The number of motorized vehicles, especially motorcycles, is also offset by increased traffic accidents. As is known, road accidents essentially depend on four interrelated factors: human behavior, vehicle efficiency, environmental conditions, and the characteristics of the infrastructure. However, most accidents are attributable to the first three factors, almost always to improper user behavior. This study aims to determine motorcyclists' socio-economic characteristics and conduct on the intensity of accidents. The research location is on the Pandaan-Purwosari National Road, Pasuruan Regency, Section 094-098 (Surabaya-Malang). Three hundred forty respondents are motorcyclists who have experienced accidents in this segment. The research method is interviews and questionnaires – data analysis using Structure Equation Modeling (SEM), with software SmartPLS (Partial Least Square).

The result of accident modeling $Y=0.299X_1+0.154X_2+ +0.077X_3+0.554X_4$. ***The first biggest influence on the chance of an accident is the characteristics of driving behavior (X4) exceeding speed (X4.10). The more often the rider exceeds the rate, the higher the chance of an accident. The second most significant influence of socio-economic characteristics (X1) is the age indicator (X1.2), the more mobility in the productive age, the higher the risk of accidents***

Keywords: traffic accidents, motorcyclist, behavior, demographics characteristics, structural equation modeling (SEM), SmartPLS (Partial Least Square)

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PREDICTION MODEL OF MOTORCYCLE ACCIDENT IN ECONOMIC AND DRIVING BEHAVIOUR FACTORS

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1. Introduction

Traffic accidents are caused by the malfunction of a system, namely, vehicles, road infrastructure, road users, and their interactions [1], and the leading cause of death worldwide and are expected to be the fifth by 2020 [2]. This is a problem because 91 % of fatalities occur on the road [3]. According to the Indonesian National Police, the highest number of accidents in Indonesia occurred in 2019, with 116,441 casualties. Previous studies have found that the human factor is the leading cause of accidents [4, 5]. Research has shown that driving behavior has a positive and significant relationship with accident involvement. Analysis by [5] revealed that driving behavior increases the risk of 50 % of having an accident. The most important part of accident involvement [6, 7].

However, previous studies that have been conducted have used less-renewable analytical methods and have not been able to describe the causes of accidents and their relationship to human factors in detail.

Therefore, research devoted to predicting the development of motorcycle accidents has scientific relevance and needs to be done to minimize the incidence of accidents.

2. Literature review and problem statement

Research conducted by [8, 9] showed that the age factor also determined the element causing the accident, but this study did not explain how the relationship between the age factor and the impact on the occurrence of accidents. However, the study used a random sample, where respondents were drawn from those who had or had never had an accident.

SEM (Structural Equation Modeling) is a multivariate data analysis technique that combines regression, factor, and path analysis. To estimate the causal relationship of latent variables at the same time [10, 11].

Road safety for two-wheeled vehicles or motorcycles has become a global concern. In 2010 there were more than one billion motor vehicles worldwide [11].

Motorcycles are an essential mode of transportation in the Indonesian public transportation system and the most significant contributor to vehicle production in Indonesia. Of the total population of vehicles (operating units) from 2010 to 2017, motorcycles were used around 82 % and used by 120 million Indonesians in 2018 [12].

However, there is an unresolved and challenging problem in transportation, namely accidents. Accidents are hazardous for road users because accidents can result in physical and material losses. Accidents are still a significant problem that must be prevented for safe transportation. Motorcycles are in great demand by road users for various reasons, and their use has continued to increase over the years. One of the reasons for their appeal, in terms of mobility, is their compact size, allowing them to park in small spaces. Its size also helps motorcyclists to move in and out of traffic quickly. Motorcycles have low mass and aerodynamic drag compared to cars, involve low CO_2 emissions, and are, therefore, a fuel-efficient mode of choice. They are attractive for leisure travel, and many return users or new users with disposable income are (re)discovering this activity [12]. However, there are drawbacks to this bicycle vehicle; for example, on the road with low traffic, motorcyclists tend to drive at high speed. Motorcycles only have two wheels meaning the rider can lose control more quickly than a car user; control can be lost due to uneven road surfaces, objects on the road, or not understanding traffic signs [13]. Therefore, motorcyclists are road users who are very vulnerable to accidents and can suffer serious injuries.

Research by [14] was found that the most significant driving behavior in shaping the chance of an accident was exceeding speed. Exceeding speed while overtaking a vehicle can lead to accidents, and the level of injury caused can lead to death. Many factors can cause this [1]. Also, disobeying traffic signs and exceeding speed while driving are some of the main factors leading to motor vehicle accidents. The socio-economic level can be roughly shown according to education level, employment status, and environmental income [15]. Lower socio-economic status is associated with a higher risk of road traffic injury [8, 16] and mortality [17]. Previous research also found that not only demographic factors but also socio-economic statuses such as individual education level, gender, age, and occupation affect the number of deaths due to road traffic accidents [18, 19].

As a result of the increasing number of traffic accidents, especially by motorcycles, several steps have been taken to address these problems, such as improving road conditions and lighting. However, research by [1] states that improvements in road conditions, the environment, and road lighting conditions can affect the driver's perception of speed choices that can affect road safety. Factors such as people, roads, vehicles, and environmental/weather conditions contribute to road accidents. Drivers' beliefs in these factors can influence road behavior. In an attempt to understand behavior, previous researchers also discussed the issue of driving regulation violations and aggressive behavior relative to traffic accidents [20]. Several researchers evaluated the impact of these factors on driver performance and have linked road accidents with damaged infrastructure and inexperience [21].

Accidents can still happen at any time; therefore, the parties involved need to be responsible and make maximum efforts to overcome these problems. In this regard, research conducted by [22] has investigated the factors that cause accidents, namely driver behavior and socio-economic factors. However, this study uses an analysis method that is not renewable and cannot describe the causes of accidents and their relationship to human factors in detail. The discussion of the causes of accidents involves only one or two elements. Meanwhile, the current research conducted by the author relates the four factors that cause accidents based on a combination of factors that do not yet exist. Therefore, it is necessary to research the causes of accidents caused by many factors.

This paper aims to determine the factors that cause accidents, especially in driving behavior and driver socio-economic characteristics, to create safe and secure transportation with SEM (Structural Equation Modeling). Previous research using the first generation in SEM with software lisrel [18], the software is a first generation sem software, which allows more and more complicated assumptions. The author uses the second generation of SEM, namely Smart PLS, which is easier to use, does not require much data, and automatic data normality makes data analysis easier. However, vehicles have an unresolved and challenging problem, namely accidents. Accidents are dangerous for road users because accidents can result in physical and material losses. Accidents are still a significant problem that must prevent for safe transportation.

3. The aim and objectives of the study

The study aims to determine the economic characteristics and driving behavior of the intensity of accidents to determine if supporting variables are needed.

To achieve this aim, the following objectives are accomplished:

– determining the most critical factor among the parameters that affect the accidents: Socio-economic Characteristics (*X*1), Driving Behavior (*X*2) against Accident Characteristics (*Y*);

– produce a prediction model of motorcycle accidents on the national road Surabaya-Malang.

4. Materials and method

Based on previous research, discussing the causes of accidents only involves one or two factors. Meanwhile, the current research conducted by the author relates the four factors that cause accidents based on a combination of factors that do not yet exist. Therefore, it is necessary to research the causes of accidents caused by many factors.

In the previous study, it is still using a simple method, namely regression. Therefore, this research complements previous research, namely analyzing driving behavior and socio-economic characteristics of the high number of accidents on the Surabaya-Malang national road with SEM (Structural Equation Modeling) SmartPLS software.

The sample in this study also uses purposive sampling, where respondents are selected only who have experienced an accident so that the results of the analysis can be detected accurately regarding the factors causing the accident.

The research was conducted in Pasuruan Regency, Gempol-Purwodadi National Road (094-098). The population of 340 respondents was taken based on Issac and Michael's tables through the total population of motorcycles in 2019 taken from the Pasuruan Regency in Center Statistics. The questionnaire only addressed motorcycle riders with an accident or purposive sample. So that the modeling results will be significant and valid. The research method is interview and questionnaire techniques—using SEM (Structural Equation Modeling) SmartPLS software.

SEM is a multivariate statistical analysis method to analyze several research variables simultaneously [23, 24]. Factors from humans have a strong influence on the severity of accidents [19]. Therefore, the authors use SEM because it is relevant to the research objectives. The research variables to be analyzed can be seen in Table 1 Research Design below.

Table 1 above shows the research design based on each indicator of socio-economic characteristics (*X*1): gender, age, work, education, income, driving license and vehicle registration. Movement characteristics (*X*2); the number of trips, mileage, travel time, travel time, and destination. Movement before riding (*X*3); checking vehicle light, checking brakes, checking tire condition, checking machine, check driving license and vehicle registration and containing fuel, driving factors; running a red light, breaking the signs, wrong track, leading to the right and left, give a turn light, check vehicle, chat, smoke and exceeding the speed limit. Accident characteristics; collision type, vehicle cons, injury, accident time, and crash type. In the research design in Table 1, all questions are from previous research. This question or variable is sure to affect the chance of an accident occurring.

Table 1

Research design

Category	Question	Scale
Screen Questions		
1	Have you ever crossed the National Road 094-098?	Yes/No
2	Have you ever had an accident in this section?	Yes/No
Socio-economic Characteristics (*X*1)		
*X*1.1	Gender	Nominal
*X*1.2	Age	Ordinal
*X*1.3	Education	Ordinal
*X*1.4	Work	Ordinal
*X*1.5	Income	Ratio
*X*1.6	Driving License	Yes/No
*X*1.7	Vehicle Registration	Yes/No
Movement Characteristics (*X*2)		
*X*2.1	Number of Trips	Ordinal
*X*2.2	Mileage	Ratio
*X*2.3	Travel Time	Nominal
*X*2.4	Traveling Time	Ordinal
*X*2.5	Travel Destination	Ordinal
Characteristics Before Riding (*X*3)		
*X*3.1	Checking Vehicle lights	Ordinal
*X*3.2	Checking Brakes	Ordinal
*X*3.3	Check tire Condition	Ordinal
*X*3.4	Checking Machine	Ordinal
*X*3.5	Checking Driving License and Vehicle Registration	Ordinal
*X*3.6	Checking Fuel	Ordinal
Driving Characteristics (*X*4)		
*X*4.1	Running a Red Light	Ordinal
*X*4.2	Breaking the Signs	Ordinal
*X*4.3	Being on the Wrong Track	Ordinal
*X*4.4	Leading to the Right	Ordinal
*X*4.5	Leading to the Left	Ordinal
*X*4.6	Give a Turn Light	Ordinal
*X*4.7	Check Vehicle	Ordinal
*X*4.8	Chat	Ordinal
*X*4.9	Smoke	Ordinal
*X*4.10	Exceeding the Speed Limit	Ordinal
Accident Characteristics (*Y*)		
*Y*1	Collision Type	Nominal
*Y*2	Vehicle Cons	Ordinal
*Y*3	Injury	Ordinal
*Y*4	Accident Time	Nominal
*Y*5	Crash Type	Ratio

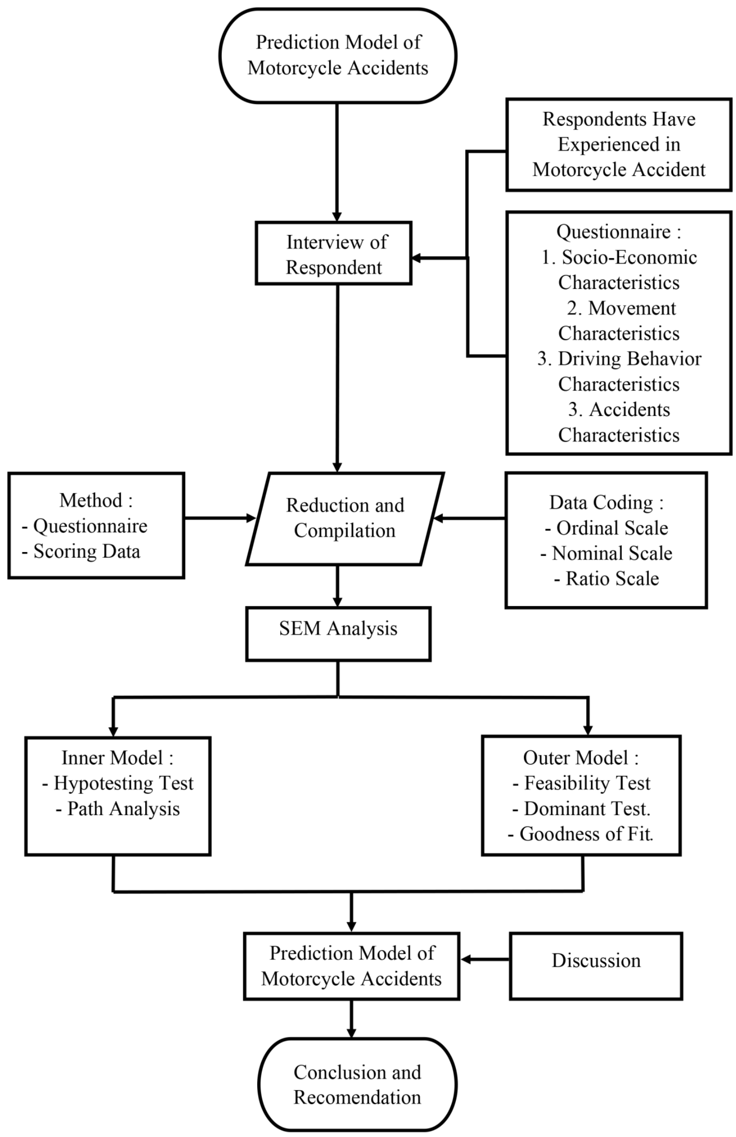

Fig. 1. Flowchart

The illustration of the flow chart of the data collection and analysis process is the steps taken by the author in obtaining data and conducting data analysis. to determine the characteristics of motorcyclists and accident characteristics, as shown in Fig. 1.

5. Results of Prediction Model of Motorcycle Accident

5. 1. Socio-economic characteristics and rider characteristics

5. 1. 1. Feasibility Test/Model Validity

This test aims to describe how well the indicators in this study can be used as instruments for measuring latent variables. With a significance of weight <0.05 (5 %). VIF value <10. As in Table 2, feasibility test.

Table 2 above shows which indicators influence accidents with valid values for the feasibility test. *X*1.2 represents age, *X*2.1 represents travel intensity, *X*3.5 represents driving license check, *X*4.10 represents overspeed, and *Y*5 represents collision type. The most powerful and dominant indicator in shaping the characteristic socio-economic variable (*X*1) is the age variable (*X*1.2), with the highest factor weighting 0.507. Thus, the higher the age, the higher the risk of being a cause of accidents. The survey results from respondents show that the age of 31–35 years (20 %) is a productive age to work and carry out activities. The indicator that plays the most role in shaping the Movement Characteristics variable (*X*2) is the intensity of the trip (*X*2.1) with the highest factor weight of 0.508; thus, the more frequent trips (draining energy when traveling), the higher the risk of being a factor causing accidents. 71 % of respondents often do mobility with the intensity of frequent trips (3–4 times) in one week. The higher the respondent's mobility will affect accidents because high travel mobility makes someone drive more often. The indicator that plays the most role in shaping the Behavior Before Driving (*X*3) variable is checking the vehicle documents *X*3.5 with the highest factor weight of 0.394. Thus, the less often you contain vehicle documents (negligent), the higher the risk of being a factor causing accidents. The most critical indicator in shaping the Behavior While Driving (*X*4) variable is exceeding the *X*4.10 speed limit with the highest weight factor of 0.358.

The vehicle's speed when driving on the road is directly proportional to the severity of traffic accidents. According to WHO, an average speed increase of 1 km/hour causes an increase in the risk of traffic accident severity.

Table 2

Feasibility test

Latent Variable	Observed Variables	Formative Indicator Factor Weight Test			Formative Indicator Independence Test (Multicollinearity)	
		Significance < 0.05 (5 %) = Valid			VIF<10 = Eligible	
		Weight Estimate	Significance of Weight	Conclusion	VIF	Conclusion
Character Characteristics (*X*1)	*X*1.2	0.507	0.000	Valid	3.112	Worthy
Movement Characteristics (*X*2)	*X*2.1	0.508	0.000	Valid	1.293	Worthy
Behavior Before Riding (*X*3)	*X*3.5	0.394	0.000	Valid	1.297	Worthy
Behavior While Driving (*X*4)	*X*4.10	0.358	0.000	Valid	1.309	Worthy
Accident Characteristics (*Y*)	*Y*5	0.596	0.000	Valid	1.33	Worthy

The indicator that plays the most role in shaping the Accident Characteristics variable (*Y*) is the type of collision (*Y*5) with the highest factor weight of 0.596 thus, the Accident Characteristics variable (*Y*) can be seen the most from the Collision Type indicator (*Y*5).

The type of collision is also influenced by the attitude of the driver in driving its vehicle, exceeding speed, changing lanes, and not focusing when driving can be an indication of a collision.

5. 1. 2. Dominant Test

The dominant test determines which variables and indicators are the main priority in overcoming accidents so that can consider it for policymakers to take strategic steps to minimize the incidence of motorcycle accidents-dominant test results as shown in Table 3 below.

Table 3

Dominant test

Effect Between Latent Variables		Path Coefficient	Ranking	Dominant Variable	Dominant indicator
Socio-Economic (*X*1)	Accident Characteristics (*Y*)	0.299	2	Second Priority	*X*1.2 (Age)
Movement (*X*2)	Accident Characteristics (*Y*)	0.154	3	Third Priority	*X*2.1 (Travel Intensity)
Behavior Before Riding (*X*3)	Accident Characteristics (*Y*)	0.077	4	Fourth Priority	*X*3.5 (Checking Vehicle Registration)
Behavior While Driving (*X*4)	Accident Characteristics (*Y*)	0.554	1	First Priority	*X*4.1 (Over Speed)

From the dominant test results in Table 3 above, the first priority that needs to be improved to minimize the incidence of accidents is the *X*4 driving behavior variable that exceeds speed (*X*4.10). Economic characteristic variable *X*1, on the age indicator. (*X*1.2), which is the second priority in accident prevention activities. The third priority is the movement variable *X*2 on the travel intensity indicator (*X*2.1). The fourth priority is the behavior variable before driving *X*3, on the hand of checking the driving license and vehicle license.

5. 1. 3. The Goodness of Fit

This test explains that the path coefficient formed can represent the observed data. The total R-square coefficient value ranges from 0.0 to 100.0 %, where the higher the total determination coefficient value, the higher the path coefficient can represent the observed data. In detail, the standard measurement results for the inner model testing criteria are based on the total determination coefficient, as shown in Table 4.

The coefficient of determination (R-square) obtained from the socio-economic Characteristics model (*X*1) and Behavioral Characteristics (*X*2) on the Accident Characteristics (*Y*) is 74.9 %, and others influence the remaining 25.1 %.

Table 4

Goodness of Fit

PLS Models			R-Square	Determination
Character Characteristics (*X*1)	→	Accident Characteristics (*Y*)	0.749	74.9 %
Movement Characteristics (*X*2)	→			
Behavior Before Riding (*X*3)	→			
Behavior While Driving (*X*4)	→			

5. 2. Accident Prediction Model

The path coefficients in the structural model as well as the weighted values of the manifest variables in the measurement model can be described through the path diagram of the measurement model and the structural model in Fig. 1 Path Chart below variables outside the study. Based on the existing reference, the R-square value is considered vital in representing the research conducted.

Model Prediction $Y=0.299X_1+0.154X_2+$ $+0.077X_3+0.554X_4$.

Fig. 1 above explains the value of each variable and indicator, where the highest path coefficient of 0.554 is found in the driver's behavior variable (*X*4) with the highest factor weight of 0.358, namely driving behavior that exceeds speed (*X*4.10). And the second highest path coefficient of 0.299 socio-economic characteristic variable (*X*1), with the highest factor weighting of 0.507, namely the rider's age (*X*1.2).

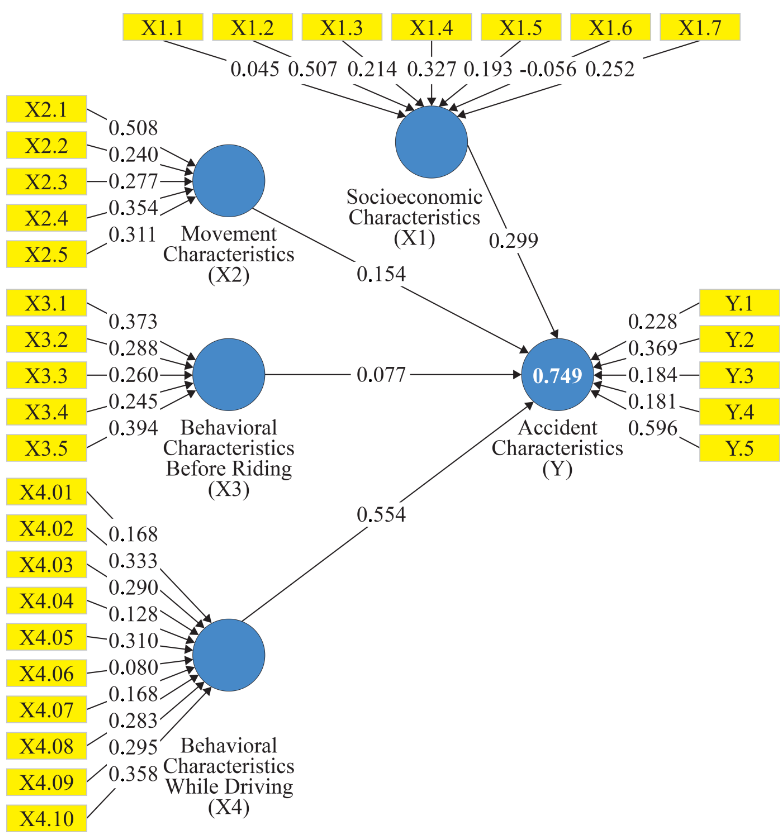

Fig. 2. Path Chart

6. Discussion of The Model Prediction

The results of the analysis of the causes of accidents using SEM (Structural Equation Modeling), it is found that the factors of driving behavior that drives vehicles exceeding speed and economic characteristics variables on the productive age indicator have significant results or influence on the occurrence of accidents (Table 3, dominant test). These results align with research conducted by [4, 19], where human factors or driving behavior are still the leading cause of accidents. The dominant indicator in shaping the behavior variable when going (*X*4) is exceeding speed (*X*4.10) (Table 3, dominant test), with a factor weight of 0.358. Thus, the more you exceed the driving speed, can increase the risk of an accident. The vehicle's speed when driving on the road is directly proportional to the severity of the traffic accident. The average increase in the rate of 1 km/h causes an increase in the risk of the severity of traffic accidents.

The dominant indicator in forming the characteristic socio-economic variable (*X*1) is the age variable (*X*1.2) (Table 3, dominant test), with a factor weight of 0.507. The survey results show that the age of 31–35 years (20 %) is a productive age to work and carry out activities. The higher the age also affects the accident. Age is one of the factors that cannot separate from the emergence of accident risk [18]. According to [24], age is one of the factors that can affect the emergence of accidents. Young age allows for fatal accidents due to lack of experience, risky behavior, and ignoring traffic rules. And compared to drivers of productive age, drivers aged >50 years have a higher risk of fatal injury in an accident [9, 25] because health factors at that age begin to decline, so the perception of risk decreases.

The dominant indicator in shaping the behavior variable when driving (*X*4) is exceeding speed (*X*4.10) (Table 3, dominant test), with a factor weight of 0.358. Thus, exceeding the speed while driving can increase the risk of an accident. The vehicle's speed when driving on the road is directly proportional to the severity of the traffic accident. The average speed increase of 1 km/hour causes an increase in the risk of traffic accident severity. The road environment can affect driver choice by influencing the driver's perception of their current speed and the speed they think is appropriate for the road. These influence and their effects on speed can affect crash rates [26].

This research uses SEM (Structural Equation Modeling) method with SmartPLS software. The advantages of using SEM (Structural Equation Modeling) are:

– its ability to handle complex relationships between variables, where variables can be hypothetical or unobservable (latent variables);

– estimate all coefficients in the model simultaneously so that one can assess the significance and strength of a particular relationship in the context of the complete model;

– its ability to consider multicollinearity and measurement error is eliminated so that the coefficients are more valid [18]. Research [24] using Lisrel, which analyzes driving behavior, also produces the same variable in the cause of accidents.

However, the research still uses the second-generation SEM (Structural Equation Modeling) method; this SmartPls software is more accessible and does not require many assumptions. The drawback of this study is that many variables have not been analyzed concerning the causes of accidents. The author's hope for future research is to include more variables that cause accidents so that they are more valid and can overcome existing problems. The analysis method also needs to be developed using the third generation (Structural Equation Modeling). Can also developed research in other areas that have almost the same characteristics.

7. Conclusions

1. Socio-economic characteristics (*X*1) affect the intensity of accidents, where the age indicator (*X*1.2) has the most significant influence on the power of accidents (*Y*). There is a need for socialization in the community, especially among drivers of productive age, so as not to force them to drive after many activities. Where in this study, the effective age is in the spotlight because of the most accidents

2. The prediction model obtained is $Y=0.299X_1+0.154X_2+0.077X_3+0.554X_4$. The highest path coefficient of 0.554 is found in the driver's behavior variable (*X*4) with the highest weight factor of 0.358. From this model, appropriate handling steps must be taken, so that the problem of motorcycle accidents can be resolved properly, such as adding billboards as a warning to reduce vehicle speed, giving shock markers to keep drivers focused on driving, and giving warnings to take breaks if they are traveling long distances.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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