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

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**Article History**: Received 21 July 2023; Revised 3 January 2024; Accepted 15 February 2024



**ABSTRACT:** Poor ergonomic environment in the train cabins can impact the passengers' discomfort and dissatisfaction while using public transport. The article provides a comprehensive analysis of passengers experienced when riding KTM Komuter in Klang Valley, Malaysia. A total of 361 respondents were selected for this study which regularly prefer the train as their main transport to workplace. The study empirically focuses to explore and examine the relationship between the ergonomic risk factors, health symptoms, passenger comfort, and passenger satisfaction through IBM-SPSS-AMOS version 25.0 software. The result shows that the ergonomic risk factors do 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 passenger 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 also an important 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. The importance of 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. User satisfaction can influence the selection of transport modes to be used and the level of use of the public transport system as a whole. Several studies have been conducted to measure KTM Komuter user satisfaction, such as the study conducted by Ahmad Nazrul was approached using both the Delphi approach and a thorough review of the current literature, focusing on a total of nine possible factors affecting passenger satisfaction with rail travel availability of service, accessibility of service, ticket or pass, punctuality, clarity of information, quality of customer service, comfort, safety, and image [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 by passengers 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 user in Malaysia in terms of ergonomic risk factors that affect the temporary unhealthy feeling to the passengers. The following sub-titles explain the literature review, research methods, findings, discussion and will end with conclusions.

## 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, etc. 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. By providing an ergonomic environment in the train cabin by the public transport company, passengers can reduce the risk of unhealthy health symptoms and, at the same time, can increase comfort of the passengers, and passengers are satisfied with the services provided by the public transport company.

### 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. Therefore, in the KTM Komuter context, when KTM Komuter train passengers feel that there is noise, vibration, and ventilation, they experience while riding this public vehicle, which harms their

musculoskeletal disorders. The more they are exposed to the ergonomic risk factors, they will have increased the symptoms of musculoskeletal disorder problems they experience. 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 was also one of the elements in finding out the effect of passengers' exposure to ergonomic risks. Therefore, in the KTM Komuter context, if the passenger is exposed to noise, vibration, and ventilation, then it will lead to unhealthy health symptoms that the passenger may experience. The second hypothesis will be:

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

### 2.4 Passenger Comfort

Comfort, by the Oxford dictionary, means being physically relaxed and free from pain or, in other words, a feeling of not suffering or worrying so much, a feeling of being less unhappy. The success of various services, such as public transportation, healthcare consideration during passenger travel time, and so on, depends on factors that affect passenger comfort. By 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 they use 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 experienced while riding the train was the main factor predicting passenger comfort during their traveling. Therefore, in the KTM Komuter context, when passengers feel comfortable when riding the train, the issue of temporary health symptoms can be reduced, and it will highly lead them to satisfy with the service provided by the public vehicle. Thus, this study has come up with the following hypothesis:

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 will be:

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. 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 research from other researchers before this regarding passenger satisfaction, this study proposed the following research framework, as shown in Figure 1.

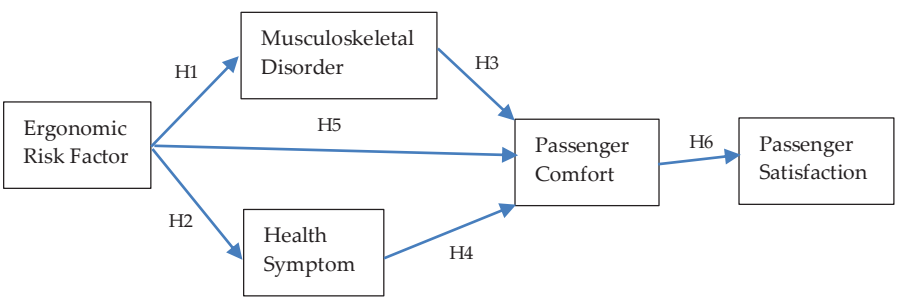


Figure 1: Research Framework

# 4.0 RESULTS

## 4.1 Reliability and Validity

A total of 361 questionnaires were returned, and the details have been expounded, indicating 90.25%. 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], who stated that Cronbach's Alpha value must exceed 0.6.

Table 1: Result 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 have met the threshold values for construct validity. The Absolute Fit in particular RMSEA is 0.047 (accomplished the limit of under 0.08), the Incremental Fit classification to be specific CFI is 0.955 (accomplished the edge of more prominent than 0.9), and the Parsimonious Fit class specifically the proportion of Chisq/df is 1.807 (accomplished the edge of 3.0). Along these lines, the measurement model for Ergonomic Risk Factor has accomplished the necessity for Construct Validity. As a result, as the items were created using previously conducted research on passenger satisfaction regarding public transit that considered ergonomic risk factors, their face validity was all valid. Accordingly, Table 2 is 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

Public transit is one of the elements that must be highlighted to get to a developed nation. Today, the general public in Malaysia's major urban areas, KTM Komuter, has monopolized the transportation industry. As a result, KTM Komuter must act appropriately to address the comfort and satisfaction of its customers. Considering several significant ergonomic risk factors, keeping a good and healthy environment will offer comfortable riding and lessen the transient health symptoms experienced by train passengers. It was unquestionably, increasing future profits. There are six direct hypotheses (H1, H2, H3, H4, H5, and H6) for this study. Among the sixth hypothesis, five were seen as statistically supported, H1, H2, H4, H5, and H6. The one hypothesis that was not upheld is H3.

Several studies from previous researchers support hypothesis 1 for the case study on the satisfaction of KTM Komuter users in using this public transport facility. There is also a study of Ergonomic risk factors that indeed affect the MSDS of KTM Commuter users, especially when they are exposed to the vibration that exceeds the appropriate limit. Regarding the second hypothesis, it is about the ergonomic risk factors of the noise, ventilation, and vibration factors that affect the health symptoms of train passengers, which has been supported through the path analysis method, proving and supporting the results of studies from other researchers such as P. Nassiri who stated that vibration giving bad health effects to passengers Apart from that, the effects of a bad ventilation system also give the effect of unhealthy health symptoms to passengers [8].

The following hypothesis is about health symptoms that affect passenger comfort. This study found that the KTM Komuter train passengers did not support the third hypothesis. Health symptoms experienced by train passengers indeed have an effect of discomfort on passengers. 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 have an effect of discomfort on them. A study by Patricia states that ergonomic risk factors from vibration, temperature, and noise affect passengers' health symptoms and create an unhealthy environment for them [9]. An addition from another study that adds to the statement of the hypothesis is from Teiwan, which found that high vibration levels occur from the train cabin floor have an impact on the ride comfort to the passenger and then have an impact on dizziness or unexplained foot numbness, especially when the passenger is sitting near to the middle of the train cabin car body [10]. For the fourth hypothesis, it has been clear that musculoskeletal disorder symptoms affect the train passengers' comfort. Several previous studies from other researchers support this statement and prove the evaluation of train users who ride the KTM Commuter train feel the effects of Musculoskeletal disorder symptoms when they ride this vehicle. Among them is Anis's study on ergonomic risk factors' effect on MsDS [11]. A survey by Irwan also proved that MsDS gives an effect discomfort to taxi drivers when riding the vehicle for an extended period [12].

Next, regarding the fifth hypothesis regarding the relationship between Health symptoms and passenger comfort which gave the result supported. In theory, passengers who board a public vehicle have high expectations to ride a comfortable vehicle throughout their journey using the public vehicle. It clearly shows that noise, vibration, and ventilation cause discomfort and also give temporary unhealthy symptom situation to passengers when boarding the train. This indirectly supports the findings of this study which states that health symptoms are not significant to passenger comfort. The last hypothesis is regarding the relationship between passenger satisfaction and passenger comfort. This study found that KTM Komuter train

passengers support this last hypothesis with the statement that passenger comfort significantly affects passenger satisfaction. And many studies states that passenger comfort plays a significant role in passenger satisfaction. When the passengers feel comfortable during their journey, it positively affects their overall experience and perception of the service the public transport company provides. 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 have to stand for a 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. Many studies have been studied by other researchers that involve workers who are exposed to ergonomic issues that cause discomfort [15] while they work that affect their health which can be adapted to carry out this study. Therefore, it is very important to pay attention to ergonomic factors in planning and operating public transportation facilities, including trains, to provide users comfort and satisfaction so as not to give side effects to the unhealthy symptom environment for the passengers.

## 6.0 CONCLUSION

Drawing from past research in the context of the train passengers of KTM Komuter, this study developed a conceptual framework to assess the effects of train passengers' overall satisfaction, which takes into account the level of passenger comfort by taking into account ergonomic risk factors which consist of noise, vibration, and ventilation which affects the level of health of the trainee passengers. With this, it can also be a benchmark for the level of user satisfaction with the level of comfort provided by the public transport company to the user. The findings reveal that ergonomic risk factors affected the passenger's health symptoms and the sign of musculoskeletal disorders in the train user. Ergonomic risk factors also impact the comfort of the train passenger, and those profoundly impact the level of user satisfaction when riding this public vehicle. To conclude, the train company of KTM Komuter should be evaluated and assessed within a broader context, not only focusing on providing comfortable service and passengers are satisfied with the service provided, but the company should also take into account ergonomic risk factors that affect the health of passengers in delivering a healthy train cabin for them. Public transportation will continue to play a significant role in enhancing economic opportunities, enhancing accessibility, and fostering excellent social development in a rising and developing economy. In order to support the National Transport Policy 2019-2030, this study can keep strengthening national public transport infrastructure and provide a sustainable transport system as the Government of Malaysia strives to drive Malaysia's economic growth.

## ACKNOWLEDGMENTS

The authors extend their gratitude to Universiti Teknikal Malaysia Melaka (UTeM) and Majlis Amanah Rakyat (MARA) for their financial support.

## AUTHOR CONTRIBUTIONS

W.H.W. Mahmood, A.F.I. Hirmawan: Conceptualization, Supervision, Validation, Writing-Reviewing and Pre-Editing; F. Abdullah: Methodology, Software, Writing- Original Draft Preparation; S.R. Kamat, M.S. Kasim: 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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