# Travel Behavior Changes during the COVID-19 Pandemic in Indonesia: Present, Past and Future

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## ABSTRACT

*COVID-19 (Coronavirus Pandemic 2019) brought major changes to the behavior and mobility of people all over the world. This change is mainly a consequence of the lockdown and social distancing taken by governments in most countries around the world. This article presents an analysis of a survey conducted in major cities from 6 big islands in Indonesia (Java, Bali, Sumatera, Kalimantan, Maluku, Papua) where citizens were asked about their mobility preferences before, during, and after the lockdown due to the virus and about factors that influence the decision in choosing a mode. The surveyors distributed the closed questionnaire using Google forms to reduce the contact time with the respondents. The data is processed through a comparative test with the Friedman Test revealed that there is an average difference in the choice of transportation mode before, during, and after the pandemic and there is also a difference about the main travel purpose of the community before, during, and after the pandemic. The main purpose of respondents' travel before the pandemic was work/school, during the pandemic it was shopping the daily needs (except those working in the essential sector) and after the pandemic returning to work/school as the main purpose of travel.*

*The results of the influence test on nine socio-demographic conditions revealed that before the pandemic there were 6 factors that influenced the mode choice, which is: gender, type of job, working in the essential sector or not, the number of people in the family, vehicle ownership and marital status influenced the modal choice, during pandemic COVID-19 there was 5 influential factors, which is: age, occupation, working in the essential sector/not, number of family members and vehicle ownership, after the pandemic are the same as before the pandemic except working in the essential sector/no*t.

**Keywords:** COVID-19 Pandemic, Modal Choice, Modal Shift, Travel Behavior, Travel Pattern.

## 1. INTRODUCTION

As an effort to prevent the spread of the SARS-CoV-2 virus, countries are implementing social distancing, using medical equipment such as mask, maintaining sanitation in every place and a lockdown policy. Many studies have proven that these efforts are effective in reducing the spread of COVID-19. Likewise Indonesia, when the COVID-19 pandemic was high, schools were closed, work and school from home and regulations to maintain distance in each area were enforced.

Social distancing policies are directly related to the movement of people and goods and are changing transportation systems and travel behavior around the world. The concern about contracting COVID-19 affects the behavior of each individual in transportation, this is reasonable considering that transportation can cause transmission of the virus and infection can spread throughout the country.

Based on the results of research in several countries, for example in Turkey, the results of surveys with the public, one of

the main efforts made by the community so that they do not get infected with COVID-19 is to avoid using public transportation and always wash their hands after every activity[1], the results of research on people in Tokyo, people avoid entertainment/recreational activities and avoid going to restaurants, but still go shopping using protective equipment such as masks, gloves, carrying hand sanitizers etc [2]. A study in Brazil mentions the fact that the use of public transportation in urban areas was reduced even before the pandemic, this reduction was even greater during the pandemic[3].

Developing countries are more vulnerable in dealing with the COVID-19 pandemic, in Tehran, the use of subways has decreased the most and the use of private vehicles has increased significantly[4]. Parker (2021) notes that many other studies have examined the impact of COVID-19 on travel behavior and public transportation early in the pandemic [1-13].

Studies regarding the impact of COVID-19 on transportation during the pandemic, starting from monitoring which modes have increased and decreased, then the policies that need to be taken to handle them need to be carried out. Even though all countries in the world experience the same difficulties, the impact is not identical in every country, therefore, comprehensive research is needed in each country. This research examines the impact of COVID-19 on changes in individual travel behavior in big cities in Indonesia.

This paper focuses on the following factors.

1. What is the factors influencing the selection of transportation modes for the main activity?
2. Is there a difference in the main travel purpose of the community before, during and after the occurrence of the COVID-19 Pandemic?
3. Is there a difference in the modes used by the community before, during and after the COVID-19 Pandemic?

## 1.1. Travel Behavior During COVID-19

Travel behavior during a pandemic is influenced by fear of contracting the virus, so that individuals tend to change their choice of transportation[1]. Most research results show that respondents prefer to use private vehicles rather than public transportation[3]. In Australia, the results of the study show that respondents feel that using trains and buses is less comfortable than using private vehicles.

In Thessaloniki, Greece, a study showed that respondents switched from public transportation to private vehicles and walking[10]. In Brazil, bus usage decreased by 55.9% between March and December 2020 when compared to the same period in the previous year NTU. However, these studies did not explain how the relationship between socioeconomic conditions and travel characteristics affected changes in the choice of transportation modes during a pandemic.

In addition, there is research that explains changes in travel characteristics with travel destinations, for example in Chicago respondents stated that going to hospitals, fitness centers and restaurants were travel destinations with the highest risk of contracting COVID-19, meanwhile visiting family and or friends and shopping is the travel destination with the lowest risk of infection[11]. In Canada the highest frequency of trips is for work or shopping [9], meanwhile in Australia the travel destinations with the least frequency are shopping, visiting friends and going to restaurants [6].

Many researchers suggest policies that can be implemented to minimize the negative impact of the pandemic on travel behavior, for example adjusting the supply of public transportation services for groups with different socio-economic conditions and different regions[10].

## 1.2. Quality of Urban Public Transportation (UPT)

Improving the quality of urban public transportation is important to attract new users and increase loyalty to the existing users. Therefore, it is important to investigate each individual's perception of service quality so as to determine the effective policies to be implemented by operators or regulators.

There are many previous researchers who suggest different indicators to assess urban public transport (TUP). Table 1 summarizes some of the most common indicators examined by past researchers. Service frequency, schedule reliability, comfort, cleanliness, safety, information and attention from field staff, and cost indicators are the indicators most used in various studies prior to the pandemic. However, the pandemic has changed the travel behavior of the community and towards the supply of public transportation, previous studies have not mentioned which factors most influence people's decisions in choosing their mode of transportation.

**Table 1. Quality indicators in urban public transportation**

| Factor | Indicator | Literatur review |
|---|---|---|
| **Accessibility** | Accessibility | Hadiuzzaman; Rahman; Ferraz; Joewono; Chen; Cheng; De Ona |
| | Distance of origin-destination and distance to station | Hadiuzzzaman; Chen; Cheng; De Ona; Hanz |
| **Flexibility** | Service frequency | Hadiuzzaman; Rahman; Ferraz; Chen; Cheng; De Ona; Han; Sa; Dos Santos |
| | The accuracy (reliability) of the schedule | Hadiuzzaman; Rahman; Ferraz; Joewono; Chen; Cheng; De Ona |
| | Trip delay | Chen; Cheng; Han |
| | Intermodal integration | Rahman; Joewono, Chen |
| | Average travel time | Hadiuzzaman; Rahman; Ferraz; Joewono; Sa; Dos Santos |
| **Fare** | Payment system | Hadiuzzaman; Rahman; Joewono; |
| | Travel expense | Hadiuzzaman; Rahman; Joewono; De Ona; Han; Sa; Dos Santos |
| **Security** | Personal security | Rahan; Ferraz; Joewono; Han; Sa; Dos Santos |
| | Women's safety | Hadiuzzaman |
| **Comfort** | Kebersihan | Hadiuzzaman; Rahman; Ferraz; Joewono; Chen; Cheng; De Ona; Han; Dos Santos |
| | Occupancy rates in the mode and at stations | Hadiuzzaman; Rahman; Joewono; Cheng; De Ona; Han |
| | Seat comfort | Hadiuzzaman; Rahman; Joewono; Chen; Han |

Some studies states that there are factors related to prevention of transmission, such as the use of masks, which are new factors that are relevant in influencing the choice of transportation mode. Therefore, this research contributes to examining the indicators that most influence urban communities in Indonesia in choosing their modes of transportation during the pandemic.

## 2. MATERIALS AND METHODS

### 2.1. Data collection method

The primary data needed in this study is data based on the respondents' answers to the questionnaires submitted. Questionnaires were compiled by asking respondents' preferences regarding the mode chosen before the pandemic and after the pandemic using the stated preference (SP) method. The questionnaire is in online form using the Google form, with the form setting to end itself if it is found that the filtered questions are being filled out by non-corresponding respondents. The questionnaire consists of 4 sections which can be seen in table 2.

**Table 2. Sections on the questionnaire**

| Section | Question |
|---|---|
| **Socio-demographics** | Domicile |
| | Gender |
| | Age |
| | Level of Education |
| | Jobs |
| | Monthly income |
| | Work in the essential/non-essential sector |
| | Number of family members |
| | Vehicle ownership |
| | Marital status |
| **Characteristics of the respondent's trip (the most done by the respondent)** | Travel mode used for main activities (before, during, and after the COVID-19 pandemic) |
| | Main activity travel purpose (before, during, and after the COVID-19 pandemic) |
| **Factors that influence the modal choice (with Likert scale)** | Travel expenses |
| | Comfort |
| | Punctuality |
| | Flexibility |
| | Hygiene |
| | Pride |

**2.2. Statistic Test**
**Normality Test**
The collected data is first tested for normality to find out if the data is distributed normally or not. This is important to do in order to further choose the right method, because normally distributed data is included in the parametric statistical category, otherwise it means entering into nonparametric statistics. These two types of statistics have different methods to perform comparative tests.

The normality test will use the Kolmogorov-Smirnov Test Method. The Kolmogorov-Smirnov Normality Test is a test performed to determine the distribution of random and specific data in a population[14]. Based on tests conducted by the National Institute of Standards and Technology, the Kolmogorov-Smirnov test is suitable for data sizes of 20 - 1000. However, in general research, the Kolmogorov Smirnov test is still used for data samples that measure more than 2000 samples ($20 \leq N \leq 1000$). So it is recommended to use the Kolmogorov Smirnov test for data above 50 samples. In testing, a data is said to be normally distributed when the significance value is more than 0.05 (sig. > 0.05).

**Comparative Test**
A comparative analysis carried out (before, during and after the pandemic), a hypothesis test will be carried out to ascertain whether there has been a significant change between the three conditions. The normality test should be done to find out the distribution of the data, and to select the proper methode to be used for the comparative analysis. The analysis plan can be seen in table 3

**Table 3. The applied comparative test**

| Variable | Hypothesis | Test | Confidence level |
|---|---|---|---|
| Travel mode before, during, after the pandemic | H0: There is no difference | Friedman Test | 95% |
| Travel purpose before, during, after the pandemic | H1: There is a difference | | |

**Correlation Test**

Correlation analysis was carried out to see the influence of the pandemic on the choice of travel mode. The choice of method used was also decided after the data distribution was known (normally distributed or not).

**Table 4. The applied correlation test**

| Variable | Test | Confidence level |
|---|---|---|
| Sosio-demographic factor: Gender, age, education level, employment, monthly income, essential worker/not, number of people in the household, car ownership, marital status | Correlation Enter method | 95% |
| Non-sosio-demographic factor: Travel cost, personal safety,comfort, punctuality, flexibility, hygiene, pride. | | |

## 3. RESULT AND DISCUSSION

**Results**

700 people from 26 big cities in Indonesia were involved in this research with the characteristics shown in table 3. The ratio between male and female respondents was almost equal, there were more female respondents than males. In terms of age, the most respondents are aged 18-30 years old as much 59,6%, respondents with college background dominating with 54,8% (summation of 39,1% bachelors and 15,7% Masters and PhDs), while respondents with education level high school and below as much 45,1%.

About their job, 80,3% respondents are employed/business owner, 18,7% are students and 1% others (retirement and housewife). The majority of respondents (81,1%) have a their own car. Interesting to see their monthly income, even 40% respondent's have below IDR 5 millions (low income), but 34,9% have above IDR 20 millions (high income), and 25,1% have IDR 5 millions – 20 millions (middle income).

**Table 5. Respondent's characteristics**

| Items | Category | Frequency | Percent |
|---|---|---|---|
| **Gender** | Female | 417 | 59,6 |
| | Male | 283 | 40,4 |
| **Age** | 18-30 | 354 | 50,6 |
| | 31-50 | 187 | 26,7 |
| | >50 | 159 | 22,7 |
| **Education level** | High school and below | 316 | 45,1 |
| | Bachelors | 274 | 39,1 |
| | Masters and PhD | 110 | 15,7 |
| **Employment** | Student | 131 | 18,7 |
| | Employed/Business | 562 | 80,3 |
| | Other | 7 | 1,0 |
| **Monthly income** | Below IDR 5 mio | 280 | 40,0 |
| | IDR 5 mio - IDR 20 mio | 176 | 25,1 |
| | Above IDR 20 mio | 244 | 34,9 |
| **Essential worker** | Yes | 150 | 21,4 |
| | No | 550 | 78,6 |
| **Number of people in the household** | 1-2 | 96 | 13,7 |
| | 3-4 | 376 | 53,7 |
| | 5 and more | 228 | 32,6 |
| **Car ownership** | Yes | 589 | 84,1 |
| | No | 111 | 15,9 |
| **Marital status** | Single | 568 | 81,1 |
| | Married | 132 | 18,9 |

Source: data

**Normality test**

The normality test is used to determine whether the data to is normally distributed or not. In this study, the Kolmogrov-Smirnov Normality Test was used because the data used was 700 respondents. The normality test's result is 0,000.

**Comparative Test**

The normality test results obtained Sig. 0.000 which means the data is not normally distributed, to test the differences between 3 interconnected samples, so the Friedman test is used for the comparative test. The following is the SPSS Friedman Test output for comparing the main modal choice.

**Table 6. Main modal choice comparative result before, during, and after pandemic**

| Test Statistics | |
|---|---|
| N | 700 |
| Chi-Square | 233,005 |
| df | 2 |
| Asymp. Sig. | 0,000 |
| Friedman Test | |

Source: data processing output

While the Friedman test output for comparing the trip purposes also resulting Asymp. Sig 0,000.

**Table 7. Main trip purposes comparative result before, during, and after pandemic**

| Test Statistics | |
|---|---|
| N | 700 |
| Chi-Square | 983,809 |
| df | 2 |
| Asymp. Sig. | 0,000 |
| Friedman Test | |

Source: data processing output

**Discussions**

With the same treatment approach, women were more easily involved as respondents, men's involvement was 40.4% while women were 59.6% of all respondents. Regarding their jobs, this research deliberately grouping jobs based on essential sectors those who have the privilege to travel around while lockdowns were implemented and non-essential sector those who must comply with lockdown and WFH policies.

Medical personnel, logistics, banker, ATM filling officers, TNI and Polri have the privilege to passing through the areas that must be sterile or locked down at the peak of the pandemic. This research needs to categorize respondents' jobs based on this to see changes in their preferences. If the monthly income range is divided into three groups: low, middle and high income, then 280 people (40%) have low income, 176 people (25%) have middle income, and 244 people (34.9%) have high income. This ratio displays a fairly balanced perspective from each group. Summarized, the majority of respondents in this study were women, of productive aged, well educated, had private vehicles and had upper-middle income.

Based on the results of the normality test, on the Kolmogorov-Smirnov and Shapiro Wilk columns. The Sig number of 0.000 is obtained where this figure is less than 0.05 which is the minimum number the data can be included as normally distributed data, so with a significance value of 0.000 the data is not normally distributed. This fact affects the decision to choose the next method.

Abnormally distributed data is included in non-parametric statistics, in this case of research with a total sample as much 700 respondents and because there are 3 samples (before, during and after) the pandemic, which come from the same subject (respondents), then the most appropriate method is the Friedman Test to compare conditions before, during and after.

The research hypothesis in the Friedman test were:
1. H0: there is no average difference in vehicle selection before, during and after the pandemic
2. Ha: there is an average difference in vehicle selection before, during and after the pandemic

Basis for decision making of Friedman test were by comparing Asymp.Sig values as follow:

1. If the Asymp. Sig. > 0.05, then $H_0$ is accepted and Ha is rejected
2. If the Asymp. Sig. <0.05, then $H_0$ is rejected and Ha is accepted

Friedmann test results to compare modal choice and to compare trip purposes were obtained the same Asymp value. Sig which is 0.000 (less than 0,05) so it means $H_0$ is rejected and Ha is accepted, in this case there are differences in the average choice of transportation mode before, during and after the pandemic and there are also differences in the main travel destinations of people before, during and after the pandemic.

**Impact of the COVID-19 Pandemic on Overall Trip Purposes**
The pandemic COVID-19 changes people travel habits, especially while the pandemic is ongoing. Picture 1 shows the main activity location (work/business and school/college).
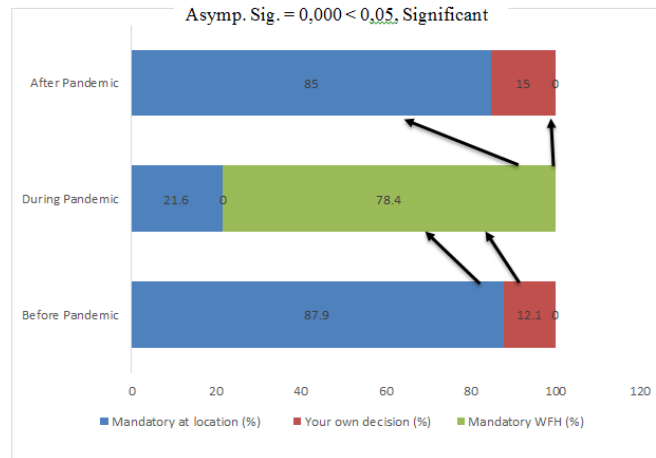


**Figure 1. The main activity location shifting**

Before the pandemic, the most of respondents (87.9%) worked/did business or studied with face-to-face methode and had to be in the office or place of education, only 12.1% of respondents had the privilege to decided of coming to the office or not, usually these were remote workers such as virtual assistants, remote teachers or consultants, application developers and online customer service. Meanwhile, none of the student respondents had the freedom to decide to carry out activities remotely, all of them had to be present at their school/campus.

During the pandemic, especially when COVID-19 peaked, the remaining 21.6% of respondents were still required to be present at their place of work/business, while 78.4% had no other choice but to comply with the work from home (WFH) rules. Included in the 21.6% of respondents who were required to come to their office/site are those who work in essential sectors (medical personnel, grocery stores, logistics delivery, banking, army and police).

After the pandemic over, 85% of respondents were again required to be present at their work/education location, this was reduced by 2.9% from the pre-pandemic condition, while the other 15% still had the privilege of deciding whether they wanted to attend on their work/education location or not.

Figure 2 shows that respondents' travel motivation changed when the COVID-19 pandemic occurred. Before pandemic, 77.3% of respondents stated that their main travel motivation was for work/business, 18.4% stated their main travel motivation was for education, 3.3% respondents stated it was for shopping activities and 1% for other activities such as accessing health facilities, recreation and social activities.
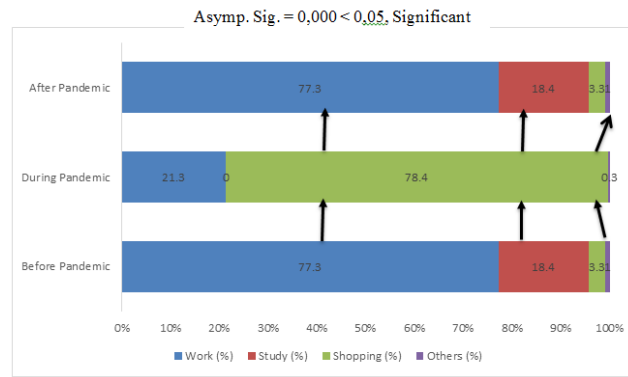
**Figure 2. Trip purposes shifting patterns**

This changed drastically during the pandemic, where the main trip purpose for work was only 21.3%, all of whom worked in the essential sector, and the rest 78.4% of the trip purpose was to buy daily necessities (shopping) and only 0.3 % for other activities such us to access medical facilities and to visit family. Furthermore, after the pandemic was over, the respondents' main trip purposes returned to what it was before the COVID-19 pandemic occurred. For more details regarding travel changes before the pandemic and during the pandemic, explained in the following paragraphs.
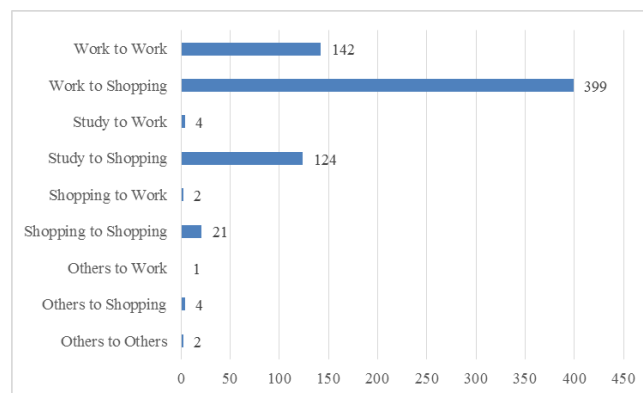


**Figure 3. Major travel shift statistics due to the pandemic**

Before the pandemic, the most of respondents prefer to use their private cars for their main activities (58.6%) but during the pandemic this decreased to 44.4%, the remaining 14.2% of private car enthusiasts chose non-motorized transportation (walking or cycling) during the pandemic. 25.6% of respondents prefer urban public transportation (UPT) before the pandemic, but during the pandemic only 5.7% continued to use UPT, the remaining 19.9% then chose to walk during the pandemic. Likewise with private motorbike users, which before the pandemic were 15.9%, fallen to 12.4%, which means 3.5% of private motorbike users switched to non-motorized modes of transportation during the pandemic. Figure 4 Explain modal shift caused by pandemic COVID-19.
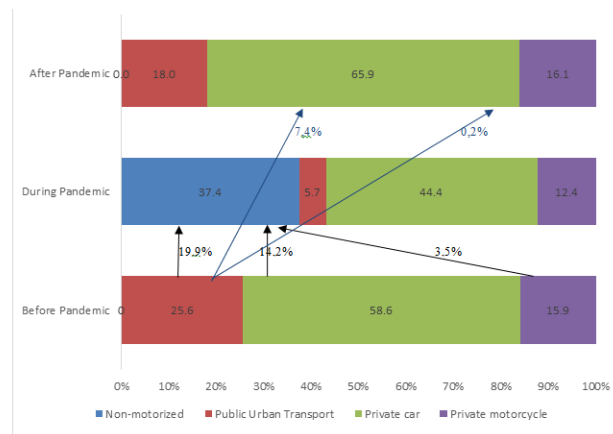
**Figure 4. Modal Shifting patterns**

After the pandemic, unfortunately only 18% of TUP users returned to TUP, the remaining 7.6% of respondents who used TUP before the pandemic, refused to return to TUP. 0.2% of TUP users before the pandemic decided to use motorbikes after the pandemic, the remaining 7.4% of respondents chose to continue using their private cars after the pandemic passed.

18% of TUP users after the pandemic over are respondents who used TUP before the pandemic occurred. Looking at their characteristics, the majority are respondents who do not have private vehicles and earn less than IDR 5,000,000 per month. Seeing that not all TUP users have returned to TUP after the pandemic, so requires efforts from various parties to increase the use of TUP, comfortable experience of using private vehicles may be difficult to replace, therefore appropriate regulations need to be implemented to shift people from private vehicles to TUP.

**Socio-demographic impact on mode choice**

An impact test was carried out to examine the influence of respondents' socio-demographics on their mode choices in 3 conditions (before, during and after) the pandemic, using the enter method with a decision making limit of 0.05.

**Table 8. Socio-demographic impact on mode choice test result**

| Item | Before | | During | | After | |
|---|---|---|---|---|---|---|
| Gender | 0.003 | * | 0.090 | | 0.000 | * |
| Age | 0.485 | | 0.000 | * | 0.119 | |
| Education level | 0.625 | | 0.302 | | 0.728 | |
| Employment | 0.000 | * | 0.025 | * | 0.001 | * |
| Monthly income | 0.830 | | 0.408 | | 0.844 | |
| Essential worker | 0.023 | * | 0.000 | * | 0.098 | |
| Number of people in the household | 0.015 | * | 0.002 | * | 0.027 | * |
| Car ownership | 0.005 | * | 0.000 | * | 0.000 | * |
| Marital status | 0.002 | * | 0.427 | | 0.005 | * |

*at a significance level of 0.05

Before the pandemic occurred, it was revealed that there were 6 socio-demographic factors that influenced the mode chosen by respondents for their main activity; gender, occupation, working in essential sectors, number of family members, vehicle ownership and marital status. Meanwhile, during the pandemic, there were 5 influencing factors, which are: age, employment, working in the essential/non-essential sector, number of family members, vehicle ownership. During the pandemic, gender no longer matters, nor does marital status. After the pandemic is over, there are still 5 influencing factors, those that were influential before the pandemic except regarding working in the essential/non-essential sector.

**Socio-demographic impact on trip purpose**

The same method as to check socio-demographic impat om mode choice also applied to check its impact on main trip purpose. As seen on Table 8, before the pandemic, there were 6 socio-demographic factors that influenced respondents' trip purpose: age, employment, monthly income, working in the essential/non-essential sector, number of people in the household, and car ownership. During the pandemic, only 3 influencing factors remained: employment, working in the essential/non-essential sector, car ownership, then after the pandemic was over, the influencing factors were the same as before the pandemic.

**Table 8. Socio-demographic impact on trip purpose test result**

| Item | Before | | During | | After | |
|---|---|---|---|---|---|---|
| Gender | 0.052 | | 0.917 | | 0.052 | |
| Age | 0.000 | * | 0.986 | | 0.000 | * |
| Education level | 0.244 | | 0.936 | | 0.244 | |
| Employment | 0.000 | * | 0.022 | * | 0.000 | * |
| Monthly income | 0.000 | * | 0.382 | | 0.000 | * |
| Essential worker | 0.023 | * | 0.000 | * | 0.023 | * |
| Number of people in the household | 0.009 | * | 0.169 | | 0.009 | * |
| Car ownership | 0.006 | * | 0.028 | * | 0.006 | * |
| Marital status | 0.068 | | 0.740 | | 0.068 | |

*at a significance level of 0.05

**Non-Socio demographic factors impact on mode choice**

In this research, there are 7 factors hypothesized to influence mode choice in urban communities: (1) travel costs; (2) personal safety; (3) comfort; (4) punctuality, (5) flexibility; (5) hygienic; (6) pride.

The questionnaire explains the following conditions:
a. Travel costs including costs incurred for all modes from starting point to ending point at the destination,
b. Security includes security inside the vehicle, outside the vehicle and at supporting facilities,
c. Comfort includes shock, seat comfort, comfort in carrying out necessary communications (telephone calls, replying to messages, etc.),
d. Punctuality includes the timeliness of arriving at the destination as estimated by the traveler,
e. The flexibility referred to in this research is the ease of stopping by at certain places, easy access the desired mode at any time,

f.  Hygienity referred to in this research is the certainty of minimal/avoid infection from other people because the mode and facilities look clean, there is no smell from sewage, rubbish is not scattered around, there is sanitizer, passengers are required to wear masks and their body temperature is checked.

g.  The pride in the questionnaire is the feeling of pride that arises as a result of choosing to use the chosen mode, whether it is pride in utilise a private car, pride in participating in overcoming congestion or pollution, etc.

In the questionnaire, respondents are asked to give a score to each factor using Likert Scale 1 to 5, where 1 is very unimportant for them in choosing a mode to use, and 5 is very important for them. It was also emphasized that they were not asked to assess the performance conditions of existing modes. Table 9 summarizes the results of the impact test that before, during, and after the pandemic.

**Table 9. Non Socio-demographic impact on mode choice test result**

| Item | Before | During | After |
|---|---|---|---|
| Travel Cost | 0,000 * | 0,148 | 0,232 |
| Safety | 0,098 | 0,762 | 0,330 |
| Comfort | 0,000 * | 0,000 * | 0,000 * |
| Punctuality | 0,000 * | 0,106 | 0,000 * |
| Flexibility | 0,000 * | 0,222 | 0,000 * |
| Hygiene | 0,163 | 0,023 * | 0,497 |
| Pride | 0,015 | 0,650 | 0,138 |

*at a significance level of 0.05

**The Impact of Travel Costs on Mode Choice**

Before pandemic COVID-19, travel costs are the main concern for respondents with monthly income less than IDR 5 million, which can be seen in the figure 5, the light blue bars are the number of respondents who gave score 4 (important) and score 5 (very important) in choosing a mode of transportation, who gave score 4 as many 79 people and 135 people gave 5 score so the total number of respondents who considered travel costs is important and very important thing was 214 people from respondents with a monthly income of less than IDR 5 million, or 30.57% of the total respondents.
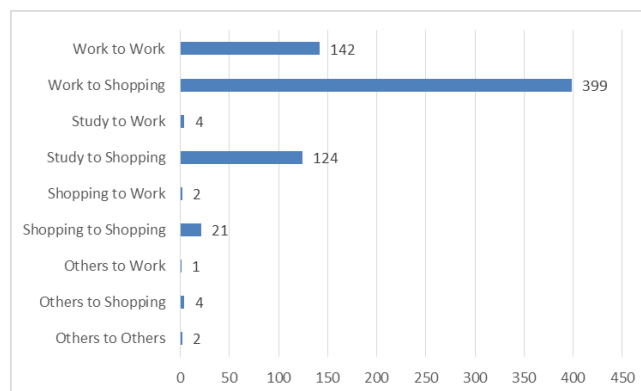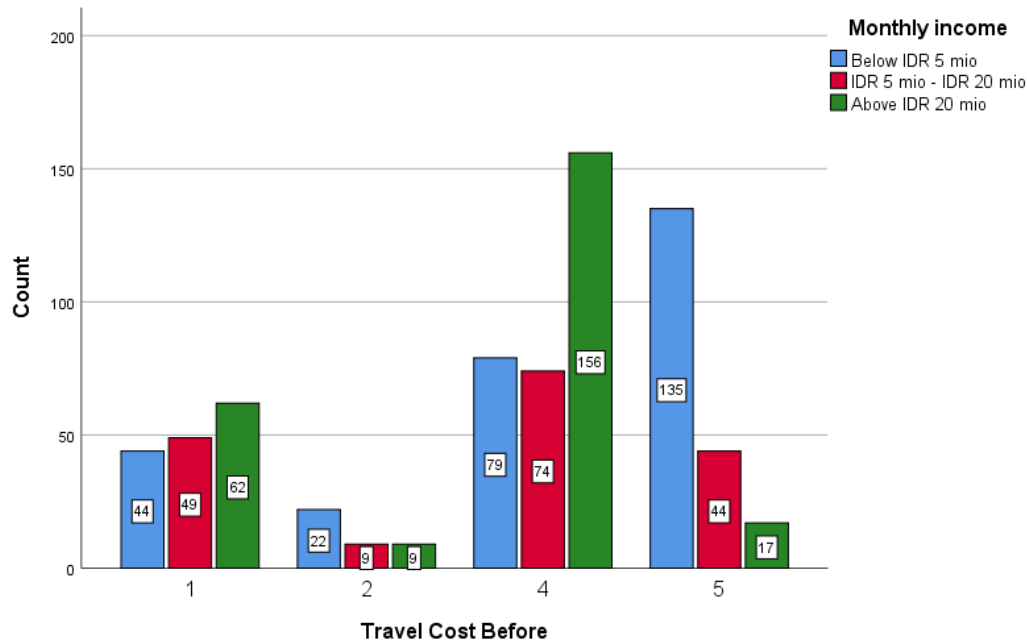
**Figure 5**. **Distribution of importance scores for travel cost factors on monthly income**

It is also necessary to pay attention to the mode of transportation chosen by respondents regarding travel cost. Based on the figure 6, it can be seen that 144 people consider travel costs important and very important has chosen urban public transportation (blue in the graph) and 107 people use motorbikes and 254 people use private cars (red in the graph).
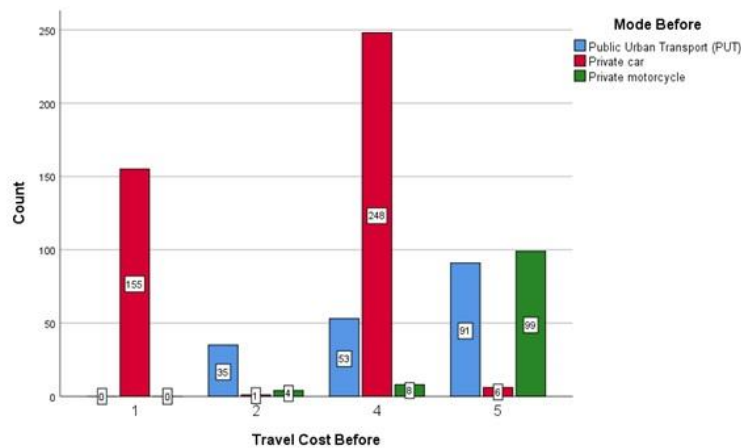


**Figure 6. Distribution of importance scores for travel cost factors on mode choice**

**The Impact of Travel Comfort on Mode Choice**

Comfort is important for some respondents, especially respondents with monthly incomes between 5 million – 20 million (middle income) and respondents with monthly incomes above IDR 20 million (upper income), as can be seen in the figure 7.
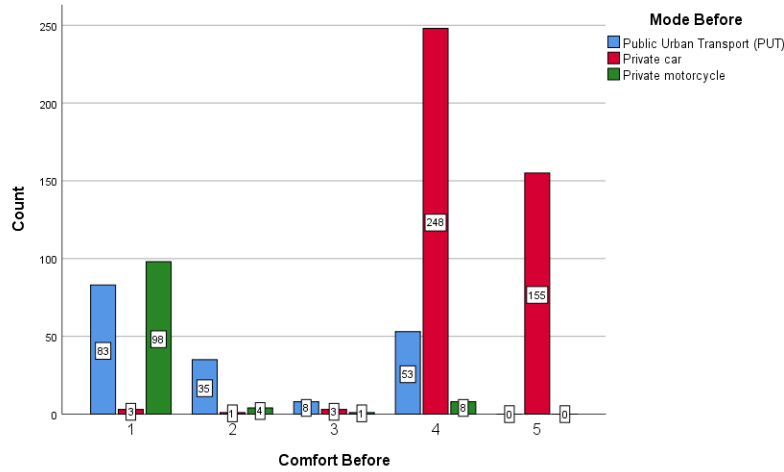
**Figure 7. Distribution of comfort factor importance scores on monthly income before the pandemic**

The most respondents from these 2 groups (middle and upper income) gave scor 4 (important) and 5 (very important). The total respondents who gave score 4 and 5 from those two groups was 74 + 156 + 49 + 62 = 341 respondents (48.71%), meanwhile respondents with monthly income of less than 3 million rupiah (low income) did not rate comfort as important factor in choosing transportation mode, the most respondents from this group gave score 1, as many as 126 people, gave point 2 as many as 22 people and answered neutral or gave point 3 as many as 9 people.

Figure 7 shows the distribution of mode choices for respondents who prioritize comfort and those who do not prioritize comfort before pandemic occurred. Of those who prioritize comfort (gave points 4 and 5 to the comfort aspect) as many as 248 + 155 = 403 people has chosen private cars and 8 people chose motorbikes. Meanwhile, those who did not prioritize comfort has chosen urban public transportation as many as 83 + 35 = 118 people, who chose motorbikes as many as 98 + 4 people = 102 people. Next, the position of comfort aspects during the pandemic will be examined.

The comfort factor remains as a significant factor in choosing a transportation mode during pandemic COVID-19 with a significance value of 0.000. Respondents who gave score 4 (important) and score 5 (very important) chose to use private car as many as 160 + 74 = 234 people and used non-motorized vehicles as many as 129 + 82 = 211 people. Perceptions of comfort during the pandemic tend to shift towards avoiding other people.
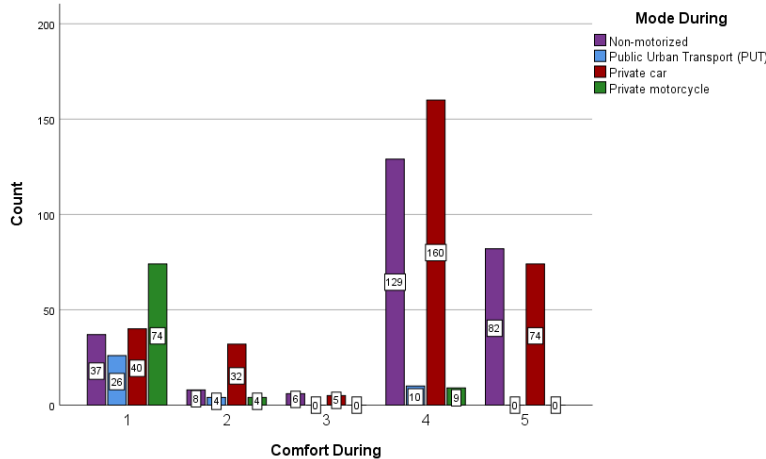


**Figure 8. Distribution of importance scores for comfort factors on mode choice during the pandemic**

After the pandemic, comfort still significantly influences the transportation mode choice, Figure 9 shows that the most respondent who gave score 4 and 5 to the comfort factor chose to use private car, the number was 254 + 155 = 409 respondents, increasing 6 respondents compared to before the pandemic occurred.
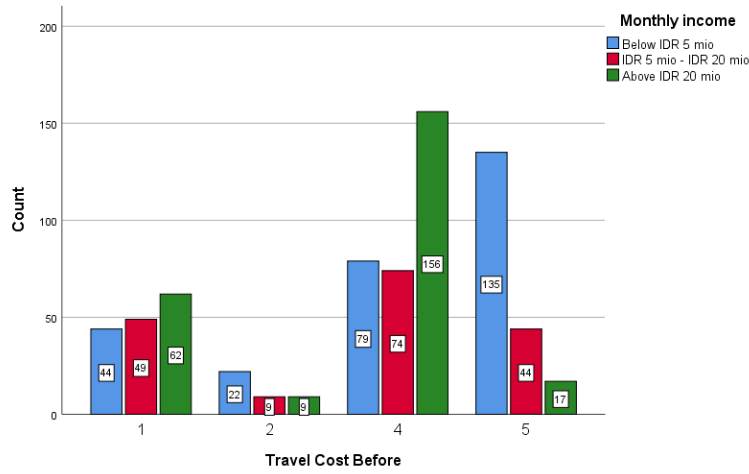
**Figure 9. Distribution of importance scores for comfort factors on mode choice after the pandemic**

**The Impact of Punctuality on Mode Choice**

Punctuality is an important factor for urban communities, this is proven by the significance of punctuality correlation to the modal choice before the pandemic COVID-19.
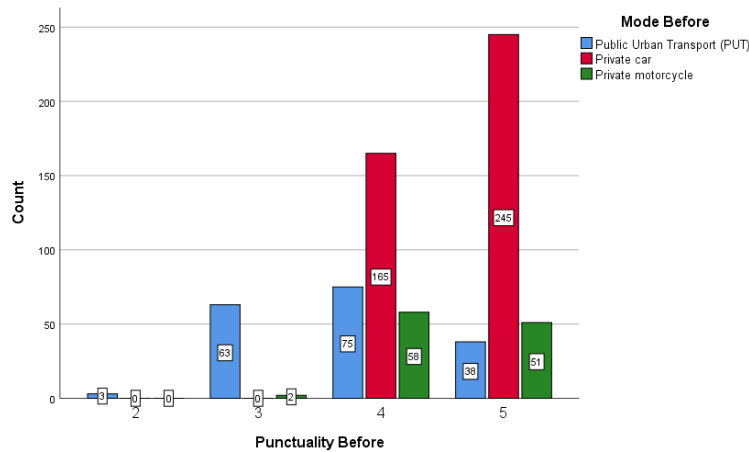


**Figure 10. Distribution of importance scores for punctuality factors on mode choices before the pandemic**

As seen in Figure 10, before the pandemic, the majority of respondents who gave a score of 4 (important) and 5 (very important) for punctuality aspect chose to use a car as many as 165 + 245 = 410 people, while 58 + 51 = 109 people used private motorbikes and people who used urban public transportation as many as 75 + 38 = 113 people.

As can be seen on Table 9, revealed that punctuality did not significantly influence modal choice during the pandemic, this was due to shifting in movement patterns due to WFH and lock down policies, but after the pandemic over and activities returned to normal as before, punctuality again had a significant influence.

Identic to condition before the pandemic occur, when the pandemic was over, the majority of respondents who scored important (4) and very important (5) chose to use private cars, but the number of people choosing private cars was greater than before, increasing from 410 people before the pandemic to 453 people, while respondents who chose to use private motorbikes decreased from 109 people before the pandemic to 106 people after the pandemic, and those who chose urban public transportation decreased from 113 people before the pandemic to 73 people after the pandemic.
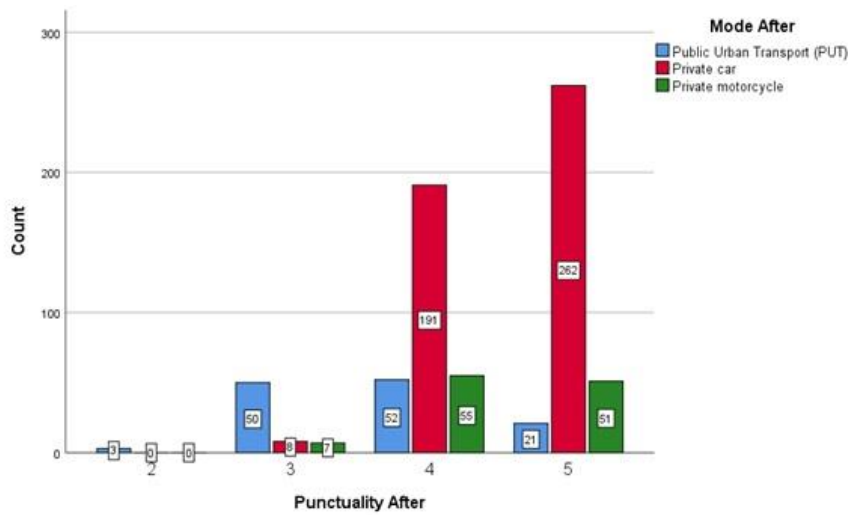
**Figure 11. Distribution of importance scores for punctuality factors on mode choices after the pandemic**

**The Impact of Flexibility on Mode Choice**

To the busy urban residents, most trips are multi-trips that have more than one destination, sometimes they have to stop at several places to fulfill other needs. For example, even though the main destination is to go to the office or campus, during the trip someone has to shop or pay bills at the bank, and so on, so modal flexibility revealed greatly influences the decision to use the mode.
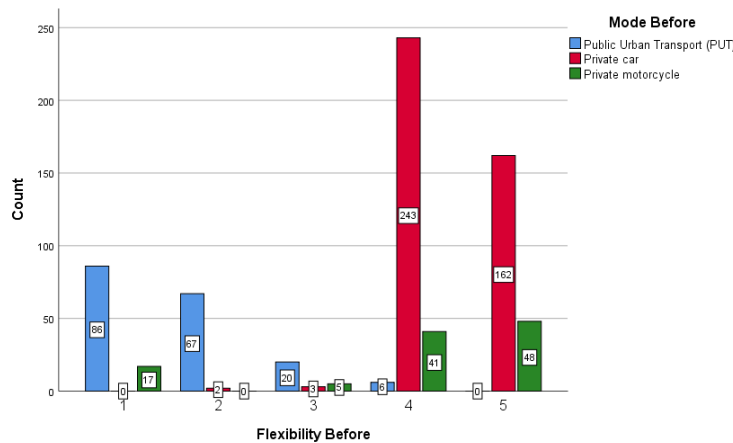


**Figure 12. Distribution of flexibility factor importance scores on mode choices before pandemic**

As seen in Figure 12, before pandemic occurred, respondents who rated flexibility as important (gave a score of 4) or very important (gave a score of 5), the majority respondents chose to use a private car as many as 243 + 162 = 405 people and those who chose to use a private motorbike as many as 41 + 48 people = 89 people. Only 4 people out of 700 respondents who consider flexibility as an important factor in choosing a transportation mode has chosen urban public transportation.
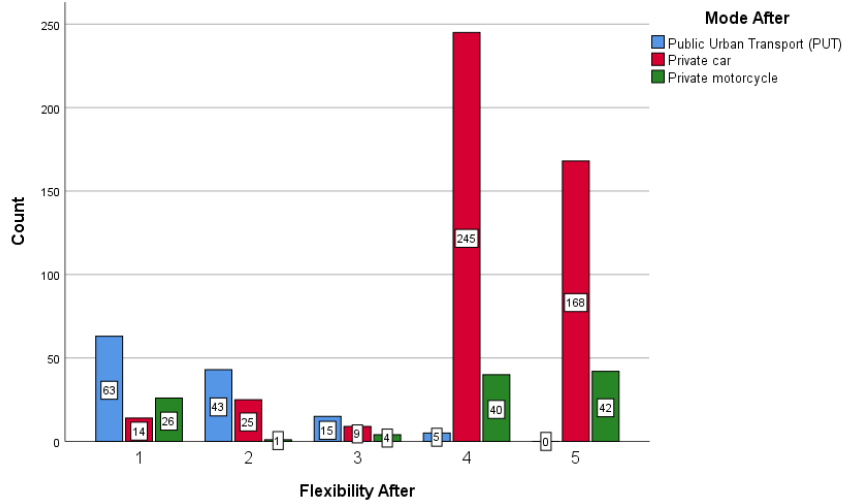
**Figure 13. Distribution of flexibility factor importance scores on mode choices after the pandemic**

During the pandemic, the flexibility factor was no longer considered important by respondents, this was because at the peak of the pandemic, lock down and WFH regulations was forced, so their main travel purpose was only shopping for daily necessities at the closest shop to home.

After the pandemic, the flexibility factor again became important and respondents who used private cars increased from 405 people before the pandemic to 245 + 168 = 413 people, while those who used private motorbikes decreased from 89 people to 82 people.

**The Impact of Hygiene on Mode Choice**

Before the COVID-19 pandemic occurred, hygiene factors were not a factor that significantly influenced the modal choice, but when the pandemic occurred hygiene became significantly influence with a Asymp. value of 0.023.
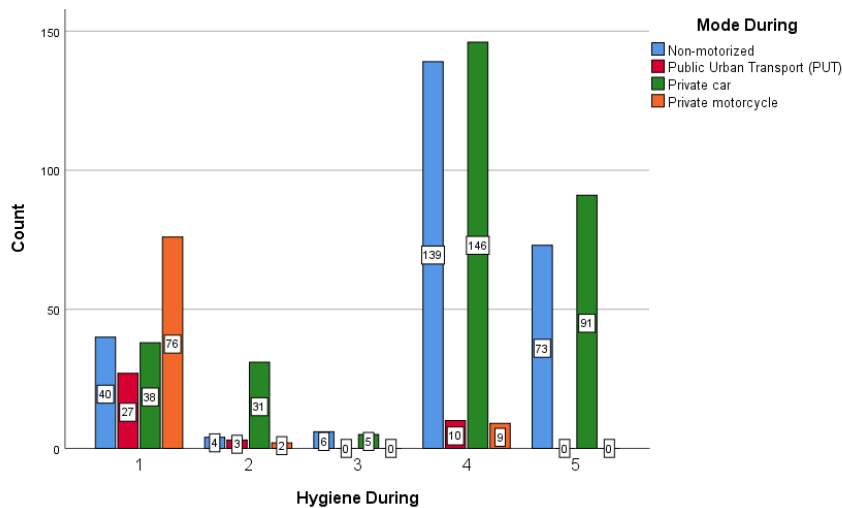


**Figure 14. Distribution of hygiene factor importance scores on mode choice during the pandemic**

Based on the picture 124 during the pandemic, the majority of respondents who considered hygiene factors as important and very important factor chose to use non-motorized vehicles and private vehicles during the pandemic. This is because people's movements during the pandemic are limited by WFH and lock down regulations, except for essential sectors, so they tend to went to the closest shop to buy daily needs by using non-motorized vehicles or car. After the pandemic, hygiene revealed as a factor that does not influence the modal choice.

## The Impact of Pride on Mode Choice

Before the pandemic, pride was a significant factor in choosing a mode of transportation. 148 respondents who used private cars gave a score of 4 (important), while 237 car users said they were neutral (score 3). For public transportation users, pride is not an important thing in choosing a mode of transportation.
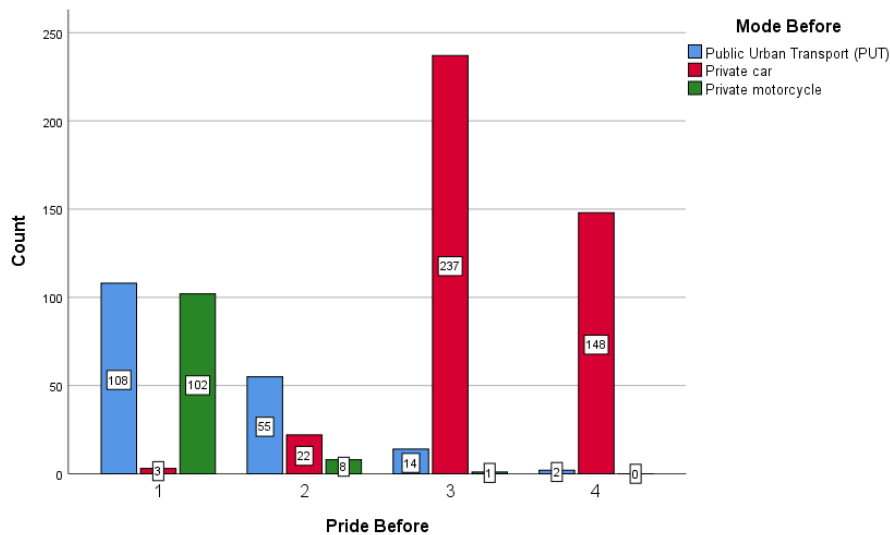


**Figure 15. Distribution of pride factor importance scores on mode choices before the pandemic**

From the results of the influence test, the pride factor was not an important factor in choosing mode during the pandemic and after the pandemic for all respondents.

Overall, based on the influence analysis of socio-demographic factors and external factors, it can be seen that there is a significant influence between the monthly income of each individual and private car ownership, this can be seen from how they give scores to the 7 factors examined as has been found in several studies that travel costs influence a person's modal choice (Hadiuzzaman; Rahman; Joewono; De Ona; Han; Sa; Dos Santos). Urban public transportation user with medium and high monthly incomes, as well as those who owned private cars tended to change their preferences during the pandemic and after the pandemic to become private car users.

During the pandemic, respondents no longer cared about travel costs, even though before the pandemic this was important (Hadiuzzaman; Rahman; Joewono; De Ona; Han; Sa; Dos Santos), as were punctuality (Hadiuzzaman; Rahman; Ferraz; Joewono; Chen; Cheng; De Ona) and flexibility (Hadiuzzaman; Rahman; Ferraz; Chen; Cheng; De Ona; Han; Sa; Dos Santos), the factors considered the most important in choosing mode of transportation is comfort and hygiene. Respondents are willing to spend more during a pandemic as long as they feel comfortable traveling and are confident that they are in a hygienic condition, which is the reason why the use of private cars has increased during the pandemic. Private cars have the characteristic of creating a sense of comfort which has been shown by various literature to be a consideration for the public in choosing transportation (Hadiuzzaman, Rahman, Joewono, Cheng, De Ona, Han) and also has the characteristic of an occupancy level that can be adjusted according to the wishes of the car owner which also creates comfort (Hadiuzzaman; Rahman; Joewono; Cheng; De Ona; Han) even cleanliness or hygiene which can always be adjusted according to the car owner's standards where this is also a consideration for the community (Hadiuzzaman; Rahman; Ferraz; Joewono; Chen; Cheng; De Ona; Han; Dos Santos).

Before pandemic COVID-19, Indonesia's transportation system is being massively improved, in recent years the mass transportation system has been improved; becoming cashless, unclear departure and arrival schedules are also being improved, as is the headway, comfort and cleanliness in modes is a priority, the need for the elderly and women is also given carefull attention[15]. Both modes of transportation and supporting infrastructure are strived to be in good condition, the activity of moving people and goods requires an excellent level of road service because damage can affect economic activity, quality of life, and the environment [16].

The habit of using a private car creates a feeling of comfort so that the mode shifting from urban public transportation to a private car which might have been planned to be used only during the pandemic then changed to be a private car user after the pandemic, this increases the use of private cars after the pandemic.

Service improvements in the transportation system must be done so that choice groups are willing to switch to public transportation[17]. Urban public transportation must have a competitive advantage. Competitive advantage is a company's ability to create value that cannot be owned and copied by competitors or the company's ability to create a superior position over its competitors. Indicators for competitive advantage can be: a) Price, when a company gives a price more competitive or lower than competitors; b) quality, when high-quality products and services increase customers and make them loyal; c) dependent on supply, interdependent between partners in the supply chain will strengthen product delivery from downstream to upstream; d) innovative product answer customer needs and better than competitors; and e) time to market is how far companies are capable of launching and introducing new products faster than competitors[18].

## 4. CONCLUSION

The conclusion that can be withdrawn are:

1.  The results of the influence test on 9 socio-demographic conditions reveal that before the pandemic there were 6 factors that influenced mode choice: gender, employment, working in the essential sector/not, number of people in the family, vehicle ownership and marital status. During the pandemic, there are 5 influencing factors: age, employment, working in the essential sector/not, number of people in the family, and vehicle ownership. After the pandemic the influencing socio-demography factors are the same as before the pandemic except for the field of work in the essential sector,

2.  There is an average difference in modal choice due to the COVID-19 pandemic, during the pandemic the majority transportation mode shifting from the largest to the fewest are: (1) private cars to non-motorized transportation; (2) urban public transportation to non-motorized transportation modes; (3) private motorbikes to non-motorized transportation modes. When the conditions before the pandemic compared to after the pandemic, the majority of modal shifts are: (1) urban public transportation to private cars; Urban public transportation to private motorbikes

3.  There were differences in people's trip purpose before, during and after the COVID-19 pandemic, before the pandemic the respondents' main trip purpose was work/school, during the pandemic the main trip purpose was shopping for daily necessities, and after the pandemic the main trip purpose was returning to work/school.

## REFERENCES

[1] M. Yıldırım, E. Geçer, and Ö. Akgül, "The impacts of vulnerability, perceived risk, and fear on preventive behaviours against COVID-19," *Psychol. Health Med.*, vol. 26, no. 1, pp. 35–43, Jan. 2021, doi: 10.1080/13548506.2020.1776891.

[2] G. Parady, A. Taniguchi, and K. Takami, "Travel behavior changes during the COVID-19 pandemic in Japan: Analyzing the effects of risk perception and social influence on going-out self-restriction," *Transp. Res. Interdiscip. Perspect.*, vol. 7, Jan. 2020, doi: 10.1016/j.trip.2020.100181.

[3] M. de Haas, R. Faber, and M. Hamersma, "How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands," *Transp. Res. Interdiscip. Perspect.*, vol. 6, p. 100150, 2020, doi: https://doi.org/10.1016/j.trip.2020.100150.

[4] M. Khadem Sameni, A. Barzegar Tilenoie, and N. Dini, "Will modal shift occur from subway to other modes of transportation in the post-corona world in developing countries?," *Transp. Policy*, vol. 111, pp. 82–89, 2021, doi: https://doi.org/10.1016/j.tranpol.2021.07.014.

[5] M. E. G. Parker *et al.*, "Public transit use in the United States in the era of COVID-19: Transit riders' travel behavior in the COVID-19 impact and recovery period," *Transp. Policy*, vol. 111, pp. 53–62, 2021, doi: https://doi.org/10.1016/j.tranpol.2021.07.005.

[6] M. J. Beck and D. A. Hensher, "Insights into the impact of COVID-19 on household travel and activities in Australia – The early days under restrictions," *Transp. Policy*, vol. 96, pp. 76–93, 2020, doi: https://doi.org/10.1016/j.tranpol.2020.07.001.

[7] X. Chen, Y. Guo, C. Yang, F. Ding, and Q. Yuan, "Exploring essential travel during COVID-19 quarantine: Evidence from China," *Transp. Policy*, vol. 111, pp. 90–97, 2021, doi: https://doi.org/10.1016/j.tranpol.2021.07.016.

[8] E. Echaniz, A. Rodríguez, R. Cordera, J. Benavente, B. Alonso, and R. Sañudo, "Behavioural changes in transport and future repercussions of the COVID-19 outbreak in Spain," *Transp. Policy*, vol. 111, pp. 38–52, 2021, doi: https://doi.org/10.1016/j.tranpol.2021.07.011.

[9] M. R. Fatmi, "COVID-19 impact on urban mobility," *J. Urban Manag.*, vol. 9, no. 3, pp. 270–275, 2020, doi: https://doi.org/10.1016/j.jum.2020.08.002.

[10] S. Hu and P. Chen, "Who left riding transit? Examining socioeconomic disparities in the impact of COVID-19 on ridership," *Transp. Res. Part D Transp. Environ.*, vol. 90, p. 102654, 2021, doi: https://doi.org/10.1016/j.trd.2020.102654.

[11] A. Shamshiripour, E. Rahimi, R. Shabanpour, and A. (Kouros) Mohammadian, "How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago," *Transp. Res. Interdiscip. Perspect.*, vol. 7, p. 100216, 2020, doi: https://doi.org/10.1016/j.trip.2020.100216.

[12] M. Xin, A. Shalaby, S. Feng, and H. Zhao, "Impacts of COVID-19 on urban rail transit ridership using the Synthetic Control Method," *Transp. Policy*, vol. 111, pp. 1–16, 2021, doi: https://doi.org/10.1016/j.tranpol.2021.07.006.

[13] K. F. Yuen, M. S. Bin Saidi, X. Bai, and X. Wang, "Cruise transport service usage post COVID-19: The health belief model application," *Transp. Policy*, vol. 111, pp. 185–196, 2021, doi: https://doi.org/10.1016/j.tranpol.2021.08.002.

[14] R. G. L. and J. R. I. M. Chakravarti, *No Title*. Hoboken: John Wiley and Sons, 1967.

[15] R. K. Kinasih, P. Joewono, S. Indriany, M. Isradi, and A. W. Biantoro, "Analyzing Toll Road as a Solution to The Existing Highway Problem," *Res Mil.*, vol. 12, no. 6, pp. 434–445, 2022, [Online]. Available: https://resmilitaris.net/menu-script/index.php/resmilitaris/article/view/2228/1859

[16] M. Isradi, J. Prasetijo, Y. D. Prasetyo, N. Hartatik, and A. I. Rifai, "Prediction of Service Life Base on Relationship Between Psi and Iri for Flexible Pavement," *Proc. Eng. Sci.*, vol. 5, no. 2, pp. 267–274, 2023, doi: 10.24874/PES05.02.009.

[17] S. Indriany, A. Sjafruddin, A. Kusumawati, and W. Weningtyas, "Mode choice model for working trip under risk and uncertainty," in *AIP Conference Proceedings*, Jun. 2018, vol. 1977. doi: 10.1063/1.5042897.

[18] A. H. D. Purwanto, M. Nashar, Y. Jumaryadi, W. Wibowo, and A. Mekaniwati, "Improving medium small micro enterprise' (MSME) performance," *Int. J. Adv. Appl. Sci.*, vol. 9, no. 5, pp. 37–46, 2022, doi: 10.21833/IJAAS.2022.05.005.

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