

DEVELOPMENT OF RELATIONSHIP BETWEEN RISK FACTORS AND
ROAD SAFETY PRACTICES AMONG BUS DRIVERS USING STRUCTURAL
MODEL

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To the Glory of God Almighty

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ABSTRACT

Most road safety research focuses on identifying the risk factors causing the accident for successful road safety practices implementation. What is missing from these studies is the relationship of how these so called risk factors affect safety practice behaviour statistically and empirically. Therefore, the objective of this research is to establish the relationships between risk factors (RF), traffic accident (TA) and driving behaviour (DB). Empirical data were collected from 465 responses from Malaysian commercial bus companies using a driver behaviour questionnaire (DBQ) designed for this purpose. In this study, all scales that were developed had an alpha (α) value greater than 0.70. Exploratory Factor Analysis (EFA) was performed using a principal component analysis with varimax as a method of extraction to determine the underlying dimensions of the risk factors and safety practices (KMO = 0.824). Preliminary analysis for model building from EFA provided evidence for five risk factor constructs (Driver, Task, Hazard, Vehicle, and Road) and two safety practice constructs (Traffic Accident and Driving Behaviour). Results from confirmatory factor analysis (GFI= 0.970; AGFI= 0.920; NNFI= 0.933; CFI=0.964; RMSEA= 0.072; CMIN= 1.778) provided additional support for the results obtained from EFA. The structural equation modelling (SEM) technique was employed to examine the relationship between these five risk factors and safety practices. The results showed that there is a significant relationship between these five risk factors, traffic accident and driving behaviour. This research has a practical value in which bus managers would be able to identify and relate the success of their safety practices through managing these associated risk factors.

ABSTRAK

Kebanyakan penyelidikan keselamatan jalan raya adalah tertumpu kepada pengenalanpastian faktor-faktor risiko yang menyebabkan kemalangan bagi melaksanakan amalan keselamatan jalan raya yang berkesan. Walaubagaimanapun, kajian-kajian yang lepas tidak mengambil kira hubungan antara faktor-faktor risiko dan cara ia mempengaruhi tingkah laku amalan keselamatan secara statistik dan empirik. Oleh itu, objektif kajian ini adalah untuk menentukan hubungan antara faktor-faktor risiko (RF), kemalangan jalan raya (TA) dan tingkah laku pemandu semasa memandu (DB). Data empirik dikumpul dari 465 respon syarikat bas komersial di Malaysia menggunakan kaedah soal selidik tingkah laku pemandu (DBQ) yang direka untuk tujuan ini. Dalam kajian ini, semua skala yang dibangunkan mempunyai nilai alpha (α) yang lebih besar daripada 0.70. Analisis Penerokaan Faktor (EFA) dilakukan dengan menggunakan analisis komponen utama dengan 'Varimax' sebagai kaedah pengekstrakan untuk menentukan dimensi asas faktor-faktor risiko dan amalan keselamatan (KMO = 0.824). Analisis awal EFA menunjukkan lima konstruk faktor risiko (Pemandu, Tugas, Bahaya, Kenderaan dan Jalan raya) dan dua konstruk amalan keselamatan (Kemalangan jalan raya dan Tingkah laku semasa memandu). Keputusan analisis pengesahan faktor (GFI = 0.970; AGFI = 0.920; NNFI = 0.933; CFI = 0.964; RMSEA = 0.072; CMIN = 1.778) menyokong keputusan yang diperolehi dari EFA. Teknik pemodelan persamaan berstruktur (SEM) digunakan untuk mengkaji hubungan antara kelima-lima faktor risiko dan amalan keselamatan ini. Keputusan kajian menunjukkan bahawa terdapat hubungan yang signifikan antara lima faktor risiko dan kemalangan jalan raya dan tingkah laku semasa memandu. Kajian ini mampu menyumbang kepada nilai praktikal di mana pengurus bas akan dapat mengenal pasti dan mengaitkan kejayaan amalan keselamatan mereka melalui pengurusan faktor-faktor risiko yang berkaitan.

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LIST OF ABBREVIATIONS

AVC	-	Automatic Vehicle Location
CFA	-	Confirmatory Factor Analysis
DB	-	Driving Behaviour
DBQ	-	Drivers Behaviour Questionnaire
EFA	-	Exploratory Factor Analysis
ERSO	-	European Road Safety Observatory
EU	-	European Union
FA	-	Factor Analysis
MIROS	-	Malaysian Institute of Road Safety
OSC	-	Organisational Safety Culture
RTA	-	Road Traffic Accident
SEM	-	Structural Equation Modeling
SOP	-	Safety Operating Procedure
TA	-	Traffic Accident

LIST OF SYMBOLS

SS	-	Sample size
Z^2	-	<i>z</i> - Score
SD	-	Standard deviation
C	-	Margin of error

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CHAPTER 1

INTRODUCTION

1.1 General Background

Basically, road accident has become a major global problem due to human, economic and social costs associated with road crashes. Road traffic accident (RTA) is the most common causes of injuries, worldwide in 2012, an estimated 1.2 million people were killed and 50 million injured in road accident, that cost the global community about USD518 billion. It is going to be the top three major causes of death globally by 2020 (Nordin *et al.*, 2014). Figure 1.1 shows bus accident trend between 2003 and 2012 in Malaysia as reported by MIROS accident investigation report.

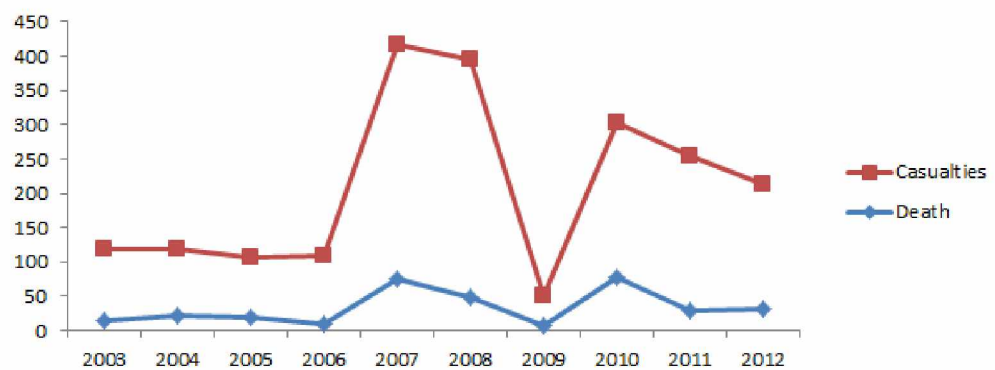


Figure 1.1 Yearly commercial bus accidents between 2003 and 2012 (MIROS, 2013)

Road accident causes a big problem, resulting in injuries, casualties or even death. Despite all, it is very unfortunate that many do not fully appreciate the size and severity of this problem. Many believe drivers' errors and vehicle faults are the main causes and neglect several other factors that might contributed to the causes and source of accidents. Between 2003 to 2012 and 2007 to 2010 data from the Malaysian Institute Road Safety (MIROS, 2013) accident database showed that commercial bus accident increases on yearly basis. This yearly increase is due to a number of factors ranging from road users, vehicle fault, risk or hazard to road infrastructures. Mostly, a clear measurement that can reveal the magnitude of the problem in a clear and understandable manner is often neglected and underestimated.

For instance, when the government or practitioners need to agree on appropriate actions or measures to reduce the incidence of accidents, then, it is important to analyse the existing road accident problems evidence at the current time as well as predicted obstacle in the future time. Therefore, conceptual models, empirical models or statistical measurements become a very important decision tools. If road users or practitioners want to point out some things about the relationship between behavioural or performance and road safety, it must be based on understandable models for such measurements.

Regrettably, the past measurements used in addressing the scale of road safety problems were mainly grounded on death rates such as deaths per vehicle or deaths per person. In a way, these proportions as means of measurements are too shallow to be applied by the policy makers. Furthermore, even the scale of the measurements is non-uniform, in the sense that the report may be biased and varies from person to person depending on how they view or witness the accident. Apart from that, there is no clear standard scale. Hence, there is a variation from one report to another resulting in ambiguous results in the form of decimal numbers.

Moreover, measurement by death rate says little about consequences and risk factors responsible for the accident (Hermans *et al.*, 2008). There is also no simultaneous analysis of the risk factor to observe their joint impact on traffic accident and driving behaviour as noted by Caird and Kline, (2015). With the above mentioned limitations of the current measurements approach, it is therefore the aim of this study, to develop a model that can provides the bus operators as well as practitioners with clear understanding of the risk factors impact on safety practices among commercial bus.

The focus is to accommodate possible improvement on safety practices. In order to fully carry out this task, the causes and risk factors as related to commercial bus need to be identified. This chapter first highlight an overview of commercial bus accident followed by the introduction to road safety practices and general issues on commercial bus. The scope, problem statement, significance of the research and the organisation of the thesis work were also discussed.

1.1.1 Commercial Bus Issues

The major mode of transportation in most developing countries is Commercial buses. In Malaysia, for instance, they are privately owned and operated generally by individuals and transportation firms. Statistics indicate that total number of commercial bus accident increases on a yearly bases, about 36% of the total bus accidents occurred between year 2008 to 2013 (MIROS, 2013). This statistics proved by recent studies indicated that the increase in bus accident is normally associated with less experienced drivers (Goh *et al.*, 2014). World Health Organisation (WHO, 2004) informed that an average of 1.24 million people died in road accidents each year. As projected, the number will triple to 3.6 million by 2030 if the trend continues. Moreover, reports from European Road Safety Observatory (ERSO, 2010) indicates that 874 fatalities (437 in urban area, 393 in rural area and

44 unknown) in crashes that involved buses or coaches occurs in year 2010 alone. Statistics have also been reported for the United State of America, in which 63,000 buses were involved in traffic crashes within the investigated years, causing a total of approximately 325 fatalities about 0.8% of total road fatalities (Cafiso *et al.*, 2013).

The Traffic safety basic facts of European Road Safety Observatory (ERSO, 2009) reported fatalities linking buses or coaches in the European Union countries stated that, car occupants represented 34%, bus occupants represented 20% and motorcyclists represented 10%. Even a Canadian study on bus crashes (Rahman *et al.*, 2011) confirmed that buses interact more closely with the road users which also contribute fairly to accident outcome from collisions. Taiwan's Ministry of Transportations and Communications, recorded an increase of fatal and serious injury crashes, involving high-deck buses on the roads, from 30% in 2005 to 53% in 2011 (Chu, 2014). This common crashes occurrence among buses shows the justification for the case study on commercial bus accident.

1.1.2 Road Safety Practices

Road safety practices are indicators or measures that reveal the operating settings of the road traffic system that stimulate the system's safety performance (Yannis *et al.*, 2013). Benchmarking and measures are terms that have been widely used in many fields of research. Researches in the past years have increase on safety practices measure with particular prominence on operational and data issues (Assum and Sørensen 2010, Thomas and Safeter, 2007, Ma *et al.*, 2011). In a similar manner, there are rapid developments of composite indicators, since the dimmensionary character of road safety implies that government and bus practitioners should take various influential factors into consideration.

1.2 Background of the Study

Vehicle crashes has been a major anxiety due to financial, social and human costs that is connected with road traffic accidents. The constant increase in motorisation and traffic volume over the years with its associated traffic complications including road accident and injuries has made road safety a major problem. The World Health Organisation (WHO, 2009) statistics projected that over 1.2 million people die every year and about 20 to 50 million sustains non-fatal injuries globally (Koshy *et al.*, 2004). In recent time, the use of risk factors and models in the field of road safety has been increasing rapidly as well.

The common traditional approach of road safety performances only relied on road safety outcome in terms of fatalities per population, vehicle fleet or exposures (e.g. fatalities per 100,000 population; mortalities per 10,000 registered vehicles or the number of death toll per million vehicle kilometers travelled) (Al-haji, 2007). There is no generally acceptable safety practices measure that gives overall road safety situation in a given country. The use of accident data or crash related indicator do not describe all the relevant risk factors of road safety problems into details.

The inconsistency in the methodology and much reliance on the accident report in judging the nature and severity of bus accident has also lead to the belief that the problem is being exaggerated, since statistics do not necessarily explain why traffic accidents occurred. This call for development of better systematic and evidence based guide lines for a better approach toward proffering solution to road accident among commercial bus.

1.3 Problem Statement and Research Questions

Current road safety model focused mainly on crash, risk (e.g driver behaviour and driving attitude) and injury as noted by Chu, (2014). There is lack of an efficient process and model to explicitly reflect road safety problems comprising mutually interacting factors. This study therefore developed model to study empirically the relationship between risk factors and how these risk factors affect traffic accident and driving behaviour. This was achieved by measuring the individual and organisational variables through its constructs separately. Most studies on road safety are based on case studies and are unreliable to assess the impact of its implementation (Edwards *et al.*, 2014).

In addition most of these studies and its investigations lack the scientific backing in its methodology to empirically identify factors that significantly affect traffic accident and driving behaviour. This study include driving behaviour as stated by Hilde and Rundino (2015) and drivers personalities trait as studied by Yang, (2015). In a similar way accident prediction model was carried out by Ashish, (2013) and accident analysis by Wahlbeg *et al.*, (2015), all these lack a reliable scientific evidence as noted by Solah *et al.*, (2005).

Therefore, there is no generally accepted and unified theory or structural model regarding their relationship. Finally there is no study that combined individual and organisational variables simultaneously to analyse traffic accident and driving behaviour. A study is therefore needed to have better understanding of how the risk factors affects traffic accident and driving behaviour through development of a conceptual model. Therefore, to explain the conceptual model and its usefulness, this research will seek to provide answers to the following questions:

- i. what are the risk factors associated with traffic accident and driving behaviours
- ii. what are the classifications that exist between the risk factors?
- iii. what is the impact of individual and organisational variables on traffic accident and driving behaviour?

1.4 Objectives of the Research

Each of the research questions will be successively discusses through the following objectives:

- i. To identify and validate the risk factors between traffic accident and driver behaviour.
- ii. To establish the contributions of organisational and individual factors towards traffic accident and driver behaviour.
- iii. To establish the impact of the individual and organisational variables on traffic accident and driving behaviour.

1.5 Scope of the Research

The research will focus on the following:

- i. Identification of road safety among commercial bus drivers.
- ii. Used a cross sectional study based on Drivers Behaviour Questionnaire survey (DBQ) carried out between the periods of October 2013 – June 2014.

- iii. Involvement of all types of commercial bus for both stage bus and express bus therefore, the results are not generalized to commercial bus with significantly different characteristics to other automobile company (e.g truck, rail, cars and air craft).
- iv. Data collected based on five bus companies in Johor.

1.6 Significances and Original Contributions of this Study

From the perspective of safety policy, a broad based model comprising both; individual and organisational factors, to measure road safety practices is important because this would enable the practitioners to plan and set targets in incorporating both factors. This is necessary since the current literatures find disagreement among the risk factors and no establish methodology to fully understand accident trend. For example studies by Plav, (2010) uses driving simulators to study the accident trend.

May *et al.*, (2008) stated that it is important to identified accident risk factors in helping to know the interventions that can reduce the risks associated with the commercial bus safety. Taylor *et al.*, (2015) argued that safety implementation efforts among commercial bus drivers have not been successful because of individual and organizational (variables) influence.

One of the earlier efforts performed by Hamed *et al.* (1998) involved a study on mini-bus traffic accidents with the purpose of gaining an insight into the factors affecting accident occurrence and severity and proposed two disaggregate models for this. Nailul *et al.*, (2011) identified the relationship between factors of fatigue such as working schedule and working condition towards the cause of bus accidents. Manika *et al.*, (2013) belief that the systematic safety practices can better be achieved through individual and organisational approach methodology. The applications of the

model will serve as a standard operating procedure (SOP) for bus stakeholders and practitioners. It will also provide an establish methodology of the risk factor interactions with the safety practices, which will also include the following contribution to the body of knowledge:

- Identifying and verifying statistically the development of a valid risk factors or constructs.
- Identifying and verifying statistically the development of a valid traffic accident constructs and driving behaviour constructs.
- Identifying and verifying statistically the structural model of the relationship between the risk factors (individual & organisation), traffic accident and driving behaviour.
- Provision of a clear picture of the interactions among the risk factors showing their impact on safety practices.

1.7 Definitions of Terminologies

There are several terms used throughout the thesis concerning road safety practices and their applications. This section provides a brief definition of the related terms in which their definition is limited to the context of this study.

- i. Road Safety – Traffic accident is often used instead of road safety since this study emphasis on road safety practices including drivers, vehicle safety and road user safety. The term “Traffic Safety” is an overall term and can be referred to the safety of all traffic modes like air traffic, rail, road and sea as noted also by (Al-haji, 2007).
- ii. Accident – A general term used for an unexpected event with negative consequences that occurred unintentionally and causes direct or indirect

suffering as the consequences. Accidents can be classified as fatal, serious or minor (Akaateba, 2012).

- iii. Casualties - A collective score of injuries and fatalities of an event and in the context of this thesis, casualties means death and injuries.
- iv. Indicator – A measure derived from variables which are factors that affect commercial bus accidents (Haji, 2005).
- v. Composite Index – A combination of various indicators or factors.
- vi. Exposure – Denotes an amount of travel made which may results to accident.
- vii. Risk – A likelihood of an accident to occur per unit of contact or can be classified as the magnitude of penalties (severity) of an accident

1.8 Thesis Structure and Organization

This thesis is organized into six chapters the first chapter highlights the background of the problem that necessitates this study. The chapter also contains the research questions, objectives, scope and significance of the research. The chapter ends with definition of terminologies used in the thesis.

Chapter two presents a review on the recent findings found in the literature associated with similar safety practices model, commercial bus accident problems and risk factors. Besides that, various methodologies currently employed in this field of study are also discussed in this chapter.

Chapter three critically evaluates the model components, development of Road Safety hypothesis and safety practices constructs based on previous reports. Rigorous methods based on literature have been applied to develop a conceptual model that is made up of the risk factors identified and how they are significantly

associated with commercial bus accident. The analytical tools used in the development of the model are also presented in this chapter.

Chapter four illustrates in detail the methodology used in this study. The chapter begins with an introduction of the research design and survey methodology, where a detailed explanation was provided on survey instrument, pilot study, population sampling of the study, reliability, expert validation and statistical analysis. Exploratory analysis of the items of the questionnaire was discussed so as to reduce the items into measurable constructs.

The fifth chapter presents the analysis of the empirical results and the types of measurements that were carried out. It starts with a discussion of general descriptive statistics of respondent's demographic factors to understand the behaviour of the sample population, validation process of the questionnaire using reliability and validity tests and explanation of the applications of the model. The results from the findings after expert validation were used to recommend road safety practices and predict common and regular factors of accident occurrence among commercial buses.

Finally, chapter six concludes the findings of the research by discussing the contributions and recommendation for further research.

1.9 Summary

This chapter established the foundation of this study by highlighting the importance of this research, introducing the background of the study, and describing the objectives and scope of the research. The significance of the study has been identified and their limitations were noted at the end of the discussion section. Definitions of terms used in this study and outline of the thesis organisation have also been presented. Therefore, not only limited to academic researchers but also, the practitioners will find this statistically and empirically tested model useful to predict how risk factors will affect traffic accident and driving behaviour.

A detailed literature review on the issues and factors associated with problems related to bus accidents were provided in the next chapter.

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