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The Antecedents for Effectiveness of Automated Enforcement System (AES) in Malaysia

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ABSTRACT

This study aims to investigate the antecedents of the effectiveness of the Automated Enforcement System (AES) in Malaysia. Apart from that, the main objective is to identify the relationship between reducing road accidents, human errors, external conditions, government revenue, and the effectiveness of AES implementation in Malaysia. A total of 200 respondents in this study were the drivers who used highways (PLUS) equipped with an AES system. Purposive and convenience sampling techniques were used with a questionnaire as the instrument. Descriptive and inferential statistics conducted are Pearson correlation and multiple regression analyses. The findings show that there is a significant relationship between reducing road accidents, human errors, external conditions, government revenue, and the effectiveness of the AES system. However, regression analysis shows that reducing road accidents was found to be the main antecedent that affected the effectiveness of AES. Hence, various parties such as authorities, non-governmental bodies, and drivers have benefited from the study.

Keywords: AES system; road accidents; fatalities; PLUS

INTRODUCTION

The current phenomenon shows that most countries around the globe are battling with the loss of lives due to road fatalities. Malaysia is also struggling in flattening the deadly accidents curve with speed limits and law enforcement among the strategies used to reduce road fatalities. This creates both positive and negative perceptions by the drivers in Malaysia. Some drivers are against the law made by the government on the speed limit. However, the government aims to ensure zero deaths due to road fatalities is above other interests. In addressing the road accident problems, Automated Enforcement System (AES) is one of the tools used by the Malaysian government through the Road Transport Department (RTD) to control the behavior of drivers and reduce traffic offenders. In contrast to other countries, the automatic enforcement system is known as Automated Speed Enforcement (ASE). However, the difference is only in the term being used but has a parallel function which is to eliminate traffic offenders. As the Malaysian government has decided to use AES, it is important to measure how this system effectively and efficiently helps the government to ensure road fatalities can be curbed and eliminated. AES is an automatic system equipped with

motor vehicle sensors that can capture the image of vehicles that exceed the speed limit and are ignorant of the red traffic light (Maryland State Highway Administration, 2021). Thus, it meets the government's ultimate aim to ensure a high level of road safety. An automated enforcement system is not only being implemented in Malaysia but in many other states around the world. The Victorian state was the first country that innovated the technology of AES in the year of 1989 (Hermann, 2017). At that time, 54 units of speed cameras were installed in Victoria. During that time, as the system is newly embedded into Victorian transportation law, the role of mass media and publicity campaigns is important in delivering the information on the concept of AES and creating awareness among the citizens. The ASE or AES system is considered a fundamental intervention due to its success in reducing about 30% of the road fatalities in Melbourne which is one of the regions in Victoria State (Hamzah et al., 2013).

In Malaysia, the fact stated that speeding is the main contributor to road accidents every year. Thus, it leads to the government taking initiative by introducing the AES system throughout the nation. It was installed in several black spots places that have higher frequencies of crash rates around Selangor, Perak, Kuala Lumpur, and Putrajaya in the year 2012 (Hamzah et al., 2013). At the early stage of the AES enforcement period, it was installed in 14 locations which are 10 locations for monitoring the excessive speeding rate and 4 locations for beating the red traffic light (Hawa et al., 2014). To acknowledge the drivers about the AES cameras installed areas, warning signs were placed around 2 to 3 kilometers ahead of the places where the AES cameras are located (Hawa et al., 2014). After years of implementation, the compliance rate by the driver toward the speed limits is inclined. It is proven in a study that stated the increment to 91% compliance rate towards the speed limits and traffic light offenses and the violation cases of red light running decreased to 2.2% after implementation of AES as compared to 4.3% before implementation of AES (Hawa et al., 2014). From the statistics, it means that AES implementation has more positive outcomes rather than negatives regardless of any aspect of the spectrum of drivers and citizens in general.

Therefore, it is shown that AES cameras were effective in combating the causes of the excessive speed limit. Thus, AES is an effective tool in dealing with human behavior in speeding. AES camera also is one of the significant mechanisms that can solve the speeding problems and the violation of red light ignorance. It is because the drivers become obliged to the specified speed limit with the presence of AES as they realize that their actions will be monitored by the AES cameras. It also leads to a safer driving environment because all drivers will follow the road rules and regulations when they are driving. Thus, accident cases can be avoided and slowly diminish. Therefore, this study's primary aim was to investigate the antecedents of the effective implementation of AES in Malaysia.

The two research questions were as follows:

(i) What is the correlational effect between the independent variables (road accidents, human errors, external conditions, government revenue) and dependent variables (effectiveness of AES)?
(ii) What is the main predictor for the effectiveness of AES implementation in Malaysia?

LITERATURE REVIEW

Automated Enforcement Systems (AES) had been applied by many countries throughout the globe such as New Zealand which started to implement AES cameras in the year of 1993 (Hagemann et al., 2018). To evaluate the successfulness of AES cameras in New Zealand, researchers such as Keall and his team made a study on the effectiveness of this system. Based on their research, it was found that in the first year of AES enforcement in the country, there was a reduction of 11% in accident rates, a 19% reduction in injuries, and also a decline of 8% in the number of injured vehicles occupant per crash (Keall et al., 2020). Hence, they conclude that the ASE or AES is indeed effective in combating crash rates since it may encourage people to be obliged to the rules and regulations on the road. On the other hand, the United Kingdom installed the AES in the year 1992 and the crash rate shows a reduction of 19% cases in a year, and the fatalities rate also shows a reduction by 44% after about a decade after the implementation of AES technology (Luoma et al., 2020). Thus, researchers believed that AES is an effective mechanism to deal with the increment in crash rates due to excessive mobile speed by the drivers on the road through sensors built in the system (Luoma et al., 2020).

Nevertheless, the Korean National Police Agency had also enforced ASE or AES in their country since 1997 when they started to install around 821 units of mobile speed cameras in various locations throughout South Korea (Thomas et al., 2018). The enforcement of AES has led to high compliance with the law on speed limits by the drivers as compared to the time before the implementation of the automatic system. In addition, the South Korean authority also installed 853 units of fixed speed cameras that were effective in reducing road accidents because it was installed upstream of curves or at the downgrade sections and together with a warning sign to road users at the distance of 500 m or 1 km from the enforcement areas (Hamzah et al., 2013). These two situations prove that AES is an effective system in helping the authority reduce road fatalities.

While in the United States, AES was only implemented in 14 regions of the country due to the decision being made when the policymakers assumed that the AES system would create controversy among the public (Hagemann et al., 2018). Based on the public survey that has been carried out in Minnesota, it shows that the majority of the citizens agreed with the enforcement of AES but with the condition that it is only limited to certain areas such as school zones and crashes or black spots areas. During the implementation, the average speed and car crashes in that particular area have reduced which proves the effectiveness of the AES system (Hagemann et al., 2018). Besides combating the crash rate, it also helps the local authority to save their expenditure of around $17M per year that will usually be used to deal with the injuries that are caused by road accidents (Hamzah et al., 2013).

Based on the analysis of previous literature, it was proven that the AES system is effective and efficient in helping the government to curb road accidents and fatalities. However, there are differences in the factors that lead to the effective and efficient implementation between Malaysian and other countries. Thus, Figure 1 presents the conceptual framework which highlights the antecedents that influence the effectiveness of AES in Malaysia.

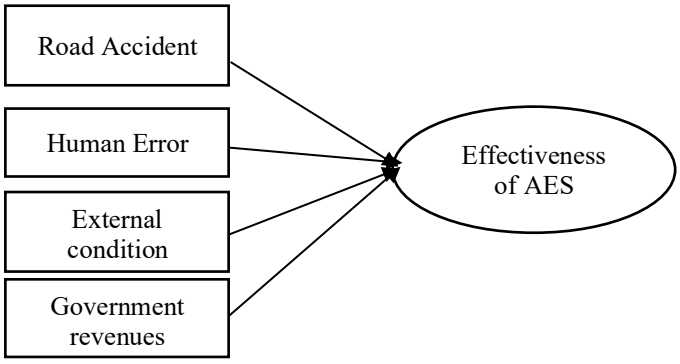

Figure 1. Conceptual framework of the study
Adapted from Keall et al. (2020); Sadaf et al. (2021); Lannon et al. (2021), Hamzah et al. (2013) & Hawa et al. (2014).

METHODOLOGY

This study embarked on using a quantitative research design. A cross-sectional methodology using the questionnaires as the instrument was carried out in gathering data at a single point at a time. The benefit of this method is that it allows the researchers to establish a comparison of different variables at the same time (Mullins et al., 2021). In this study, the data were collected from Malaysian drivers who used highways where the AES system was installed and monitored by RTD and PLUS. Self-administered questionnaires were distributed to the drivers in several RNR stations. The sample size involved was 200 respondents from the drivers that use highways. The reason for selecting only 200 respondents as the sample size is to fulfill the need for statistical analysis. Furthermore, this study used Pearson correlation and multiple regression analyses as the statistical test to answer the objectives which determine the effectiveness of AES implementation. Thus, it is suitable to cope with the statistical need. The range of the age of the drivers was not fixed, it is uncluttered to all the legal drivers that use highway services. Non-probability sampling which is purposive and supported by convenience sampling techniques was used as the tool in collecting

the data. Purposive sampling was used because researchers had set the criteria which are legal drivers and using highways that implemented the AES system. Convenience sampling or also known as accidental sampling is the method of gathering data by choosing the people as the respondents because of the availability and easy access to reach the people. There are many advantages to using these two methods. The data can be gathered faster and easily accessible. The cost and time required can also be reduced when using this prodigious method (Agarwal et al., 2015). In brief, the respondents can be anyone and from anywhere as long as they are drivers that use the highways equipped with the AES system.

To ensure the validity and reliability of data, the measurements and items used in the questionnaire were adopted and adapted from the literature where validity and reliability were proven by the previous researchers. The measurement for variables namely AES effectiveness, road accident, human error, external condition and boost government revenues were taken from Keall et al. (2020), Sadaf et al. (2021), Lannon et al. (2021), Hamzah et al. (2013) and Hawa et al. (2014). All dimensions for each variable used the Likert Scale to examine how strong the respondents agree or disagree with statements on a five-point scale. The collected data were analyzed using SPSS Version 26. The collected data were analyzed through the descriptive, measure of central tendency, correlational, and regression as statistical tests to derive the output in answering the objective of the study which is to examine the antecedents that lead to the effectiveness of AES implementation in Malaysia.

RESULTS

Descriptive analysis

Table 1 presents the profile of respondents who participated in this study. The respondents in this study consist of highway users in all areas that have been implemented with Automated Enforcement System (AES). From the data collected, 56 of respondents are males and they hold a lower percentage of 28 percent as compared to the number of female respondents which is 144 or 72 percent. The age of the respondents is in the range of 21 to 30 years old which has a percentage of 78.5 percent. It is followed by the range of age 31 to 40 and 41 to 50 years old with the same percentage of 9.5 percent. In addition, the description of respondents for this study shows that the majority of the respondents drive their car in the range of between 90 to 110 km/h with 74 respondents or 37 percent. Next, it is followed by 80 to 90 km/h which comprises 30.5 percent or 61 respondents who have a usual speed limit. Lastly, 20 respondents (20 percent) drive their car at the usual average limit of 70 to 80 km/h. There are 25 respondents (12.5 percent) who have an average speed limit above 110 km/h which is the limit speed set by the law. This means that only a minority of the drivers drive at a speed limit of more than 110 km/h. From the descriptive analysis, most of the respondents were found to bond to the rules of the highway which is not to exceed 110 km/h. Among the reasons given was they do not want to be trapped by the AES system implemented by RTD and PLUS highway. This is a sign of the effectiveness of AES implementation to combat road crashes and deathly accidents.

Table 1. Profile of respondents

	Frequency	Percentage
GENDER		
Male	56	28.0
Female	144	72.0
AGE		
21-30	157	78.5
31-40	19	9.5
41-50	19	9.5
>50	5	2.5
AVERAGE SPEED		
70-80 km/h	40	20.0
80-90 km/h	61	30.5

Table 1. (continued)

	Frequency	Percentage
90-110 km/h	74	37.0
>110 km/h	25	12.5

Goodness of measures

Table 2 illustrated the normality test of independent variables and dependent variables involved in the study. The results of the normality test show that all the variables involved were respectively between the range of -2 and +2. The dependent variable of this study which is the effectiveness of AES has a skewness value of -0.250 and a kurtosis value of 0.082 which shows that the values fall in the range of -2 and +2 of the normality test. All the independent variables in this study also fulfilled the fitness for the parametric test as all values of skewness and kurtosis for the variables respectively propose that the variables are considered to be normally distributed. The normality assumption was made based on the justification provided by Kline (2005) that proposed the skewness value should be in the range of -2.0 to +2. 0 and -7.0 to +7.0 of the kurtosis values that should be achieved to indicate the normal distribution. Thus, the data for this study is fit for the parametric test which is correlation and regression analysis.

Table 2. Normality Test

Variables	Skewness	Kurtosis	Remarks
Effectiveness of AES	-0.250	0.082	NORMAL
Reduce Road Accident	-0.284	0.273	NORMAL
Human Error	-0.233	0.448	NORMAL
External Condition	-0.143	1.293	NORMAL
Boost Government Revenue	-0.398	1.052	NORMAL

Correlational analysis

Table 3 outlined the strongest correlation between the dependent variable (the effectiveness of AES) and the independent variables, namely reducing road accidents with the value of r: 0.781, $p<0.05$. This statistic shows that there is a strong relationship between the effectiveness of AES and reducing the rate of road accidents. On the other hand, the effectiveness of AES on the variable of boosting government revenue has a moderate correlation with the value of r: 0.403, $p<0.05$. This is followed by the human error that has a moderately low value of correlation with the dependent variable which is r: 0.308, $p<.005$. Lastly, the lowest correlation value is the independent variable of the external condition with the value of r: 0.241, $p<0.05$. Hence, this finding suggests that AES is effective in reducing road accidents while external conditions such as weather and car conditions did not affect the effective implementation of AES as this variable is under the control of drivers.

Table 3. Pearson correlation test

	Variables	1	2	3	4	5
1	Effectiveness of AES	-				
2	Reduce Road Accident	0.781**	-			
3	Human Error	0.308**	0.453**	-		
4	External Condition	0.241**	0.357**	0.365**	-	
5	Boost Government Revenue	0.403**	0.473**	0.262**	0.395**	-

N = 200 ** Sig. p value < 0.05

Regression analysis

Multiple regressions are used to determine the main factor that leads to the effectiveness of the AES system in Malaysia. Preliminary analysis was conducted to ensure no violation of the

assumptions of the ratio of cases for the independent and dependent variables, outliers, multicollinearity, normality, linearity, homoscedasticity, and independence of residuals. Based on the result in Table 4, shows that all independent variables can explain 61 percent of the variance (R square=0.616) in measuring the effectiveness of AES system implementation. The F-value of 77.758 and P-value of 0.000, ($p < 0.05$) indicate that the model is statistically significant. There are four antecedents identified as independent variables in this study which reduce road accidents, human error, external conditions, and boost government revenues. Among these variables, only one factor was found to have a significant influence namely reducing road accidents. Thus, the main antecedent that leads to the effective implementation of the AES system is reducing road accidents (Beta Std. =0.792).

Table 4. Regression test

Variable	Standardized β
Reduce Road Accident	0.792**
Human Error	-0.053
External Condition	-0.045
Boost Government Revenue	0.061
R Square	0.616
F	77.758
Sig.	0.000[b]
Durbin-Watson	1.664
Sig. P-value < 0.05	

DV: Effectiveness of AES ** Sig. p value < 0.05

DISCUSSION

The first hypothesis of this study is to justify the relationship between reduce road accident rates and the effectiveness of AES implementation in Malaysia. From the correlation and regression value, it is proven that there is a significant impact on reducing road accidents through the implementation of the AES system. Thus, it justifies the effectiveness of the system in combating road fatalities thus the hypothesis was accepted. This idea is parallel to scholars' views as promoted by Jannusch et al. (2021), Sadaf et al. (2021), and Nemitz (2018) who justified that artificial intelligence that mobilized through an automated system in controlling traffic benefited the authority in reducing road fatalities. Thus, the finding justifies the importance of implementing an automated system for the related stakeholders such as RTD, PLUS, and the drivers. It will also help the authority in creating awareness and understanding of the public on the importance of implementing such a system to save lives.

Theoretically, this finding has added to the literature on reducing road fatalities by using AES or any automated system. For the public policymakers and politicians, this finding will give them some insights into that AES implementation is not about the government's intention to increase revenue. This is due to the finding which shows that AES has no significance toward inclining revenues for the government. Thus, they should work parallel with the authority to ensure everyone in the nation follows the road's laws and regulations.

In addition, the finding of this study also justified the effort of the government in enforcing the AES program to combat the rate of road accidents in Malaysia as effective and efficient. It is worth mentioning that this study has proposed that human error, external conditions, and government revenues did not have significant regression on the effectiveness of AES implementation. Thus, it justifies that the main idea of the government in enforcing the AES system to reduce road accidents and fatalities is well accepted by the drivers. The drivers believe in the sincerity of the government in introducing AES to save the lives of people on the road with no other intention such as imposing fines to increase government revenues.

This finding is parallel to Hosseinzadeh et al. (2020) study which stated that the rate of road accidents is currently the eighth-most prominent cause of death globally and assumed that in the year 2021-2022 it is predicted to be the major cause of death. Based on their findings, it was discovered that there is a significant correlation between the reduced rate of accidents and the effectiveness of the AES system with the value of Pearson correlation of 0.78 which indicates a

high positive strong relationship between the AES system and reducing road accidents and fatalities. This study's finding corroborated Mullins et al. (2021) who found the same relationship between AES and reducing road fatalities. Thus, this study successfully added to the literature on implementing the AES system by strengthening the model of positive correlation between reducing road accidents and the effectiveness of the AES system. The model generated from this study also explains that reducing road accidents is one of the important contributors to the successfulness of AES implementation in Malaysia.

Furthermore, the reduction rates of road accidents could also be observed in the aftermath of the implementation of AES across various countries. In France, the death rate was reduced by 27 percent in the early three years of the implementation of AES whereas in Germany it was found that 80 percent reduction in vehicle speed at locations where the automated speed cameras were installed (Lannon et al., 2021). Therefore, the effort of the government to implement AES in Malaysia must be supported since it may help in reducing the number of accidents that occur in Malaysia. In addition, lives must be saved and deathly accidents must be avoided, thus the AES system is one of the strategic actions that can be taken by the authorities.

This study also found that human error technically and statistically did not influence the effectiveness of AES implementation in Malaysia. However, this finding contradicts study by Mullins et al. (2021) who described that the increase of road accidents by 58 percent is mostly due to human errors on the part of the drivers which involved speeding, fatigue driving, drowsiness, and loss of control on the vehicle. Mullins et al. (2021) study was found to be parallel with finding from Keall et al. (2020) which concluded that the AES hidden cameras are significantly effective in modifying the behaviors of drivers and increasing the compliance of speed limit and this was backed up the significant statistic reduction of 11 percent in road accidents, 19 percent reduce in fatalities and 8 percent in the total number of injuries per crash in the area of AES camera enforcement. Based on these two empirical studies, it can be concluded that human error has a significant impact on the effectiveness of AES enforcement. The reason for contradiction with this study's finding does not mean that human error should be abandoned even though the statistic from regression did not show any significant impact. However, the correlational analysis conducted in this study shows a positive correlational effect between human errors and AES implementation which is the same as the previous study by scholars such as Keall et al. (2020) and Mullins et al. (2021). Human error was not counted in modeling AES effectiveness implementation in Malaysia purely due to regression modeling analysis but it remains an important predictor to reduce road fatalities in the country.

Next, Jannusch et al. (2021) claim that many violations that lead to road fatalities are raised by the issues of infrastructure setting including insufficient road signage, bad weather conditions, and poor road lighting while human errors were left. In addition, the study also mentions that the physical condition of the roads plays an important part in causing road accidents. The predictor of external conditions tested in this study shows the same situation as the previous predictor where regression modeling left external conditions with no significant impact. Even though regression modeling left this variable, the correlational analysis justified the importance of external conditions as a predictor that will determine the behavior of drivers. Hence, it can be assumed that external conditions should be one of the aspects that must be considered in determining the effective implementation of the AES system initiative in this country.

Nemitz (2018) stated that one of the key benefits of implementing the AES system is related to the enhancement of government revenue in terms of fines and summons. This is the same with previous studies on AES systems for instance in Germany. The fines collected from the enforcement of the AES system will be channeled to the public concerned such as building public amenities (Hamzah et al., 2013). In addition, it could be a significant source of revenue as seen in the city of Berlin where a total of 64 million euros are collected annually from the implementation of the AES system (Hamzah et al., 2013). Therefore, AES as an automated system will help the authorities in Malaysia to identify the wrongdoers on the road and issue a summons that directly increases government revenues. However, this will not only increase government revenues but the most important aim is to reduce the number of road fatalities and can be the instrument to create ethical drivers in Malaysia. This study suggests that there is a significant correlational impact between the AES and improving government revenue from fines and summons. However, the

regression modeling left this predictor from the model as most of the drivers believe in the government's good intention in implementing AES to reduce death due to road crashes. Nevertheless, the revenue collected from AES implementation can be used to improve the system to the latest technology and at an efficient cost. It is the public money and the government needs to ensure the fines collected from AES implementation will be channeled to the building of public amenities and also conducting programs related to ethical driving behavior.

CONCLUSIONS

In conclusion, this study aimed to investigate the antecedents that lead to the effectiveness of the Automated Enforcement System (AES) in combating road accidents. From the results, it is shown that reducing the road accident rate is the most prominent factor that contributes to the effectiveness of the implementation of the AES system in Malaysia. This finding supported the main debate of this study which is to determine the main antecedent of effective AES system implementation throughout Malaysia. Apart from that, the AES is a modern tool that is used to detect road-related issues. It is also beneficial to all drivers since this system can help in shaping the behaviors of drivers especially while driving on the highway. It is undeniable that AES can aid in reducing accidents and increasing speed compliance. Hence the government's effort to implement AES will help in reducing road fatalities. This indirectly helps save lives from road accidents and fatalities.

There are a few limitations in this study that limit its generalizability. First, this study relied on a survey approach that may affect the results. Some of the respondents may not state they are true responses as they want to keep their perceptions confidential. Thus, for future study, it is proposed to adopt a qualitative approach such as interview, observation, and focus group discussion. Second, the model of the study is limited in in-depth explanations of the effectiveness of the AES system as there are only four independent variables and one dependent variable tested. It can lead to a lack of internal and external validity. A study in the future should consider expanding analysis by including other variables to improve the quality of the existing model. Practically, it is recommended that the governments and related authorities install the latest technology for the AES system to eliminate and curb road accidents and fatalities. The use of high artificial intelligence technology will help in reducing the dependency on the human workforce. This also will improve the effectiveness and efficiency of traffic systems which directly lead to reducing figures in on-road fatalities and deathly accidents. In the end, saving the lives of drivers, passengers, and all road users is the ultimate objective of the implementation of an automated traffic controlling system.

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CONFLICT OF INTERESTS

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

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