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THE IMPACT OF ELECTRIC TRAIN SYSTEM (ETS) ON AIR AND ROAD TRANSPORTATION

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ABSTRACT

The development of effective and efficient public transportation services is crucial in order to attract more people to use public transport, as visualized by the Land Public Transport Agency or known as Agensi Pengangkutan Awam Darat (APAD) to have 60 percent of Malaysian citizens travel using public transport. This will greatly aid the purpose of overcoming the issue of traffic congestion in Malaysia. Thus, this research aims to determine the best value offered to the customers in terms of travel time, fare, and comfort by performing a survey using questionnaires on citizens that uses public transportation, which is then analyzed using the Chi-Square test, Kaiser-Meyer-Olkin (KMO) and Bartlett's test, and Rotated Factor Matrix. Results from the analysis show that for a short distance, ETS and express bus provide the most value to their customers while air travel is preferable for long distance given the low travel time despite the travel cost. Value perception also varies based on the age given that young travelers put more emphasis on a low fare while older travellers value low travel time. Finally, other factors such as travel comfort, availability, and safety are gaining more awareness in value when choosing travel options hence these factors should not be ignored when operating a public transportation service.

Keywords*: Chi-test, Electric Train System (ETS), Factor Analysis, Rotated Factor Matrix,* SPSS.

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1. Introduction

Transportation in Malaysia has developed considerably since the days of British imperial rule. Today, the nation's transportation system is now more varied and has expanded to handle the increasing number of citizens and the ever-evolving technology. Malaysia's highway network is extensive, reaching up to 144,403 kilometres, which includes almost 1,821 kilometres of expressways (Prasarana, 2016). The core highway of the nation spreads over 800 kilometres, stretching to the Thai border from Singapore. Even though the network of transportation in western Peninsular Malaysia is vast, the road structure in eastern Peninsular Malaysia is

lacking. The main types of transport in Peninsular Malaysia include buses, trains, cars, and to an extent, domestic flights via aeroplanes.

Electrified trains offer many benefits including lighter weight, higher speed, and higher passenger capacity, and faster travel times. Electric locomotives can potentially take advantage of renewable energy sources, which would result in zero tailpipe emissions. Unfortunately, most electrical-powered vehicles obtain electrical power from the electric grid whereas most electricity generation plants are coal-powered (Chester & Horvath, 2008). A few studies documenting air transportation and Electric Train System (ETS) in France, Spain, and Japan conclude that it is very difficult for air transportation to compete effectively in short-haul markets of 500 kilometres or less (Park & Ha, 2006). The other impacts of the introduction of ETS are that there will be less air and noise pollution. The electrically powered train will subsequently reduce air and noise pollution (Bruun, 2005) and found that the Electric Train System (ETS) is typically cheaper to operate per passenger-space-kilometre than regular buses.

In recent years, the number of vehicle owners in Malaysia is growing rapidly. Currently, the total number of registered motor vehicles in Malaysia is approximately 23 million. This has led to massive traffic congestion in the heavily populated area and their surrounding area (Hafezi & Ismail, 2011). Thus, in order to provide information for existing government policies to encourage people to use public transportation instead of a private car to the reduction of traffic congestion, environmental concerns (Hafezi *et al.*, 2012), as well as air pollution (Burhan *et al.*, 2011), it is important to understand why people dislike using public transport. The previous study was done to investigate the motivational factors underlying the decision to commute by car or public transportation by performing a survey using a questionnaire (Beirão & Cabral, 2007). The findings provided strong evidence for the conclusion that individuals prefer options yielding shorter travel time as well as an alternative with the high frequency of public transport. Beirão and Cabral found that Portuguese citizens put emphasis on the importance of a cost-friendly and low-stress public transport service. Hence, they tend to choose rail transport because it is less stressful since there is little personal involvement during travel and being able to relax or perform other activities such as reading (Tranter, 2004).

The Value of Travel Time (VTT) refers to the cost of time spent on transport, including waiting as well as actual travel (Mokhtarian & Salomon, 2001). Travel time is one of the largest categories of transport costs, and time savings are often claimed to be the greatest benefit of transport projects such as roadway and public transit improvements. Factors such as traveler comfort and travel reliability can be quantified by adjusting travel time cost values. On average people devote 60-90 minutes a day to travel. Most people seem to enjoy a certain amount of personal travel, about 30 daily minutes, and dislike devoting more than about 90 minutes a day (Mokhtarian & Salomon, 2001).

One possible strategy to improve the accessibility of public transport is to integrate various public transportation networks along with personal transportation by providing adequate parking lots (Krygsman *et al.*, 2004). The basic idea is that even if one public transport network (e.g., rail) alone cannot provide high accessibility, integrated use of different networks (e.g. rail network interconnected with a bus network) can. When a combination of transport modes is involved, interconnection represents a key part of the trip and determines the quality of the interconnectivity network (Keller, 2001). By interconnecting multiple transportation networks, residence gains a sense of security and control by being able to plan their travels more accordingly (Shaaban & Maher, 2020).

This research determined which modes of transportation have the better value for the customers in terms of travel time and fares. The relationship between quantitative and qualitative values in the passenger's public transport preferences is analyzed using a factor

matrix analysis that indicates the significant factors of the preferred modes of transportation chosen by the public, based on attributes such as the ergonomics design, the travel time, the fares and the degree of comfort. The analysis can further assist the Land Public Transport Agency (APAD) in providing better public transportation to the public. Improving the transportation services in the country will lead to economic growth. In Malaysia, the growth and technological advancement in the transportation sector has contributed up to 3.5% of Malaysia's GDP (Ministry of Transport, 2019).

2. Methodology

In this research, a correct methodology plan was outlined to ensure all engineering measures are implemented in the right order. The process flow is presented by using a flowchart to give the general idea on how the research will be completed.

2.1 Problem Identification

Identification of the problem is the vital process in a project planning stage. From the identified problem, a solution can be planned to solve the problem. The main problem of this research is to identify which modes of transportation are the best based on the travel time and its fares. The problem was identified using a simple mind map technique depicted in Figure 1.

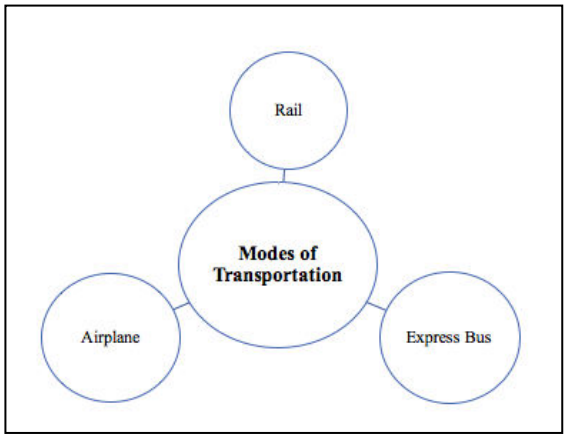

Figure 1: Problem Identification Process.

2.2 Data Collection

During this phase, data were gathered from several sources from articles, journals, magazines, related research papers, and websites in order to reinforce and direct the research process. Using the database that was provided by the library of various universities and other establishments enables access to information via the internet. Data used are the routes of the LRT, the travelling time, the fares, and the connecting stations for the intermodal stations. Valid information from APAD, Keretapi Tanah Melayu Berhad (KTMB), and Rapid KL which is a service brand used by Prasarana Malaysia are the main sources of information for this research. The mapping method is used to ensure the mapping sequences are valid by

using the devices and applications such as Google Maps, Apple Maps, and Waze to ensure routing distance is consistent. The mapping method focuses on the three routes of this research which are Ipoh, Butterworth, and Alor Setar for each mode of transportation of this research, which are ETS, the Airplane, and the Express Bus.

The objectives of the questionnaire are to collect qualitative data on public preferences for public transportation. The collected data determine the underlying reasons and motivations of the public to use public transportation, for example, the joy of travelling, the ergonomic factors, and the rate of the air conditioning design. This research has collected data from 200 respondents. The outcome of this questionnaire managed to reveal an initial understanding and sound base for further decision making. The conduct of analyzing the results from the survey questionnaire is not an informal procedure. Rather, it should follow a series of logical, interconnected steps that progress toward the final end product of the survey. The stages in a typical sample survey are shown in the figure below, and the issues to be addressed within each of these stages are listed in Figure 2.

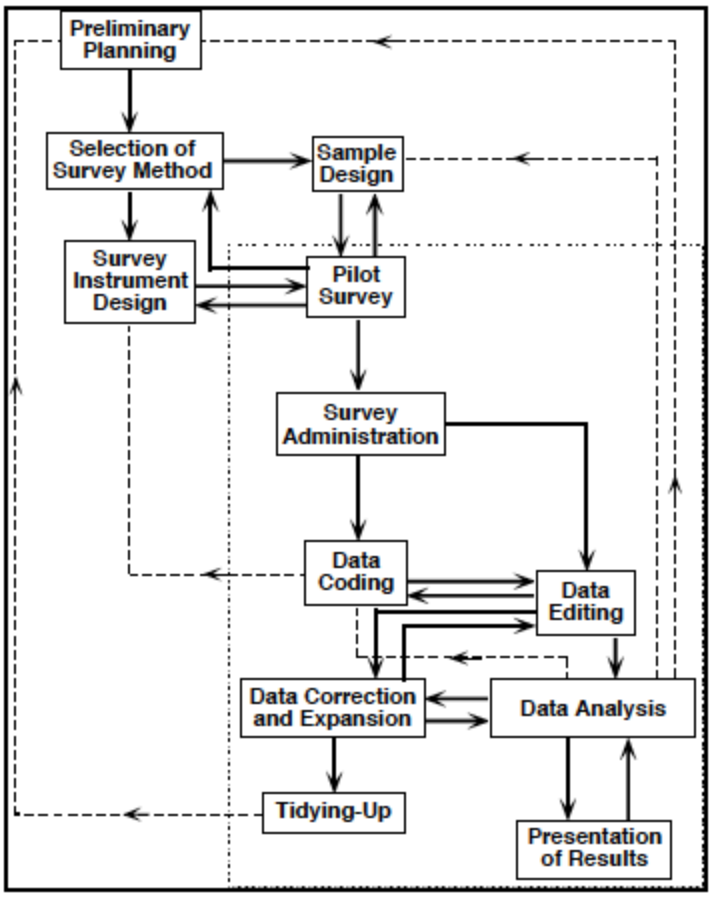

Figure 2: Questionnaire Development Process.

3. Results and Discussion

The public preferences on public transportation are very valuable especially to the APAD in order to enhance the public transportation service to the public and visualize the aspiration of having 60 percent of the public have the privilege of using public transportation. The

quantitative values were evaluated with the matrices based on the travelling time and the fares. The qualitative values were analyzed by using the Statistical Package for Social Sciences (SPSS) based on the response from respondents on the developed questionnaire said by Abd Rahman *et al.* (2022), and Tuan Hassan and Masrom (2022).

3.1 Quantitative Results

The matrices and the data assortment from the three destinations gave an impeccable indicator and guidelines to the public on which modes of transportation is the best concurring to its travelling time and fares. The intermodal connections data collection from four (4) cities in Klang Valley clarified the hidden cost and time to travel to the preferred destination. Quantitative data collection is used to assist the public to choose the best modes of transportation. The data collection at the same time would increase public awareness of the hidden time and cost expended throughout their travel. Table 1 shows the results of the matrix of travel time and fares for each mode of transportation for travelling to Alor Setar.

Table 1. Matrix for travel time and fares to Alor Setar.

	Average Travelling Time	**Average Fare (RM)**
Electric Transport System	5 hours	70
Airplane	3 hours 20 minutes	210
Express Bus	8 hours 10 minutes	50

As shown in Figure 3, the Electric Train System (ETS) and the bus express show to give the public a superior value in terms of fares for short distances travelled. If one were to travel to Ipoh and Butterworth, it is better to travel using the ETS and the express bus as the fares are significantly lower and the travel time is not that significant. Moreover, there is no available direct flight from the KLIA to the Sultan Azlan Shah Airport, Ipoh. However, if you were to travel for a longer route which in this research is Alor Setar, the plane would probably be the smartest choice in terms of shorter travelling time. The differences in the travel time are very significant if you were to travel to Alor Setar by using the ETS, it will take you an average of five (5) hours from the departure point whereas it will only take you only an average of three (3) hours by travelling by plane. Travelling by plane will surely be costly, but a businessman or the elderly, could possibly ignore the high fares just to be able to travel faster and probably avoid any kind of distress during the travelling, thus the plane is the best choice. The factor mentioned is qualitative which will be discussed based on the survey questionnaire analysis using the SPSS.

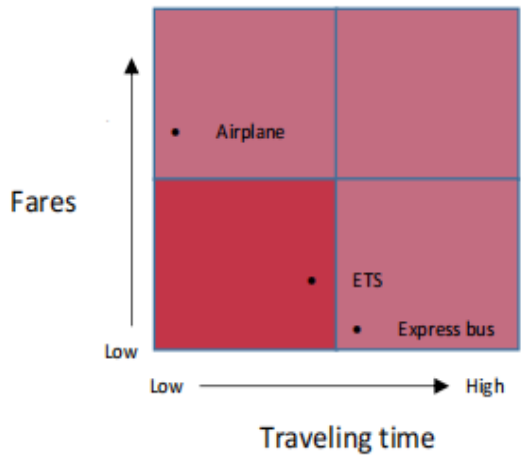

Figure 3: The matrix for fares and travel time.

3.2 Qualitative Results

The qualitative values such as the degree of comfort, the ergonomic design, the joy of the travel and the surrounding temperature inside the public transport were gathered. The qualitative data collected from the response of the respondent to the questionnaire is analyzed and identified by using the SPSS software. The cross-tabulation method will be used to cross-tabulate two variables, for example, the respondent's gender and preferred public transportation. The cross-tabulation method will display their relationship in tabular form. The chi-square test of independence will be done after the cross-tabulation in order to gain the P-value to verify that the initial hypothesis of the questionnaire results has a significant relationship between the two variables. The P-value is the probability of observing a sample statistic as extreme as the test statistic and the df is the degrees of freedom. Before doing the chi-square test, an initial hypothesis and alternative hypothesis must be made to ensure that the relationship between the variables is significant or not.

The gender and age variables are cross-tabulated with other variables such as the motive of using public transportation, the preferred mode of transportation to travel for short and long distances, and the priorities if travelling for a long time. From Table 2, the male and female respondents would likely use public transport for daily travel.

Table 2. Cross-tabulation for gender and motive.

Cross-tabulation			**Why do you use public transportation?**			
			To go to workplace	**Daily travel**	**For vacation**	**Total**
Gender	Male	Count	39	40	38	117
		Expected Count	33.3	43.3	40.4	117.0
	Female	Count	18	34	31	83
		Expected Count	23.7	30.7	28.6	83.0
Total		Count	57	74	69	200
		Expected Count	57.0	74.0	69.0	200.0

To validate the relationship between the gender and the motive of public transportation, the chi-square test was done as in Table 3. Based on the Chi-square tests, the p-value of the test is 0.197 which is greater than <0.001 for the 2 degrees of freedom. From the chi-square test, the initial hypothesis of the genders will affect the motive of using public transportation is accepted (Chi-square = 3.247, DF=2, $p<0.001$). $X2 = 0.197$ which is <0.001 for 2 degrees of freedom which make the relationship between two variables significant. After finishing the Chi-square test for each of the selected variables for the age and gender variables, it is verified with confidence that variables such as the motive of using the public transportation, the priorities when using the public transportation and preferred mode of transportation are significantly related to the variables such as age and genders.

Table 3. Chi-square test for the cross tabulation.

	Value	**Degree of Freedom**	**Asymptotic Significance**
Pearson Chi-Square	3.247	2	.197
Likelihood Ratio	3.312	2	.191
Linear-by-Linear Association	2.104	1	.147
N of Valid Cases	200		

The conclusion of the Chi-square test is that the variables age between 31 years old and above will have a high probability of choosing comfort over low fares. For example, the older public will choose to use the Airplane over the Express bus for a long journey because of the short travelling time and the comfort level during travel compared to the low fares emphasized by the Express Bus. The Older public tends to have no concern over the expensive fares provided by the Airlines due to the fact that they enjoy having the luxury of short travelling time and the more ergonomic design of the Airplane.

For the gender variables, the male respondents would choose to use public transportation such as the train to go to the workplace contradicting the female who would not prefer to use public transportation to the workplace due to a few concerns such as the safety level and to avoid the crowd during the peak hours. The male and female respondents agree that the train would give the most satisfaction in terms of comfort to travel for a long time based on its ergonomics features such as an easier embarkation system and the passenger's seat design which has more space to reserve their luggage and increase their mobility thus increasing the comfort.

3.2.1 Factor Analysis

Factor Analysis attempts to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables. Factor Analysis is often used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables. Factor Analysis can also be used to generate hypotheses regarding causal mechanisms or to screen variables for subsequent analysis. For this research, Factor Analysis will be used to identify the preferred public transportation to the public. Factor Analysis will also be used to identify collinearity prior to performing a linear regression analysis. There will be a few steps that need to be followed to ensure the Factor Analysis is done properly.

Kaiser-Meyer-Olkin (KMO) is a number which measures the proportion of variants in the variables that might be explained by the underlying factors which will be explained in the next subtopic. The closer the KMO value to 1, the better. For this research questionnaire, the value of KMO .658 (refer Table 4) which is exceptionally good. The results of Bartlett's test for this questionnaire is good which means that the questionnaire is structured and there are factors that can be pulled out because it is an interrelated question.

Table 4. KMO and Bartlett's test results.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.658
Bartlett's Test of Sphericity	Approx. Chi-Square	1142.279
	DF	210
	Sig.	.000

The extraction of the factor is done by doing total variance. Total variance table in Table 5 shows the number of factors that have been analyzed on the extraction sums of squared loadings whereas the initial Eigenvalues show how the factors were extracted. From 22 questions on the questionnaire, it has been reduced to only eight (8) questions which are the most significant variables from the questionnaire. A total of 8 factors are chosen based on the Eigenvalue which has been set to 1 for this questionnaire.

Table 5. The factor extraction result.

Initial Eigenvalues				**Extraction Sums of Squared Loadings**		
Factor	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3.107	14.794	14.794	2.811	13.384	13.384
2	2.810	13.381	28.174	2.284	10.878	24.261
3	2.132	10.154	38.328	1.724	8.210	32.417
4	1.483	7.061	45.389	1.051	5.004	37.475
5	1.367	6.512	51.901	.836	3.982	41.458
6	1.148	5.469	57.369	.582	2.769	44.227
7	1.039	4.948	62.317	.448	2.132	46.359
8	1.004	4.781	67.098	.346	1.650	48.008
9	.926	4.408	71.506			
10	.827	3.937	75.443			
11	.781	3.717	79.160			
12	.719	3.408	82.568			
13	.656	3.122	85.690			
14	.568	2.706	88.396			
15	.547	2.606	91.002			
16	.451	2.146	93.148			
17	.416	1.983	95.131			
18	.360	1.715	96.846			
19	.294	1.402	98.247			
20	.222	1.058	99.306			
21	.146	.694	100.00			

The pattern matrix shows the loadings values which range from -1 to +1. The min value is -1 and the max value is +1. Table 6 shows the pattern matrix from this research questionnaire. Based on Table 6, the highlighted negative values mean that the respondents are the opposite of the question, for example, the usage of public transportation. The other important thing highlighted by the matrix is the motive of using public transportation variables will be neglected because it is on the two-factor column (1 and 5) and the factor is not unidimensional.

Table 6. The results from the questionnaire pattern matrix.

	Factor				
	1	**2**	**3**	**4**	**5**
Experience of using public transport	.930				
Rating on the public transportation system	.892				
Usage of public transport	-.456				
Best connectivity		.673			
Low fares or short travel time		.559			
Preferred option		.556			
Seat Design		.479			
Embarkation system		.442			
Travelling for more than 250km		.442			
Travelling for less than 250km		.386			
Comfort		.348			
Ventilation system			.780		
Seat design rating			.742		
Booked seat			.607		
Air-conditioning design rating				-.849	
Temperature (comfort)				.849	
Motive of using public transportation	.420				-.522
Expected experience					.453
Gender					-.360
Age					
Priorities (long travel)					

Table 7 shows the factor loadings prior to the Rotated Factor Matrix while will show the rotated factor loadings. From the rotated matrix, eliminate any undesirable rotated loadings which score below 0.32. However, our factors consist of many complex variables. Instead of using the different significant loadings cut-off of 0.40. After sorting the significant factors on the rotated factor matrix table, naming the variables based on the attributes to best represent the variables within the factors.

The last part of the Factor Analysis is to do the Factor Transformation Matrix. Through this matrix, validation of the rotation technique to be used is verified. It is due to the fact that the results are the nearly symmetrical off-diagonal element (refer to Table 8). This indicates that the choices for modes of transportation are correlated. Based on the Rotated Factor Matrix, the factor which has been sorted in the Component Transformation Matrix can be renamed based on the strongest factor of the variables. The new factor names will be correlated to the variables which have a score higher than 0.40 in the factor column. A score that is higher than 0.40 is highlighted in the Rotated Factor Matrix. The final results of the Factor Analysis are, there are three (3) factors that affected the public preferences in choosing their mode of public transportation. The three (3) factors are ergonomic features, the degree of comfort, and the values of public transportation.

Table 7. The results from the rotated factor matrix.

	1	2	3
Rating on the public transportation system?	.293	.269	.750
Experience in using public transport	.296	.359	.685
Expected experience	.164	.239	-.191
Usage of public transport	-.133	.130	-.692
The motive for using public transportation	-.057	-.147	.762
Traveling for less than 250km	.116	.514	-.191
Traveling for more than 250km	-.018	.574	-.127
Low fares or short travel time	.005	.647	-.030
Best connectivity	-.004	.673	.090
Preferred option	-.040	.564	.090
Comfort	-.065	.317	.095
Priorities (long travel)	-.061	-.010	.109
Embarkation system	-.136	.497	-.065
Booked seat	.562	.126	-.159
Seat design rating	.708	-.037	.028
Seat design	-.154	.451	.082
Ventilation system	.810	.042	.123
Temperature (comfort)	-.666	.158	-.064
Air-conditioning design rating	.751	-.180	.051

Table 8. The final Component Transformation Matrix with renamed factors.

Component	Ergonomics feature	Degree of comfort	Values of public transportation
Ergonomics feature	.874	-.043	.484
Degree of comfort	.091	.993	-.076
Values of public transportation	-.478	.110	872

4. Conclusion

Based on the matrix for both quantitative and qualitative data and the Factor Analysis, all of this research's objectives have been achieved. Analysis from the quantitative data shows if one were to travel a short distance, it is better to opt for the ETS and the express bus option due to the low fares whereas, for long travels, the Airplane is preferred based on its short travelling time.

The qualitative data analysis indicates that the age and gender variables have a significant relationship with the preferred modes of transportation. For example, the older respondents tend to be more biassed towards choosing short travelling times and do not care about the high fares provided. It is due to the fact that the Airplane (high fares) provides shorter travelling time and gives them more comfort due to the ergonomics features provided. The younger respondents will be more biassed towards choosing a low fares mode of transportation such as the ETS and the Express Bus. They seemingly tend to choose the low fares modes of transportation to be able to save their expenditure.

The factor analysis has given the factors which favour the respondents in choosing their modes of transportation by analyzing the rotated matrix factor on the questionnaire answers by the respondents. The most significant factor is the ergonomics feature provided by the public transportation, the degree of comfort such as the embarkation system, the ease of accessing the luggage and the footrest area, and the final factor is the respondent's value on the public transport. Additionally, the reputation and the image of public transportation such

as the frequency of the services, the reliability of the services such as the frequency of delayed services, and the number of accident cases prove to be significant factors in influencing the preference of transportation modes. Understanding these factors will assist the aims of the National Transport Policy (NTP) 2019-2030 to promote the model shift from personal vehicle travel to using public transportation by taking advantage of technological progress and preparing for the upcoming Fourth Industrial Revolution (IR 4.0).

However, recent crises from the COVID-19 pandemic and climate change have caused a significant paradigm shift in the public transportation sector and its commuters. Concerning the increase in global carbon emissions, governments, and environmental agencies are pushing for the implementation of a greener transportation system. Unfortunately, the COVID-19 pandemic has led to a massive change in public transportation commuting behavior since commuters are required to maintain a safe distance (1 metre) from each other. This caused public transportation networks to operate at sub-optimal capacity since they have to limit the number of passengers aboard thus leading to people using personal transportation for travel.

Facing these two crises proved to be a daunting challenge for all those involved in the public transportation sector because a possible solution for one may worsen the other. Hence, all parties involved should cooperate closely with each other to perform additional studies for the implementation of a more robust transportation system while also handling the risk of infection from the pandemic to ensure both the sustainability of the transportation system and the safety of their passengers.

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Author Contribution

Author1 prepared the literature review and oversaw the article writing. Author2 wrote the research methodology, conducted the statistical analysis and interpreted the results.

Conflict of Interest

The authors have no conflicts of interest to declare.

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