

## **THE STRUCTURAL MODEL OF NOISE, VIBRATION AND VENTILATION TOWARD TEMPORARY PASSENGER HEALTH IN THE MOVING TRAIN**

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**ABSTRACT:** Poor ergonomic environment in the train cabins can affect passengers' comfort and satisfaction while using public transport. The article provided a comprehensive analysis of passengers' experience when riding KTM Komuter in Klang Valley, Malaysia. For this study, a total of 361 respondents who frequently use the train as their primary mode of transportation to work were chosen. The study empirically examined the relationship between the ergonomic risk factors, health symptoms, passenger comfort, and passenger satisfaction through IBM-SPSS-AMOS version 25.0 software. The results showed that the ergonomic risk factors did not have significant effect on passengers' comfort. Although the initial study found the passengers discomfort, through well-intention impulses, the passengers could find that the train is currently the best option while staying in the big city. However, as public transport provider, the train operators are suggested to consider the ergonomic risk factors in their future train design and

development as well as to promote passengers' safety and well-being.

**KEYWORDS:** *Public Transport; Ergonomic; Health Symptoms; Musculoskeletal Disorder; Comfort*

## **1.0 INTRODUCTION**

KTM Komuter Berhad is a commuter rail service operated by Keretapi Tanah Melayu Berhad (KTMB), the national railway operator of Malaysia. KTM Komuter primarily serves the Klang Valley region, which includes the cities of Kuala Lumpur and its surrounding areas, as well as some parts of Seremban, Negeri Sembilan. KTM Komuter Berhad is vital in providing reliable and accessible transportation options for residents and visitors in the Klang Valley region and is a key component of Malaysia's public transportation system. User satisfaction in public transport such as KTM Komuter is important because it can greatly impact the use and sustainability of the public transport system. The degree of utilisation of the public transportation system as a whole as well as the choice of modes of transportation can be influenced by user satisfaction. The availability of service, accessibility of service, ticket or pass, punctuality, clarity of information, quality of customer service, comfort, safety, and image are just a few of the nine potential factors affecting passenger satisfaction with rail travel that have been the subject of several studies, including the one by Ahmad Nazrul, which use both the Delphi approach and a thorough review of the current literature [1]. Apart from that, Isai has also conducted a study on user satisfaction using KTM Komuter, which aims to evaluate the customers' satisfaction with KTMB intercity regarding the performance delivery of various services [2].

In this study, the concept of satisfaction and comfort refers to a passenger's evaluation of the noise, vibration, and ventilation experienced when riding the train. In line with these recent studies, the authors aimed to study the factors affecting traveler comfort and satisfaction with the KTM Komuter in Malaysia in terms of ergonomic risk factors that affect their comfort and satisfaction.

## **2.0 LITERATURE REVIEW**

### **2.1 Ergonomic Risk Factor**

Ergonomics, as defined by the Board of Certification for Professional Ergonomist (BCPE) is the ability of the human body, human characteristics and human limitation that are relevant to design. Another definition of ergonomics is a scientific field that studies how people interact with other system elements. While, Nor Suzila defined ergonomics as the science, it is a tight, user-centered approach to research and design [3]. It is applied widely in transportation systems, sports, construction, education, public facilities, and the workplace [4].

The transportation system includes the environment inside the train cabin experienced by passengers when boarding the train. Besides, ergonomics is a broad scientific environment that can affect passenger health, comfort, and satisfaction, including noise, vibration, and ventilation. These factors can result in injuries or related problems that may develop into musculoskeletal disorders and temporary health symptoms such as headache, tiredness, dry skin, vomiting, and others. Therefore, it is important to consider the ergonomic risk factor in knowing the level of user satisfaction when riding the train and ensure that the atmosphere in the train cabin is ergonomic. The provision of an ergonomic environment within the train cabin by public transportation companies helps passengers lower their chance of experiencing health problems while simultaneously improving their comfort level and satisfaction with the company's services.

## **2.2 Musculoskeletal Disorder**

Musculoskeletal disorders (MSD) can happen to passengers who travel for extended periods, particularly in cramped or uncomfortable seating arrangements. MSD refers to a range of injuries and conditions that affect the body's muscles, tendons, ligaments, nerves, and joints. Sitting in a fixed position for a long time can cause discomfort and stiffness in the back, neck, shoulders, and legs, contributing to the development of MSD. As a result, in the setting of the KTM Komuter train, passengers' musculoskeletal diseases are harmed when they endure noise, vibration, and ventilation when using this public transportation. Their musculoskeletal condition symptoms will worsen in proportion to their level of exposure to ergonomic risk factors. Thus, we have come up with the following hypothesis:

H1: Ergonomic Risk Factor has a positive effect on Musculoskeletal Disorder.

## **2.3 Health Symptoms**

A health symptom is a subjective indication of an individual's physical or mental state that may indicate a disease, disorder, or illness. Symptoms can be experienced by an individual forms, such as pain, discomfort, fatigue, nausea, dizziness, or other abnormal sensations that the individual perceives. Apart from that, health symptom is also one of the elements in finding out the effect of passengers' exposure to ergonomic risks. Consequently, in the context of the KTM Komuter, exposure to vibration, noise, and ventilation may result in adverse health effects for the passenger. The second hypothesis is as follows :

H2: Ergonomic Risk Factor has a positive effect on Health Symptom

## **2.4 Passenger Comfort**

Comfort, by the Oxford dictionary, refers to being physically relaxed and free from pain or, in other words, feeling of not suffering or worrying so much, feeling of being less unhappy. The success of various services, such as public transportation, healthcare consideration during passenger travel time, and others, depends on factors that affect passenger comfort. Providing a comfortable travel experience for passengers is crucial for promoting passenger satisfaction, attracting and retaining passengers, reducing stress and fatigue, promoting equity and access, and achieving broader societal goals related to environmental sustainability and social equity. Passengers' comfort when using KTM Komuter is evaluated through three sub criteria: noise level, vibration inside the train cars, and air conditioning system (i.e., temperature and humidity). In addition to passenger comfort, consideration should also be given to the passenger's satisfaction. Several empirical studies are related to health symptoms related to passenger comfort while riding the train. Yet, passenger perception of temporary health symptoms they experience while riding the train is the main factor predicting passenger comfort during their traveling. Thus, in the context of the KTM Komuter, when travellers are at ease on the train, the problem of temporary health conditions can be minimised, which will greatly increase their level of satisfaction with the public transportation system's services. Thus, the following hypotheses are formed:

H3: Health Symptom has a positive effect on Passenger Comfort,

H4: Musculoskeletal Disorder has a positive effect on Passenger Comfort,

H5: Ergonomic Risk Factors has a positive effect on Passenger Comfort.

## **2.5 Passenger Satisfaction**

Passenger satisfaction is a term used to describe how satisfied passengers are with their experience while traveling, typically on a plane, train, bus, or another mode of transportation. It encompasses a wide range of factors, including the level of comfort, safety, convenience, and customer service provided by the transportation provider. Passenger satisfaction is important for transportation companies as it can directly impact their bottom line. Satisfied

passengers are more likely to become repeat customers and recommend the company to others. In contrast, dissatisfied passengers may choose to use a different transportation provider in the future and leave negative reviews that can damage the company's reputation. Transportation companies can improve passenger satisfaction by providing a comfortable and convenient travel experience. Apart from that, satisfaction was also one of the elements for public transport companies to provide comfortable transport facilities to passengers so that they are satisfied with the facilities provided. Therefore, in the KTM Komuter Berhad context, if the passenger has a comfortable journey, they will be satisfied with the transport services provided by the public transport company. The last hypothesis is as follows:

H6: Passenger Comfort has a positive effect on Passenger Satisfaction.

### **3.0 METHODOLOGY**

A theoretical structural model is a model that represents the relationships between different variables in a theoretical framework or conceptual model. It is often used in social science research, such as psychology, or economics, to test hypotheses and theories about how different factors or constructs are related. By specifying the relationships among the variables in the model, researchers can generate testable predictions about how changes in one variable will affect the others. For this study, the relationship between ergonomic risk factors, health symptoms, passenger comfort, and passenger satisfaction who ride KTM Komuter has been drawn up to provide a formal representation of a theory or hypothesis that can be tested using empirical data.

A theoretical structural model provides a systematic and organized way of thinking about the relationships between variables in a particular domain. It helps researchers develop and test hypotheses about how different factors are interrelated. The focus of this research is to investigate the structural relationship between passenger satisfaction and comfort and temporary health symptoms experienced by passengers who consider the ergonomic risk factor as the cause of the temporary ill health experienced by the passenger. After reviewing past studies regarding passenger satisfaction, this study proposed the following research framework, as shown in Figure 1.

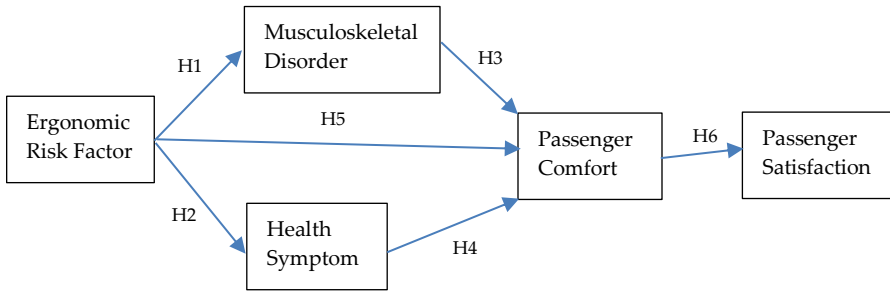


Figure 1: Research Framework

## 4.0 RESULTS

### 4.1 Reliability and Validity

Results from 361 completed surveys have been elaborated upon; 90.25% of the total was obtained. The reliability of the items representing particular constructs was evaluated using Cronbach Alpha values. The result shows that Cronbach's Alpha values ranged between 0.897 and 0.951 as shown in Table 1, indicating that the instrument for the study is reliable. It is consistent with the rule of thumb by [7], where Cronbach's Alpha value must exceed 0.6.

Table 1: Results of Internal Consistency Analysis of Research Variables

Group Variable		Types of Variables	Number of Indicators	Cronbach's Alpha Value
ERS	Noise	Independent	7	0.900
	Vibration	Independent	8	0.951
	Ventilation	Independent	10	0.929
MSD		Mediating	11	0.934
HS	HS from noise	Mediating	7	0.943
	HS From vibration	Mediating	7	0.909
	HS from ventilation	Mediating	7	0.900
PC		Construct	8	0.951
PS		Dependent	6	0.897

ERS: Ergonomic Risk Factors

PC: Passenger Comfort

HS: Health Symptom

MSD: Musculoskeletal Disorder

PS: Passenger Satisfaction

## 4.2 Path Analysis of Research Model and Hypothesis Testing

The Fitness Indexes met the threshold values for construct validity. The Absolute Fit in particular RMSEA was 0.047 (accomplished the limit of under 0.08), the Incremental Fit classification to be specific CFI was 0.955 (accomplished the edge of more prominent than 0.9), and the Parsimonious Fit class specifically the proportion of Chisq/df was 1.807 (accomplished the edge of 3.0). Along these lines, the measurement model for Ergonomic Risk Factor accomplished the necessity for Construct Validity. As a result, as the items were created using past studies on passenger satisfaction regarding public transit that considered ergonomic risk factors, their face validity was valid. Accordingly, Table 2 illustrates the research hypothesis summary.

Table 2: The hypothesis summary

Construct	Path	Construct	Beta Estimate	Standard Error	Critical Region	P-Value	Results
MSD	<---	ERS	0.442	0.047	9.395	0.001	Significant
HS	<---	ERS	0.439	0.053	8.262	0.001	Significant
PC	<---	ERS	-0.005	0.052	0.0092	0.926	Not Significant
PC	<---	MD	-0.769	0.087	-8.850	0.001	Significant
PC	<---	HS	-0.171	0.046	-3.688	0.001	Significant
PS	<---	PC	0.734	0.065	11.374	0.001	Significant

## 5.0 DISCUSSION

One of the things that has to be emphasised in order to reach a developed country is public transport. The general public, or KTM Komuter, has taken over the transport sector in Malaysia's urban areas today. KTM Komuter must therefore take the necessary action to ensure the comfort and satisfaction of its clients. Maintaining a clean and healthy atmosphere will provide comfortable travel and reduce the temporary health problems that passengers on trains may encounter, taking into account a number of important ergonomic risk factors. Without a doubt, it is boosting profit in the future. There are six direct hypotheses (H1, H2, H3, H4, H5, and H6) for this study. Among the sixth hypothesis, five are statistically supported, H1, H2, H4, H5, and H6. The one hypothesis that is not upheld is H3.

Hypothesis 1 for the case study on the satisfaction of KTM Komuter users in using this public transport facility is supported by a number of studies conducted by earlier researchers. Additionally, an investigation has been conducted on the impact of ergonomic risk factors on the



MSDS of KTM Commuter users, particularly in cases where they experience vibration levels beyond the recommended threshold. Regarding the second hypothesis, which focuses on the ergonomic risk factors of ventilation, noise, and vibration factors that affect train passengers' health symptoms, the path analysis method has been used to support the findings of other researchers' studies, including P. Nassiri's, which found that vibration had a negative impact on passengers' health. In addition, passengers may have other negative health impacts as a result of a poor ventilation system. [8].

The following hypothesis is about health symptoms that affect passenger comfort which is not supported. Health symptoms experienced by train passengers indeed affect their comfort. It aligns with the survey results obtained and the calculation results from the AMOS software, which refutes this third hypothesis. This hypothesis is further strengthened by the results of other studies, which support that the health symptoms experienced by passengers indeed affect their comfort. A study by Patricia stated that ergonomic risk factors from vibration, temperature, and noise affect passengers' health symptoms and create an unhealthy environment for them [9]. Another study from Teiwan supports the hypothesis by finding that high vibration levels from the train cabin floor affect passengers' ride comfort, which in turn affects dizziness or unexplained foot numbness, particularly when the passenger is seated close to the middle of the train cabin car body [10]. Regarding the fourth hypothesis, it's evident that symptoms of musculoskeletal disorders affect how comfortable train passengers are. This claim is corroborated by a number of earlier studies conducted by different academics, which demonstrate how passengers on the KTM Commuter train experience the symptoms of musculoskeletal disorders. Among them is Anis's study on ergonomic risk factors' effect on MsDS [11]. A survey by Irwan also proved that long-term use of the vehicle by taxi drivers can cause discomfort due to MsDS [12].

The fifth hypothesis, which provided support for the outcome, examined the relationship between health symptoms and passenger comfort. When using a public transport vehicle, passengers theoretically expect to travel in a comfortable manner the entire time. It is evident from this that when passengers board a train, noise, vibration, and ventilation all contribute to their discomfort and may even temporarily create unhealthy symptoms. This indirectly supports the findings of this study which states that health symptoms are not significant to passenger comfort.

The final hypothesis examines the relationship between comfort and

satisfaction among passengers. According to this study, passengers on KTM Komuter trains strongly agree with the last premise, which states that passenger comfort has a significant effect on satisfaction. Additionally, a number of studies indicate that passenger satisfaction is significantly influenced by passenger comfort. Passengers' overall experience and perception of the public transport provider are positively impacted when they are comfortable during their trip. Among the studies that support this hypothesis is from Chunqin, who found that comfort when riding the train in China train public transport significantly positively affects passenger satisfaction [13]. Apart from that, another study that supports this hypothesis is a study from Yalong which found that passenger comfort has given satisfaction to users of rail transport in China [14].

Ergonomic risk factors can cause discomfort to train passengers because these factors can cause stress on the human body, which affects temporary health symptoms for train passengers. For example, sitting positions that are not ergonomic or comfortable can cause stress on the spine, neck, shoulders, and back. If the situation in the train cabin is too full, causing passengers to stand for a long period which causes them to be uncomfortable when boarding the train. In addition, the inappropriate air temperature in the train cabin, excessive noise, and lack of movement space can have a negative effect on the health and comfort of users. All these factors can affect the health and comfort of train passengers and ultimately can reduce user satisfaction. Other researchers have conducted numerous studies that can be adapted to this study. These studies focus on workers who are exposed to ergonomic concerns that cause discomfort [15] as they work and have an impact on their health. Thus, it is crucial to consider ergonomics while designing and running public transport systems, such as trains, in order to ensure user comfort and satisfaction and prevent the spread of unhealthy symptom among passengers.

## **6.0 CONCLUSION**

This study develops a conceptual framework to assess the effects of train passengers' overall satisfaction, drawing on previous research in the context of KTM Komuter train passengers. This framework takes into account the level of passenger comfort by accounting for ergonomic risk factors, such as noise, vibration, and ventilation, which affect the passengers' health. This study can serve as a standard for measuring how satisfied customers are with the degree of comfort offered by the public transport provider. The results show that ergonomic risk factors influence the health symptoms of passengers as well as the indications of musculoskeletal problems in train users. The degree of user satisfaction experienced when using this public transport is significantly affected by ergonomic risk factors, which also have an effect on train passenger comfort. In summary, it is imperative to evaluate and assess KTM Komuter's train company in a wider context. This entails not only ensuring that passengers receive comfortable service and are satisfied with the level of care they receive, but also considering ergonomic risk factors that may impact passengers' health and providing a healthy train cabin. In a rising and increasing economy, public transport will remain crucial for improving accessibility, economic opportunities, and outstanding social development. As the Malaysian government works to propel the country's economy forward, this study can continue bolstering the nation's public transport infrastructure and provide a sustainable transport system in support of the National Transport Policy 2019–2030.

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## **AUTHOR CONTRIBUTIONS**

W.H.W. Mahmood: Conceptualization, Supervision, Validation, Writing-Reviewing and Pre-Editing; F. Abdullah: Methodology, Software, Writing- Original Draft Preparation; S.R. Kamat: Proofreading, Final Editing.

## **CONFLICTS OF INTEREST**

The article has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission and declare no conflict of interest on the article.

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