ORIGINAL ARTICLE

Development of Mobile Application in Assessing Commuting Accident Risk (CommuRisk) Amongst Commuters at Klang Valley

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ABSTRACT

Introduction: Globally, commuting accident risks are always neglected in an organisation. There is a need to assess the impact of commuting accidents based on sociodemographic, human, vehicle, road, and environmental factors and to find suitable and effective mitigation strategies to alleviate the associated undesirable outcomes. **Methods:** This research was designed to develop a mobile application to assess commuting accident risk levels using artificial intelligence principles, as we are now in the 21st-century technology era. A total of 216 respondents from private and government industries participated in this study. Besides, to prove the developed application's effectiveness, the study evaluated the effectiveness of the identified risk factor in determining the level of commuting risks predicted by respondents with the risk level calculated by the mobile application. **Results:** A major contribution of this paper is the effectiveness and accuracy of a mobile application known as CommuRisk. The app was developed using Android Studio and natively uses Java. There was a significant difference between with and without mobile applications in determining the level of commuting risks, and the effectiveness was proven with a (p-value = 0.001) at a 95% confidence interval with large sample size. **Conclusion:** Thus, this paper proved the effectiveness and accuracy of a mobile application in calculating risk levels exposed by commuters compared to risk levels predicted by commuters.
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INTRODUCTION

In road traffic accidents worldwide, between 20 and 50 million people suffer non-fatal injuries, with many of them becoming disabled as a result of their injuries. As a result, approximately 1.35 million lives were lost (32). Road accidents are a significant global health issue that causes fatalities, and disabilities, are due to speeding, driving under the influence of alcohol and other psychoactive substances, non-use of motorcycle helmets, seat-belts, and child restraints, unsafe road infrastructure, inadequate post-crash care, inadequate law enforcement of traffic laws (Oyono et al., 2022) and negative socioeconomic results (15). There is no argument that Malaysia's prosperity has been significantly boosted by motorization. However, the cost for this is astronomical. In Malaysia, it is estimated that road accidents result in a yearly economic loss of almost RM 7 billion due to property damage, loss of manpower, lost productivity, high medical costs, expense management, and other factors (12). The average payout per claim made by insurance for actual physical damage to vehicles increased from RM 3,846 in 1995 to RM 4,293 in 1998.

Malaysia is one of the countries that have many industries where workers are involved in commuting accidents that cause the most accidental deaths. There is a general tendency that Malaysian industrial accidents are decreasing. However, throughout the course of the last 6 years, the number of commuting accidents has climbed by about 49%, from 17,682 accidents in 2007 to 26,262 incidents in 2012 (20). According to research conducted by the Social Security Organization (SOCSO) in partnership with regional colleges, 88% of accidents happened when people were travelling to and from work. The study also discovered that 55% of accidents were less than 5 km from the areas where the victims worked, and 68.8% of occurrences included workers who worked in the morning (31). Commuting accidents ordinarily involve multiple injuries, which are worse and more traumatising compared to workplace injuries, where there was a 28.3% increase from 2001 to 2010 in the claimed number of commuting accidents (39). The number of accidents reported from 2017 to 2018 showed an increment of 3.88%, or 2,714 cases, where 48.49% were commuting accidents (42). Based on the previous research, there were many existing factors that contributed to commuting accidents.

An accident results from the combination and interaction of the systems comprising roads, the environment, vehicles, road users and how these factors interact with each other (49). For this study, several factors have been categorised as human factors, vehicle factors, road factors, and environmental factors. Each element will address different variables. Apart from the above factors, sociodemographic characteristics were found to be one of the contributing factors to commuting accidents. The critical variables were age, with the elderly being at a higher risk than teens due to vision problems (38), gender (female or male), and occupation, with a person working either shift hours or overtime as a result of stress and fatigue (47). Based on SOCSO statistics, commuting accidents occur because workers rush to work, along with other underlying factors, such as speeding, reckless driving, and texting while driving (23). Furthermore, workplace demography like the type of industry, occupation, and exposure hazards; and employee/worker demography like gender, age, duration of employment, health status, type of commute, and journey management, such as driving profile, route hazards, vehicle condition, and mileage were, amongst the factors contributing to commuting accidents among SOCSO contributors (2). Besides, there is an emerging trend in online delivery services during the pandemic and an increase in the trend of commuting accidents (10).

This study used the risk matrix concept to identify high, medium, and low risk for each variable. The risk matrix is broadly used in risk management and is a simple tool to rank and prioritise risks of common adverse events and to decide whether certain risks can be tolerated or not where it contains and displays the basic properties of consequence and likelihood (16). A risk assessment is required for road safety performance analysis. Previously, the different exposure variables were directly tied to and computed using the road safety outcome, but addressing the multiple variables remained a challenge. It is vital to assess the risk and its relationship to the performance indicators for road safety (40). The risk matrix is a mechanism for characterising and ranking process hazards that are often detected through one or more multifunctional review processes, including audits, incident investigations, and hazard analysis (27).

Global businesses are developing in Industry 4.0, where technology has made it possible for new goods and services that improve the effectiveness and enjoyment of our daily lives (48). Moreover, the developments in mobile technology have brought an excessive change in the daily lifestyle of every employee. Besides, every day, thousands of mobile apps are released on Google's Play Store and Apple's App Store, and the use of smartphones or any mobile device is widespread in all aspects of the working environment (41). Therefore, it has led to intense demand for developing artificial intelligence software on mobile devices (19). The concept of this study is shown in Fig. 1. Hence, the objective of the study is to develop a mobile application in assessing commuting risk.

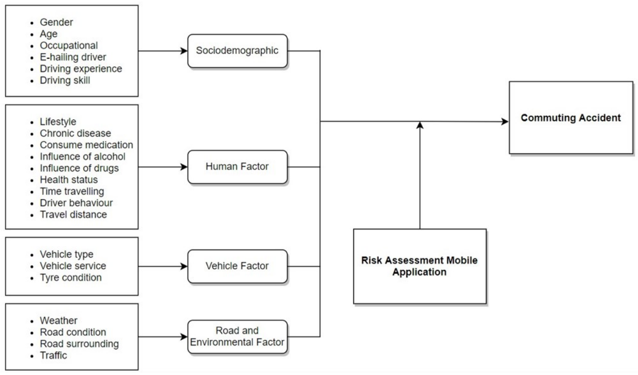

Figure 1: A study concept. Crucial factors and sub-elements were identified from the various literature reviews that became trigger factors for a commuting accident.

MATERIALS AND METHODS

Study Design
This study applies an intervention study design using the artificial intelligence principle to develop a mobile application using an Android smartphone. The app was developed using Android Studio and natively uses Java. The front-end of the app was developed using XML. The database was connected using the PHP script, and all the API functions were coded in PHP. The app called every API function in the PHP script to store and access data from the database. Existing factors that contributed to commuting accidents were extracted based on previous related studies for the conceptual basis of the commuting accident.

Sample population and sampling frame
The sample population in this study was commuters from Klang Valley. The inclusion criteria were (i) having a valid driving license, and (ii) having a grey fleet, while the exclusion criteria were (i) travelling to the workplace via public transportation, (ii) walking to the workplace, and (iii) working from home. The sampling frame is the commuters who travel to or from their place of work in private and government sectors that fit the criteria.

Sampling Method
This study used simple random sampling, the most direct and pure probability sampling technique. This is also the most common technique to select a sample from the population for a variety of objectives. Every individual in

the population has an equal probability of being chosen for the sample in basic random sampling. It has been stated that "the logic behind simple random sampling is that it removes bias from the selection procedure and should result in representative samples". The study used the method of the lottery.

Sampling Size
The sample size for this study was calculated based on the objectives of this research, and the largest sample size estimation was chosen to be used in this research. The sample size was calculated based on the intervention study design (37) and 212 respondents were needed in this study with a 95% confidence interval. The formula for sample size calculation is below.
Formula:
$k = n2 / n1 = 1$
$= (\sigma\ 2/1 + \sigma\ 2/2 / K)\ (z1-\alpha/2+z1-\beta)^2 / \Delta^2$
$= (12.5^2 + 12.5^2 / 1)\ (1.96 + 0.84)^2 / 4.8^2$
$= 106$
$= K$

Where;
$\Delta = |\mu2-\mu1|$ = the difference between two means
$\sigma1, \sigma2$ = mean #1 and #2 variance
n1 = group #1 sample size
n2 = group #2 sample size
α = type I error probability (usually 0.05)
β = type II error probability (usually 0.2)
z = a given α or β critical Z value
k = group #2 to group #1 ratio of sample size

The respondents were stratified based on the sampling method. The actual total number of respondents was 216.

Study Instruments

Questionnaire
The questionnaire was developed and structured. The sub-element of each factor in the questionnaire was based on various literature reviews. The content in the questionnaire was been pre-tested and validated. There were four sections in the questionnaire used in this study which were categorized as driver's profile or known as sociodemographic characteristics, human factors, vehicle factors, and road & environmental factors, respectively.

A content validity study was conducted to ensure the degree to which this instrument can evaluate all aspects of the construct and that it is designed for a particular assessment purpose. The assessment tool measures the representativeness and clarity of each item on a scale of 1 to 2, with 1 indicating that the item is not representative (No) and 2 signifying that the item is representative (Yes).

The effectiveness and success of this study have been ensured, the quality requirements were fulfilled where it concentrated on data collection technique using validated methodology prior to any field works, a set of questionnaires was tested for reliability through a pre-test survey and all information gathered were strictly confidential while quality control was focused on meeting quality requirements (25). The questionnaire was validated by an experienced and the comments were integrated into the questionnaire.

A pilot study was conducted on 30 respondents among UPM OSH staff, Kuala Lumpur Pavilion Staff, and random people in Selangor areas. Furthermore, the international consistency was measured via Cronbach's coefficient alpha. The analysis revealed that Cronbach's alpha value is 0.70. According to (9), a reliability coefficient of 0.70 or higher is acceptable. Table I shows the questionnaire of the study.

Focus group discussion (FGD)
A focus group discussion entailed bringing together people with equivalent backgrounds or experiences to explore a particular topic of interest. The focus group discussion was conducted with the expertise of the Accident Prevention Section Department, SOCSO, programmers, and Occupational Safety and Health, UPM via face-to-face interaction and via WhatsApp. The Internet's evolving interactive capabilities at the turn of the century has opened up new options for online study. Aside from the introduction of a new perspective for online research methodologies, such as Blank's chapter on big data and the "qualitative data revolution" (4), more traditional qualitative procedures such as interview sessions, evaluation, or focus group discussion have been translated into online equivalents (6, 46). Technology-unrestrained possibilities are referred to as affordances. Depending on how the technology is used and interpreted, these alternatives may or may not be applied (14, 36, 50). The Focus Group Discussions protocols are as follows:
1. Four subject matter experts were identified from various industries
2. A group leader was then nominated as a group representative
3. A brief project description and objectives were explained
4. The total duration for the FGD allocated was four hours
5. They will discuss and provide their perceptions attitudes, beliefs, and ideas
6. A rapporteur will take notes on all the issues being raised
7. A final consensus on the agreement was then finalized by the expert.

Mobile Android Application
Various tools and interfaces are used to create and build mobile apps. Despite this, it has helped in the making and presenting of the best UI and top-notch UX for all users.

Table I: A questionnaire

DRIVER'S PROFILE This section referred to socio-demographic background information. You are required to tick or write the answer in the space provided.		
1.	Gender	(1) Male (2) Female
2.	Age	
3.	Working industry	
4.	Job title	
5.	E-hailing driver	(1)Yes (2) No
6.	Driving experience	
7.	Driving skills	(1) very poor (2) Poor (3) Average (4) Good (5) Excellent
HUMAN FACTORS This section referred to human factor information. You are required to tick one or more than one answer or write the answer in the space provided.		
1.	Lifestyle	(1) Smoking (2) vaping (3) drinking (alcohol) (4) gaming (5) none of the above
2.	Chronic disease	(1) Yes (2) No
3.	Consume Medication	(1) Yes (2) No
4.	Influence of alcohol	(1) Yes (2) No
5.	Influence of drugs	(1) Yes (2) No
6.	Health Status	(1) vision problem (2) stress (3) fatigue (4) headache (5) not relevant
7.	Time of travelling	
8.	Driving Behavior	(1) Rushing (2) Speeding (3) Mobile Phone (4) Sleepiness (5) Normal
9.	Travel distance (km)	
VEHICLE FACTORS This section referred to vehicle factor information. You are required to tick **one or more than one answer** in the box provided.		
1.	Type of vehicle	(1) Motorcycle (2) Car (3) Lorry (4) Bus (5) Bicycle
2.	Vehicle service on time?	(1) Yes (2) No
3.	Tyre condition	(1) expired tyre (2) bald tyre (3) under inflation (4) over inflation (5) proper inflation
ROAD AND ENVIRONMENTAL FACTORS This section referred to road and environment factor information. You are required to tick **one or more than one answer** in the box provided.		
1.	Travelling in bad weather condition?	(1) Yes (2) No
2.	Road condition (s)	(1) Slippery (2) Uneven surface (3) pothole (4) under construction (5) normal
3.	Road surrounding	(1) Winding road (2) Hilly road (3) Dark road (4) Normal (5) Others
4.	Traffic	(1) Heavy (2) Slightly heavy (3) Normal
COMMUTING RISK LEVEL		
Rate your commuting risk level based on the scenario answered: (1) Low (2) Medium (3) High		

A questionnaire was created based on a previous literature review and it consists of four main sections which are sociodemographic, human factors, vehicle factors and road and environmental factors. The last question in the questionnaire requires respondents to predict their risk levels based on the answer given.

i. Defined and comprehended the issue as well as its causes.
ii. Clarified which commuting risk factors are to be used.
iii. Identified the mobile application platforms.
iv. Identified how to assess the level of commuting risks.
v. Tested and refined on a small scale.
vi. Collected sufficient evidence of effectiveness to justify implementation.

A flowchart for mobile application development and design is shown in Fig. 2.

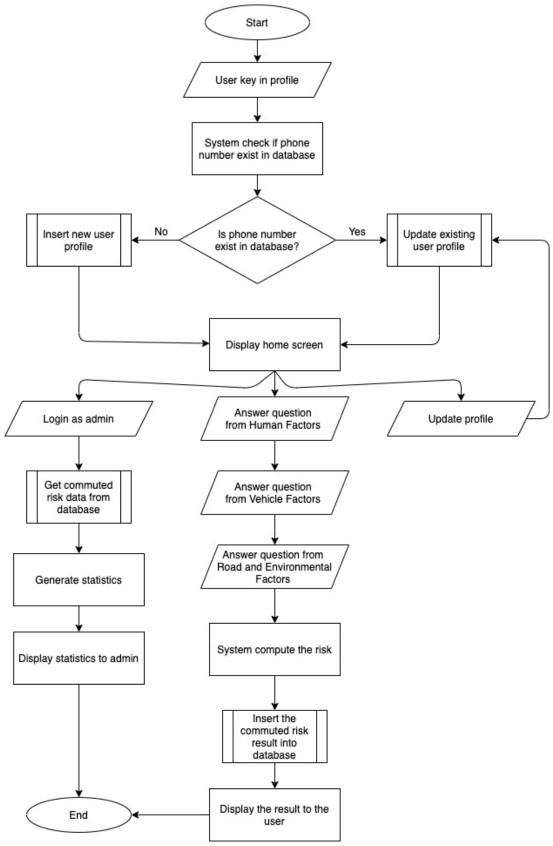

Figure 2: Flow Chart of mobile application development and design. An overview of how a CommuRisk mobile application was developed, designed and functioned from start to end user.

Statistical analysis

The data were analysed using Microsoft Excel, the Risk Matrix table, and the IBM® Statistical Package for Social Sciences (SPSS) Version 26. The app was tested for indoor testing by relevant organisations to ensure the functions of the app meet the requirements.

Ethics approval

This study was submitted and approved by the Universiti Putra Malaysia Ethics Committee (JKEUPM) with reference number JKEUPM-2021-089.

RESULTS

The study analysed the effectiveness of the identified risk factors in determining the level of commuting risks predicted by respondents with risk levels calculated by the mobile application. The Wilcoxon signed-rank test statistic was chosen as the statistical analysis for this objective to compare measurements under two different conditions: where respondents predict the risk level (nominal) and the risk level calculated by a mobile application (ordinal). Analysis showed that the median for both measurements was the same (Mdn = 2.0). The test revealed a statistically significant difference between with and without a mobile application in determining the level of commuting risks, Z = -7.016, p = .001, at a 95% confidence interval.

The association correlation between each variable with the level of commuting risks was analyzed using bivariate analysis which is chi-square. Analysis was revealed that there was no significant association between driving skill $\chi 2$ (6, N=216) = 8.320, p = 0.216, time travelling $\chi 2$ (14, N=216) = 21.278, p = 0.095, and travelling distance $\chi 2$ (6, N=216) = 6.978, p = 0.323 with commuting of risk levels where p-value greater than α value (0.05) at 95% confidence interval. Besides, there was a significant association between working industry $\chi 2$ (16, N=216) = 26.908, p = 0.043, e-hailing status $\chi 2$ (2, N=216) = 9.445, p = 0.009, life style $\chi 2$ (20, N=216) = 37.170, p = 0.011, medication intake $\chi 2$ (2, N=216) = 8.675, p = 0.013, alcohol consume $\chi 2$ (2, N=216) = 6.281, p = 0.043, health status $\chi 2$ (2, N=216) = 49.090, p = 0.008, driving behaviour $\chi 2$ (32, N=216) = 69.631, p = 0.000, type of transportation $\chi 2$ (8, N=216) = 20.516, p = 0.009, vehicle service timing $\chi 2$ (2, N=216) = 16.065, p = 0.000, tyre condition $\chi 2$ (16, N=216) = 28.952, p = 0.024, travelling in bad weather $\chi 2$ (2, N=216) = 82.615, p = 0.000, road condition $\chi 2$ (28, N=216) = 130.435, p = 0.000, road obstacles $\chi 2$ (22, N=216) = 38.485, p = 0.016 and traffic $\chi 2$ (4, N=216) = 44.974, p = 0.000 with commuting of risk levels where p-value smaller than α value (0.05) at 95% confidence interval. The chi-square table is shown in Table II.

Table III: Chi-square analysis to determine the association between sub-element factors (human, vehicle, road, and environmental factors) and the level of commuting risks.

Variables	Chi-square ($\chi 2$)	*p*-value
Gender	4.765	0.092
Age	0.950	0.622
Working industry	26.908	0.043
E-hailing driver status	9.445	0.009
Driving skill	8.320	0.216
Life style	33.170	0.011
Chronic disease	3.319	0.190
Medication	8.675	0.013
Alcohol	6.281	0.043
Drug	1.548	0.461
Health status	49.090	0.008
Time of traveling	21.278	0.095
Driving behavior	69.631	0.000
Traveling distance	6.978	0.323
Transportation	20.516	0.009
Vehicle service on time?	16.065	0.000
Tyre condition	28.952	0.024
Traveling in bad weather?	82.615	0.000
Road condition	130.435	0.000
Road Obstacle	38.485	0.016
Traffic	44.974	0.000

A chi-square value for each sub-element factor with commuting accident risk levels where the *p*-value is smaller than the α value (0.05) at 95% confidence interval ($p = 0.001$).

DISCUSSION

In a commuting accident analysis, route planning, navigation, and other mobility services, accurate predictions of such traffic information are critical (24). The study uses risk management systems to calculate risk levels. In the risk management process, there are three steps. Establish a risk management system first, then assess the management mechanism's risk, and then respond to the risk assessment's findings (45). Risk identification, risk analysis, and risk assessment are the three stages that invent risk assessment. The most popular techniques include the risk matrix, principal component analysis, the risk index, and brainstorming. The column of risk variables, the column of risk impact, the column of risk probability, and the column of risk grade are all included in the first risk matrix, as shown in Fig. 3, Fig. 4, and Fig. 5, adapted from previous studies and the Occupational Safety and Health Act 1994 under NADOPOD regulation (30, 33, 45).

All variables undergo the process to get the risk number calculated, and the result is inverted into the CommuRisk Application. The formula for risk is as follows:

Risk = Likelihood (L) x Consequences (C)

The repercussions of an event, including changes in circumstances and the likelihood that they will occur, are frequently combined to describe risk (43). The likelihood is defined as the chance of something and can be expressed qualitatively or quantitatively.

Rating	Consequence	Description
5	Catastrophic	Fatal injury or multiple serious bodily injuries
4	Major	Serious bodily injury or major fractures
3	Moderate	Injury or requiring medical treatment leading to disability
2	Minor	Injury or requiring medical treatment leading to temporary disability or first aid only
1	Negligible	Not likely to cause injury

Figure 3: Risk consequence classification (severity). The severity of consequences assigns a rating based on the impact of an identified risk to safety, resources, work performance, property, and/or reputation. Each rating is then assigned a value. (E.g., a "Negligible" may be assigned a value of 1; a "Catastrophic" rating may be assigned a value of 5.)

Probability level	Probability range (%)	Description
A – 5	91 – 100	Almost certain
B – 4	61 – 90	Likely
C – 3	41 – 60	Possible
D – 2	11 – 40	Remote
E – 1	0 – 10	Rare

Figure 4: Risk probability level (likelihood). Probability of occurrence explores the likelihood that an identified risk could occur. Probability of occurrence uses a rating and value scale ranging from Rare (1) to Almost Certain to Certain (5).

			Consequence				
			Negligible	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
Likelihood	Almost certain	5	5	10	15	20	25
	Likely	4	4	8	12	16	20
	Possible	3	3	6	9	12	15
	Remote	2	2	4	6	8	10
	Rare	1	1	2	3	4	5

Figure 5: Risk matrix. The numerical values from the severity of consequences will contribute to other types of risk rating tools, like the hazard risk rating with standard linear scaling. Risk Rating (RR) = Probability of Occurrence (OV) x Severity of Consequences Value (CV). As the formula indicates, the higher the assessed probability of occurrence and severity of consequences, the greater the risk rating will be.

Nevertheless, the predicted risk by respondents did not involve any calculation, and the accuracy and precision were found difficult to prove because they were not involved in any method. Thus, calculating risk using an assessment method based on the risk matrix method has outstanding outcomes such as convenience, objectivity, and effectiveness. It can identify and scientifically determine the commuting risk levels compared to the predicted risk by commuters.

This study has proven that commuting accidents have happened as a result of the driving system malfunctions found in the components of humans, vehicles, infrastructure and environment, and their interactions, except for several variables that were found not significant when the variable was independent. The findings in this study were similar to previous studies by (5, 8, 44), which indicated that there was a significant association between socio-demographic characteristics, humans, vehicles, roads, and the environment with commuting accidents. A comprehensive accident study offers a complete picture of all the variables at play. The suggested actions should eliminate the causes and consequently the effects of road accidents, as one of the findings of an extensive accident analysis (8).

This study proved that road accidents have resulted from the driving system malfunction found in the components of human, vehicle, and road infrastructure and environment and their interactions except for several variables. The findings in this study were similar to previous studies (8, 18, 44), which indicated that; there was a link between socio-demographic factors, humans, vehicles, and roads, as well as the environment, and road accidents. According to the findings of this study, industry, e-hailing driver status, the influence of alcohol, influence of a drug, consume medication, having a chronic disease, lifestyle, driving behaviour, type of transportation, vehicle service schedule, tyre condition, travelling in bad weather, road obstacles, road surrounding and traffic conditions were found significant to the commuting accidents and risk levels.

A large number of studies (1, 3, 7, 11, 21, 22, 39, 40, 46) devoted to the influence of alcohol, the influence of a drug, consume medication, having a chronic disease, lifestyle, driving behaviour, type of transportation, vehicle service schedule, tyre condition, travelling in bad weather, road obstacles, road surrounding and traffic conditions on the accident rates of motor vehicles were published over the last decades and all authors claimed that those elements were a major factor affecting risk levels. In conjunction with the above statement (13), claimed that increased traffic volume consistently improves severity, whereas speed has a variable influence on severity depending on flow conditions (34). Besides, the demand for e-hailing services has surged as a result of the present pandemic crisis. Furthermore, the findings of this research were similar to findings from (26), an increase in ride-hailing traffic volume and driver population leads to an increase in the number of ride-hailing-related crashes.

Nevertheless, the study found that males and females (gender), age, driving experience, driving skills, travelling distance, and travelling time were not significant to commuting accident risk levels. The finding of this study was similar to several studies from (17, 23, 35), were also found that gender alone (male and female), and age are not significant in the risk level of accidents. Driving experience indeed helps increase a driver's ability to handle a car (e.g., keep the car on the road and to make progress); however, experience also helps increase the driver's confidence, which in turn decreases the driver's safety concerns. Moreover, overconfidence may result in more unsafe driving behaviours (28, 29).

Recommendation
Some improvements can be added and considered to upgrade the application. For example, a pop-up notification/reminder to check the risk level by filling in current information before travelling. Hence, the user will be more aware of their risk level and the surrounding environment, as well as be more cautious. Besides, the CommuRisk application was built with a focus on being user-friendly, simple, and minimalist. Nonetheless, there are still various interface frameworks that can be considered.

Limitation
Worldwide, all countries were affected due to COVID-19. The World Health Organization (WHO) recognised the spread of the COVID-19 virus as a pandemic on March 11, 2020, and Malaysia began implementing the Movement Control Order (MCO) from March 18, 2020, until December 31, 2021. Due to the pandemic, the progress of the application development, function testing, and recruiting of respondents were affected and have been adjusted to suit the current situation. Besides, the developed application is Android-based; hence, respondents who used an iPhone were excluded. Additionally, the mobile application can only be accessed by Android version 8.0 and up-to-date users. Associated with attitudes, respondents listed a number of reasons why they did not download or remove the app. Their decision not to utilise the app was mostly motivated by their perception that it was neither effective nor useful. Technical issues like draining the battery, being afraid of viruses, and mobile phone storage were also mentioned.

CONCLUSION

According to the findings, the CommuRisk mobile application has successfully determined commuters' levels of commuter risk. It also provides risk actions that can be taken to reduce commuting accidents in an organisation.

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