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Analyzing Transportation Barriers and Their Impact on Commuting

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Abstract

This study observes transportation barriers and their impact on daily commuting, considering demographic, socioeconomic, and environmental factors. A structured survey was conducted, and statistical analyses, including Chi-square tests, crosstabulations, and cluster analysis, were applied to study associations between gender, age, income, occupation, and commuting experiences. Results indicate that gender significantly affects the frequency of transportation barriers and primary transport mode choice, income influences public transport usage, age relates strongly to traffic stress and barrier inconvenience, and occupation impacts commute safety perceptions. Both natural barriers (floods, landslides, fog, heavy rainfall) and artificial barriers (traffic congestion, road construction, weak traffic management) were found to disrupt mobility. Survey responses suggest that wider and well-structured roads, durable infrastructure, improved public transport, and efficient traffic control can moderate these challenges. Cluster analysis discovered that income, road quality, and exposure to barriers are key variables influencing commuting inconvenience, with some groups facing higher costs or delays due to poor infrastructure or environmental factors. The findings emphasize the need for inclusive, age- and income-sensitive transportation planning, infrastructure development, and sustainable alternatives such as carpooling, ride-sharing, and telecommuting. Overall, the study provides actionable insights for more efficient, and equitable transportation systems.

Keywords: *Transportation Barriers, Natural and Artificial Constraints, Cluster Analysis, Commuting Costs, Transportation Planning*

1. Introduction

Transportation problems caused by natural barriers like mountains, rivers, and extreme weather are common in many places and affect people's daily lives. From the survey responses, several useful ideas were suggested to solve these problems. First, many people think that building wider and properly planned roads can help reduce traffic jams, especially in areas where narrow roads make travel difficult. These roads should be designed carefully to handle hilly areas, sharp turns, and heavy rains. Second, improving public transport is another important idea. If there are enough buses, trains, and other options, people won't need to rely so much on their own vehicles, which can make roads less crowded and travel safer. Some people also suggested using modern technology and expert organizations like DRDO to build strong bridges, tunnels, and other special structures that can handle tough weather and natural challenges. A few responses mentioned that creating awareness through community programs can also help people understand how to deal with transport problems during natural disasters. Finally, some suggested that roads and transport systems should be built in a way that they can adjust to repeated natural problems like floods or landslides — for example, by making raised roads or better drainage systems. In simple words, solving transportation issues caused by natural barriers needs good planning, smart technology, strong public transport, and people's awareness so that everyone can travel safely and easily.

1.1 Problem Description (Natural Barrier):

Many people shared real-life experiences where natural barriers made commuting difficult for them. One of the most common problems mentioned was getting stuck in traffic jams, especially on narrow or damaged roads that can't handle too much traffic. Some people talked about how thick fog during winter made it hard to see while driving, which caused delays and made traveling unsafe. A few others mentioned facing hurricanes and bad weather, which sometimes damaged roads or blocked their way completely. Interestingly, some respondents also pointed out that crowded towns and cities make

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things worse, especially when there aren't enough good roads to manage both people and natural challenges. On the other hand, a few people said they never faced such problems, which shows that the impact of natural barriers can depend on where you live and how good the roads and transport systems are in that area. Overall, these responses remind us how important it is to have better roads, proper traffic management, and strong infrastructure that can handle difficult weather. If these issues are addressed, people can travel more safely and comfortably, even when nature makes things tough.

1.2 Problem Description (Artificial Barrier)

Many people shared that traffic congestion and ongoing construction work are some of the biggest artificial barriers they face while commuting. They talked about how road repairs, bridge construction, and redevelopment projects often cause long delays and make their journeys stressful. Some also mentioned getting stuck due to vehicle checking, memo issuing, and poor traffic management. A few even pointed out that when public spaces like roundabouts are being redeveloped, it makes routes longer and increases traffic jams. To solve these issues, many suggested that roads should be properly maintained, and construction work should be completed quickly to avoid unnecessary delays. People also believe that strict enforcement of traffic rules and having active traffic police on duty can help reduce congestion. There were suggestions for better urban planning and smart management of cities to avoid frequent road closures. Improving public transport and providing safe walking spaces were also seen as important steps to reduce the number of vehicles on the road. Some felt that controlling traffic through proper rules and encouraging disciplined driving could make commuting much easier. Overall, everyone agreed that better planning, strong traffic control, and cooperation from the public are essential to overcome these transportation problems.

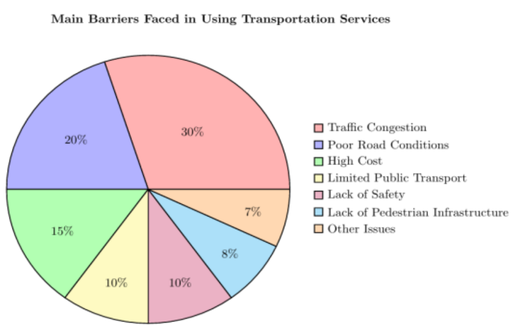
1.3 Cluster Analysis as a Tool for Transportation Research

Cluster analysis is a statistical technique used to identify natural groupings within a dataset based on shared characteristics, allowing researchers to uncover patterns and relationships without requiring prior classification. By organizing data into clusters of similar observations, this method simplifies the interpretation of complex and multidimensional information, making it a powerful tool across various fields such as marketing, healthcare, and urban planning.

In the context of transportation systems, cluster analysis proves particularly useful for examining the wide array of constraints that affect efficiency and performance. Issues such as infrastructure limitations, service delays, rising operational costs, and regulatory challenges often occur simultaneously and interact in complicated ways. Applying cluster analysis enables these interrelated problems to be grouped into coherent categories—such as infrastructural deficiencies, time-related delays, financial inefficiencies, or policy-based restrictions—based on underlying data patterns. This organization helps researchers and practitioners make sense of chaotic transportation data, transforming it into actionable insights. Consequently, transportation planners, engineers, and policymakers can better prioritize interventions, develop customized strategies, and design more resilient and efficient transport networks rooted in data-informed decision-making.

1.4 Transportation Barriers: Structural and Environmental Factors

Figure 1: Pie Chart of Main Barriers Faced in Using Transportation Services

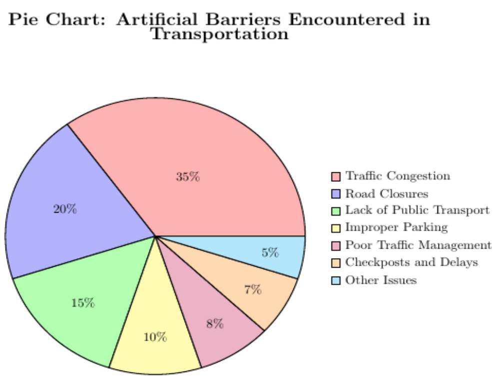


The analysis highlights that traffic congestion is the most common transportation barrier, faced by 31.58% of individuals, showing a clear need for better traffic management. Poor road conditions follow closely at 21.05%, emphasizing the necessity of regular road maintenance. Additionally, transportation costs are a challenge for 15.79%, making daily commuting expensive for many. Issues like limited public transport options and safety concerns each affect 10.53% of respondents, pointing to gaps in accessibility and security. Finally, pedestrian infrastructure problems (5.26%) and other unique barriers (5.26%) also contribute to daily commuting struggles. Overall, these statistics highlight the urgent need for improved infrastructure, affordable transport options, and safer commuting environments.

Many people face flooded roads (28%) and heavy rainfall (22%), which are the most common natural barriers causing delays and unsafe travel. Around 18% of respondents struggle with waterlogging, while fog and low visibility (12%) create risks, especially in winter. Additionally, landslides (10%) and unsafe river crossings (10%) are major concerns in hilly and rural areas. These statistics highlight the urgent need for better drainage, strong roads, and safety measures to ensure smoother and safer daily travel for everyone.

1.5 Alternative Transportation Strategies and the Financial Impact of Mobility Constraints

Figure 2: Pie Chart of Aritificial Barriers Encountered in Transportation



There are many alternative ways people can use to overcome transportation problems, such as carpooling, ride-sharing, telecommuting, and public transport. Carpooling and ride-sharing are great options because they help reduce traffic and pollution, and also make traveling cheaper by sharing the cost among passengers. Public transportation, when available and well-managed, is often a convenient and affordable choice that helps people avoid the hassle of driving in traffic. In recent times, telecommuting or working from home has become a very useful option, especially when there are roadblocks, bad weather, or long commutes. It gives people more flexibility, saves time, and reduces stress. However, these alternatives work best when there are good public transport facilities and reliable internet connections for working online. To make these options more effective and popular, better awareness and improvements in infrastructure are needed. Overall, choosing different ways to travel, like sharing rides or working remotely, can make commuting much easier if supported by good planning and facilities.

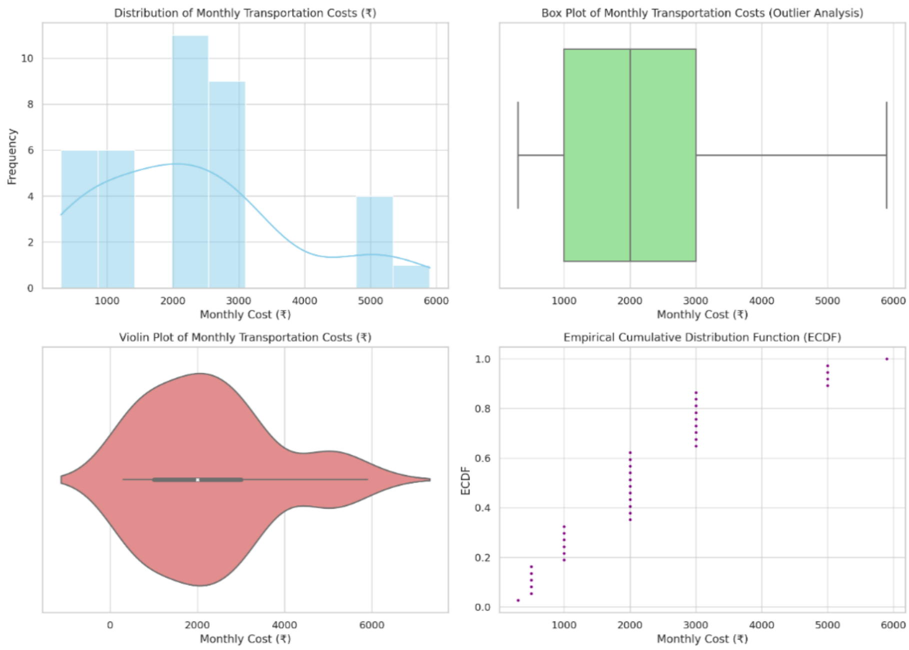
Table 1: Descriptive Analysis of Monthly Transportation Costs

Sr. No.	Particulars	Values
1	Total Number of Respondents (Valid Entries)	37
2	Average (Mean) Monthly Cost (₹)	2262.16
3	Median Monthly Cost (₹)	2000.0
4	Minimum Monthly Cost (₹)	300.0
5	Maximum Monthly Cost (₹)	5900.0
6	Standard Deviation (₹)	1470.14

7	Variance (₹²)	2161306.31
8	Range (₹)	5600.0
9	25th Percentile (₹)	1000.0
10	75th Percentile (₹)	3000.0
11	Interquartile Range (IQR) (₹)	2000.0

The distribution plot gives a clear picture of how much people are spending every month to deal with transportation barriers. From this graph, we can see that most individuals are spending between ₹1000 to ₹3000, and the highest peak of the graph is around ₹2000. This means that, for many people, monthly commuting costs are manageable but still notable. However, the graph also shows a long tail extending towards ₹6000, which tells us that some people are spending a lot more due to transportation issues like lack of proper roads, detours, or expensive private transport. So, while many can manage within a certain limit, others are facing significant financial pressure.

Figure 3: Visual Analysis of Monthly Transportation Costs Using Distribution, Outlier, Density, and



ECDF Plots

The box plot helps us to understand this in a simpler way by showing the spread of the data, including where the average cost lies and who is spending much more than usual. It shows that the median cost is ₹2000, meaning half of the people are spending below that amount. Most of the people's costs lie between ₹1000 and ₹3000, but there are quite a few people spending above ₹4000, and even close to ₹6000. These are the outliers, representing individuals who are struggling with very high transportation costs. This might be because they live far from essential services or work, or they don't have access to affordable transportation.

The violin plot gives a more detailed look at how these costs are distributed. The widest part of this plot is between ₹1500 and ₹2500, showing that this is where most people's costs fall. But just like the other graphs, this plot also has a long shape stretching upwards, meaning that while many people spend a moderate amount, some are forced to spend a lot more. This again highlights that transportation problems affect people differently — for some it's a small struggle, and for others, it's a big issue.

The Empirical Cumulative Distribution Function (ECDF) graph shows what percentage of people spend up to a certain amount. From this graph, we can see that about 70% to 80% of people are

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spending up to ₹3000, which means a large majority are within this range. However, when the line starts to flatten, it shows that only a few people are spending above ₹4000. But for those few, these high costs could be a serious issue and a major part of their monthly expenses.

If we put all these findings together, the average monthly cost people are spending due to transportation barriers comes out to be ₹2262.16, which is not a small amount for regular commuters. The median cost is ₹2000, showing that half of the people spend under this, but many spend much more. The range of spending goes from ₹300 to as high as ₹5900, showing that while some people are fortunate to manage with low costs, others are heavily burdened. Also, a standard deviation of ₹1470.14 shows there's a lot of difference from one person to another when it comes to transportation expenses.

In simple terms, this analysis tells us that transportation barriers are causing a real and measurable financial burden for many people. While a majority are managing within ₹3000, a significant portion is struggling with much higher costs. These differences are important to note because they highlight the urgent need for better transportation options, improved infrastructure, and cost-effective solutions. If transportation services are made more accessible and affordable, it could help reduce these costs, especially for those who are currently forced to spend a big part of their income just to get to work or essential services.

1..6 Traffic Congestion and Proposed Solutions:

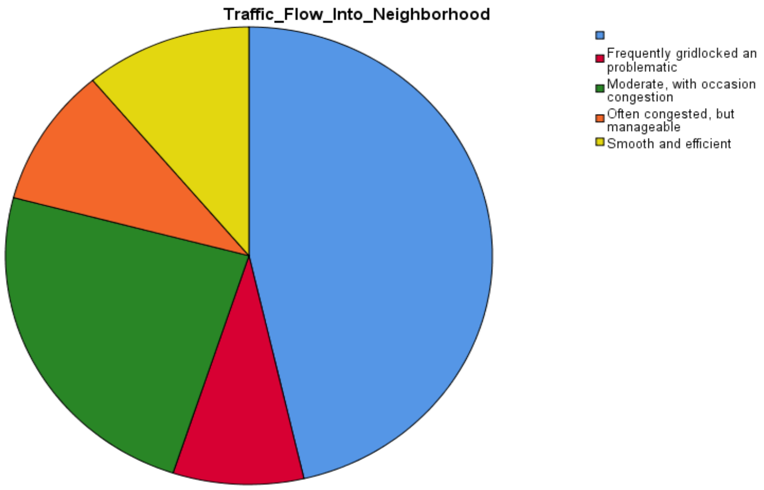

Figure 4: Pie Chart of Traffic Flow Into Neighbourhood

Based on the data, 46% of traffic flow is frequently gridlocked and problematic, indicating severe congestion. 24% face moderate congestion, while 10% report being often congested but manageable. Only 11% experience smooth and efficient flow, and 9% are problematic but less frequent. Thus, 80% of traffic flow faces some level of congestion, highlighting significant transportation barriers.

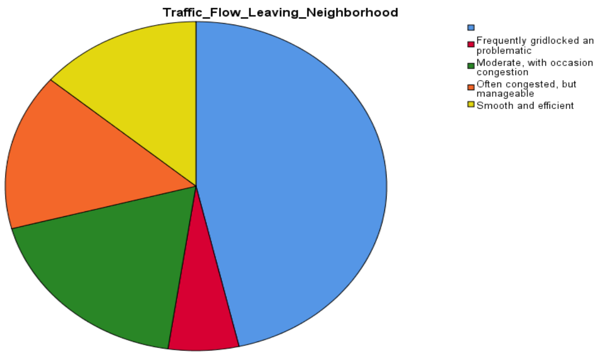

Figure 5: Pie Chart of Traffic Flow Leaving Neighbourhood

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From the chart, 46% of traffic leaving the neighbourhood is frequently gridlocked and problematic, showing serious congestion issues. 18% face moderate congestion, and 15% are often congested but manageable. Only 14% experience smooth and efficient flow, and 7% report occasional problems, indicating that nearly 80% struggle with traffic barriers when leaving the area.

From the survey, 32% of people said we need to put up traffic signals and have police manage traffic to reduce jams. Around 26% think widening roads and building bypasses for trucks and buses would help a lot. About 22% of people want better public transport like more buses and shared rides, so fewer people need to use their own vehicles. Finally, 20% said it's important to fix broken roads and potholes that slow down traffic.

Overall, people believe that better roads, more public transport, and proper traffic management are key to solving the traffic problems they face every day.

To better understand the range of transportation challenges commuters face, this study uses a structured, data-driven approach. Cluster analysis is applied to group individuals based on their travel experiences and personal characteristics. The next section presents an analysis of transportation constraints using cluster analysis.

2 Analysing Transportation Constraints Using Cluster Analysis

The cluster analysis was conducted to group people based on their transportation experiences, challenges, and key personal factors like income, age, and gender. The study helped identify three different groups, each facing unique travel-related issues. Some individuals experience more difficulties, such as unreliable public transport, high travel costs, or long delays, while others have smoother and more convenient commuting options. By classifying people into these groups, the study provided a clearer picture of how different factors influence transportation access and ease of travel.

Table 2: Initial Cluster Centers

	Cluster		
	1	2	3
AnnualIncome	0	4	0
Primary_Transport_Mode	4	4	4
Transport_Barrier_Inconvenience_Level	4	2	3
Crowd_Level_Rating	5	3	3
Road_Size_Rating	5	5	2
Road_Adequacy_Rating	4	1	4
Natural_Barrier_Inconvenience_Level	1	4	3
Artificial_Barrier_Inconvenience_Level	3	3	5
Barrier_Impact_Time	1	4	4
Public_Transport_Usage	2	2	2
Commute_Safety_Concerns	2	1	2
Additional_Costs_From_Barriers	1	2	1
Late_Due_To_Barriers	1	1	1
Environmental_Concern_From_Barriers	2	2	1
Eco_Friendly_Transport_Usage	2	2	2
Tech_Solutions_Barrier_Mitigation_Belief	1	2	2
Traffic_Points_Encountered_Daily	1	1	1
Traffic_Signal_Inconvenience_Level	3	3	5
Traffic_Management_Efficiency_Rating	1	5	4
Traffic_Signal_Satisfaction-	4	3	1
Traffic_Problem_Frequency	3	1	2
Traffic_Stress_Level	3	3	3
Traffic_Problem_Reporting_Awareness	1	1	1
Route_Change_Due_To_Traffic_Problems	2	2	2
Traffic_Flow_Management_Opinion	1	1	2

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	Cluster		
	1	2	3
New_Traffic_Signal_Technology_Support	1	1	2
Navigation_App_Usage	1	1	2

Table 3: Iteration History

Iteration	Change in Cluster Centers		
	1	2	3
1	3.221	3.815	3.441
2	.000	.000	.000

Table 4: Final Cluster Centers

	Cluster		
	1	2	3
AnnualIncome	1	4	1
Primary_Transport_Mode	3	4	4
Transport_Barrier_Inconvenience_Level	4	3	3
Crowd_Level_Rating	4	3	4
Road_Size_Rating	4	3	3
Road_Adequacy_Rating	4	3	3
Natural_Barrier_Inconvenience_Level	2	3	3
Artificial_Barrier_Inconvenience_Level	3	2	4
Barrier_Impact_Time	1	4	4
Public_Transport_Usage	2	2	2
Commute_Safety_Concerns	2	1	2
Additional_Costs_From_Barriers	2	2	1
Late_Due_To_Barriers	2	2	2
Environmental_Concern_From_Barriers	2	2	2
Eco_Friendly_Transport_Usage	2	2	2
Tech_Solutions_Barrier_Mitigation_Belief	2	2	2
Traffic_Points_Encountered_Daily	1	1	1
Traffic_Signal_Inconvenience_Level	3	3	3
Traffic_Management_Efficiency_Rating	2	3	3
Traffic_Signal_Satisfaction	2	3	2
Traffic_Problem_Frequency	3	1	2
Traffic_Stress_Level	3	4	3
Traffic_Problem_Reporting_Awareness	2	2	1
Route_Change_Due_To_Traffic_Problems	1	2	2
Traffic_Flow_Management_Opinion	1	1	2
New_Traffic_Signal_Technology_Support	2	2	2
Navigation_App_Usage	2	1	2

Table 5: ANOVA

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
AnnualIncome	12.342	2	2.188	12	5.642	.019
Primary_Transport_Mode	1.008	2	1.532	12	.658	.536
Transport_Barrier_Inconvenience_Level	1.008	2	.865	12	1.165	.345
Crowd_Level_Rating	1.267	2	.433	12	2.923	.092
Road_Size_Rating	3.225	2	1.496	12	2.156	.159
Road_Adequacy_Rating	2.850	2	1.358	12	2.098	.165
Natural_Barrier_Inconvenience_Level	3.350	2	.919	12	3.644	.058
Artificial_Barrier_Inconvenience_Level	2.933	2	1.011	12	2.901	.094
Barrier_Impact_Time	9.342	2	.854	12	10.937	.002
Public_Transport_Usage	.150	2	.219	12	.684	.523
Commute_Safety_Concerns	.633	2	.194	12	3.257	.074

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	Cluster		Error			
	Mean Square	df	Mean Square	df	F	Sig.
Additional_Costs_From_Barriers	.633	2	.194	12	3.257	.074
Late_Due_To_Barriers	.025	2	.274	12	.091	.913
Environmental_Concern_From_Barriers	.075	2	.232	12	.323	.730
Eco_Friendly_Transport_Usage	.067	2	.067	12	1.000	.397
Tech_Solutions_Barrier_Mitigation_Belief	.283	2	.153	12	1.855	.199
Traffic_Points_Encountered_Daily	.000	2	.000	12	.	.
Traffic_Signal_Inconvenience_Level	.367	2	1.417	12	.259	.776
Traffic_Management_Efficiency_Rating	3.825	2	.774	12	4.944	.027
Traffic_Signal_Satisfaction	1.092	2	1.129	12	.967	.408
Traffic_Problem_Frequency	2.233	2	.461	12	4.843	.029
Traffic_Stress_Level	1.700	2	.961	12	1.769	.212
Traffic_Problem_Reporting_Awareness	.417	2	.208	12	2.000	.178
Route_Change_Due_To_Traffic_Problems	.475	2	.199	12	2.392	.134
Traffic_Flow_Management_Opinion	.733	2	.178	12	4.125	.043
New_Traffic_Signal_Technology_Support	.283	2	.153	12	1.855	.199
Navigation_App_Usage	.633	2	.194	12	3.257	.074

Table 6: Number of Cases in each Cluster

Cluster	1	4.000
	2	6.000
	3	5.000

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

This grouping is important because it helps in understanding why some people face more transportation problems than others. By analyzing these differences, policymakers and city planners can create better solutions to improve transportation for everyone. For example, if a group struggles with expensive travel, authorities can introduce more affordable transport options. If another group faces delays due to poor traffic management, steps can be taken to improve road conditions and public transit systems. In this way, the study helps in making transportation more accessible and efficient for all individuals.

Another significant finding from the analysis was the variation in the level of inconvenience caused by transportation barriers among the different clusters. Cluster 1 experienced the highest level of difficulty, indicating that individuals in this group frequently encountered obstacles such as poor public transport availability, long travel times, high commuting costs, and inadequate infrastructure. These issues made their daily transportation more challenging, affecting their mobility and overall accessibility. On the other hand, Cluster 3 faced a moderate level of inconvenience, with a particular struggle against artificial barriers. These artificial barriers could include factors such as traffic congestion, poorly designed road networks, or inefficient public transportation systems, which created hurdles in their daily commute.

In contrast, individuals in Cluster 2 reported relatively fewer concerns regarding general transportation barriers, suggesting that they had better access to transportation services and more convenient travel routes. However, this group showed a higher sensitivity to natural barriers such as extreme weather conditions, floods, or road damage due to environmental factors. This indicates that geographical conditions and infrastructure quality play a crucial role in shaping the transportation experiences of different groups. The findings highlight the need for targeted transportation policies that address specific barriers faced by each group, ensuring improved accessibility, better infrastructure, and more resilient transport systems to accommodate diverse challenges.

The study found noticeable differences in how people perceive road conditions and deal with traffic-related issues. Cluster 1 had the most positive view of road size and quality, while Cluster 2 found the roads less satisfactory, and Cluster 3 reported the worst conditions. This highlights the importance of proper infrastructure maintenance in shaping commuting experiences. Transportation barriers also affected travel times differently—individuals in Clusters 2 and 3 experienced significant delays, whereas those in Cluster 1 had fewer disruptions. Additionally, concerns about traffic varied across groups, with differences in how efficiently traffic is managed, how often transport issues occur, and how people perceive traffic flow. These findings suggest the need for better urban planning, improved traffic management, and enhanced public transport systems to ensure smoother and more accessible travel for everyone.

The ANOVA results further reinforced these findings, with statistically significant differences observed in annual income (p = 0.019), barrier impact time (p = 0.002), traffic management efficiency rating (p = 0.027), traffic problem frequency (p = 0.029), and traffic flow management opinions (p = 0.043). These variables played a crucial role in differentiating the clusters and highlighted the disparities in transportation experiences. However, factors such as public transport usage, environmental concerns, and navigation app usage did not show significant differences, suggesting that these aspects might not be the primary drivers of cluster formation.

The final cluster distribution consisted of 4 individuals in Cluster 1, 6 in Cluster 2, and 5 in Cluster 3, making the dataset relatively small. Additionally, a significant number of missing cases (688) limited the generalizability of the findings. Despite these limitations, the analysis provided valuable insights into how income disparities, transport barriers, and traffic inefficiencies impact different groups.

In summary, the analysis reveals that income levels play an important role in shaping individuals' transportation experiences, with those in lower-income groups often encountering more significant difficulties. The results also show that traffic delays and inefficiencies in traffic management are particularly problematic for individuals categorized in Clusters 2 and 3. These patterns point to the need for more inclusive infrastructure planning, efficient traffic control measures, and responsive policy actions that can address the diverse needs of different population groups.

3. Statistical Analysis of Transportation Barriers

1. **Analyzing the Association Between Gender and Frequency of Transportation Barriers: A Chi-Square Test Approach**

Table 7: Chi-Square Test of Association Between Gender and Frequency of Transportation Barriers

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.038	4	0.026
Likelihood Ratio	11.196	4	0.024
Linear-by-Linear Association	0.005	1	0.945

A Chi-Square Test of Independence was conducted to observe the relationship between Gender and Frequency of Transportation Barriers. The key results are: Pearson Chi-Square = 11.038, df = 4, p-value = 0.026, Likelihood Ratio = 11.196, df = 4, p-value = 0.024, Linear-by-Linear Association = 0.005, p-value = 0.945, Valid Cases = 555.

Since p-value (0.026) < 0.05, we reject the null hypothesis. This means there is a significant relationship between Gender and Frequency of Transportation Barriers. Since p-value (0.024) < 0.05, this also confirms that 'Gender' significantly affects Frequency of Transportation Barriers. This means that the there is significant relation between frequency of transportation barriers of Male and Female.

From, Linear-by-Linear Association, A high p-value (0.945) > 0.05 means there is no linear trend between Gender and Frequency of Transportation Barriers. The relationship may be non-linear or influenced by other factors.

In conclusion, gender is significantly associated with transportation barriers, though the relationship is not linear.

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2. Analyzing the Influence of Gender on Primary Transport Mode Choice

Table 8: : Crosstabulation Between Gender and Primary Transport Mode

Count								
		Primary_Transport_Mode						Total
			1	2	3	4	5	
Gender		148	0	0	0	0	0	148
	1	0	55	22	10	131	37	255
	2	0	67	30	9	155	39	300
Total		148	122	52	19	286	76	703

*Count 1=Male, Count 2=Female

*Count1=Private vehicle (car, motorcycle, etc.), Count2=Public transportation (bus, subway, train, etc.), Count3=Bicycles or e-scooters, Count4=Walking, and Count4=Carpools or ridesharing services

Null Hypothesis (H_0):

There is no significant relationship between gender and primary transport mode choice.

Alternative Hypothesis (H_1):

There is a significant relationship between gender and primary transport mode choice.

Transport mode 1 was chosen by a significant amount of people. Transport mode 5 was also a very popular mode.

Table 9:Chi-Square Test of Association Between Gender on Primary Transport Mode Choice

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	704.124	10	0.000
Likelihood Ratio	724.489	10	0.000

The Pearson Chi-Square value is 704.124, and the "Asymptotic Significance (2-sided)" is 0.000. The test statistic p-value is less than 0.05, indicating a statistically significant relationship between gender and primary transport mode choice. In simpler terms, gender does influence how people choose to travel based on the data. With a high chi-square value and low p-value, we are very confident that gender affects transportation choices. The degrees of freedom provide insight into the data structure, and although one cell had a low expected count, the overall results are still robust.

Since the p-value is less than 0.05, we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). This means there is a significant relationship between gender and primary transport mode choice, and gender must be considered when building transportation models.

3. Analyzing the Influence of Annual Income on Public Transport Usage Frequency

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Null Hypothesis (H_0):

There is no significant relationship between annual income and public transport usage frequency.

Alternative Hypothesis (H_1):

There is a significant relationship between annual income and public transport usage frequency.

This table shows a clear connection between income levels and public transport use. People without any income mostly depend on public transportation and use it frequently. As income rises, fewer people rely on public transport regularly, suggesting they may opt for other travel options. However, even among those with higher incomes, many still use public transport, indicating that factors like convenience, availability, and personal preference also play a role in commuting choices. This analysis highlights how income influences travel decisions while also showing that public transport remains important for people across different income groups

Table 10: Crosstabulation Between Annual Income and Public Transport Usage

Count					
		Public_Transport_Usage			Total
			1	2	
AnnualIncome		148	0	0	148
	0	0	66	167	233
	1	0	15	18	33
	2	0	18	36	54
	3	0	37	73	110
	4	0	22	32	54
	5	0	22	49	71
Total		148	180	375	703

*Count0= No Income, Count1= Below 1 lakh, Count2= 1-2 lakh, Count3= 2-5 lakh, Count4= 5-10 lakh, Count5= Above 10 lakh

*Count1= No, Count2=Yes

Table 11: Chi-Square Test of Association Between Annual Income and Public Transport Usage

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	710.863	12	0.000
Likelihood Ratio	729.656	12	0.000

The Pearson Chi-Square test ($\chi^2 = 710.863$, df = 12, $p < 0.05$) and the Likelihood Ratio ($\chi^2 = 729.656$, df = 12, $p < 0.05$) confirm a statistically significant association between income and public transport usage. The large chi-square values suggest a strong relationship. All cells had expected counts greater than 5 (minimum = 6.95), validating the test's reliability. Lower-income groups rely more heavily on public transport, while higher-income groups exhibit moderate but still predominant usage. The significant p-value ($p < 0.001$) rejects the null hypothesis, indicating income significantly influences public transport usage patterns.

The chi-square test results show a strong connection between age groups and traffic stress levels. Both Pearson's chi-square ($\chi^2 = 730.513$, df = 25, $p < 0.05$) and the likelihood ratio test ($\chi^2 = 750.037$, df = 25, $p < 0.05$) have p-values of 0.000, indicating there is an extremely low probability that the observed patterns occurred randomly. Since the significance level is $p < 0.05$, the results confirm that age is an important factor in how people experience traffic-related stress.

4. **Analyzing the Influence of Age Groups on Public Transport Usage Frequency**

Null Hypothesis (H_0):

There is no significant relationship between age groups and traffic stress levels.

Alternative Hypothesis (H_1):

There is a significant relationship between age groups and traffic stress levels.

These findings collectively suggest an inverted U-shaped relationship between age and traffic stress, where stress levels rise through early adulthood, peak during middle age, and then gradually decline in later years. This pattern has important implications for transportation planning and stress-reduction interventions, particularly the need for targeted support for middle-aged commuters who appear most affected by traffic-related stress.

Table 12: Crosstabulation Between Age and Traffic Stress Level

Count								
		Traffic_Stress_Level						Total
			1	2	3	4	5	
Age		148	0	0	0	0	0	148
	1	0	5	11	22	6	7	51
	2	0	29	56	120	48	25	278

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	3	0	9	17	38	1	9	74
	4	0	2	17	18	6	7	50
	5	0	9	22	49	12	10	102
Total		148	54	123	247	73	58	703

Count1= 20 and below, Count2= 21-30, Count3= 31-40, Count4= 41-50, Count5= 50 above

Count of Traffic Stress Level: 1 = Not at all, 5 = Extremely

Table 13: Chi-Square Test of Association Between Age and Traffic Stress Level

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	730.513	25	0.000
Likelihood Ratio	750.037	25	0.000

The chi-square test results ($\chi^2 = 730.513$, df = 25, $p < 0.05$) support the **alternative hypothesis**, as the p-value is less than 0.05. This indicates that there is a statistically significant relationship between age groups and traffic stress levels. Therefore, we reject the null hypothesis, confirming that age does influence how individuals experience tr0affic-related stress.

Upon examining the data, we observe an **inverted U-shaped relationship** between age and traffic stress. Stress levels rise through early adulthood, peak during middle age, and then gradually decline in later years. This suggests that middle-aged individuals are more likely to experience higher levels of traffic stress, possibly due to factors like work and family obligations.

While most test conditions are met, a small limitation exists regarding expected frequencies. Around 11% of the cells (4 out of 36) have expected counts lower than 5, with the smallest being 3.84. This suggests that some caution is needed when interpreting results for age groups with smaller sample sizes. However, since 88.9% of the cells meet the required threshold, the overall conclusion remains valid.

The high chi-square values and the large degrees of freedom (25) suggest not just statistical significance but also a meaningful connection between age and traffic stress. These findings emphasize the importance of considering age-specific differences when addressing urban commuting stress. Middle-aged individuals, in particular, seem to experience higher levels of traffic stress, highlighting the need for targeted solutions to improve their commuting experience and well-being.

5. Analyzing the Relationship Between Commute Safety Concerns and Occupation Type

Null Hypothesis (H_0):

There is no significant relationship between commute safety concerns and occupation type.

Alternative Hypothesis (H_1):

There is a significant relationship between commute safety concerns and occupation type.

Table 14: Chi-Square Test of Association Between Commute Safety Concerns and Occupation Type

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	739.812	40	.000
Likelihood Ratio	757.912	40	.000

This study examines whether commute safety concerns are linked to occupation type and whether the level of barrier inconvenience varies across different age groups.

The Pearson Chi-Square value is 739.812 with a p-value of 0.000, and the Likelihood Ratio is 757.912 with a p-value of 0.000. Since the p-value is less than 0.05, we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). This suggests that individuals in different professions perceive commute safety differently, likely due to variations in working hours, travel modes, and job-related risks.

Similarly, the chi-square test for barrier inconvenience across age groups yielded a Pearson

Chi-Square value of 216.956 (df = 25, p = 0.000) and a Likelihood Ratio of 273.249 (df = 25, p = 0.05). With a highly significant p-value ($p < .05$), the findings confirm that perceptions of barrier inconvenience differ significantly among age groups. Younger and middle-aged individuals may face more challenges due to work-related travel, while older individuals might experience mobility limitations, affecting their tolerance to commuting barriers.

Overall, these results highlight the importance of customized transportation policies that address both occupation-based commute safety concerns and age-specific barrier challenges, ensuring safer and more accessible commuting experiences for all.

6. Analyzing the Impact of Age on Barrier Inconvenience Levels

Null Hypothesis (H_0):

There is no significant relationship between Impact of Age and Barrier Inconvenience Levels.

Alternative Hypothesis (H_1):

There is a significant relationship between Impact of Age and Barrier Inconvenience Levels.

The chi-square test results show a Pearson chi-square value of 216.956 (df = 25, p = 0.000) and a likelihood ratio of 273.249 (df = 25, p = 0.000). Since the p-value is less than 0.05, we reject the null hypothesis and accept the alternative hypothesis. This indicates that there is a statistically significant relationship between age groups and barrier inconvenience levels. This suggests that different age groups face varying levels of inconvenience, which may be influenced by mobility differences, accessibility needs, or adaptability to obstacles.

Table 15: Chi-Square Test of Association Between Age and Levels of Barrier Inconvenience

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	216.956	25	.000
Likelihood Ratio	273.249	25	.000

The findings highlight the need for age-sensitive solutions to minimize these inconveniences. Younger individuals may navigate barriers with greater ease, while older adults might face more difficulties due to physical limitations or reliance on specific infrastructure.

4 Scope of the Study

This chapter investigates the impact of transportation challenges on various commuter groups through cluster-based analysis. It examines how variables such as income level, transport access, and barrier exposure affect travel experiences. The aim is to generate insights that can inform inclusive and data-driven transportation planning.

5 Limitation of the Study

This study uses a sample, enabling detailed insights into transportation constraints within a defined context. Selective variables were used to maintain precision and clarity in analysis.

6 Conclusion

This chapter showed that people face different transportation challenges depending on their background and travel experiences. The cluster analysis helped identify how things like income, delays from barriers, and views on traffic management affect commuting. The results highlight the need for planning and policies that match the specific needs of each group to make travel easier and more accessible for everyone.

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