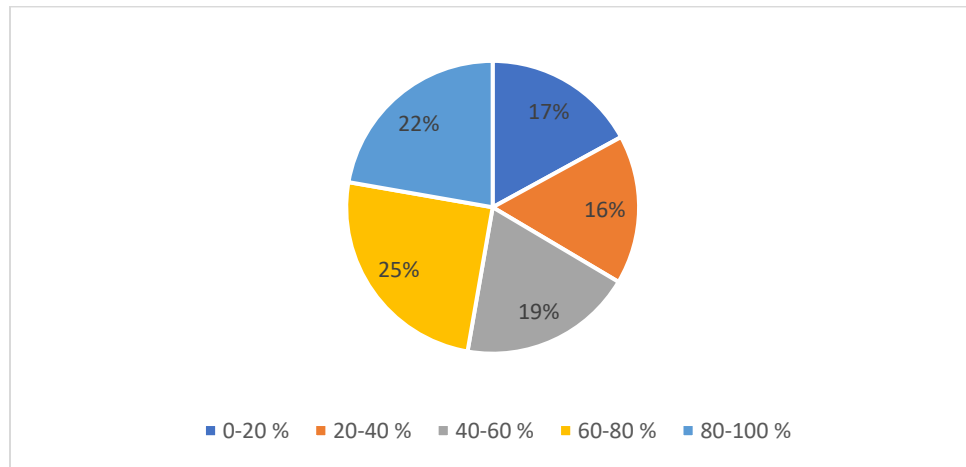


Figure 4.65: Fuel Saving percentage during the Pandemic when compared to normal situation – India.

Figure 4.65 above indicates that respondents are almost equally distributed (as also explained by table 4.76 below using chi-square test) in respect to percentage of fuel saving during COVID-19 compared to normal situation. Highest percentage is for respondents that were saving 60-100% (Total 47%). The lowest percentage is for respondents that were saving 20-40% (16%).

Table 4.78: Fuel saving (during Covid - 19) - Chi-Square analysis - India.

Reduction percentage range	Actual Number of responses	Expected Number of responses
0-20 %	62	73
20-40 %	60	73
40-60 %	70	73
60-80 %	91	73
80-100 %	81	73

$$Xc^2_{critical} = 9.48$$

$$Xc^2_{stat} = 9.43$$

Since Xc^2_{stat}

$< Xc^2_{critical}$, then the null hypothesis of equal frequencies is Accepted

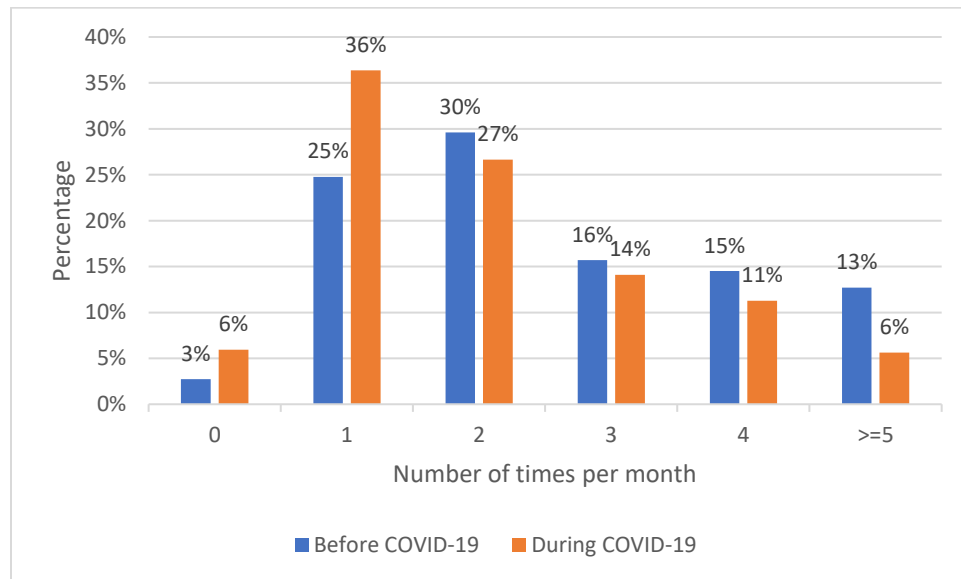


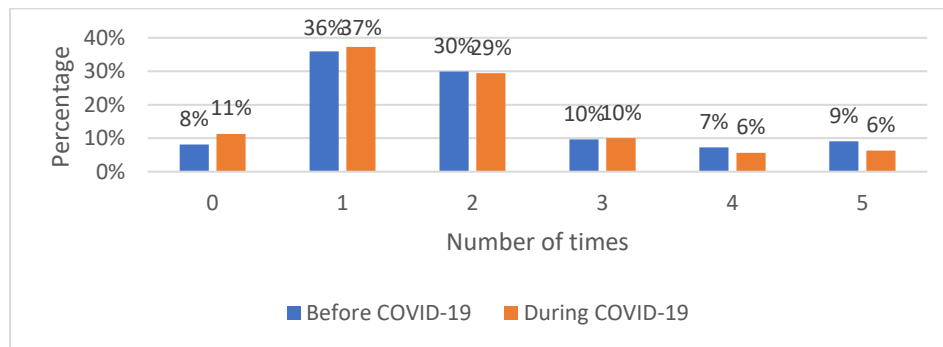
Figure 4.66: Main grocery in a month - India

Figure 4.66 shows slight differences between the two situations (before and during COVID-19). The majority of respondents were performing main grocery twice a month (before COVID-19). Contrary, the majority were performing once a month during COVID-19 (36%). This can most likely be attributed to the fact that many people choose to remain in as a precautionary measure.

Table 4.79: Number of monthly main grocery trips - Z Test - India

Statistical category	Before COVID-19	During COVID-19
Mean	2.53	2.05
Known Variance	1.96	1.70
Observations	331	319
Hypothesized Mean Difference	0	
z	4.45	
z Critical two-tail	1.96	

As shown in table 4.79 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

**Figure 4.67: Number of times top-up grocery in a week , India.**

As demonstrated in figure 4.67 above, the majority were performing top-up grocery 1-2 times a week (total of 66% before COVID-19 and during COVID-19). The lowest percentage is for people that were performing 4 times a week top-up grocery (7% before COVID-19 and 6% during COVID-19). As clearly shown, no noticeable differences between before COVID-19 and during COVID-19 situation. The main reason is that top-up grocery can be considered as a necessity and most probably would not be affected by the outbreak.

Table 4.80: Weekly top-up grocery trips - Z Test - India

Statistical category	Before COVID-19	During COVID-19
Mean	1.99	1.80
Known Variance	1.89	1.68
Observations	331	319
Hypothesized Mean Difference	0	
z	1.80	
z Critical two-tail	1.96	

As shown in table 4.80 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

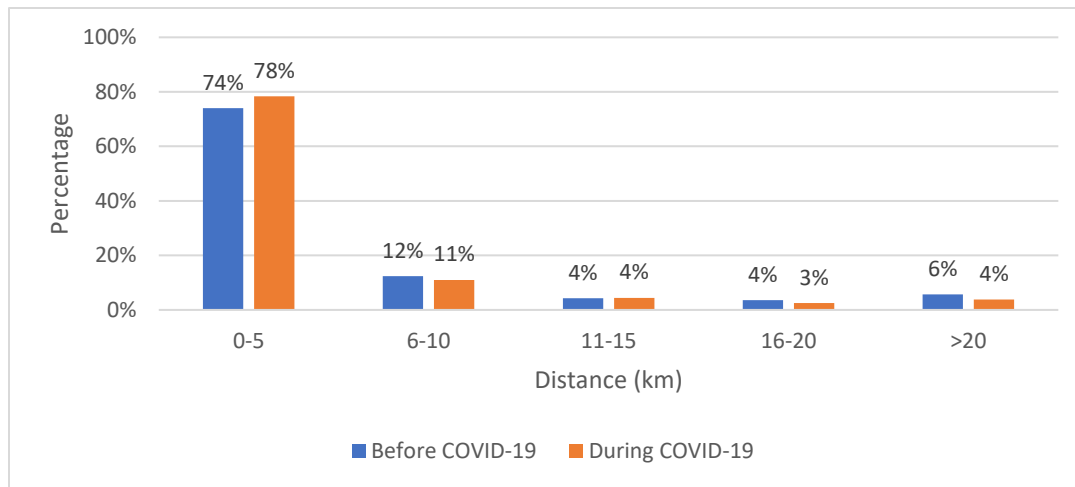


Figure 4.68: Approximate distance from home to shopping location in kilometers. - Main Grocery – India

As can be seen in figure 4.68, there was almost no variation in the respondents' main grocery distances the majority of respondents reported main grocery distances ranging from 0 to 5 km (74% before COVID-19 and 78% during COVID-19, respectively). This indicates that the vast majority of respondents did not switch to a different primary food store or relocate.

Table 4.81: Home-to- main grocery distance (km) - India - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	5.68	4.56
Known Variance	65.14	44.69
Observations	331	319
Hypothesized Mean Difference	0	
z	1.932	
z Critical two-tail	1.96	

As shown in table 4.81 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

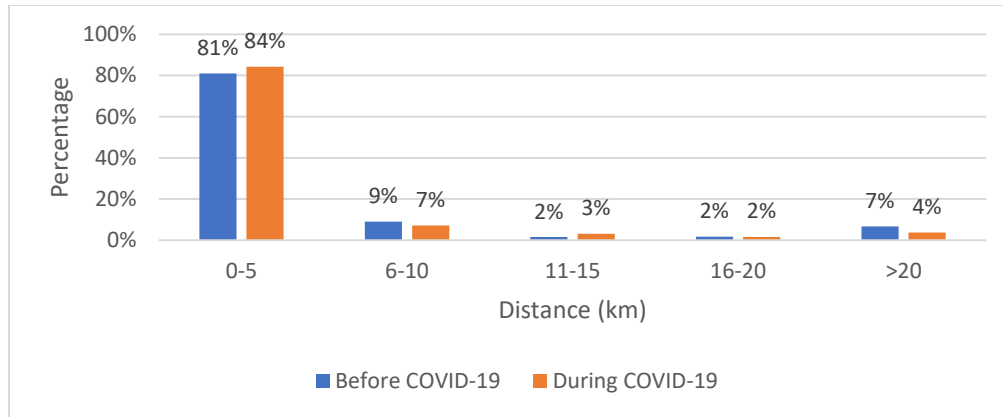


Figure 4.69: Approximate distance from home to shopping location in kilometers. - Top-up Grocery

Close observations were spotted while comparing the distances of the respondents' planned top-up groceries, as shown in figure 4.69 above. The highest proportion of respondents who stated that their desired top-up grocery was located 0-5 km away (81% before COVID-19 and 84% during COVID-19). The lowest proportion for those who experienced to travel 16-20 km (2% before and during COVID-19). This suggests that the great majority of respondents did not relocate or change their regular top-up grocery shop.

Table 4.82: Home-to- top up grocery distance (km) - India - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	4.54	3.77
Known Variance	64.29	46.92
Observations	331	319
Hypothesized Mean Difference	0	
z	1.32	
z Critical two-tail	1.96	

As shown in table 4.82 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

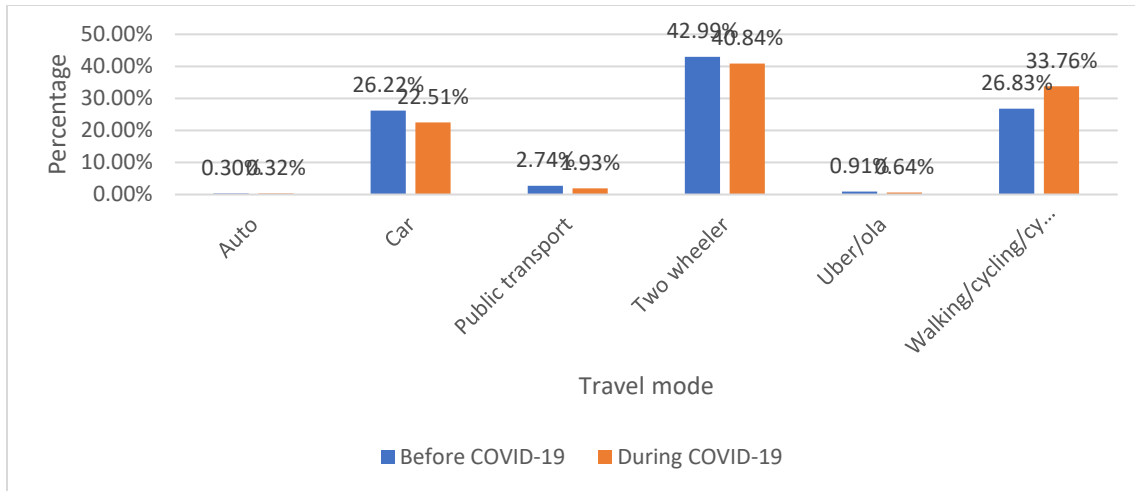


Figure 4.70: Predominant Travel mode for shopping activities - Main Grocery (India)

As indicated in figure 4.70 above, the majority of respondents comprising 43% before COVID-19 and 41% during COVID-19, reported using a two-wheeler as their primary mode of transportation for grocery shopping. The lowest percentage for respondents that were using auto, public transport and uber/ola (3.95% in total before COVID-19 and 3.89% during COVID-19). Travel mode choices were not affected during the outbreak. However, proportions are not similar and slight variances regarding the preferred travel modes chosen before and during COVID-19.

Table 4.83: India: Travel mode vs. grocery shopping (pre-COVID) Chi-Square.

Travel mode	Actual number of responses	Expected number of responses
Auto	1	55
Car	86	55
Public transport	9	55
Two wheeler	141	55
Uber/ola	3	55
Walking/cycling/cycle rickshaw	88	55

$$Xc^2_{critical} = 11.07$$

$$Xc^2_{stat} = 314.29$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

Table 4.84: India: Travel mode vs. grocery shopping (during-COVID) Chi-Square.

Travel mode	Actual number of responses	Expected number of responses
Auto	1	52
Car	70	52
Public transport	6	52
Two wheeler	127	52
Uber/ola	2	52
Walking/cycling/cycle rickshaw	105	52

$$Xc^2critical = 11.07$$

$$Xc^2stat = 308.2$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

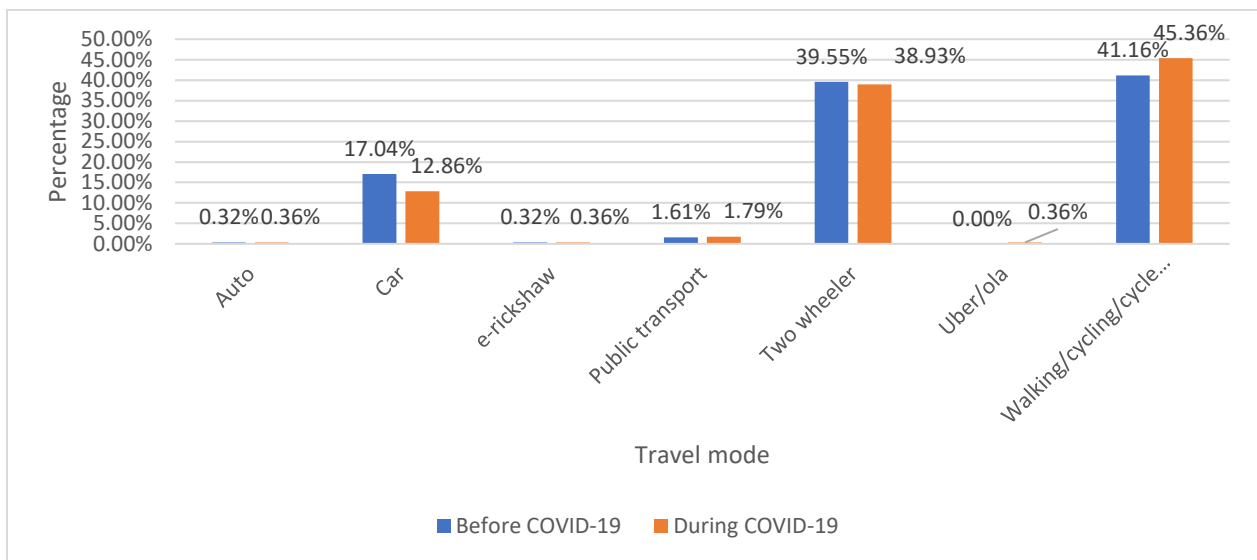


Figure 4.71: Predominant Travel mode for shopping activities - Top-up Grocery (India)

According to figure 4.71 above, the majority of respondents (41.16% during COVID-19) and those (45.36% before COVID-19) used Walking/cycling/cycle rickshaw for their top-

up grocery shopping. The lowest percentage of respondents (0% overall before COVID-19 and 0.36% during COVID-19) reported utilizing an uber/ola. Modes of transportation were unaffected by the pandemic. However, there are small differences in the proportions and favored transport modes.

Table 4.85: India: Travel mode vs. top-up Grocery (pre-COVID) - Chi-Square

Travel mode	Actual number of responses	Expected number of responses
Auto	1	44
Car	53	44
E-rickshaw	1	44
Public transport	5	44
Two wheeler	123	44
Uber/ola	0	44
Walking/cycling/cycle rickshaw	128	44

$$Xc^2_{critical} = 12.59$$

$$Xc^2_{stat} = 462.13$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.86: India: Travel mode vs. top-up Grocery (during-COVID) - Chi-Square

Travel mode	Actual number of responses	Expected number of responses
Auto	1	40
Car	36	40
E-rickshaw	1	40
Public transport	5	40
Two wheeler	109	40
Uber/ola	1	40
Walking/cycling/cycle rickshaw	127	40

$$Xc^2_{critical} = 12.59$$

$$Xc^2_{stat} = 453.35$$

Since Xc^2stat

$> Xc^2critical$, then the null hypothesis of equal frequencies is rejected

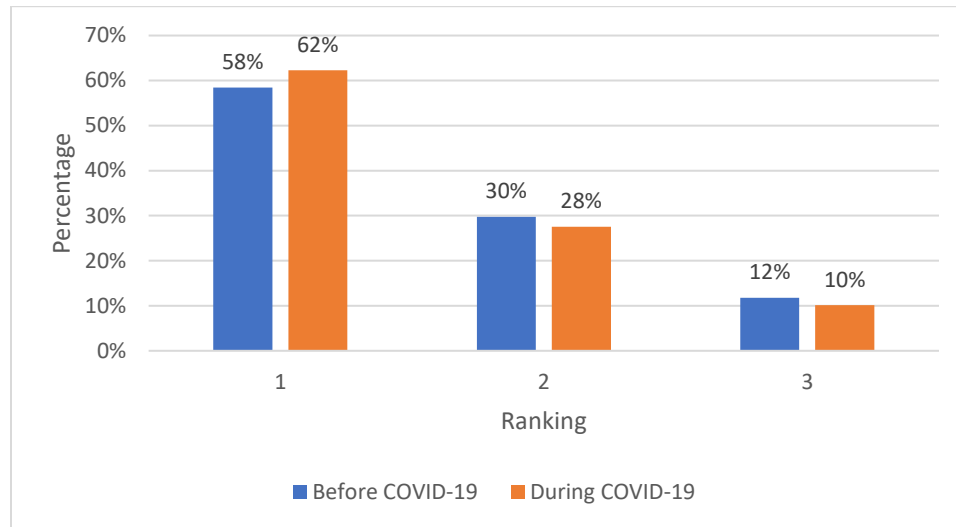


Figure 4.72: Alone – Main Grocery (India) – (Rank from 1 – 3)

Figure 4.72 above shows that most respondents ranked 1 as a most preferred option to be alone in performing main grocery with slight difference between the two situations (Before and during COVID-19) (58% before COVID-19 and 62% during COVID-19). It is noticeable that a considerable percentage ranked 2 (they have fair or moderate preference being alone performing main grocery (30% before COVID-19 and 28% during COVID-19). It is also obvious that respondents who ranked 1 increased during COVID-19 (even if slight) while decreased in respect to 2 and 3 rankings which basically reflects the situation during COVID-19 that people tended to take the proper precautions.

Table 4.87: Alone – Main Grocery (India) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.53	1.48
Known Variance	0.49	0.46
Observations	272	138
Hypothesized Mean Difference	0	
z	0.77	
z Critical two-tail	1.96	

As shown in table 4.87 above, $+ z critical \leq z \leq - z critical$ and hence the hypothesis of equal mean is accepted.

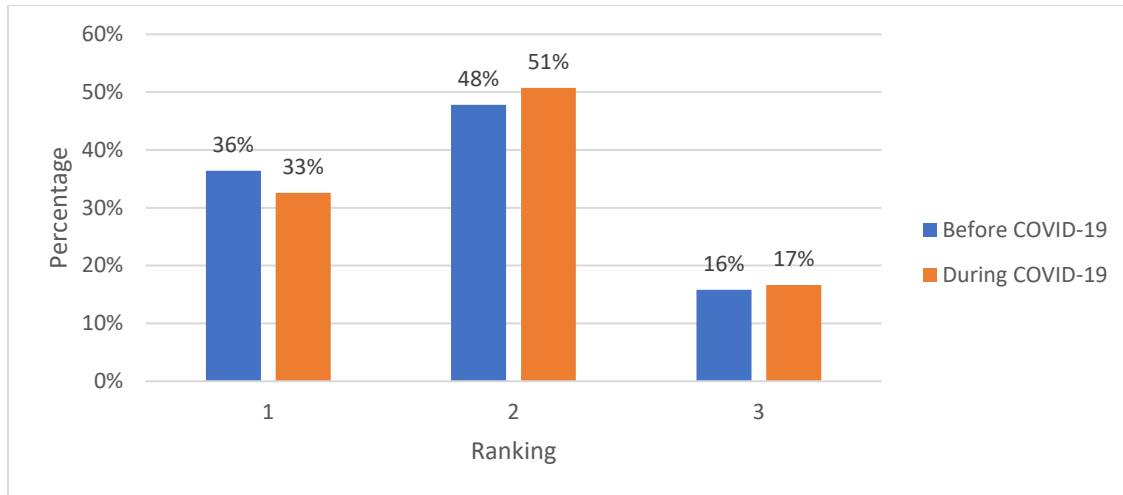


Figure 4.73: With family – Main Grocery (India) – (Rank from 1 – 3)

Figure 4.73 above demonstrates that the majority of respondents chose option 2 as their first choice while completing their main grocery shopping with family, with just a little variation between both times (before and during COVID-19) (48% before COVID-19 and 51% during COVID-19). It is apparent that a sizeable portion of respondents, 36% before COVID-19 and 33% during COVID-19, rated 1 (they preferred being with family in performing main groceries). It is also clear that respondents who ranked 1 decreased (even slightly) during COVID-19 while rankings for 2 and 3 increased, which essentially represents the fact that during COVID-19, individuals were willing to take the appropriate precautionary measures.

Table 4.88: With family – Main Grocery (India) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.79	1.84
Known Variance	0.48	0.47
Observations	272	138
Hypothesized Mean Difference	0	
z	-0.65	
z Critical two-tail	1.96	

As shown in table 4.88 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

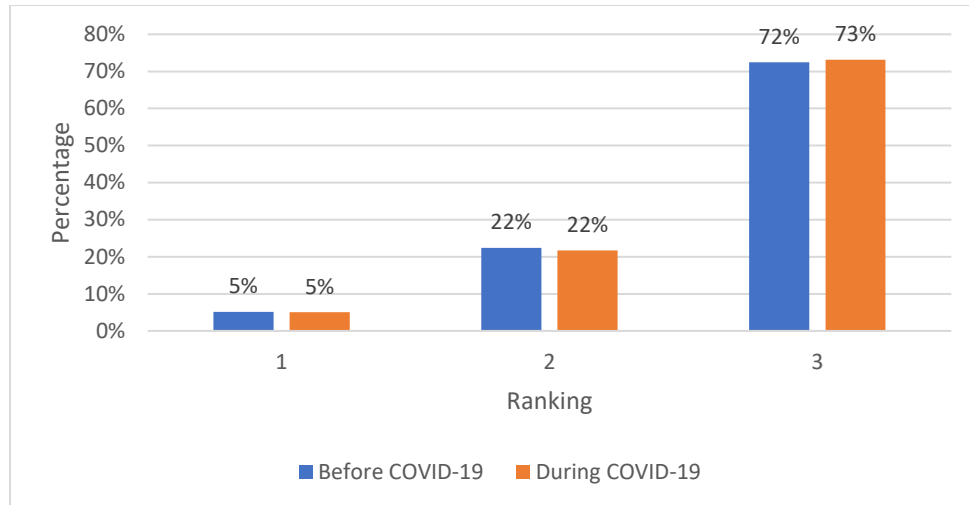


Figure 4.74: With friends – Main Grocery (India) – (Rank from 1 – 3)

According to Figure 4.74, the majority of respondents (72% before COVID-19 and 73% during COVID-19) did not like doing their main food shopping with friends. But a sizable portion (Rank 2) were moderate (22% before and during COVID-19). It is clear that the pandemic had no effect on their preference.

Table 4.89: With friends – Main Grocery (India) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.67	2.68
Known Variance	0.32	0.32
Observations	272	138
Hypothesized Mean Difference	0	
z	-0.14	
z Critical two-tail	1.96	

As shown in table 4.89 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

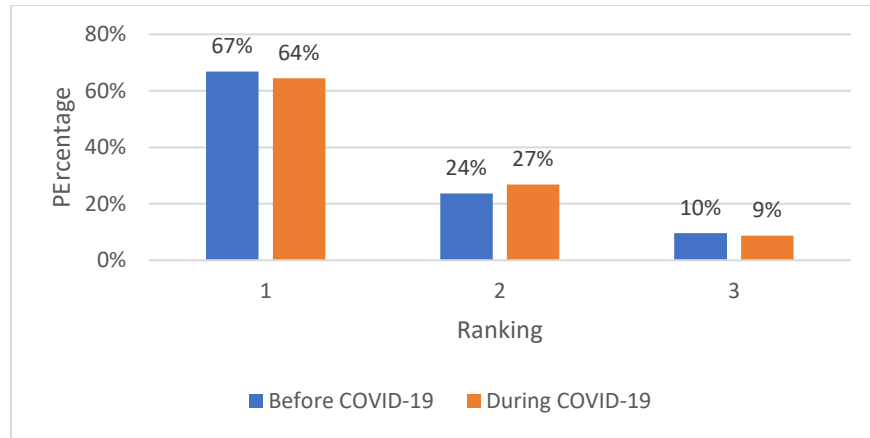


Figure 4.75: Alone – Top-up Grocery (India) – (Rank from 1 – 3)

With just a little difference between the two periods (before and during COVID-19), Figure 4.75 above shows that the majority of respondents picked option 1 as their first choice while conducting their top-up grocery shopping alone (67% before COVID-19 and 64% during COVID-19). It is clear that a sizable percentage of respondents—27% during COVID-19 and 24% before COVID-19—rated 2 (they have a medium or moderate preference for doing their top-up shopping alone). Both situations have the similar types of responses (before and during COVID-19) and as proved in the Z-test performed below (table 4.89).

Table 4.90: Alone – Top-up Grocery (India) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.43	1.44
Known Variance	0.44	0.42
Observations	271	149
Hypothesized Mean Difference	0	
z	-0.22	
z Critical two-tail	1.96	

As shown in table 4.90 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

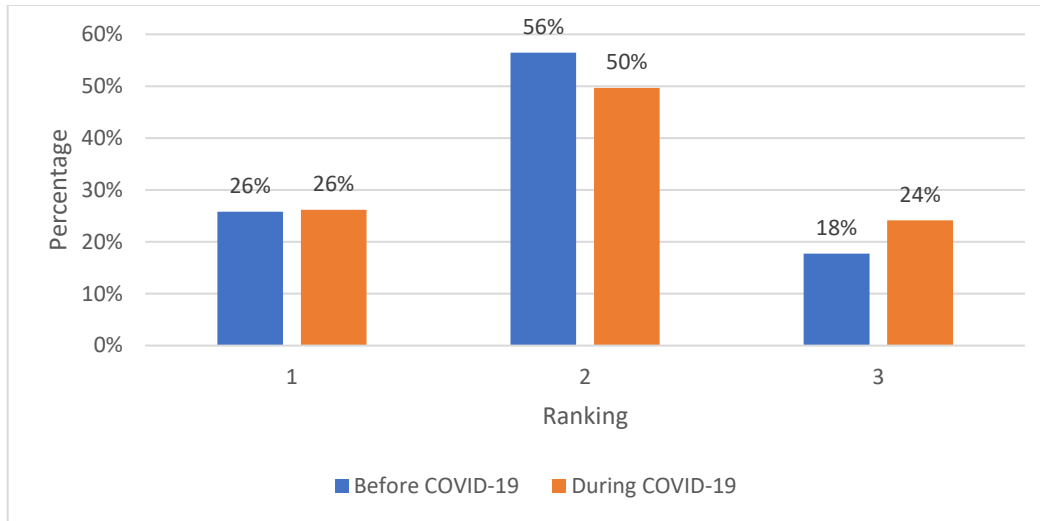


Figure 4.76: With family – Top-up Grocery (India) –Rank from 1 – 3)

With just a little difference between both times periods (before and during COVID-19). Figure 4.76 above shows that the majority of respondents picked option 2 as their first choice while doing their top-up grocery shopping with family (56% before COVID-19 and 50% during COVID-19). It is clear that a sizable percentage of respondents—26% before and during COVID-19 rated 1 (they preferred doing the top-up grocery with family). As seen in the Z-test conducted below (table 4.91), both scenarios (before and during COVID-19) had comparable sorts of replies.

Table 4.91: With family – Top-up Grocery (India) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.92	1.98
Known Variance	0.43	0.51
Observations	271	149
Hypothesized Mean Difference	0	
z	-0.86	
z Critical two-tail	1.96	

As shown in table 4.91 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

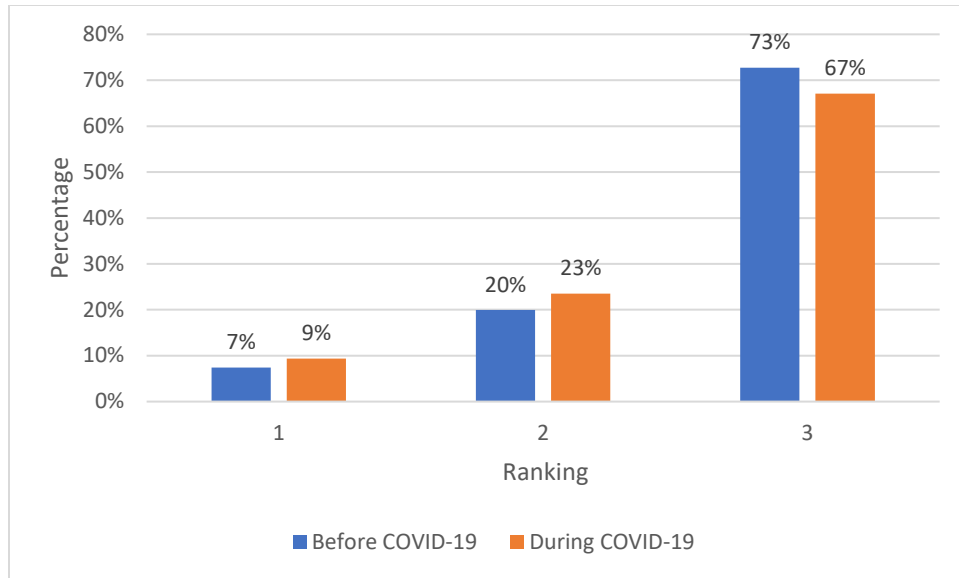


Figure 4.77: With friends – Top-up Grocery (India) – (Rank from 1 – 3)

Figure 4.77 shows that the majority of survey participants (73% before COVID-19 and 67% during COVID-19) did not prefer performing top-up grocery shopping with friends. However, considerable percentage (20% before COVID-19 and 23% during COVID-19). The epidemic clearly had no impact on their preference.

Table 4.92: With friends – Top-up Grocery (India) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.65	2.58
Known Variance	0.37	0.43
Observations	271	149
Hypothesized Mean Difference	0	
z	1.16	
z Critical two-tail	1.96	

As shown in table 4.92 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

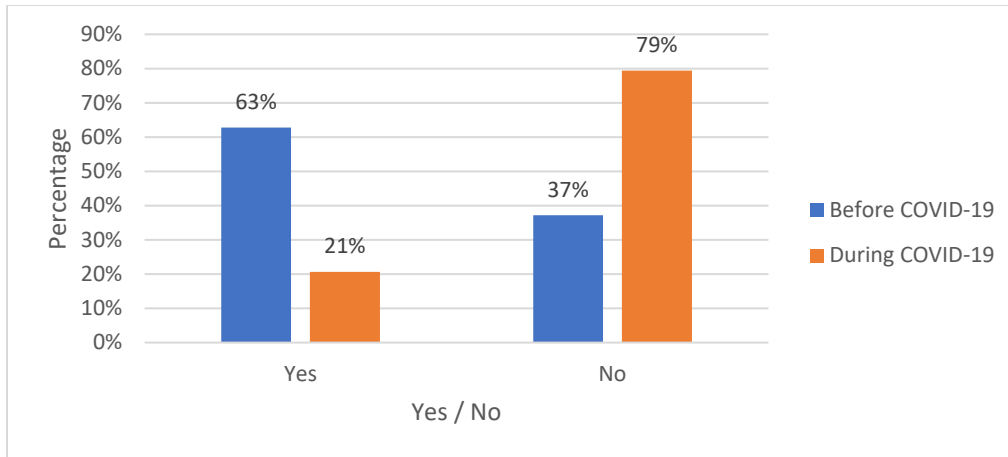


Figure 4.78: Whether or not performing out-of-home activities, India.

Figure 4.78 above demonstrates that there was a substantial decrease in the respondents that were performing Out-of-Home activities before COVID-19 comparing to during COVID-19 situation (63% of respondents were performing out-of-home activities while 79% were not performing any out-of-home activities) which clearly shows the impact of precautionary measures and governmental restrictions / rules during the outbreak.

Table 4.93: Chi-Square Test: Out-of-home activities pre-COVID-19 (India).

Respondent answer	Actual number of responses	Expected number of responses
Yes	199	159
No	118	159

$$Xc^2_{critical} = 3.84$$

$$Xc^2_{stat} = 20.67$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.94: Chi-Square Test: Out-of-home activities during-COVID-19 (India).

Respondent answer	Actual number of responses	Expected number of responses
Yes	65	158
No	250	158

$$Xc^2_{critical} = 3.84$$

$$Xc^2_{stat} = 108.65$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

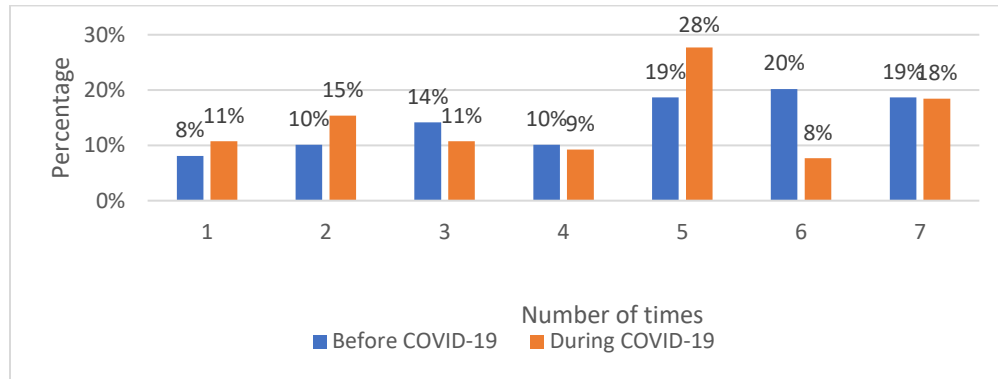


Figure 4.79: Times of performing Out-of-home physical activities in a week (Before and During COVID-19) – India

Figure 4.79 above demonstrates that respondents are roughly equally distributed in their performance of out-of-home activities with the largest percentage for respondents that were performing out-of-home activities 5 times a week during COVID-19 (28%) and 6 times a week (before COVID-19 – 20%). Results (before and during COVID-19) are close since people who continued to perform out-of-home activities would most probably perform them with the same frequency.

Table 4.95: Times of performing out-of-home activities in a week - Z test (India)

Statistical category	Before COVID-19	During COVID-19
Mean	4.57	4.25
Known Variance	3.65	3.94
Observations	198	65
Hypothesized Mean Difference	0	
z	1.14	
z Critical two-tail	1.96	

As shown in table 4.95 above, $+ z_{critical} \leq z \leq - z_{critical}$ and hence the hypothesis of equal mean is accepted.

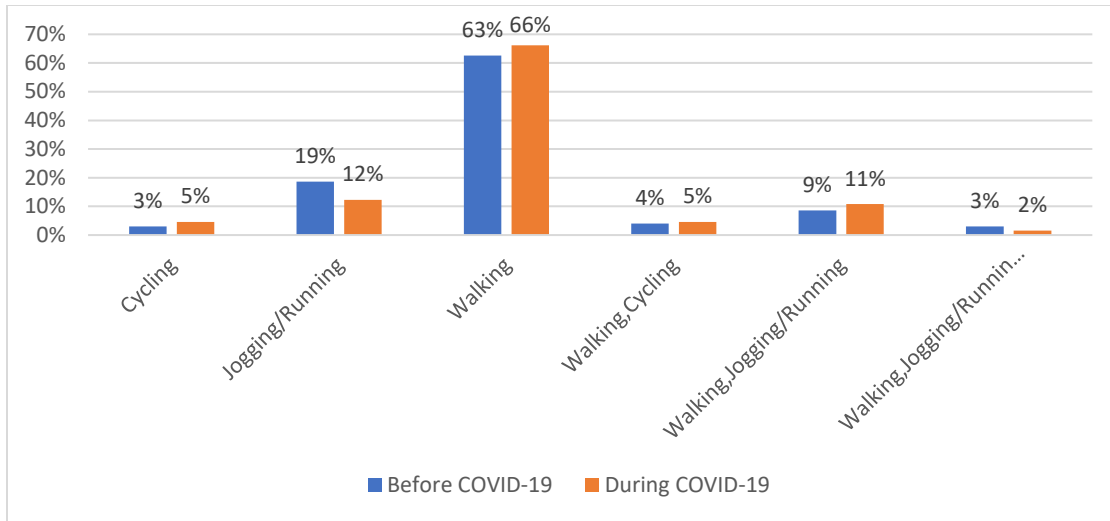


Figure 4.80: Normally performed out-of-home activities – India

As illustrated in figure 4.80 above, majority were performing out-of-home activities by walking (63% before COVID-29 and 66% during COVID-19), while the minority were performing walking, jogging/ Running, cycling (3% before COVID-19 and 2% during COVID-19). Negligible differences between both situations as people's preferences in performing out-of-home activities normally would not change if there was no governmental or restrictions in respect to certain type of out-of-home activities.

Table 4.96: Out-of-home activities (Before COVID-19) – India - Chi Square Test

Statistical category	Actual number of responses	Expected number of responses
Cycling	6	33
Jogging/Running	37	33
Walking	124	33
Walking,Cycling	8	33
Walking,Jogging/Running	17	33
Walking,Jogging/Running,Cycling	6	33

$$Xc^2_{critical} = 11.07$$

$$Xc^2_{stat} = 322.30$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.97: Out-of-home activities (during COVID-19) – India – Chi Square Test

Statistical category	Actual number of responses	Expected number of responses
Cycling	3	11
Jogging/Running	8	11
Walking	43	11
Walking,Cycling	3	11
Walking,Jogging/Running	7	11
Walking,Jogging/Running,Cycling	1	11

$$Xc^2_{critical} = 11.07$$

$$Xc^2_{stat} = 117.86$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

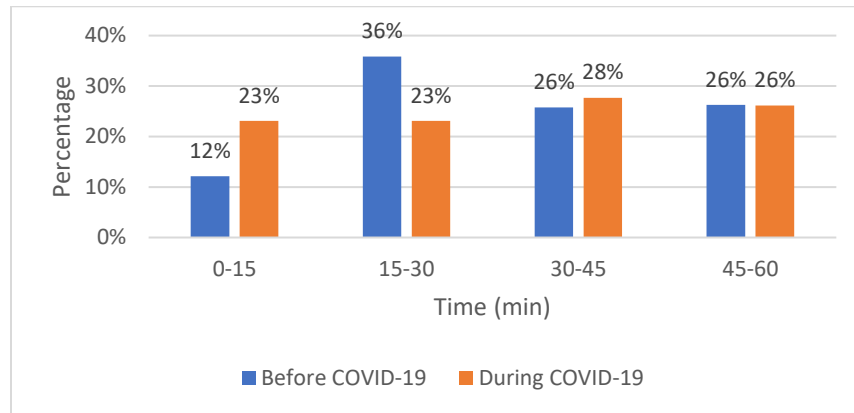


Figure 4.81: Average time spent to perform out-of-home physical activities in minutes per day – India

Figure 4.81 shows that average time spent in performing outside-the-home activities in minutes per day is approximately evenly distributed, with the biggest percentage for respondents who were conducting outside-the-home activities 30-45 minutes per day during COVID-19 (28%) and 30-45 minutes per day before COVID-19 (36%). Results (before and during COVID-19) are comparable because those who continued to engage in outside-the-home activities would likely do so with the same pace.

Table 4.98: Out-of-home physical activities in minutes per day - India (Z test)

Statistical category	Before COVID-19	During COVID-19
Mean	32.42	31.04
Known Variance	224.23	281.03
Observations	198	65
Hypothesized Mean Difference	0	
z	0.59	
z Critical two-tail	1.96	

As shown in table 4.98 above, $+ z_{critical} \leq z \leq - z_{critical}$ and hence the hypothesis of equal mean is accepted.

Table 4.99: Summary– India

Subject	Before COVID-19	During COVID-19
Occupational Status	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected.
Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Trips Performed via bus/train/metro on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Fuel saving percentage as compared to normal situation	The null hypothesis of equal frequencies is accepted	
Number of times the main grocery was performed in a month	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Number of times top-up grocery in a week was performed	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers. - Main Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers - Top-up Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Predominant Travel mode for shopping	The null hypothesis of equal frequencies is	The null hypothesis of equal frequencies is

activities - Main Grocery	rejected	rejected
Predominant mode for shopping activities - Top-up Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Alone – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With family – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With friends – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Alone – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With family – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With friends – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Whether or not performing out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Times of performing out-of-home activities in a week	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Normally performed out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Average time spent to perform out-of-home physical activities in minutes per day	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	

Table 4.99 above summarizes the findings of all the questionnaire items pertaining to responses greater than 30. Statistical tests are carried out (both before and during COVID-19) to show the variance (difference) between the two given conditions. With the exception of fuel saving question which accepts the null hypothesis of equal frequencies (based on 5% tolerance), the chi-square test rejects the null hypothesis of equal frequencies for each of the examined question (which means that there are discernible

differences between the studied categories of each tested question). On the other hand, questions examined using the Z-test reveal close means (both before and during COVID-19), based on a tolerance of 5% except questions in regards to trips performed using various modes + number of times main grocery was performed in a month.

4.2.3.4 Pakistan

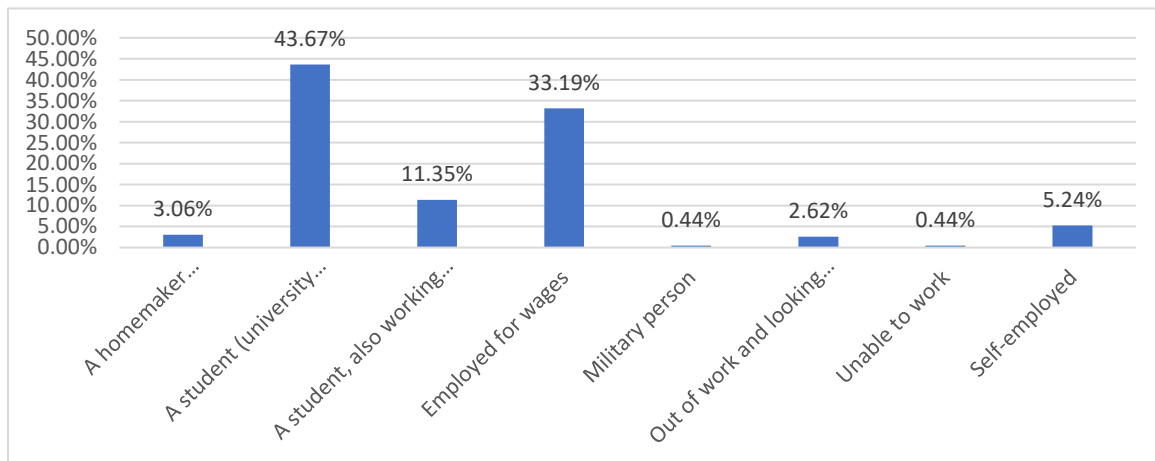


Figure 4.82: Occupational Status before COVID-19 – Pakistan

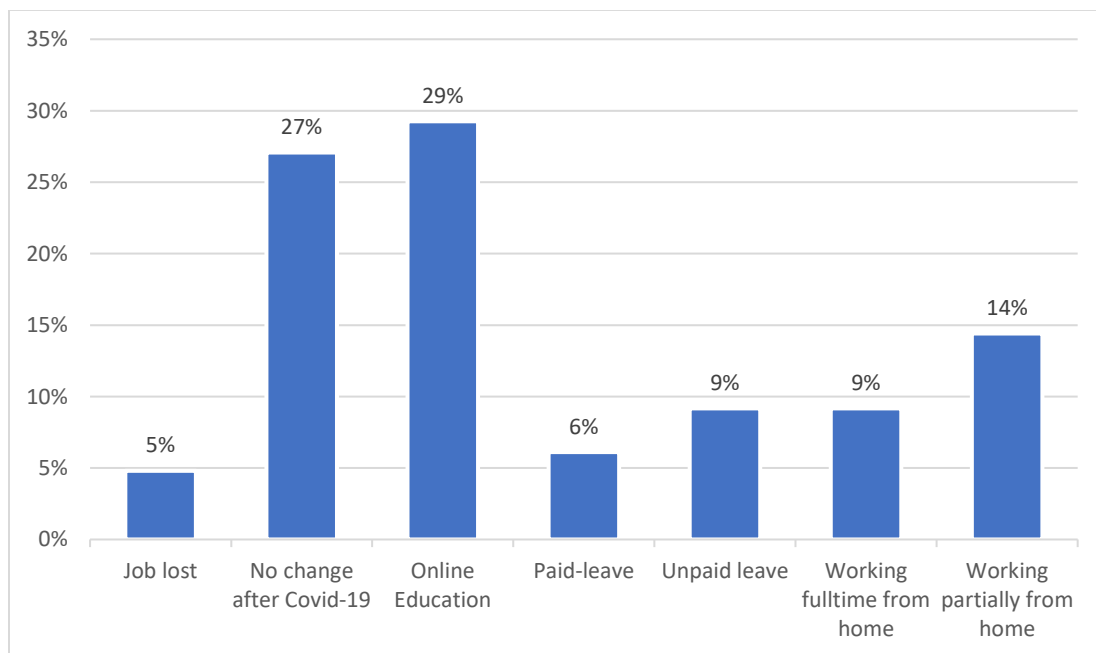


Figure 4.83: Occupational Status before COVID-19 / Pakistan

As shown in figures 4.82 and 4.83 above, before COVID-19, most respondents were students and employees (employed for wages). During COVID-19, most respondents shifted to online education (29%) and a considerable percentage did not experience any change (27%). 23% in total for respondents that were working full-time and partially from home. Results of this depend on circumstances and situations of the organizations / educational institutions as different entities would have different policies to combat the virus outbreak and find the optimum solutions.

Table 4.100: Chi Square Test - (Occupation Status Before COVID-19, Pakistan)

Occupational status	Actual number of responses	Expected number of responses
A homemaker (housewife or househusband)	7	29
A student (university and similar), not working.	100	29
A student, also working part-time.	26	29
Employed for wages	76	29
Military person	1	29
Out of work and looking for work	6	29
Unable to work	1	29
Self-employed	12	29

$$Xc^2_{critical} = 14.07$$

$$Xc^2_{stat} = 353.8$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.101: Chi Square Test - (Occupation Status During COVID-19, Pakistan)

Occupational status	Actual number of responses	Expected number of responses
Job lost	11	33
No change during Covid-19	62	33
Online Education	67	33
Paid-leave	14	33
Unpaid leave	21	33
Working fulltime from home	21	33
Working partially from home	33	33

$$Xc^2_{critical} = 12.59$$

$$Xc^2_{stat} = 95.66$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

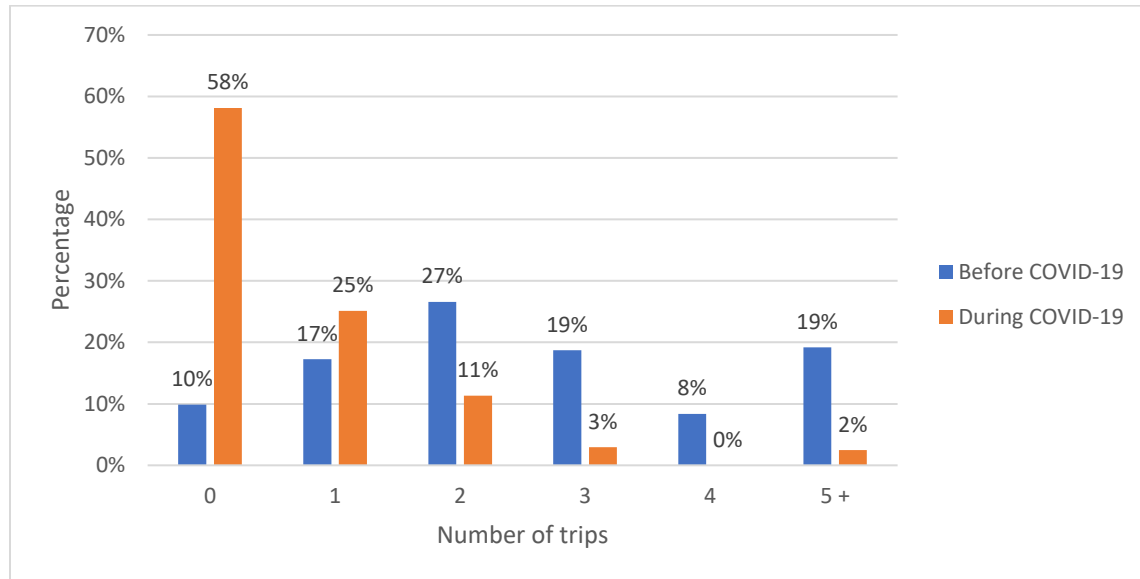


Figure 4.84: Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day – Pakistan.

Figure 4.84 above demonstrates that before COVID-19, results were almost equally distributed with no substantial differences between the number of trips. However, during COVID-19, respondents tended not to perform any activity using the car/carpooling /motorcycle/taxi/uber (58%) and 5% in total were performing 3+ trips on average per day. This gives a clear indication and explanation that people were taking the appropriate precautionary measures against infection and spreading of the virus.

Table 4.102: Trips/day via car/carpooling/motorcycle/taxi/Uber - Z Test - Pakistan

Statistical category	Before COVID-19	During COVID-19
Mean	2.56	0.69
Known Variance	2.51	1.12
Observations	203	203
Hypothesized Mean Difference	0	
z	14.00	
z Critical two-tail	1.96	

As shown in table 4.102 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

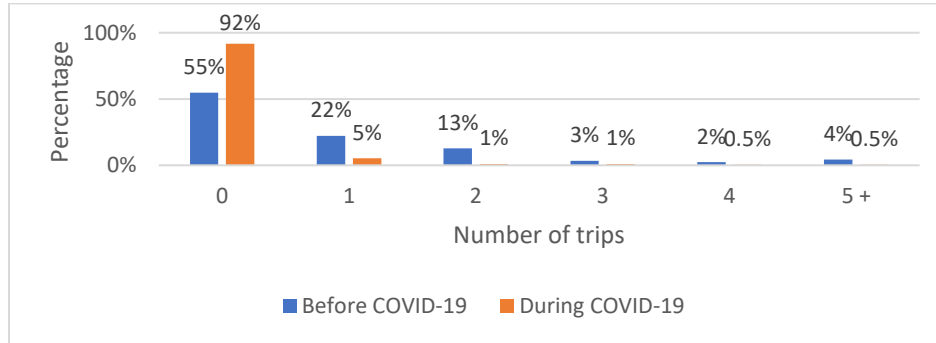


Figure 4.85: Trips performed via bus/train/metro on an average per day.

Figure 4.85 above clearly illustrates that number of respondents who were not performing any trips (0 trips) by bus/train/metro increased from 55% (before COVID-19) to 92% (During COVID-19). This exponential increase most probably was due to precautions, quarantine, governmental controls, etc.

Table 4.103: Trips/day via bus/train/metro - Z Test – Pakistan

Statistical category	Before COVID-19	During COVID-19
Mean	0.90	0.15
Known Variance	1.74	0.36
Observations	203	203
Hypothesized Mean Difference	0	
z	7.40	
z Critical two-tail	1.96	

As shown in table 4.103 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

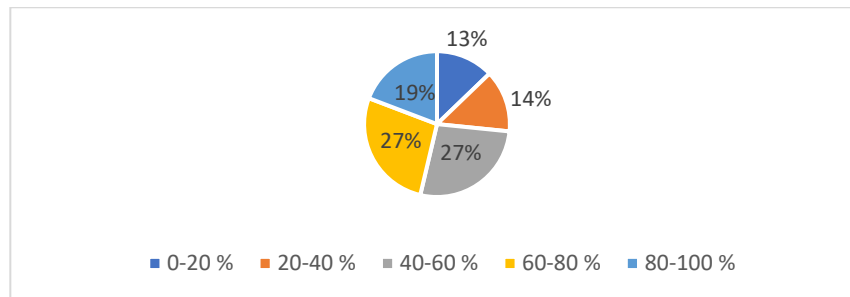


Figure 4.86: Fuel Saving percentage during the Pandemic when compared to normal situation – Pakistan.

Referring to figure 4.86 above, majority of the sample (54% in total) were saving around 40-80%. Only 13% stated that they were saving 0-20%. This indicates that people were more cautious when it comes to recreational trips and other unnecessary trips during the time of the outbreak.

Table 4.104: Fuel saving (during Covid - 19) - Chi-Square analysis - Pakistan.

Reduction percentage range	Actual Number of responses	Expected Number of responses
0-20 %	26	41
20-40 %	28	41
40-60 %	55	41
60-80 %	55	41
80-100 %	39	41

$$Xc^2_{critical} = 9.49$$

$$Xc^2_{stat} = 19.44$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

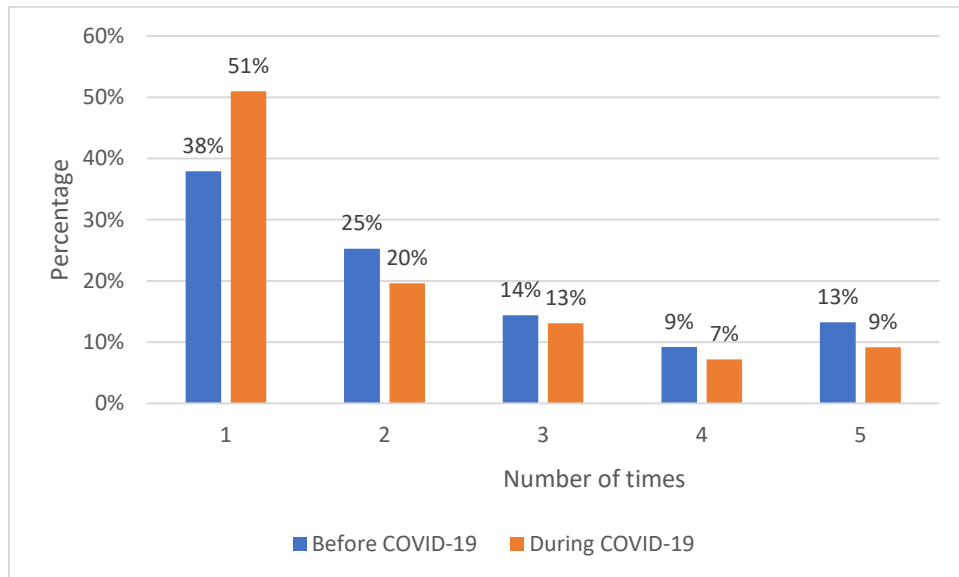


Figure 4.87: Main grocery in a month - Pakistan

Figure 4.87 above shows that results are close to each other to some extent. Respondents that were performing main grocery only once a month increased from 38% (before COVID-19) to 51% (during COVID-19). This increase is due that people tended to stay at home more (perhaps shopping online, buying the necessities with large quantities, etc.).

Table 4.105: Number of monthly grocery trips - Z Test - Pakistan

Statistical category	Before COVID-19	During COVID-19
Mean	2.34	2.04
Known Variance	1.9729	1.76
Observations	174	153
Hypothesized Mean Difference	0	
z	2.02	
z Critical two-tail	1.96	

As shown in table 4.105 above, since $Z_{stat} > Z_{critical}$, then the null hypothesis of equal mean is rejected.

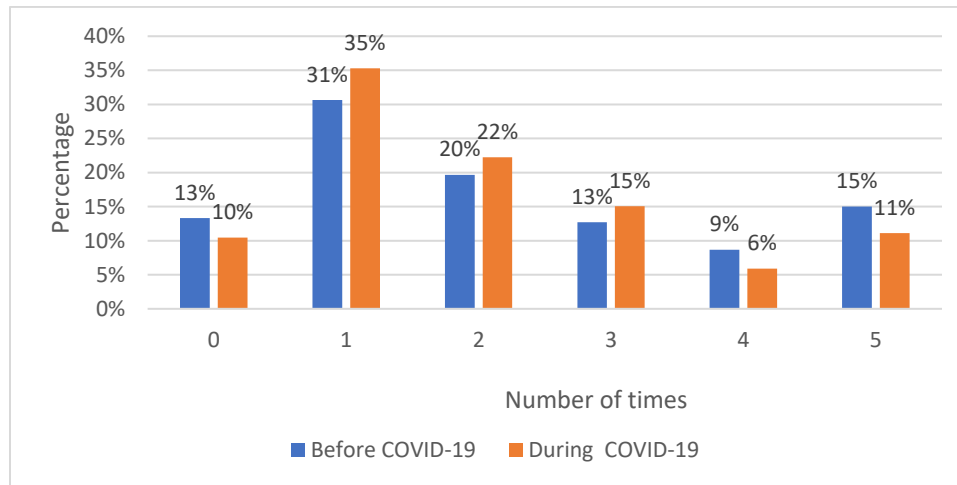


Figure 4.88: Top-up grocery in a week - Pakistan

As demonstrated in figure 4.88 above, majority of respondents (31% before COVID-19 and 35% during COVID-19) were performing 1 time top-up grocery in a week. The minority were performing 4 times top-up grocery in a week (9% before COVID-19 and 6% during COVID-19). Results are close and based on 5% tolerance, mean between the two situations can be considered as equal or similar (based on table 4.106 below)

Table 4.106: Weekly top-up grocery trips - Z Test – Pakistan

Statistical category	Before COVID-19	During COVID-19
Mean	2.18	2.04
Known Variance	2.65	2.17
Observations	173	153
Hypothesized Mean Difference	0	
z	0.82	
z Critical two-tail	1.96	

As shown in table 4.106 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

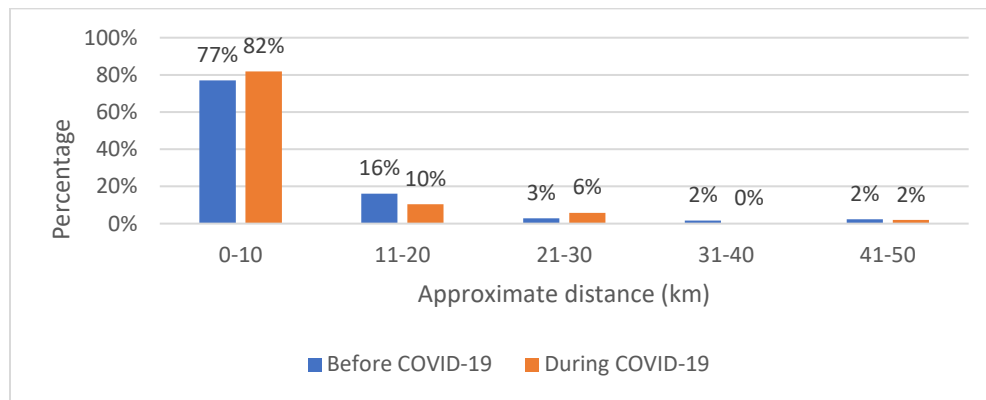
**Figure 4.89: Approximate distance from home to shopping location in kilometers. - Main Grocery – Pakistan**

Figure 4.89 above illustrates the main differences in approximate distances to the main grocery. As clearly indicated, respondents did not tend to relocate during the outbreak or change their targeted main grocery at that time - Results are almost similar and respondents (which may give a proper indication to the whole population) were not experiencing any change in this regard.

Table 4.107: Home-to- main grocery distance (km) - Pakistan - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	8.07	7.49
Known Variance	80.36	70.70
Observations	174	154
Hypothesized Mean Difference	0	
z	0.61	
z Critical two-tail	1.96	

As shown in table 4.107 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

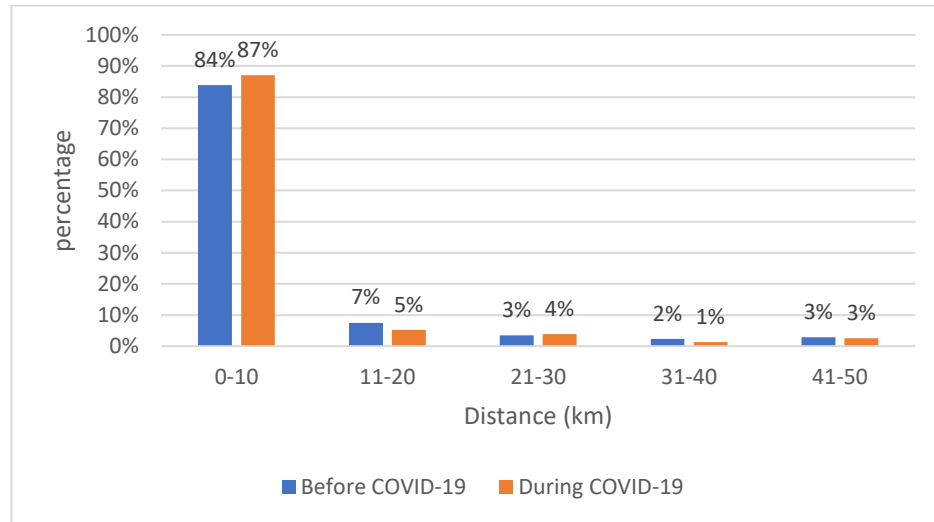


Figure 4.90: Approximate distance from home to shopping location in kilometers. - Top-up Grocery – (Pakistan)

The key distinctions in the approximate distances to the main food store are shown in Figure 4.90 above. As is obvious, respondents did not tend to move during the epidemic or change their primary grocery stores at that time. The results are nearly identical, and respondents—who may provide a reliable indicator of what has happened to the entire population—were not reporting any changes in this area.

Table 4.108: Home-to- top up grocery distance (km) - Pakistan - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	6.862068966	6.344155844
Known Variance	112.67	92.48
Observations	174	154
Hypothesized Mean Difference	0	
z	0.46	
z Critical two-tail	1.96	

As shown in table 4.108 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

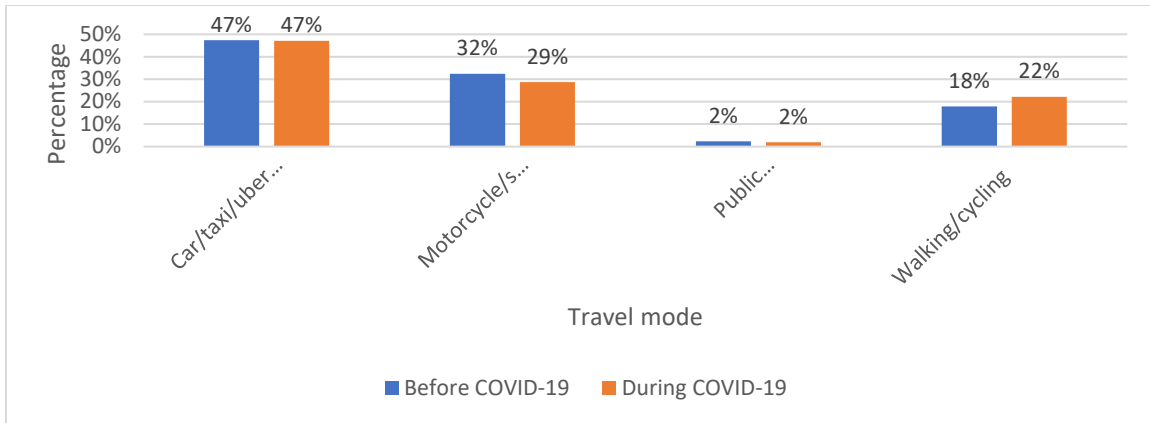


Figure 4.91: Predominant Travel mode for shopping activities - Main Grocery (Pakistan)

As shown in figure 4.91 above, before and during COVID-19 experienced the same proportions and percentages regarding the travel modes with the lowest one for public transport (2% before and during COVID-19) and the highest one for the car/ taxi / uber / careem / rickshaw (47% before and during COVID-19). This result indicates that people in Pakistan did not tend to change their travel mode to main groceries regardless of the outbreak.

Table 4.109: Pakistan: Travel mode vs. grocery shopping (pre-COVID) Chi-Square.

Travel mode	Actual number of respondents	Expected number of respondents
Car/taxi/uber/careem/rickshaw	82	43
Motorcycle/scooter	56	43
Public Transport	4	43
Walking/cycling	31	43

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 77.56$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.110: Pakistan: Travel mode vs. grocery shopping (during-COVID) Chi-Square.

Travel mode	Actual number of respondents	Expected number of respondents
Car/taxi/uber/careem/rickshaw	72	38
Motorcycle/scooter	44	38
Public Transport	3	38
Walking/cycling	34	38

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 63.6$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

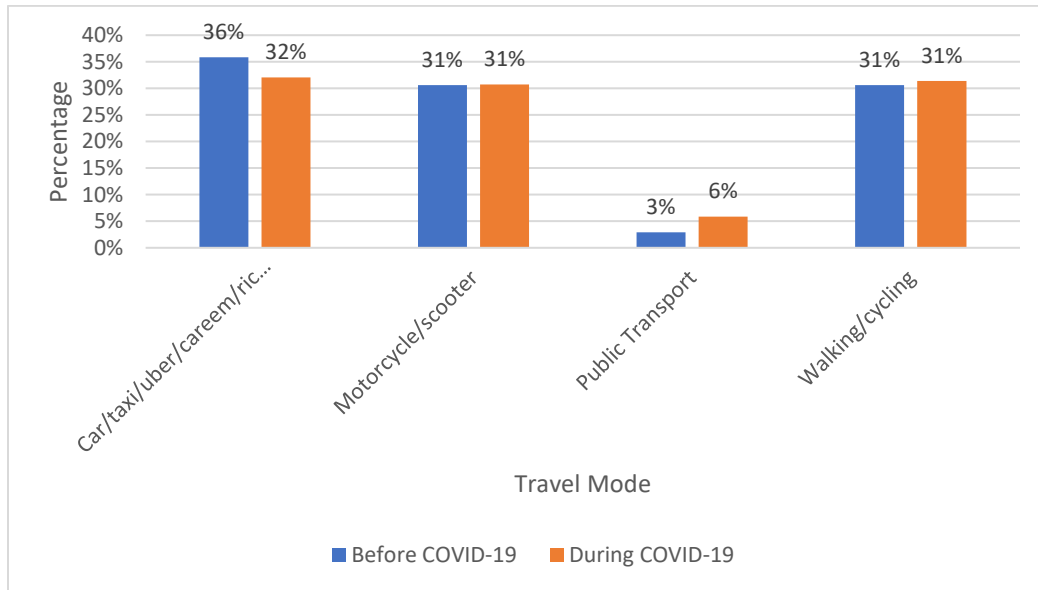


Figure 4.92: Predominant Travel mode for shopping activities - Top-up Grocery (Pakistan)

The same proportions and percentages of travel modes were utilized before and during COVID-19, as shown in figure 4.92 above, with the lowest percentage being for public transportation (2% before COVID-19 and 6% during COVID-19) and the highest percentage being for cars, taxis, uber, careem, and rickshaws (36% before COVID-19 and 32% during COVID-19). This finding suggests that despite the epidemic, Pakistanis did

not have a tendency to switch from their primary method of transportation to top-up grocery.

Table 4.111: Pakistan: Travel mode vs. top-up Grocery (pre-COVID) - Chi-Square

Travel mode	Actual number of responses	Expected number of responses
Car/taxi/uber/careem/rickshaw	62	43
Motorcycle/scooter	53	43
Public Transport	5	43
Walking/cycling	53	43

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 46.35$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.112: Pakistan: Travel mode vs. top-up Grocery (during-COVID) - Chi-Square

Travel mode	Actual number of responses	Expected number of responses
Car/taxi/uber/careem/rickshaw	49	38
Motorcycle/scooter	47	38
Public Transport	9	38
Walking/cycling	48	38

$$Xc^2_{critical} = 7.81$$

$$Xc^2_{stat} = 29.88$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

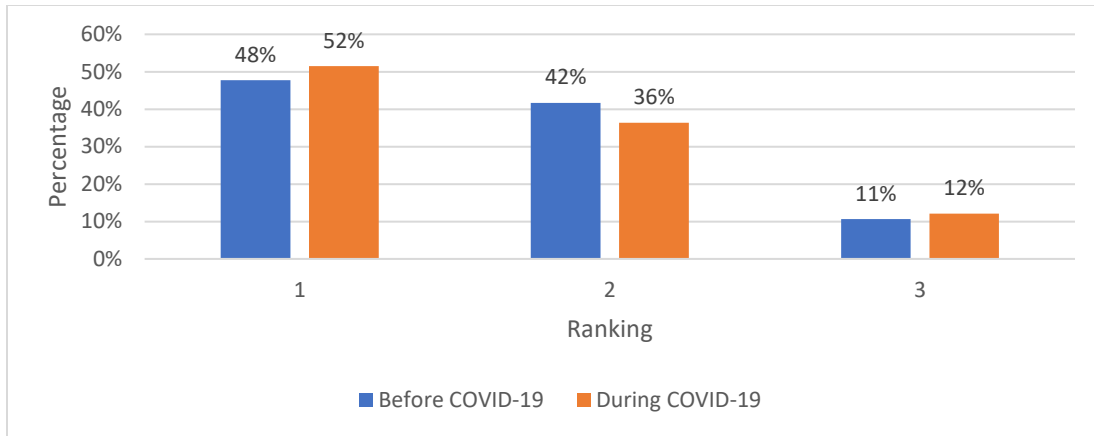


Figure 4.93: Alone – Main Grocery (Pakistan) – (Rank from 1 – 3)

Figure 4.93 above demonstrates that the majority of respondents chose option 1 as their first choice while completing their main grocery shopping alone, with just a little variation between the two periods (before and during COVID-19) (48% before COVID-19 and 52% during COVID-19). It is apparent that a sizeable portion of respondents, 42% before COVID-19 and 36% during COVID-19, ranked 2 (they have medium or moderate preference being alone completing main groceries). The preferences did not change during the pandemic / outbreak as always being alone even during the outbreak the ideal choice to avoid any kind of infections.

Table 4.113: Alone – Main Grocery (Pakistan) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.63	1.61
Known Variance	0.45	0.49
Observations	132	66
Hypothesized Mean Difference	0	
z	0.22	
z Critical two-tail	1.96	

As shown in table 4.113 above, $+ z \text{ critical} \leq z \leq - z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

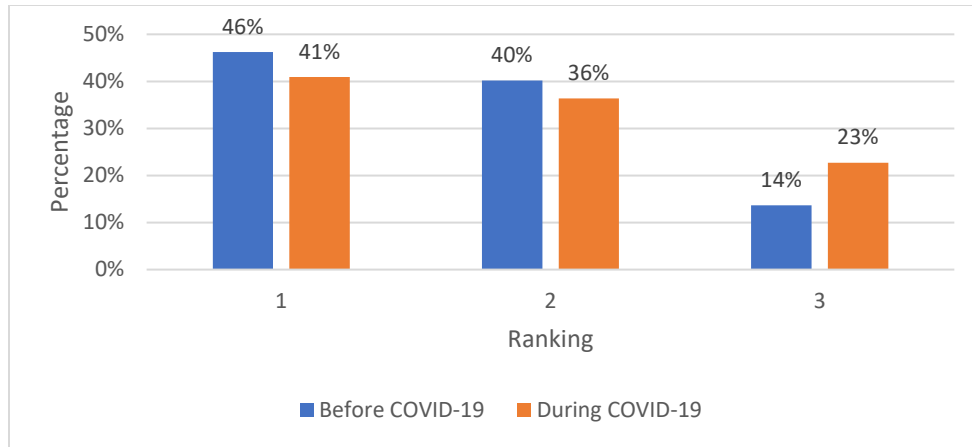


Figure 4.94: With family – Main Grocery (Pakistan) – (Rank from 1 – 3)

With just a little difference between the two studied periods (before and during COVID-19), Figure 4.94 above shows that the majority of respondents picked option 1 (they preferred being with family in performing the main grocery) as their first choice while doing their primary grocery shopping with family (46% before COVID-19 and 41% during COVID-19). It is clear that a sizable percentage of respondents, 40% before to COVID-19 and 36% during COVID-19, gave the answer 2 (they had moderate or fair preference being with family in performing their main grocery activities). It is also apparent that respondents who ranked 3 increased, which effectively shows that people were willing to take the recommended precautions during COVID-19.

Table 4.114: With family – Main Grocery (Pakistan) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.67	1.82
Known Variance	0.50	0.61
Observations	132	66
Hypothesized Mean Difference	0	
z	-1.26	
z Critical two-tail	1.96	

As shown in table 4.114 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

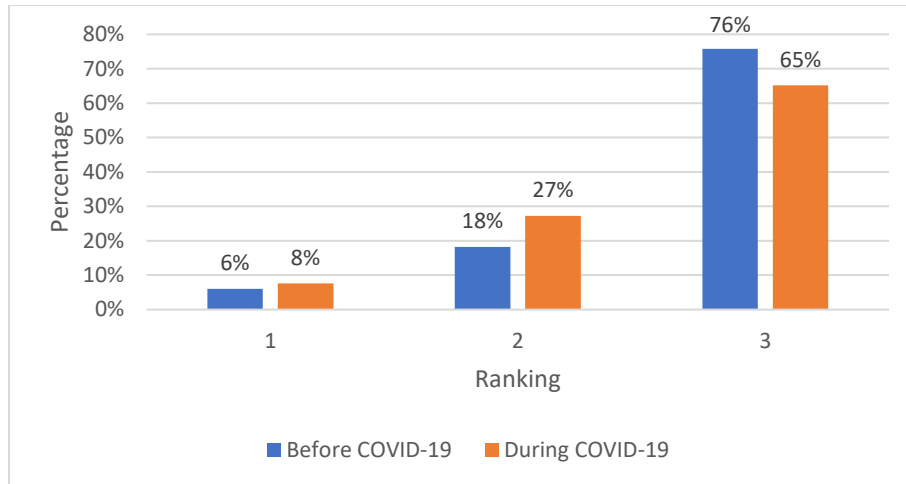


Figure 4.95: With friends – Main Grocery (Pakistan) – (Rank from 1 – 3)

The majority of respondents (76% before COVID-19 and 65% during COVID-19), as shown in Figure 4.95, did not prefer performing main grocery shopping with friends. Considerable percentage, however, were moderate (18% before COVID-19 and 27% during COVID-19). The epidemic clearly had no impact on their preference.

Table 4.115: With friends – Main Grocery (Pakistan) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.67	2.58
Known Variance	0.33	0.40
Observations	132	66
Hypothesized Mean Difference	0	
z	1.30	
z Critical two-tail	1.96	

As shown in table 4.115 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

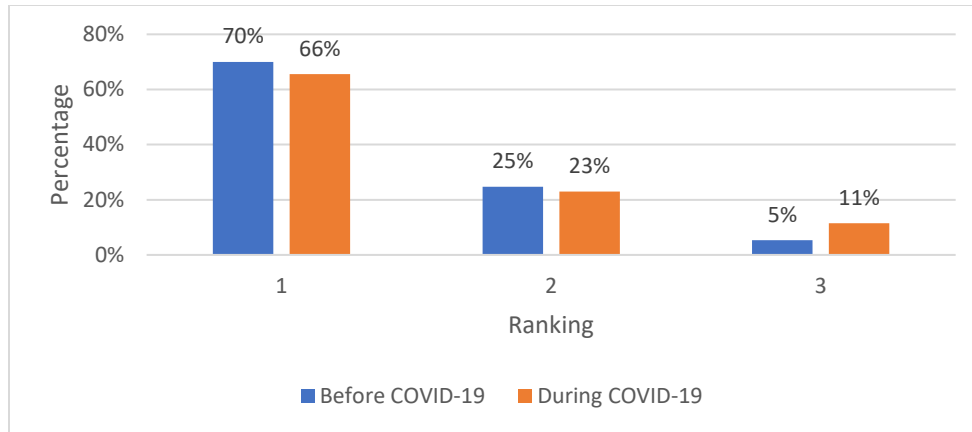


Figure 4.96: Alone – Top-up Grocery (Pakistan) – (Rank from 1 – 3)

Figure 4.96 above gives some explanation regarding the preference of being alone in performing the top-up grocery. The vast majority preferred being alone in performing the top-up grocery alone (70% before COVID-19 and 66% during COVID-19). This dominance is due that in most situations, intended top-up groceries are close to domiciled location and no need for such companion.

Table 4.116: Alone – Top-up Grocery (Pakistan) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.35	1.46
Known Variance	0.34	0.49
Observations	150	61
Hypothesized Mean Difference	0	
z	-1.05	
z Critical two-tail	1.96	

As shown in table 4.116 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

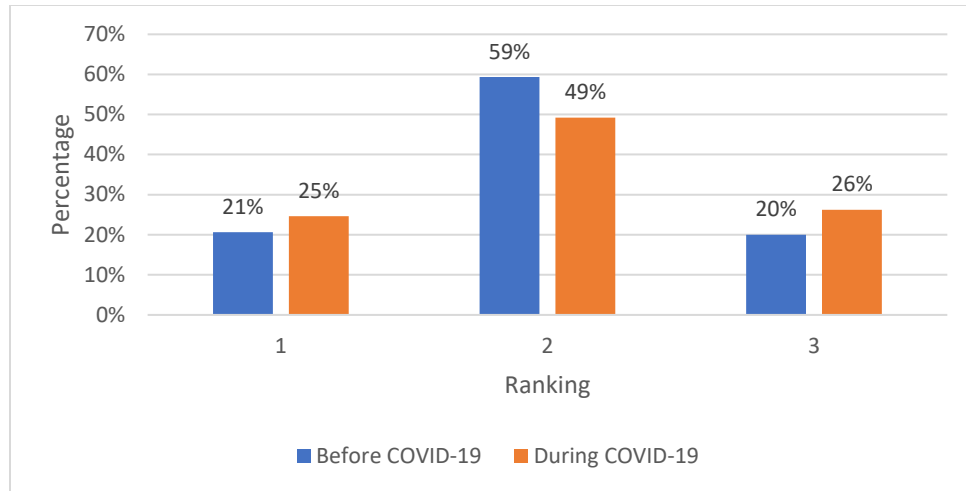


Figure 4.97: With family – Top-up Grocery (Pakistan) – (Rank from 1 – 3)

Figure 4.97 above shows that the highest percentage is for respondents that were moderate in preference being with family in performing the top-up grocery (59% before COVID-19 and 49% during COVID-19). Preferences are close to each other in both situations which basically gives a clear vision that the vast majority of population did not tend to change their preferred companion during the outbreak.

Table 4.117: With family – Top-up Grocery (Pakistan) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	1.99	2.02
Known Variance	0.41	0.52
Observations	150	61
Hypothesized Mean Difference	0	
z	-0.22	
z Critical two-tail	1.96	

As shown in table 4.117 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

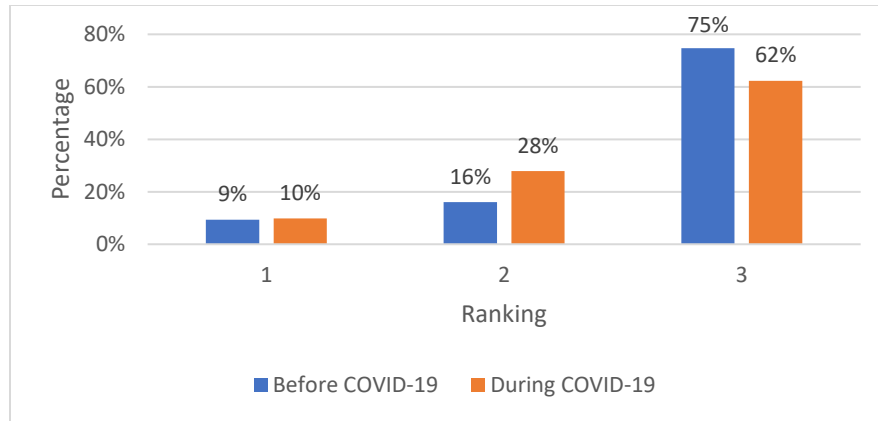


Figure 4.98: With friends – Top-up Grocery (Pakistan) – (Rank from 1 – 3)

According to Figure 4.98, the majority of respondents (75% before COVID-19 and 62% during COVID-19) did not prefer doing their main food shopping with friends. However, a sizable portion (16% before to COVID-19 and 28% during COVID-19) were moderate. It is obvious that the outbreak had no effect on respondents' preferences.

Table 4.118: With friends – Top-up Grocery (Pakistan) – (Rank from 1 – 3) - Z test

Statistical category	Before COVID-19	During COVID-19
Mean	2.65	2.52
Known Variance	0.42	0.45
Observations	150	61
Hypothesized Mean Difference	0	
z	1.27	
z Critical two-tail	1.96	

As shown in table 4.118 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

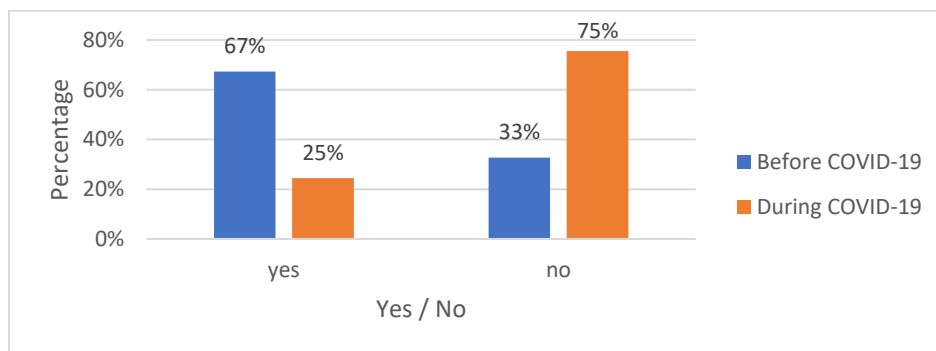


Figure 4.99: Percentages of whether or not performing physical activities – Pakistan.

As figure 4.99 illustrates, the majority of respondents were performing out-of-home physical activities before COVID-19 (67%). However, a substantial decrease is noticed during the COVID-19 findings (majority of respondents were not performing any out-of-home activities during COVID-19)

Table 4.119: Chi-Square Test: Out-of-home activities pre-COVID-19 (Pakistan).

Respondent answer	Actual number of responses	Expected number of responses
Yes	103	77
No	50	77

$$Xc^2_{critical} = 3.84$$

$$Xc^2_{stat} = 18.36$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.120: Chi-Square Test: Out-of-home activities during-COVID-19 (Pakistan).

Respondent answer	Actual number of responses	Expected number of responses
Yes	37	76
No	114	76

$$Xc^2_{critical} = 3.84$$

$$Xc^2_{stat} = 39.26$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

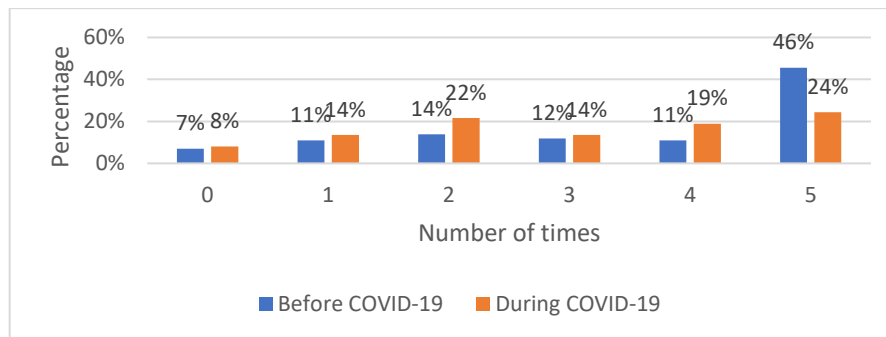


Figure 4.100: Times of performing Out-of-home physical activities in a week – Pakistan.

Figure 4.100 above displays that the number of times of performing out-of-home activities did not change substantially. However, it is noticeable that the percentage of respondents who were performing 5 times out-of-home activities before COVID-19 dropped almost 50% during COVID-19 (from 46% to 24%). This decrease gives a clear indication of fear from being infection and the precautionary measures taken at that time.

Table 4.121: Times of performing out-of-home activities in a week - Z test (Pakistan)

Respondent answer	Before COVID-19	During COVID-19
Mean	3.44	2.95
Known Variance	2.95	2.72
Observations	99	37
Hypothesized Mean Difference	0	
z	1.55	
z Critical two-tail	1.96	

As shown in table 4.121 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

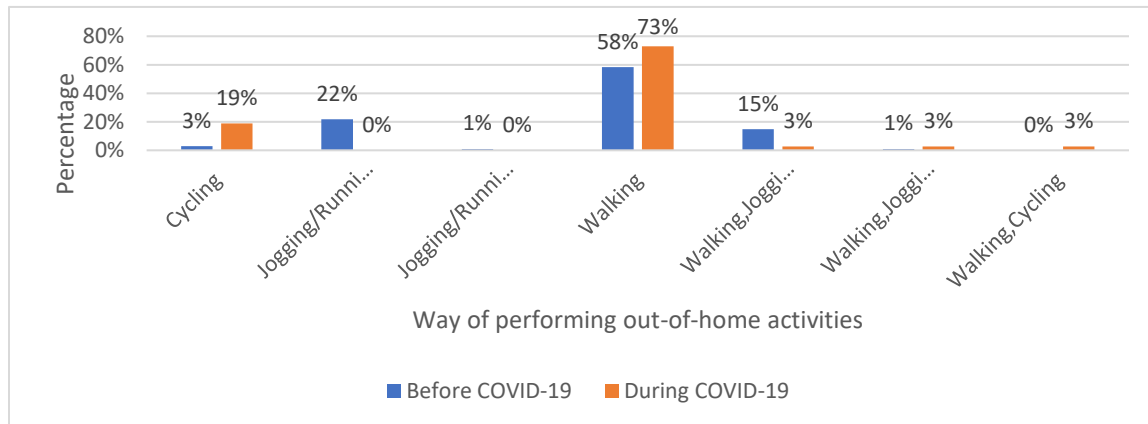


Figure 4.101: Normally performed out-of-home activities – Pakistan

Figure 4.101 examines the out-of-home activities performed during the studied periods (before and during COVID-19). It is clear that took the dominance before and during COVID-19 (58% before COVID-19 and 73% during COVID-19). This also gives clear indication that data is bias towards a certain direction (walking) among all other categories.

Table 4.122: Out-of-home activities (before COVID-19) – Pakistan - Chi Square Test

Out-of-home activity	Actual number of responses	Expected number of responses
Cycling	3	17
Jogging/Running	22	17
Jogging/Running,Cycling	1	17
Walking	59	17
Walking,Jogging/Running	15	17
Walking,Jogging/Running,Cycling	1	17

$$Xc^2_{critical} = 11.07$$

$$Xc^2_{stat} = 148.56$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

Table 4.123: Out-of-home activities (during COVID-19) – Pakistan – Chi Square Test

Out-of-home activity	Actual number of responses	Expected number of responses
Jogging/Running	7	7
Walking	27	7
Walking,Cycling	1	7
Walking,Jogging/Running	1	7
Walking,Jogging/Running,Cycling	1	7

$$Xc^2_{critical} = 9.48$$

$$Xc^2_{stat} = 68.54$$

Since Xc^2_{stat}

$> Xc^2_{critical}$, then the null hypothesis of equal frequencies is rejected

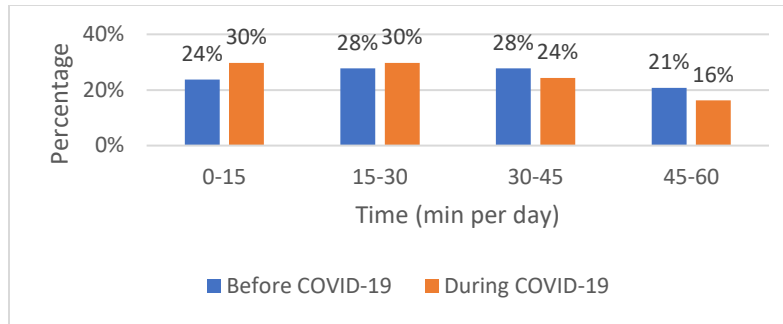


Figure 4.102: Average time spent to perform out-of-home physical activities in minutes per day – Pakistan

Figure 4.102 above shows that data is almost equally distributed. There difference between the two situations (before and during COVID-19) is negligible. Below test (z test – table 4.124) emphasizes this point as it proves that both samples show the same mean (given a tolerance of 5%).

Table 4.124: Out-of-home physical activities in minutes per day – Pakistan (Z test)

Statistical category	Before COVID-19	During COVID-19
Mean	29.32	26.55
Known Variance	258.86	258.11
Observations	99	37
Hypothesized Mean Difference	0	
z	0.89	
z Critical two-tail	1.96	

As shown in table 4.124 above, $+z \text{ critical} \leq z \leq -z \text{ critical}$ and hence the hypothesis of equal mean is accepted.

Table 4.125: Summary - Pakistan

Subject	Before COVID-19	During COVID-19
Occupational Status	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Trips Performed via car/carpooling /motorcycle/taxi/uber on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Trips Performed via bus/train/metro on an average per day	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Fuel saving percentage as compared to normal situation	The null hypothesis of equal frequencies is rejected.	
Number of times the main grocery in a month was performed	Since $Z_{Stat} > Z_{critical}$, the null hypothesis of equal mean is rejected.	
Number of times top-up grocery in a week was performed	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers. - Main Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Approximate distance from home to shopping location in kilometers - Top-up Grocery	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Predominant Travel mode for shopping activities - Main Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Predominant Travel mode for shopping activities - Top-up Grocery	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Alone – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With family – Main Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With friends – Main Grocery (Rank from 1 –	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean	

3)	is accepted.	
Alone – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With family – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
With friends – Top-up Grocery (Rank from 1 – 3)	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Whether or not performing out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Times of performing out-of-home activities in a week	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	
Normally performed out-of-home activities	The null hypothesis of equal frequencies is rejected	The null hypothesis of equal frequencies is rejected
Average time spent to perform out-of-home physical activities in minutes per day	Since $+ z_{critical} \leq z \leq - z_{critical}$, the hypothesis of equal mean is accepted.	

The results of all the questionnaire items relevant to replies larger than 30 are summarized in Table 4.125 above. Before and during COVID-19, statistical tests are carried out to demonstrate the difference between the two situations (before and during COVID-19). The chi-square test rejects the null hypothesis of equal frequencies for each of the examined questions. This indicates that there are observable differences between the studied categories of each tested question. In contrast, questions investigated using the Z-test indicate close means (both before and during COVID-19), based on a tolerance of 5%, with the exception of questions pertaining to trips made using a variety of modes + the frequency of main grocery.

4.3 Regression Model

Multiple regression is a statistical technique that allows to analyze the relationship between a dependent variable and multiple independent variables. There are various methods of multiple regression, including stepwise regression. Stepwise analysis is a method used in regression analysis to automatically select a subset of predictors from a larger set of potential independent variables. It aims to identify the most relevant variables that contribute significantly to the prediction of the dependent variable (Jacobs, 1982). Categorical variables are classified as categorical for proper coding.

4.3.1 Bahrain (Before COVID-19):

	-----Step 1-----		-----Step 2-----	
	Coef	P	Coef	P
Constant	3.229		2.19	
Did you normally (before Covid- Your Occupational Status before	-2.073	0.000	-1.185	0.001
			1.54	0.032
S	1.92078		1.87259	
R-sq	23.89%		30.90%	
R-sq(adj)	23.04%		26.86%	
AICc	759.29		759.34	
BIC	771.88		795.94	

Figure 4.103: Stepwise analysis - Before COVID-19 – Bahrain

By using the stepwise analysis, the above model as per figure 4.103 is concluded with S value of 1.87.

Total number of trips= 2.19 – 1.185 * (whether or not performing out-of-home activities)
+ 1.54 * (occupational status before COVID-19).

4.3.2 Bahrain (During COVID-19)

	-----Step 1-----		-----Step 2-----	
	Coef	P	Coef	P
Constant	0.679		0.498	
How many times are you performi	0.2545	0.003	0.2409	0.004
Approximate distance from home			0.0266	0.018
S	1.46275		1.44392	
R-sq	4.91%		7.86%	
R-sq(adj)	4.38%		6.83%	
Mallows' Cp	20.92		16.75	
AICc	659.05		655.41	
BIC	668.53		668.00	

Figure 4.104: Stepwise analysis - During COVID-19 – Bahrain

Total number of trips = 0.498 + 0.0266 * Approximate distance from home to shopping location (main grocery) + 0.2409 * times of performing out of home activities.

Regression Model (Bahrain) – Before and During COVID-19:

As clearly stated in the before and during equations, estimated number of trips is based on different elements before and during COVID-19. For example, categorical variables have more influence estimating the number of trips before COVID-19 which are whether or not performing out of home activities (negative effect) and the occupational status. On the other hand, continuous variables have more influence during COVID-19 which are times of performing out of home activities and approximate distance from home to shopping location (main grocery).

4.3.3 Europe (Before COVID-19)

	-----Step 1-----		-----Step 2-----		-----Step 3-----	
	Coef	P	Coef	P	Coef	P
Constant	2.587		1.915		2.510	
Did you normally (before Covid- With whom you usually perform_5	-2.314	0.000	-1.643	0.001	-2.237	0.000
With whom you usually performed			0.417	0.002	0.551	0.000
					-0.776	0.003
S	1.49099		1.42109		1.35687	
R-sq	29.23%		36.43%		42.70%	
R-sq(adj)	27.66%		34.29%		40.09%	
Mallows' Cp	11.94		3.88		-2.88	
AICc	343.62		335.89		328.52	
BIC	353.30		347.86		342.74	

α to enter = 0.05, α to remove = 0.05

If a term has more than one coefficient, the largest in magnitude is shown.

Figure 4.105: Stepwise analysis - Before COVID-19 – Europe

Minitab developed three regression model equations depending on whether or not respondents were performing out of home activities and the third equation for people who did not mention anything in this regard.

Table 4.126: Regression equations - Before COVID-19 - Europe

No	Total trips = 2.510 – 0.776 * preference on performing main grocery alone + 0.551 * preference on performing top-up grocery with family.
Yes	Total trips = 2.413 – 0.776 * preference on performing main grocery alone + 0.551 * preference on performing top-up grocery with family.
Not mentioned	Total trips = 0.273 – 0.776 * preference on performing main grocery alone + 0.551 * preference on performing top-up grocery with family.

4.3.4 Europe (During COVID-19)

	-----Step 1-----		-----Step 2-----	
	Coef	P	Coef	P
Constant	0.2001		0.0478	
Approximate distance from hom_1	0.0486	0.001	0.0452	0.001
Average time spend to perform o			0.00882	0.002
S	0.605320		0.578275	
R-sq	11.25%		19.89%	
R-sq(adj)	10.27%		18.11%	
AICc	174.80		167.45	
BIC	182.13		177.13	

α to enter = 0.05, α to remove = 0.05

Figure 4.106: Stepwise analysis - During COVID-19 – Europe

Total trips = 0.0478 + 0.0452 * approximate distance from home to shopping location (top-up grocery) + 0.00882 * average time spent to perform out-of-home activities.

Regression Model (Europe) – Before and During COVID-19:

As clearly illustrated in the above models, and as concluded from the collected data, models differ between before and during situations as different factors contribute to concluding the total number of trips. Before COVID-19 factors that contribute to determining the total number of trips are the preference questions (negative impact regarding performing main grocery alone and positive regarding performing top-up grocery with family). In during COVID-19 factors such as approximate distance from home to shopping location for top-up grocery and average time spent to perform out of home activities have positive impact.

4.3.5 India (Before COVID-19)

	----Step 1----		----Step 2----		----Step 3----	
	Coef	P	Coef	P	Coef	P
Constant	4.00		2.84		2.39	
Predominant Travel mode for sho	-3.39	0.000	-2.45	0.000	-2.28	0.000
Your Occupational Status before			2.154	0.000	2.468	0.000
Approximate distance from home					0.0546	0.000
How many times did you perform						
S	2.12544		2.06703		2.04325	
R-sq	27.35%		32.41%		34.09%	
R-sq(adj)	26.46%		30.45%		32.04%	
Mallows' Cp	53.98		32.48		21.99	
AICc	2177.82		2158.66		2148.22	
BIC	2211.22		2224.93		2218.57	
	----Step 4----					
	Coef	P				
Constant	1.91					
Predominant Travel mode for sho	-2.00	0.049				
Your Occupational Status before	2.350	0.000				
Approximate distance from home	0.0599	0.000				
How many times did you perform	0.2450	0.003				
S	2.02632					
R-sq	35.31%					
R-sq(adj)	33.16%					
Mallows' Cp	14.92					
AICc	2141.04					
BIC	2215.44					
α to enter = 0.05, α to remove = 0.05						
If a term has more than one coefficient, the largest in magnitude is shown.						

Figure 4.107: Stepwise analysis - Before COVID-19 – India

Total Number of trips = $1.91 - 2 * \text{Predominant Travel mode for shopping location (main grocery)} + 2.35 * \text{occupational status before COVID-19} + 0.0599 * \text{Approximate distance from home to shopping location (main grocery)} + 0.2450 * \text{times of performing out-of-home activities}$

4.3.6 India (During COVID-19)

	----Step 1----		----Step 2----		----Step 3----	
	Coef	P	Coef	P	Coef	P
Constant	2.00		4.23		2.96	
Predominant Travel mode for sho	2.17	0.000	5.20	0.000	5.49	0.000
Predominant Travel mode for s_1			-9.43	0.000	-8.97	0.000
Approximate distance from hom_1					0.0399	0.001
With whom are you performing _4						
With whom are you performing _5						
S	1.31952		1.28914		1.27568	
R-sq	14.96%		19.98%		21.81%	
R-sq(adj)	13.92%		17.84%		19.54%	
AICc	1702.06		1686.36		1676.99	
BIC	1735.47		1748.56		1743.27	
	----Step 4----		----Step 5-----			
	Coef	P	Coef	P		
Constant	2.66		2.46			
Predominant Travel mode for sho	5.93	0.000	6.92	0.000		
Predominant Travel mode for s_1	-9.12	0.001	-9.89	0.000		
Approximate distance from hom_1	0.0409	0.001	0.0386	0.001		
With whom are you performing _4	0.1746	0.010	0.479	0.000		
With whom are you performing _5			-0.3202	0.000		
S	1.26821		1.25034			
R-sq	22.88%		25.19%			
R-sq(adj)	20.49%		22.71%			
AICc	1672.24		1659.20			
BIC	1742.58		1733.60			

α to enter = 0.05, α to remove = 0.05
If a term has more than one coefficient, the largest in magnitude is shown.

Figure 4.108: Stepwise analysis - During COVID-19 – India

Total number of trips = $2.66 + 5.93 * \text{Predominant Travel mode for shopping location (main grocery)} - 9.12 * \text{Predominant Travel mode (top-up grocery)} + 0.0409 * \text{approximate distance from home to shopping location (top-up grocery)} + 0.1746 * \text{preference performing top-up grocery with family}$.

Regression Model (India) – Before and During COVID-19:

Comparing between the two models, predominant travel mode for shopping location has negative impact in before COVID-19 situation and positive impact in during COVID-19 situation. Occupational status before COVID-19 also has a positive impact on the number of trips including approximate distance from home to shopping location (main grocery – both before and during COVID-19) and times of performing out-of-home activities (both before and during COVID-19 situation).

4.3.7 Pakistan (Before COVID-19)

	----Step 1----		----Step 2----		-----Step 3-----	
	Coef	P	Coef	P	Coef	P
Constant	3.549		3.088		5.79	
Predominant Travel mode for sho	2.951	0.000	2.892	0.000	3.206	0.000
Your Occupational Status before			1.213	0.000	-1.305	0.000
Which out-of-home physical acti					4.65	0.000
S	1.81833		1.73210		1.65173	
R-sq	39.94%		46.91%		52.69%	
R-sq(adj)	39.16%		44.80%		49.80%	
AICc	1273.82		1252.20		1229.51	
BIC	1296.04		1303.29		1301.63	

α to enter = 0.05, α to remove = 0.05

If a term has more than one coefficient, the largest in magnitude is shown.

Figure 4.109: Stepwise analysis - Before COVID-19 – Pakistan

Total number of trips = 5.79 + 3.206 * predominant travel mode for shopping location (main grocery) – 1.305 * occupational status before COVID-19 + 4.65 * type of out-of-home activities

4.3.8 Pakistan (During COVID-19)

	-----Step 1-----		-----Step 2-----	
	Coef	P	Coef	P
Constant	0.5983		0.4724	
How many times are you performi	0.3026	0.000	0.2720	0.000
Approximate distance from home			0.0279	0.006
S	1.17647		1.15963	
R-sq	9.66%		12.62%	
R-sq(adj)	9.27%		11.85%	
AICc	728.41		722.86	
BIC	738.60		736.42	

α to enter = 0.05, α to remove = 0.05

Figure 4.110: Stepwise analysis - During COVID-19 – Pakistan

Total number of trips = 0.4724+ 0.2720 * (times of performing out-of-home activities in a week) + 0.0279 * (approximate distance from home to shopping location – main grocery)

Regression Model (India) – Before and During COVID-19:

The regression models analyze the impact of various factors on the total number of trips before and during the COVID-19 pandemic. The results indicate that the predominant travel mode for shopping has a positive effect on the total number of trips, meaning that an increase in the mode of travel is associated with more trips. On the other hand, occupational status before COVID-19 has a negative effect, implying that a higher occupational status is linked to a decrease in the total number of trips. Additionally, the type of out-of-home activities positively influences the total number of trips. These findings provide valuable insights for transportation planning and infrastructure development, enabling policymakers to better understand and address travel behavior patterns.

Table 4.127: Regression model summary

Region	Before COVID-19	During COVID-19
Bahrain	Total number of trips= $2.19 - 1.185 * (\text{whether or not performing out-of-home activities}) + 1.54 * (\text{occupational status before COVID-19})$.	Total number of trips = $0.498 + 0.0266 * (\text{Approximate distance from home to shopping location (main grocery)} + 0.2409 * (\text{times of performing out of home activities}))$.
Europe	Whether or not performing out-of-home activities: No: Total trips = $2.510 - 0.776 * (\text{preference on performing main grocery alone} + 0.551 * (\text{preference on performing top-up grocery with family}))$. Yes: Total trips = $2.413 - 0.776 * (\text{preference on performing main grocery alone} + 0.551 * (\text{preference on performing top-up grocery with family}))$. Not mentioned: Total trips = $0.273 - 0.776 * (\text{preference on performing main grocery alone} + 0.551 * (\text{preference on performing top-up grocery with family}))$.	Total trips = $0.0478 + 0.0452 * (\text{approximate distance from home to shopping location (top-up grocery)} + 0.00882 * (\text{average time spent to perform out-of-home activities}))$
India	Total Number of trips = $1.91 - 2 * (\text{Predominant Travel mode for shopping location (main grocery)} + 2.35 * (\text{occupational status before COVID-19} + 0.0599 * (\text{Approximate distance from home to shopping location (main grocery)} + 0.2450 * (\text{times of performing out-of-home activities})))$	Total number of trips = $2.66 + 5.93 * (\text{Predominant Travel mode for shopping location (main grocery)} - 9.12 * (\text{Predominant Travel mode (top-up grocery)} + 0.0409 * (\text{approximate distance from home to shopping location (top-up grocery)} + 0.1746 * (\text{preference performing top-up grocery with family})))$
Pakistan	Total number of trips = $5.79 + 3.206 * (\text{predominant travel mode for shopping location (main grocery)} - 1.305 * (\text{times of performing out-of-home activities in a week})) + 0.0279 * (\text{times of performing out-of-home activities in a week})$	Total number of trips = $0.4724 + 0.2720 * (\text{times of performing out-of-home activities in a week}) + 0.0279 * (\text{times of performing out-of-home activities in a week})$

	occupational status before COVID-19 + 4.65 * type of out-of-home activities	(approximate distance from home to shopping location – main grocery)
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Referring to table 4.127, following points are concluded:

- 1) Predominant travel mode for shopping: This factor appears to have a significant influence on the total number of trips in both the "Before COVID-19" and "During COVID-19" periods in multiple regions, such as Bahrain, India, and Pakistan.
- 2) Occupational status before COVID-19: The occupational status before the pandemic is a common factor influencing the total number of trips in Bahrain and India during the "Before COVID-19" period.
- 3) Frequency of out-of-home activities: The frequency of performing out-of-home activities has an impact on the total number of trips in both the "Before COVID-19" and "During COVID-19" periods, as observed in Bahrain, Europe, and Pakistan.
- 4) Distance to shopping location: The approximate distance from home to the shopping location affects the total number of trips in India and Pakistan during the "Before COVID-19" period.
- 5) Preference on performing main/top-up grocery with family: This factor is influential in Europe during the "During COVID-19" period, specifically regarding grocery shopping with family members.

Chapter 5 (Conclusion and Recommendations)

5.1 Conclusion

5.2 Recommendations

5.3 Future Studies

5.1 Conclusion

In conclusion, The COVID-19 pandemic has significantly impacted traffic and transportation in Bahrain, India, Pakistan, and Europe, emphasizing the need to understand its long-term effects and develop appropriate strategies. The measures implemented to curb the spread of the virus, such as lockdowns and travel restrictions affected various aspects like trips, work/education routines, fuel saving, etc. Trips for essential purposes showed minimal changes before and during COVID-19, as confirmed by the acceptance of the null hypothesis of equal means in most questions related to top-up/main grocery. However, the frequency of main grocery trips decreased as individuals opted to purchase bulk items to limit the number of trips made in a month. Fuel was saved by 60-80% for majority of the respondents which gives a clear indication that overall number of trips reduced substantially during the outbreak.

Significant differences are also noticed when it comes to trips performed using car/carpooling or bus and public transportation. This indicates that people acted in different ways to limit their unnecessary activities to protect themselves from being infected. When it comes to out-of-home activities, most respondents tended not to perform any out-of-home activities during the pandemic except for Europe as respondents preferred to continue performing out-of-home activities even during the pandemic. However, respondents who continued performing out-of-home activities did not change their way of performance (walking, cycling, running, etc.) and also did not change the duration of performing the preferred out-of-home activities (in minutes per day). During the COVID-19 pandemic, many governments around the world implemented lockdowns and travel restrictions to slow the spread of the virus. These measures had a significant impact on people's travel behavior, particularly in terms of non-essential trips such as leisure and tourism. The aftermath of the COVID-19 pandemic calls for proactive measures to be taken regarding traffic, transportation, and travel patterns in anticipation of potential future pandemics. The lessons learned from the recent crisis provide valuable insights that can guide decision-makers in implementing necessary changes and enhancing preparedness. Key areas of focus should include:

- 1- Flexible and adaptive traffic management strategies: Implementing dynamic traffic management systems capable of swiftly adapting to changing conditions during a

pandemic. This may involve real-time monitoring, data analysis, and the ability to quickly modify traffic flow patterns to ensure efficient movement while adhering to health and safety guidelines.

- 2- Robust public transportation systems: Strengthening public transportation networks by incorporating measures that prioritize passenger safety and hygiene. This may involve increased sanitization protocols, improved ventilation systems, and the implementation of crowd management strategies to ensure social distancing.
- 3- Emphasis on alternative modes of transportation: Encouraging the use of alternative modes of transportation such as cycling, walking, and
- 4- micro-mobility options to reduce reliance on crowded public transport and promote physical distancing. Developing infrastructure and policies that support these modes of transportation can create a more resilient and adaptable transportation system.

Enhanced digitalization and remote work options: Investing in digital infrastructure to support remote work and virtual meetings can reduce the need for daily commuting and minimize traffic congestion. Embracing telecommuting and flexible work arrangements can not only mitigate the impact of future pandemics but also contribute to long-term sustainability and work-life balance. The COVID-19 pandemic is expected to have enduring effects on transportation systems that will persist beyond the pandemic itself. These long-term effects include shifts in travel behavior, changes in transportation preferences, altered commuting patterns, reduced reliance on public transportation, increased demand for private vehicles, and a continued emphasis on hygiene and safety measures. As the world emerges from the pandemic, it is imperative for transportation planners and policymakers to anticipate and respond to these effects by implementing strategies that promote sustainable mobility, address changing travel patterns, and ensure the health and well-being of individuals. By acknowledging and adapting to these long-term effects, transportation systems can be better prepared to meet the future needs of individuals and communities. The regression analysis provided valuable insights into the factors influencing travel behavior and transportation patterns before and during the COVID-19 pandemic in different regions. The distance from home to the shopping location, frequency of grocery shopping, and mode of transportation used for shopping activities were consistently identified as significant variables affecting the number of

trips performed. These findings can inform policymakers and stakeholders in developing effective strategies and policies to address the challenges posed by the pandemic and adapt transportation systems to meet the evolving needs of individuals in the post-pandemic era.

5.2 Recommendations

This research met the purpose of providing a clear vision on areas which have been impacted during the pandemic. It also provides regression models which can be implemented for estimation purposes of the number of trips before and during COVID-19. Following points are concluded as below:

- 1- Foster a resilient transportation system: The COVID-19 pandemic has highlighted the importance of building a resilient transportation system that can adapt to unexpected disruptions. Based on the study's findings, it is crucial to invest in technologies and systems that enable flexible transportation services, such as real-time traffic monitoring, dynamic routing, and demand-responsive transportation. By integrating resilience measures into transportation planning and operations, authorities can better respond to future crises and maintain essential transportation services.
- 2- Promote telecommuting and flexible work arrangements: The study indicates a significant reduction in commuting patterns during the pandemic. Governments and employers should consider promoting telecommuting and flexible work arrangements as a long-term solution to mitigate traffic congestion and reduce the environmental impact of commuting. This can be achieved through incentives, supportive policies, and infrastructure improvements that facilitate remote work.
- 3- Enhance data-driven decision-making: The document mentions the use of data analysis methods and regression models to understand the impact of COVID-19 on transportation. Building on this approach, governments and transportation authorities should continue to invest in data collection, analysis, and modeling capabilities. By leveraging real-time data, such as traffic patterns, travel behavior, and air pollution levels, decision-makers

can make informed and evidence-based decisions to optimize transportation systems and mitigate future disruptions.

5.3 Future Studies

Based on the results of this study, it is recommended that further research be conducted to provide more comprehensive explanations and connections. Examples of such studies include:

- 1- Long-term impact assessment: A longitudinal study to assess the long-term effects of specific interventions or policies implemented in various sectors (e.g., healthcare, education, environment) and their influence on desired outcomes. This study can provide valuable insights into the effectiveness and sustainability of these interventions regardless of pandemic circumstances.
- 2- Traffic congestion management: Investigation of innovative approaches and strategies for managing traffic congestion in urban areas. This study can explore the effectiveness of various measures such as intelligent transportation systems, congestion pricing, public transportation enhancements, and infrastructure improvements.
- 3- Driver behavior analysis: Analyze driver behavior patterns and their impact on traffic flow and safety. This study can utilize data from traffic monitoring systems, GPS tracking, or surveys to understand factors contributing to aggressive driving, distracted driving, and traffic violations. The findings can inform targeted interventions and educational campaigns to improve driver behavior.

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Appendices

Appendix (1) : Questionnaire questions.

Appendix (2) : URL of the questionnaire questions.

Appendix (3): Example of Z-test Calculation.

Appendix (4): Example of t-test Calculation.

Appendix (1)

Table A. 1: Questionnaire questions

Number	Question	Bahrain	Europe	India	Pakistan
Section I: Questions About Socio-Demographic Aspects					
1	Age in years				
	Total Number of Responses	150	93	400	229
	Overall Average (in years)	25	28	32	26
	Overall Standard Deviation	8	16	12	7
2	Gender				
	Total Number of Responses	152	76	400	229
	Male / Female	47%/53%	54%/46%	52%/48%	80%/20%
3	List of Countries				
	Total Number of Responses	88%/12%	97%/3%	96% / 4%	96% / 4%
	Corresponding Region / Other regions	152	76	400	229
4	What is your nationality?				
	Total Number of Responses	152	76	400	229
	Corresponding Region / Other regions	70%/30%	57%/43%	98.5% /1.5%	98%/2%
5	Your Occupational Status before Covid-19 pandemic.				
	Total Number of Responses	153	76	400	229
	Result of major percentage	Student (63%)	Employed for Wages (46%)	Employed for wages (52%)	Student (43%)
6	What is the highest degree of education you have obtained?				
	Total Number of Responses	152	76	400	229
	Result of major percentage	High School (53%)	Master's Degree (51%)	Bachelor (32.5%)	Student (44%)
7	What is your household gross income per month in Bahraini dinar?				

	Total Number of Responses	124	76	400	188
	Overall Average (in years)	BHD 1,020	3,062.5 (in Euros)	57,762 (in Rupees)	113,431(in rupees)
	Overall Standard Deviation	BHD 811	2,673(in Euros)	34,324 (in Rupees)	81,651 (in Rupees)
8	Your current Occupational Status				
	Total Number of Responses	153	70	400	229
	Result of major percentage	Online Education (58%)	Work From home (41%)	No Change During COVID (31%)	Online Education (29%)
9	Is your household income affected due to current lockdown situation because of Covid-19 pandemic?				
	Total Number of Responses	153	76	400	229
	Yes/ No	36%/64%	39%/61%	61%/39%	59%/41%
10	Kindly express your income reduction in percentage?				
	Total Number of Responses	49	27	224	122
	Overall Average	32.6	40.55	37.9	40
	Overall Standard Deviation	24.23	25.07	24	23.6
11	Select the option that describes your family setup best				
	Total Number of Responses	138	73	364	204
	Result of major percentage	Couple with Children (37%)	Single Adult without children (32%)	Couple with Children (38%)	Joint Family (44%)
12	Number of cars/motorbikes in your house				
	Total Number of Responses	138	73	364	204
	Overall Average	2	1	2	2
	Overall Standard Deviation	1	1	1	1
13	How many trips did you perform (before Covid-19 pandemic) via car/car-pooling/motorcycle/taxi/uber on an average per day?				
	Total Number of Responses	137	73	364	203
	Overall Average	3	1	2	2.5

	Overall Standard Deviation	1.25	1.3	1.5	1.6
14	How many trips are you performing (during Covid-19 pandemic) via car/car-pooling/motorcycle/taxi/uber on an average per day?				
	Total Number of Responses	137	73	364	203
	Overall Average	1	0.2	0.6	0.7
	Overall Standard Deviation	1.2	0.5	1	1
15	How many trips did you perform (before Covid-19 pandemic) via bus/train/metro on an average per day?				
	Total Number of Responses	135	73	364	203
	Overall Average	0.4	1.23	0.86	0.9
	Overall Standard Deviation	1	1.4	1.16	1.32
16	How many trips are you performing (during Covid-19 pandemic) via bus/train/metro on an average per day?				
	Total Number of Responses	136	73	364	203
	Overall Average	0.14	0.16	0.18	0.14
	Overall Standard Deviation	0.7	0.53	0.64	0.6
17	How much is the fuel saved per week during Covid-19 pandemic as compare to normal situation?				
	Total Number of Responses	137	73	364	203
	Overall Average (%)	56.4	46	53.8	55.2
	Overall Standard Deviation (%)	26	35.7	28	25.5
Section II: Questions about your household activity travel routine (Work/Education activity Before Covid-19 pandemic)					
18	How many times you perform work/education activity in a week?				
	Total Number of Responses	129	49	356	192
	Overall Average	5	4	4	4
	Overall Standard Deviation	2	2	2	2
19	Average travel time required in minutes to reach the work/education activity				

	location.				
	Total Number of Responses	130	44	331	192
	Overall Average	27	29.3	35	26.7
	Overall Standard Deviation	17.7	18.7	25.7	20.7
20	Predominant Travel mode for work/education activity				
	Total Number of Responses	130	44	331	192
	Result of major percentage	Car (90%)	Cycling (34%)	Car (29%)	Car (34%)
21	Were you travelling				
	Total Number of Responses	129	44	331	192
	Result of major percentage	Alone (60%)	Alone (82%)	Alone (73%)	Alone (71%)
Section II: Questions about your household activity travel routine (Work/Education activity During Covid-19 pandemic)					
22	Are you currently (during Covid-19 pandemic) performing the Work/Education activity from home?				
	Total Number of Responses	130	71	352	193
	Yes / No	80% / 20%	87% / 13%	63% / 37%	52% / 48%
23	How many times are you performing work/education activity in a week?				
	Total Number of Responses	23	8	127	88
	Overall Average	4	2.4	3	3
	Overall Standard Deviation	2.5	2.65	2.5	2.6
24	Average travel time required in minutes to reach the work/education activity location.				
	Total Number of Responses	22	5	127	88
	Overall Average	25.2	28.5	29.8	25.7
	Overall Standard Deviation	15.8	20	24.5	23.24
25	Predominant Travel mode for work/education activity.				
	Total Number of Responses	23	5	127	88
	Result of	Car (70%)	Cycling	Two Wheeler	Car -

	major percentage		(60%)	(28%)	Scooter/motorbike (26%)
26	Are you travelling?				
	Total Number of Responses	23	5	127	88
	Result of major percentage	Alone (61%)	Alone (100%)	Alone (72%)	Alone (74%)
How do you normally (before Covid-19 pandemic) perform the grocery and top-up shopping activities?					
27	How many times did you perform the main grocery in a month?				
	Total Number of Responses	174	70	331	174
	Overall Average	2.35	3.8	2.52	2.34
	Overall Standard Deviation	1.4	3.2	1.4	1.4
28	How many times did you perform top-up grocery in a week?				
	Total Number of Responses	122	80	331	173
	Overall Average	1.78	1.7	2	2
	Overall Standard Deviation	1.18	1.4	1.4	1.6
29	Approximate distance from home to shopping location in kilometers. - Main Grocery				
	Total Number of Responses	124	68	331	174
	Overall Average	11	4.42	5.7	8
	Overall Standard Deviation	9.7	5.83	8	9
30	Approximate distance from home to shopping location in kilometers. - Top-up Grocery				
	Total Number of Responses	124	68	331	174
	Overall Average	6.2	3	4.54	6.86
	Overall Standard Deviation	8	4.6	8	10.6
31	Predominant Travel mode for shopping activities. - Main Grocery				
	Total Number of Responses	120	68	328	173
	Result of major	Car (88%)	Walking / Cycling	Walking / Cycling (	Car (47%)

	percentage		(51%)	26.83%)	
32	Predominant Travel mode for shopping activities. - Top-up Grocery				
	Total Number of Responses	120	66	311	173
	Result of major percentage	Car (76%)	Walking / Cycling (74%)	Walking / Cycling (41.16%)	Car (36%)
33	With whom you usually performed trips for main grocery? Rank items by dragging them up and down. - Alone				
	Total Number of Responses	95	56	272	132
	Overall Average	1.53	1.32	1.53	1.63
	Overall Standard Deviation	0.6	0.47	0.7	0.67
34	With whom you usually performed trips for main grocery? Rank items by dragging them up and down. - With family				
	Total Number of Responses	95	56	272	132
	Overall Average	1.66	2.12	1.8	1.67
	Overall Standard Deviation	0.66	0.8	0.69	0.7
35	With whom you usually performed trips for main grocery? Rank items by dragging them up and down. - With friends				
	Total Number of Responses	95	56	272	132
	Overall Average	2.8	2.55	2.67	2.69
	Overall Standard Deviation	0.5	0.63	0.57	0.6
36	With whom you usually performed trips for top-up grocery? Rank items by dragging them up and down. - Alone				
	Total Number of Responses	97	46	271	150
	Overall Average	1.45	1.17	1.43	1.35
	Overall Standard Deviation	0.61	0.44	0.66	0.58
37	With whom you usually performed trips for top-up grocery? Rank items by dragging them up and down. - With family				
	Total Number of Responses	97	46	271	150
	Overall Average	1.89	2.33	1.92	1.99
	Overall	0.73	0.67	0.66	0.64

	Standard Deviation				
38	With whom you usually performed trips for top-up grocery? Rank items by dragging them up and down. - With friends				
	Total Number of Responses	97	46	271	150
	Overall Average	2.66	2.5	2.65	2.65
	Overall Standard Deviation	0.6	0.6	0.6	0.64
How are you currently (during Covid-19 pandemic) performing the main grocery and top-up shopping activities?					
39	How many times did you perform the main grocery in a month?				
	Total Number of Responses	118	70	319	153
	Overall Average	2	2.77	2.05	2.04
	Overall Standard Deviation	1.7	1.58	1.3	1.33
40	How many times did you perform top-up grocery in a week?				
	Total Number of Responses	153	70	319	153
	Overall Average	2	1.36	1.8	2.04
	Overall Standard Deviation	1.47	1.12	1.3	1.47
41	Approximate distance from home to shopping location in kilometers. - Main Grocery				
	Total Number of Responses	119	66	319	154
	Overall Average	10.8	4.4	4.56	7.5
	Overall Standard Deviation	10.16	5.8	6.68	8.4
42	Approximate distance from home to shopping location in kilometers. - Top-up Grocery				
	Total Number of Responses	119	66	292	154
	Overall Average	6.24	2.92	3.77	6.34
	Overall Standard Deviation	8.9	5	6.85	9.61
43	Predominant Travel mode for shopping activities. - Main Grocery				
	Total Number of Responses	115	66	311	153

	Result of major percentage	Car (86%)	Walking/cycling (50%)	Two wheeler (40.84%)	Car (47%)
44	Predominant Travel mode for shopping activities. - Top-up Grocery				
	Total Number of Responses	104	62	280	153
	Result of major percentage	Car (74%)	Walking/cycling (71%)	Walking/cycling (45.36%)	Car (32%)
45	With whom you usually performed trips for main grocery? Rank items by dragging them up and down. - Alone				
	Total Number of Responses	80	38	138	66
	Overall Average	1.46	1.26	1.48	1.6
	Overall Standard Deviation	0.62	0.5	0.68	0.7
46	With whom you usually performed trips for main grocery? Rank items by dragging them up and down. - With family				
	Total Number of Responses	80	38	138	66
	Overall Average	1.76	2.3	1.84	1.82
	Overall Standard Deviation	0.64	0.73	0.7	0.8
47	With whom you usually performed trips for main grocery? Rank items by dragging them up and down. - With friends				
	Total Number of Responses	80	38	138	66
	Overall Average	2.78	2.45	2.68	2.58
	Overall Standard Deviation	0.53	0.65	0.57	0.63
48	With whom you usually performed trips for top-up grocery? Rank items by dragging them up and down. - Alone				
	Total Number of Responses	69	35	149	61
	Overall Average	1.4	1.2	1.44	1.46
	Overall Standard Deviation	0.57	0.47	0.65	0.7
49	With whom you usually performed trips for top-up grocery? Rank items by dragging them up and down. - With family				
	Total Number of Responses	69	35	149	61
	Overall	1.9	2.3	2	2

	Average				
	Overall Standard Deviation	0.7	0.7	0.7	0.7
50	With whom you usually performed trips for top-up grocery? Rank items by dragging them up and down. - With friends				
	Total Number of Responses	69	35	149	61
	Overall Average	2.7	2.5	2.6	2.5
	Overall Standard Deviation	0.6	0.6	0.66	0.67
51	How often are you shopping online these days (during Covid-19 pandemic)?				
	Total Number of Responses	116	69	319	153
	Result of major percentage	1-2 times a month / Never /(31%)	1-2 times a month (41%)	Never (52%)	Never (50%)
52	Have you changed your grocery shopping place due to Covid-19 pandemic)?				
	Total Number of Responses	117	69	319	153
	Yes / No	26% / 74%	26% / 74%	52% / 48%	42% / 58%
Out of home activities (Before COVID-19)					
53	Did you normally (before Covid-19 pandemic) perform out-of-home physical activities? Out-of-home physical activities include all activities, at any intensity, performed outdoors during any time of day or night. Examples are walking, jogging/running, cycling etc.				
	Total Number of Responses	118	69	317	153
	Yes / No	59% / 41%	78% / 22%	63%/37%	67% / 33%
54	How many times you performed out-of-home physical activities in a week?				
	Total Number of Responses	70	52	198	101
	Overall Average	3.23	3.63	4.56	3.46
	Overall Standard Deviation	1.55	1.74	1.9	1.71
55	Which out-of-home physical activities you normally performed?				
	Total Number of Responses	70	52	198	101
	Result of major percentage	Walking (51%)	Walking (25%)	Walking (63%)	Walking (58%)
56	Average time spent to perform out-of-home physical activities in minutes per day				
	Total Number of Responses	70	52	198	101
	Overall	34.7	37.5	32.4	29.3

	Average				
	Overall Standard Deviation	15.2	12.9	15	16
57	With whom you usually performed out-of-home physical activities? Rank items by dragging them up and down. - Alone				
	Total Number of Responses	60	47	164	85
	Overall Average	1.67	1.36	1.36	1.47
	Overall Standard Deviation	0.73	0.6	0.6	0.63
58	With whom you usually performed out-of-home physical activities? Rank items by dragging them up and down. - With family				
	Total Number of Responses	60	47	164	85
	Overall Average	2.32	2.4	2.13	2.28
	Overall Standard Deviation	0.8	0.74	0.7	0.71
59	With whom you usually performed out-of-home physical activities? Rank items by dragging them up and down. - With friends				
	Total Number of Responses	60	47	164	85
	Overall Average	2	2.23	2.5	2.25
	Overall Standard Deviation	0.81	0.7	0.71	0.83
Out of home activities (During COVID-19)					
60	Are you currently (during Covid-19 pandemic) performing out-of-home physical activities?				
	Total Number of Responses	118	67	315	151
	Yes / No	31% / 69%	69% / 31%	21% / 79%	25% / 75%
61	How many times are you performing out-of-home physical activities in a week?				
	Total Number of Responses	35	46	65	37
	Overall Average	2.86	4	4.25	2.94
	Overall Standard Deviation	1.5	1.94	2	1.65
62	Which out-of-home physical activities are you performing these days?				
	Total Number of Responses	35	46	65	37
	Result of major	Walking (37%)	Walking – Walking /	Walking (66%)	Walking (73%)

	percentage		Cycling		
63	Average time spent to perform out-of-home physical activities in minutes per day				
	Total Number of Responses	35	46	65	37
	Overall Average	34.5	36.5	31	26.55
	Overall Standard Deviation	16.6	15.62	16.76	16.05
64	With whom are you performing out-of-home physical activities? Rank items by dragging them up and down. - Alone				
	Total Number of Responses	29	37	51	28
	Overall Average	1.6	1.4	1.3	1.36
	Overall Standard Deviation	0.68	0.5	0.55	0.56
65	With whom are you performing out-of-home physical activities? Rank items by dragging them up and down. - With family				
	Total Number of Responses	29	37	51	28
	Overall Average	2.2	2.35	2.06	2.21
	Overall Standard Deviation	0.76	0.82	0.65	0.63
66	With whom are you performing out-of-home physical activities? Rank items by dragging them up and down. - With friends				
	Total Number of Responses	29	37	51	28
	Overall Average	2.24	2.27	2.63	2.43
	Overall Standard Deviation	0.87	0.73	0.66	0.84
Section III: Questions about occasional and collective mobility behavior					
67	How many long-distance trips planned by you in March/April/May 2020 postponed/canceled due to Covid-19 Pandemic? Long-distance trips include those trips in which you stay away from home for a minimum of 24 hours				
	Total Number of Responses	116	67	313	139
	Overall Average	2.4	2.91	2.13	2.73
	Overall Standard Deviation	3.7	3.42	2.5	3.6
68	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers -				

	Work/business trip - Personal Vehicle				
	Total Number of Responses	23	9	68	47
	Overall Average	162	70.67	763.64	151.6
	Overall Standard Deviation	459.7	161.8	3818.5	337
69	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Work/business trip - Bus				
	Total Number of Responses	7	9	20	19
	Overall Average	6.7	18.36	105.9	87
	Overall Standard Deviation	11.64	32	245.7	168
70	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Work/business trip - Train				
	Total Number of Responses	7	10	25	9
	Overall Average	5.7	164.5	404.32	368.5
	Overall Standard Deviation	15.1	173.18	424.7	564.8
71	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Work/business trip - Cruise				
	Total Number of Responses	7	3	7	6
	Overall Average	112.4	0	0.7	0.7
	Overall Standard Deviation	297	0	1.9	1.63
72	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Work/business trip - Aeroplane				
	Total Number of Responses	11	7	30	5
	Overall Average	658	2538	3263	1060
	Overall Standard Deviation	1217	4309	7083	1737
73	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers -				

	Education/Research based trip - Personal Vehicle				
	Total Number of Responses	22	8	46	33
	Overall Average	19	68.125	187.59	43
	Overall Standard Deviation	21.63	174.641	662.16	80.7
74	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Education/Research based trip - Bus				
	Total Number of Responses	8	13	16	16
	Overall Average	11	43	85.6	155
	Overall Standard Deviation	17	72	157	395
75	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Education/Research based trip - Train				
	Total Number of Responses	7	12	12	7
	Overall Average	1.43	291	96.4	186
	Overall Standard Deviation	3.78	355	158	448.6
76	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Education/Research based trip - Cruise				
	Total Number of Responses	7	5	5	6
	Overall Average	84	0	0	0.67
	Overall Standard Deviation	222.24	0	0	1.63
77	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Education/Research based trip - Aeroplane				
	Total Number of Responses	8	10	10	6
	Overall Average	134.63	5250	797.4	1501
	Overall Standard Deviation	280	5893	887	2344.57
78	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers -				

	Recreational/leisure trip - Personal Vehicle				
	Total Number of Responses	22	16	86	43
	Overall Average	28.3	198.13	553.8	177.53
	Overall Standard Deviation	48.3	264.24	1542.56	321.7
79	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Recreational/leisure trip - Bus				
	Total Number of Responses	7	10	19	14
	Overall Average	3.43	275.5	120.6	147.8
	Overall Standard Deviation	7.4	453.64	177.3	230.4
80	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Recreational/leisure trip - Train				
	Total Number of Responses	6	10	27	9
	Overall Average	833.3	390.9	500	411.4
	Overall Standard Deviation	2041.2	538	540.5	808.3
81	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Recreational/leisure trip - Cruise				
	Total Number of Responses	6	3	9	7
	Overall Average	1666.7	0	0	0.6
	Overall Standard Deviation	4082.5	0	0	1.5
82	Please mention the approximate distance to be traveled using different travel modes for each type... - Travel Distance using each mode in kilometers - Recreational/leisure trip - Aeroplane				
	Total Number of Responses	10	15	33	5
	Overall Average	1366.2	3163	1756.3	1260
	Overall Standard Deviation	2540.5	4407.24	2548.4	2653
83	Over all, the road congestion during the Covid-19 pandemic gets reduced?				
	Total Number	111	64	305	140

	of Responses				
	Result of major percentage	Strongly Agree (55%)	Strongly Agree (83%)	Strongly Agree (78%)	Strongly Agree (67%)
84	Over all the commuting become more safer (lower crashes) during the Covid-19 pandemic.				
	Total Number of Responses	111	64	305	140
	Result of major percentage	Somewhat Agree (45%)	Strongly Agree (45%)	Strongly Agree (61%)	Strongly Agree (59%)
85	The aggressive or reckless driving behavior on the roads get reduced during the Covid-19 pandemic.				
	Total Number of Responses	111	64	305	140
	Result of major percentage	Somewhat Agree (30%)	Neither agree nor disagree (34%)	Strongly Agree (59%)	Strongly Agree (51%)
86	Working from home increases productivity.				
	Total Number of Responses	110	64	305	140
	Result of major percentage	Neither agree nor disagree (34%)	Neither agree nor disagree (31%)	Neither agree nor disagree (27%)	Neither agree nor disagree (26%)
87	How is your experience with online/remote education method as compared to the conventional one?				
	Total Number of Responses	77	28	95	70 ¹
	Result of major percentage	Somewhat better - Somewhat worse (31%)	Somewhat worse (39%)	Somewhat better (29%)	Somewhat worse (41%)

¹ Questions 10,18-21,23-26,57-59,64-64-66,68-82,87 are all excluded due to the condition mentioned in chapter three (one of the regions or the corresponding comparing question has one or more regions of responses below than 30).

Appendix (2)

https://uhasselt.eu.qualtrics.com/jfe/form/SV_6WN8tMLSXf5thKR
https://uhasselt.eu.qualtrics.com/jfe/form/SV_6WN8tMLSXf5thKR

Effect of Covid-19 on Individual

Survey Completion 0% 100%

Section I: Questions About Socio-Demographic Aspects

Q1. Age in years

Q2. Gender

Male Female Transgender Prefer not to answer

Q3. In which country do you currently reside?

Q4. What is your nationality?

Q5. Your Occupational Status before Covid-19 pandemic.

Figure A.1: Questionnaire Website

Appendix (3):

In this appendix, the method of calculating the Z-test is illustrated numerically with the exact steps using a random example for explanation purposes only.

Table A.2: Z- test Example

Before COVID-19	During COVID-19
3	3
4	5
2	2
8	9
10	10
15	17
15	15
3	1
1	2
10	10
8	8
30	31
8	0
24	14
10	10

- The null hypothesis: $H_0: \mu_1 - \mu_2 = \delta_0$ (constant)
 δ_0 is assumed to be zero and accordingly the null hypothesis is $H_0: \mu_1 = \mu_2$. The alternative hypothesis $H_1: \mu_1 \neq \mu_2$.
- Finding z_{critical} from the z-table (table 3.2 and 3.3) by taking $\alpha/2$. Given α 0.05, accordingly z_{critical} equals to 1.96.

if z_{stat} does not fall within the rejection region, hypothesis is accepted. On the other hand, if it does fall within the rejection region, then it is rejected.

According to equations 3.1, 3.5 and 3.11

$$\bar{X}_1 = \frac{3 + 4 + 2 + 8 + 10 + 15 + 15 + 3 + 1 + 10 + 8 + 30 + 8 + 24 + 10}{15} = 10.067$$

$$\overline{X2} = \frac{3 + 5 + 2 + 9 + 10 + 17 + 15 + 1 + 2 + 10 + 8 + 31 + 0 + 14 + 10}{15} = 9.133$$

$$S^2_1 = \frac{936.933}{15} = 62.462$$

$$S^2_2 = \frac{907.733}{15} = 60.516$$

$$Z \text{ stat} = \frac{10.067 - 9.133}{\sqrt{\frac{62.462}{15} + \frac{60.516}{15}}} = 0.326$$

Since $-Z_{\text{critical}} \leq Z \text{ stat} \leq Z \text{ critical}$, then the null hypothesis is accepted (according to figure 3.2)

Appendix (4):

In this appendix, the method of calculating the Chi-square test is illustrated numerically with the exact steps using a random example for explanation purposes only.

Suppose the following distribution in regards to the travel frequently used

Table A.3: Chi-Square Test Example

Car	13
Public Transportation	14
Cycling	17
Walking	11

No, we have to illustrate the expected number of trips for each mode.

Table A.4: statistical Calculations - Chi square test

	Actual	Expected (average)	$(\text{observed value} - \text{Expected value})^2$
Car	13	14	1
Public Transportation	14	14	0
Cycling	17	14	9
Walking	11	11	0

Referring to equation 3.12

$$\frac{10}{14} = 0.714$$

Referring to 3.4, critical value is 7.81, and since the statistical value is less than critical value (figure 3.3) then the null hypothesis of equal frequency is accepted.

Appendix (5):

This appendix explains the expanded categorical equations depending on category selected with their corresponding coefficient. The answer for each would be either Yes (1) or no (0).

Method

Categorical predictor coding (1, 0)

Figure A.2: Categorical Predictor coding

Your Occupational Status before					
A student (university and similar), not working.	1.07	1.91	0.56	0.574	47.03
A student, also working part-time.	0.70	2.01	0.35	0.727	8.77
Employed for wages	0.96	1.92	0.50	0.618	30.83
Military person	0.65	2.32	0.28	0.779	3.04
Not mentioned	-0.88	1.90	-0.46	0.645	25.22
Out of work and looking for work	0.86	2.07	0.41	0.679	5.96
Self-employed	1.54	2.18	0.71	0.480	4.00
Unable to work	0.50	2.29	0.22	0.828	2.97
Did you normally (before Covid-					
Not mentioned	-1.185	0.426	-2.78	0.006	2.14
Yes	0.322	0.356	0.90	0.367	1.56

Figure A.3: Categorical Coefficients for Bahrain - Before COVID-19

Did you normally (before Covid-					
Not mentioned	-2.237	0.449	-4.99	0.000	1.84
Yes	-0.367	0.337	-1.09	0.279	1.13

Figure A.4: Categorical Coefficients for Europe - Before COVID-19

Your Occupational Status before					
A pensioner/retired	1.535	0.964	1.59	0.112	1.34
A student (university and similar), not working.	1.364	0.521	2.62	0.009	5.57
A student, also working part-time.	2.350	0.766	3.07	0.002	1.67
Employed for monthly salary	1.234	0.509	2.42	0.016	7.64
Not mentioned	-0.167	0.566	-0.29	0.768	6.19
Out of work and looking for work	0.984	0.965	1.02	0.308	1.34
Self-employed	2.041	0.583	3.50	0.001	3.18
Unable to work	1.76	1.27	1.39	0.165	1.17
Predominant Travel mode for sho					
Car	-1.40	2.05	-0.68	0.494	72.76
Not mentioned	-1.74	2.06	-0.85	0.398	115.80
Public Transport	-0.54	2.16	-0.25	0.803	10.05
Two wheeler	-0.66	2.04	-0.32	0.746	102.55
Uber/ola	-2.00	2.35	-0.85	0.396	4.01
Walking/cycling/cycle rickshaw	-1.05	2.05	-0.52	0.606	73.85

Figure A.5: Categorical Coefficients for India - Before COVID-19

Predominant Travel mode for sho					
Car	-0.36	1.28	-0.28	0.780	63.49
Not mentioned	-1.40	1.30	-1.07	0.283	127.57
Public Transport	1.84	1.43	1.29	0.198	7.72
Two wheeler	-0.39	1.27	-0.30	0.762	97.76
Uber/ola	6.92	1.94	3.57	0.000	4.79
Walking/cycling/cycle rickshaw	-0.41	1.28	-0.32	0.750	87.29
Predominant Travel mode for s_1					
Car	-1.42	1.47	-0.96	0.336	46.33
e-rickshaw	-2.05	1.93	-1.06	0.290	2.39
Not mentioned	-0.86	1.46	-0.59	0.554	166.95
Public Transport	-1.90	1.47	-1.30	0.195	6.82
Two wheeler	-1.26	1.46	-0.86	0.390	116.77
Uber/ola	-9.89	2.29	-4.32	0.000	3.35
Walking/cycling/cycle rickshaw	-1.51	1.46	-1.03	0.304	129.73

Figure A.6: Categorical Coefficients for India - During COVID-19

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	5.79	1.17	4.96	0.000	
Your Occupational Status before					
A student (university and similar), not working.	0.229	0.650	0.35	0.725	10.54
A student, also working part-time.	1.076	0.710	1.52	0.131	4.40
Employed for wages	0.287	0.658	0.44	0.663	9.14
Military person	0.86	1.78	0.48	0.630	1.16
Not mentioned	-1.305	0.678	-1.92	0.055	10.46
Out of work and looking for work	-0.819	0.930	-0.88	0.379	1.86
Self-employed	0.552	0.795	0.69	0.488	2.67
Unable to work	-1.14	1.78	-0.64	0.522	1.16
Predominant Travel mode for sho					
Motorcycle/scooter	0.045	0.305	0.15	0.884	1.57
Not mentioned	-1.539	0.337	-4.57	0.000	3.23
Public Transport	3.206	0.859	3.73	0.000	1.07
Walking/cycling	-0.676	0.374	-1.81	0.072	1.43
Which out-of-home physical acti					
Jogging/Running	-1.77	1.03	-1.71	0.088	8.00
Jogging/Running,Cycling	-1.40	1.96	-0.72	0.475	1.40
Not mentioned	-2.949	0.983	-3.00	0.003	24.28
Walking	-2.696	0.995	-2.71	0.007	17.38
Walking,Jogging/Running	-2.24	1.07	-2.10	0.037	5.97
Walking,Jogging/Running,Cycling	4.65	1.94	2.39	0.017	1.38

Figure A.7: Categorical Coefficients for Pakistan - Before COVID-19

الخلاصة:

تتناول هذه الدراسة تأثير جائحة كوفيد-19 على حركة المرور والنقل في البحرين والهند وباكستان والدول الأوروبية (معظمها بلجيكا وإيطاليا). تشير النتائج إلى تغييرات كبيرة في سلوك السفر وانخفاض كبير في إجمالي الرحلات أثناء الوباء. وتنوع المشاركون في أنشطتهم خارج المنزل، حيث أبدت أوروبا تفضيلها لمواصلة هذه الأنشطة. تسلط الدراسة الضوء على الحاجة إلى سياسات واستراتيجيات فعالة لمواجهة التحديات التي يفرضها الوباء وتوفر رؤى قيمة للتأهب للأوبئة في المستقبل. علاوة على ذلك، تستكشف الدراسة التأثيرات طويلة المدى على سلوك السفر، وتفضيلات النقل، وتدابير النظافة، مع التركيز على أهمية تكيف أنظمة النقل لتلبية الاحتياجات المتطورة.

جامعة البحرين

قسم الهندسة المدنية



كلية الهندسة

نمذجة تأثيرات كوفيد- 19 عبر البلدان على المستوى العام سلوكيات المرور والسفر

أطروحة مقدمة كجزء من متطلبات الحصول على درجة الماجستير في الهندسة المدنية

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