Modelling of Pedestrian Severity Factors in Traffic Accident in Depok

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Abstract. **Purpose:** Every country has a transportation system problem that can be solved in various different ways. But often, handling the transportation system is not accompanied by an increase in road facilities for vulnerable road users. One of them and the most often ignored is the provision of adequate facilities for pedestrians. Especially for big cities that are developing in Indonesia, such as satellite cities around Jakarta. Depok as satellite cities in Jakarta also have the same problem. As a result, the rapid population growth followed by vehicle growth and not being accompanied by good regional planning can harm the community, especially pedestrians. This study aims to modeling pedestrian severity factors in traffic accident in Depok. **Methodology:** The pedestrian severity observed was death, heavy injury and minor injury. Analysis carried out using multinomial logistic regression method so that later the opportunity model will be generated for the severity of traffic accidents based on prediction variables that have been tested. **Results:** The result, a statistically significant factor affecting the severity of pedestrian accident victims is the age of pedestrians and type of vehicle. **Applications/Originality/Value:** This study aims to determine the factors that cause pedestrian accidents in the city of Depok based on their severity. By knowing the factors that cause pedestrian accidents, it is hoped that the Depok city government can take further action to reduce the number of traffic accidents, especially those involving pedestrians as vulnerable road users.

1. Introduction

The surge in population growth that occurred in the city around the capital city of Jakarta such as Depok will also increase the need of transportation mode. The population explosion will result in pollution and traffic congestion problems. Traffic congestion is an impact of the level of motor vehicle density that has exceeded the tipping point [1,2]. Congestion that occurs in Depok city must be happening during rush hours where most of the population travel for various activities such as work and school.

Most people choose to use private transportation to do their daily activities, including motorcycle and city car. Not surprisingly, the growth rate of motorized vehicles in the Depok city increase 9% annually, while the road growth rate is only 0.7% [3,4].

Meanwhile, research shows that there is a clear relationship between the number of motorized vehicles used to predict road traffic accident rates. The study was conduct in various cities such as London and Stockholme. As a result, policies used to reduce the volume of motorized vehicles on the road have an impact on reducing the level of traffic accident [5].
In Indonesia, an average of 3 people per hour die from traffic accidents. According to WHO 2013, almost half the victims died due to traffic accidents are vulnerable road user categories. The road users that include in the category are motorcycle riders, cyclists and pedestrian.

Based on world traffic accident data, pedestrians contribute more than 1/5 of fatalities due to traffic accident [6]. In Indonesia, based on data taken from 2015 to the end of November 2018, the accident rate involving pedestrians were 17% of the total traffic accidents [7]. From this situation it can be seen that Indonesia has not made any efforts to give special attention to pedestrians. In Depok city, from 2015 to 2017 pedestrian crashes accounted for more than 25% of total traffic accidents. From these figures, it can be judged that Depok is not a friendly city for pedestrians. The main risks for traffic accidents involving pedestrians include a variety of factors, including speed, alcohol consumption while driving, the use of helmets for two-wheeled vehicle users, the use of safety and safety belts for children passenger.

This study aims to determine the factors that cause pedestrian accidents in the city of Depok based on their severity. By knowing the factors that cause pedestrian accidents, it is hoped that the Depok city government can take further action to reduce the number of traffic accidents, especially those involving pedestrians as vulnerable road users.

2. Theoretical Review

In the Republic of Indonesia Government Regulation No. 37 of 2017 [8] concerning Traffic Safety and Public Transportation, the definition of Traffic and Road Transportation (LLAJ) is a unified system consisting of traffic, road transport, traffic and road transport networks, traffic infrastructure and road transport, vehicles, drivers, road users, and their management. Traffic Safety and Road Transportation (KLLAJ) is a condition that avoids everyone from the risk of accidents during traffic caused by humans, vehicles, roads and / or the environment.

Theoretical review in Government Regulation No. 43 of 1993 [9] it is written that a traffic accident is an unexpected and unintentional road event involving vehicles with or without other road users, resulting in human casualties or property loss. Still in the same regulation states that the intended accident victims include the following three categories:

(i) Death Victims. A death victim is a victim who is confirmed dead as a result of a traffic accident within a maximum period of 30 (thirty) days after the accident.

(ii) Seriously Injured Victims. Seriously injured victims are victims who suffer permanent disability or must be treated within 30 (thirty) days of the accident.

(iii) Minor Injured Victims. Minor injured victims described in this regulation are victims who are not included in the definition of dead victims and seriously injured victims.

Factors that cause accidents begin by classifying the movement of road users shortly before the accident occurred. In addition, every road user, both person and vehicle, is analyzed for each accident. Another thing shows that road factors and regulatory systems are often judged to have contributed to the mistakes of people in every traffic accident [10]. So that there are 3 factors causing traffic accidents, namely human factors, road factors, and vehicle factors, as will be explained as follows:

2.1. Human Factor

Human factors are considered to have contributed to the causes of traffic accidents. Based on analyzed data, speed is considered to contribute to 49% of accidents including 32% in which the driver goes beyond the speed limit and 17% further where the driver does not adjust their speed according to conditions [11–13]. In their research, the Damage Review Team assessed that 20% of accidents were due to too high speed limits, and the remaining 11% were due to inadequate cues or signs for the specified speed [14–16]. Obstacles or disruptions are considered
to contribute to 18% of total accidents. The research also suggests raising awareness about potential disturbances other than cell phones such as passengers, navigation and shoulder check. Poor vision is bad when turning right or entering traffic (including gap assessment errors) and confusion due to road configuration contribute 21% and 4% of accidents respectively [17, 18]. The results show these values are consistent with Austroads research conducted in 2012 and 2014. Non-prominent human accident factors in this study are problems related to medical conditions or drugs (10%), failure to properly illuminate vehicles (9%), and “corner-cutting” (4%) [19, 20].

2.2. Road Factor
Among the road factors or regulatory systems considered to have a substantial proportion of errors are silent and moving visual barriers (34% of collisions), speed limits too high (20%), inadequate shoulders (18%), inadequate delineation adequate (7%); steep turning points (9%), complicated road configurations, out of tune, or unusual (10%). The study also identified problems with inadequate speed (11% of accidents), including the lack of speed signs as highlighted by Austroads (2014). The study also identified various design problems at the intersection of major roads with small roads, including the absence or poor placement of signs highlighted by Austroads (2012). The accident factors that were less visible by this study were poor road surface (10%) and damage management and road works that were not good (7%).

2.3. Vehicle Factor
The damage review team acknowledged that technology in fulfilling vehicle safety with a reasonably good market offer can prevent many accidents. But in case discussions that are more individual in nature, the research team usually does not specify the technology used. Accident mitigation that can be offered is to optimize the control of restraint system measurements and emotional control, and improve vehicle interior design for vehicle safety technology.

3. Research Method
Variable dependent is the severity that occurs in pedestrians involved in traffic accidents. This category originates from Government Regulation of the Republic of Indonesia Number 43 of 1993 Chapter XI article 93 which is presented in Table 1. As for the independent variables that will be studied in this study are presented in Table 2.

| Table 1: Category Variable Dependent |
|--------------------------------------|
| Category | Variable Dependent | Number of observations |
|----------|--------------------|------------------------|
| 1        | Minor Injury       | 36                     |
| 2        | Heavy Injury       | 87                     |
| 3        | Death              | 37                     |

3.1. Independence Test
Independence test or contingency table test aims to determine whether the data is cross-classified independently (not bound to each other) or not. Independent testing can be done using the Chi-Square test. In the Chi-Square test procedure, the hypothesis used is: $H_0 =$ There is no relationship between variables, $H_1 =$ There is a relationship between variables. The formula used
Table 2: Category Variable Independent

| No | Variable Independent | Scale      | Information              |
|----|----------------------|------------|--------------------------|
| 1  | Time                 | Categorical| 1 = Morning               |
|    |                      |            | 2 = Afternoon             |
|    |                      |            | 3 = Afternoon             |
|    |                      |            | 4 = Night                 |
| 2  | Lighting Conditions | Categorical| 1 = Light                |
|    |                      |            | 2 = Dim / Dark            |
| 3  | Weather Conditions  | Categorical| 1 = bright               |
|    |                      |            | 2 = Cloudy / Fog / Wind   |
| 4  | Vehicle type        | Categorical| 1 = Motorcycle            |
|    |                      |            | 2 = Small Car             |
|    |                      |            | 3 = Big Car               |
| 5  | SIM ownership       | Categorical| 1 = Licenced              |
|    |                      |            | 2 = Unlicenced            |
| 6  | Pedestrian Gender   | Categorical| 1 = Man                  |
|    |                      |            | 2 = Woman                 |
| 7  | Pedestrian Age      | Categorical| 1 = <17                  |
|    |                      |            | 2 = 17 – 60               |
|    |                      |            | 3 = >60                  |
| 8  | Road Type           | Categorical| 1 = Undivided            |
|    |                      |            | 2 = Divided               |
| 9  | Road Function       | Categorical| 1 = Environment          |
|    |                      |            | 2 = Collector             |
|    |                      |            | 3 = Artery                |

to calculate the test ratio is:

\[
RU_{x^2} = x^2_{test} = \sum \left[ \frac{(O - E)^2}{E} \right]
\]  
(1)

Where: \(O\) = observed frequency (sample), \(E\) = estimated frequency (hypothesis) if \(H_0\) is correct, Reject \(H_0\) and accept \(H_1\) if \(RU_{x^2} > x^2\). If not, accept \(H_0\).

3.2. Multinomial Logistic Regression

Multinomial logistic regression as stated in the previous sub-chapter is a type of logistic regression used for dependent variables that have more than two categories, or polytomous. Specifically, in a multinomial logistic regression model it will produce a multivariate model. If the number of dependent variables is \(K\) category, the result of the modeling is the opportunity of each category \(\pi = \{\pi_1, ..., \pi_k\}\) as a function of independent variables. Then the total of opportunities generated is 1, and the probability of the \(K\)-bound variable will be determined by the probability of other variables [13]. The equation used in logistic regression is:

\[
\pi_k(x) = \frac{\exp(\beta_0k + \beta_1kx_1 + \ldots + \beta_{pk}x_p)}{\sum_{m=1}^{k} \exp(\beta_{0m} + \beta_{1m}x_1 + \ldots + \beta_{pm}x_p)}
\]  
(2)
By doing a logit transformation at $\pi(x)$, the equation is obtained:

$$P_1(x) = \ln \left( \frac{P(Y = 1|x)}{P(Y = 0|x)} \right) = \beta_{10} + \beta_{11}x_1 + \beta_{12}x_2 + \ldots + \beta_{1b}x_b = x'\beta_1$$  \hspace{1cm} (3)

$$P_2(x) = \ln \left( \frac{P(Y = 1|x)}{P(Y = 0|x)} \right) = \beta_{20} + \beta_{21}x_1 + \beta_{22}x_2 + \ldots + \beta_{2b}x_b = x'\beta_2$$  \hspace{1cm} (4)

then the following equation is used:

$$\pi_0 = \frac{1}{1 + \exp P_1(x) + \exp P_2(x)}$$  \hspace{1cm} (5)

$$\pi_1 = \frac{\exp P_1(x)}{1 + \exp P_1(x) + \exp P_2(x)}$$  \hspace{1cm} (6)

$$\pi_2 = \frac{\exp P_2(x)}{1 + \exp P_1(x) + \exp P_2(x)}$$  \hspace{1cm} (7)

3.3. Parameter Estimation

Parameter estimation is needed in logistic regression because as the name implies this model uses logit transformation on the dependent variable. The procedure to be used in estimating parameters in logistic regression is the Maximum likelihood procedure [13]. The equation is:

$$L = \sum_{k=1}^{K} \sum_{y_i=k} \log \pi_{k(i)}$$  \hspace{1cm} (8)

3.4. Testing the Significance of Parameters

In logistic regression, testing the significance of the parameters used Wald test. This test gives the statistical significance of the results so that the hypothesis is the same as the hypothesis in multiple linear regression. With the statistical significance of logistic parameters, it can be assessed the effect of these variables on the opportunities generated [13]. Simultaneous testing is performed to test the $\beta$ coefficient simultaneously on the dependent variable. The equation used is as follows:

$$G = -2\ln \frac{L_1}{L_0}$$  \hspace{1cm} (9)

Where: $L_1 = $ Likelihood without independent variables, $L_0 = $ Likelihood with independent variables. In this test the hypotheses used are: $H_0 = \beta_1 = \beta_2 = \ldots = \beta_b = 0$, $H_1 = $ There is at least one $\beta_j \neq 0, j = 1,2,\ldots,b$, Reject $H_0$ accept $H_1$ if the value of $G > X^2_{b,v}$. Partial tests are tests conducted in part to check the coefficient $\beta$. This test uses the Wald test, with the test equation as follows:

$$W^2 = \frac{\hat{\beta}^2_j}{SE \left( \hat{\beta}^2_j \right)}$$  \hspace{1cm} (10)

Where: $SE \left( \hat{\beta}^2_j \right) = $ Standard error coefficient $\hat{\beta}_j = $ the estimated coefficient value of the independent variable. In this test the hypotheses used are: $H_0 = \beta_j = 0$ $H_1 = \beta_j \neq 0, j = 1,2,\ldots,b$ Reject $H_0$ accept $H_1$ if the value of $W^2 > X^2_{b,v}$.  

5
3.5. Model Suitability Test
The model’s suitability test uses the Pearson and deviance statistics goodness-of-fit, which is used generally in multiple regression. The equation is as follows:

\[ X^2 = \sum_{i=1}^{n} \sum_{k=1}^{K} \frac{(y_{ik} - n_i \hat{\pi}_{ik})^2}{n_i \hat{\pi}_{ik}} \]  

(11)

The hypothesis used is: \( H_0 = \) Model is appropriate, \( H_1 = \) Model does not match. Reject \( H_0 \) accept \( H_1 \) if value \( X^2 > X^2_{\alpha,v} \). While the deviations are as follows:

\[ G^2 = 2 \sum_{i=1}^{n} \sum_{k=1}^{K} y_{ik} \log \left( \frac{y_{ik}}{n_i \hat{\pi}_{ik}} \right) \]  

(12)

When there is only one replication, it can be noted that observations have a low estimate probability for that category, but for nominal data there is no idea that explains how far the actual category is from the predicted [12].

3.6. Model Interpretation
Model interpretation is done using odds ratio values compared to the dependent variable as a baseline. The formula used is as follows:

\[ OR_j(ab) = \frac{P(Y=j|X=a)}{P(Y=0|X=a)} / \frac{P(Y=j|X=b)}{P(Y=0|X=b)} \]  

(13)

The odds ratio value will show the relationship of an independent variable to the dependent variable, where the dependent variable will be based on the baseline or the reference set at the beginning of the study.

4. Research Result
4.1. Independence Test
Before doing modeling using the Multinomial Logistic Regression method, then the independence test on each independent variable is performed on the dependent variable. This test aims to see whether there is a relationship between the independent variables with the dependent variable before being included in the modeling. The results of the independence test can be seen in the Table 3 with notation \( C_S \): Value Chi Square Test, \( C_A \): Asymptotic Significance (2-sided).

The results of this test analysis are illustrated in a hypothesis: \( H_0 = \) There is no relationship between variables, \( H_1 = \) There is a relationship between variables.

If the Asymptotic Significance (2-sided) value is less than alpha 5% (0.05) then the decision rejects \( H_0 \) means that there is a relationship between the independent variable and the dependent variable. The table shows that only factor X7 (Asymptotic Significance = 0.013 < 0.05), which is the age of pedestrians, influences the severity of traffic accidents. However, if the Asymptotic Significance (2-sided) value is less than alpha 10% (0.10), then 2 factors will be significantly affected, namely the type of vehicle (X4) and the age of the victim (X7). Therefore, in the next step, only variables X4 and X7 will be included in the modeling.

4.2. Multinomial Logistic Regression Modelling
In Table 4, suitability test of this model, the hypothesis Reject H0 accept H1 is used if value of \( X^2 > X^2_{\alpha,v} \). In the results of the above table, a significance value of 0.204 is identified, with the following hypotheses: \( H_0 = \) Model is appropriate, \( H_1 = \) Model does not match. The conclusion drawn is reject H0 if the significance value < alpha 5% (0.05). Seen in the feasibility test of the
### Table 3: Chi Square test Variabel

| Variable            | \( C_S \) | df | \( C_A \) |
|---------------------|-----------|----|-----------|
| X1 Time             | 2,569     | 6  | 0,861     |
| X2 Lighting Conditions | 1,602   | 2  | 0,449     |
| X3 Weather Conditions | 0,791   | 2  | 0,673     |
| X4 Vehicle type     | 9,127     | 4  | 0,058     |
| X5 SIM ownership    | 0,302     | 2  | 0,86      |
| X6 Pedestrian Gender | 0,434  | 2  | 0,805     |
| X7 Pedestrian Age   | 12,591    | 4  | 0,013     |
| X8 Road Type        | 3,146     | 2  | 0,207     |
| X9 Road Function    | 2,949     | 4  | 0,566     |

### Table 4: Model Suitability Test

|            | Chi-Square | df | Sig. |
|------------|------------|----|------|
| Pearson    | 10,959     | 8  | 0,204|
| Deviance   | 12,157     | 8  | 0,144|

### Table 5: Pseudo R-Square Model

| Pseudo R-Square   |
|-------------------|
| Cox and Snell     | 0,157   |
| Nagelkerke        | 0,182   |
| McFadden           | 0,085   |

Pearson method of significance value of 0.204 so accept the hypothesis H0. This means that the model is appropriate or the model can explain the data.

The suitability test of the model this time uses the Pseudo R-Square value in Table 5. R-Square pseudo value in logistic functions has the same function as R-Square value in linear regression. Its function is to see the magnitude of the influence of independent variables on the dependent variable. Seen in the largest Pseudo R-Square value table is 0.182 = 18.2%. This value illustrates that the influence of pedestrian age on severity is only 81.8%, the rest is influenced by other factors not included in the model.

4.3. Testing the Significance of Parameters
In this test carried out to check the coefficient \( \beta \) simultaneously, the results can be seen in the Table 6.

The analysis results are obtained based on the hypothesis: \( H_0 = \beta_1 = \beta_2 = \ldots = \beta_b = 0 \), \( H_1 = \) There is at least one \( \beta_j \neq 0, j = 1, 2, \ldots, b \). In the model it can be seen that the value of Chi Square calculation is 27.405 while the value of Chi Square table with an alpha value of 10% and df 8 of 13.382. Then 27.405\_\_\_13.382 so it was concluded rejecting the hypothesis H0 which means that there is at least one variable that statistically significantly influences the dependent variable. This test is carried out to see the coefficient \( \beta \) individually, the results can be seen in the Table 7. The results of the analysis are based on hypotheses: \( H_0 = \beta_j = 0 \),
Table 6: Simultaneous Test Model

| Model                | Model Fitting Criteria | Likelihood Ratio Tests |
|----------------------|------------------------|------------------------|
|                       | -2 Log Likelihood     | Chi-Square | df | Sig. |
| Intercept Only        | 72,807                 |            |    |      |
| Final                | 45,401                 | 27,405      | 8  | 0.001|

Table 7: Model Partial Test

| Effect                | Model Fitting Criteria | Likelihood Ratio Tests |
|-----------------------|------------------------|------------------------|
|                       | -2 Log Likelihood of Reduced Model | Chi-Square | df | Sig. |
| Intercept             | 45,401a                | 0.000                  | 0  |      |
| Vehicle type          | 58,800                 | 13,399                 | 4  | 0.009|
| Pedestrian Age        | 63,916                 | 18,514                 | 4  | 0.001|

\( H_1 = \beta_j \neq 0, j = 1, 2, \ldots, b \). Conclusion reject \( H_0 \) if Significance > 10% (0.1). Both the type of vehicle and the age of the victim have a conclusion rejecting \( H_0 \), namely the two variables in this partial test can be seen that the variable is statistically significant influence the dependent variable.

4.4. Interpretation of Multinomial Logistics Regression Analysis

The parameters that will become the model are obtained from the beta value, while the odds ratio can be seen in the value of exp beta. The following beta and exp beta values generated from this model presented in Table 8.

Table 8: Parameter Estimation and Model Ratio Odds

| Severity | Heavy Injury | Death |
|----------|--------------|-------|
| Intercept | 1,451        | 2,538 |
| [Vehicle type = 1.00] Motorcycle | 0,800 | -1,076 |
| [Vehicle type = 2.00] Small car | 0,054 | 0,396 |
| [Vehicle Type = 3.00] Big car | 0 | 0 |
| [Pedestrian_Age = 1.00] <17 years | -1,162 | -3,292 |
| [Pedestrian_Age = 2.00] 17 - 60 years | -1,660 | -2,027 |
| [Pedestrian_Age = 3.00] >60 years | 0 | 0 |

| Intercept | Exp B |
|----------|-------|
| [Vehicle type = 1.00] Motorcycle | 2,226 | 0,341 |
| [Vehicle type = 2.00] Small car | 1,056 | 1,485 |
| [Vehicle Type = 3.00] Big car | 0,313 | 0,037 |
| [Pedestrian_Age = 1.00] <17 years | 0,190 | 0,132 |
| [Pedestrian_Age = 2.00] 17 - 60 years | 0,190 | 0,132 |
| [Pedestrian_Age = 3.00] >60 years | 0,190 | 0,132 |
So the logit transformation equation model is:

\[ P_1(x) = \ln \left( \frac{P(Y = 1|x)}{P(Y = 0|x)} \right) = 1.451 + (0.800)x_{4.1} + (0.054)x_{4.2} + (-1.162)x_{7.1} + (-1.660)x_{7.2} \]  

\[ P_2(x) = \ln \left( \frac{P(Y = 1|x)}{P(Y = 0|x)} \right) = 2.538 + (-1.076)x_{4.1} + (0.396)x_{4.2} + (-3.292)x_{7.1} + (-2.027)x_{7.2} \]  

Next, the logistic equation model is obtained:

\[ \pi_0 = \frac{1}{1 + \exp P_1(x) + \exp P_2(x)} \]
\[ \pi_1 = \frac{\exp P_1(x)}{1 + \exp P_1(x) + \exp P_2(x)} \]
\[ \pi_2 = \frac{\exp P_2(x)}{1 + \exp P_1(x) + \exp P_2(x)} \]  

The beta value in the equation model above illustrates the effect of each independent variable in each category. A positive beta value means that the independent variable strengthens the chance of the observed dependent variable. While a negative beta value means that the independent variable weakens the chance of the observed dependent variable.

4.5. Accuracy of Classification

In Table 9 classification model it can be seen that the number of victims observed suffered minor injuries as many as 33 + 3 = 36 people, heavy injured 81 + 6 = 87 people, and died as many as 28 + 9 = 37 people. So that the accuracy of the model is obtained at 56.3%. Then this model has a classification error of 43.7%.

| Observed | Predicted | Minor Injury | Heavy Injury | Death | Percent Correct |
|----------|-----------|--------------|--------------|-------|----------------|
| Minor Injury | 0 | 33 | 3 | 0,0% |
| Heavy Injury | 0 | 81 | 6 | 93,1% |
| Death | 0 | 28 | 9 | 24,3% |
| Overall Percentage | 0,0% | 88,8% | 11,3% | 56,3% |

5. Discussion

Exp beta value illustrates the odds ratio value which shows the tendency of that category to the control category. In the table it can be seen that the types of motorbike vehicles have a tendency to risk serious injuries (rather than minor injuries) 2.226 greater than those on large car vehicles. Small car vehicles have a tendency to risk more serious injuries (than minor injuries) 1.056 greater than large car vehicles. For the risk of death, large vehicle types have a risk of dying (rather than minor injuries) \( \frac{1}{0.341} = 2.933 \) greater than motorcycle vehicles. However, small car vehicles have a tendency to risk dying (from minor injuries) 1.485 greater than large car vehicles.

The risk of serious injury to pedestrian accidents based on the type of vehicle is more influenced by the type of motor vehicle. Other studies have shown that motor vehicles and heavy trucks also affect the severity of death and serious injuries [14]. It appears that the small
car vehicle has the greatest possible risk effect on the severity of death. This is similar to research conducted in 2010, in which stated that driving an SUV (Small Car) is one of the factors that increases the mortality rate in pedestrians [15]. However, it is different from other studies which show that the severity of death is due to large vehicles such as trucks and buses [17].

In the age factor of pedestrians, pedestrians aged > 60 years have a risk tendency to suffer serious injuries (rather than minor injuries) \( 1 / 0.313 = 3.195 \) greater than pedestrians under the age of 17 years, and \( 1 / 0.190 = 5.263 \) more big compared to pedestrians aged 17-60 years. For the risk of death, pedestrians aged > 60 years will have a risk of death (rather than minor injuries) of \( 1 / 0.037 = 27.027 \) greater than pedestrians aged <17 years and \( 1 / 0.132 = 7.576 \) greater than pedestrians aged between 17-60 years.

Seen that the age of pedestrians over 60 years will increase the risk of serious injury and death. Almost all research also shows the same thing. The size in other studies is more varied, > 65 years, > 85 years, there are also states that are not as specific as older age. But all the results show that aging will increase the risk of a higher severity [14–20].

Older pedestrians, when an accident increases the risk of higher severity. In addition to a body that is no longer healthy, congenital diseases can also increase the risk of death. In this study, the factors that significantly influence the severity of pedestrian victims were obtained only by vehicle type and pedestrian age. With the accuracy of the classification of the research model by 56.3%. For this reason, it is recommended that further research be carried out to obtain data that is more relevant to its original state. Further research can be done by adding the time vulnerable observed. In addition, the addition of free variables can be done so that more factors can better describe the model.

6. Conclusion

Based on the analysis that has been done, the following conclusions are obtained: Significant factors affecting the severity of pedestrians in traffic accidents in this study with a significance level of 10% are the age of pedestrians and the type of vehicle. Multinomial Logistic Regression Model is formed for this equation The severity of pedestrians in traffic accident victims can be seen in the nomenclature section.

Acknowledgments

The present study was funded by Universitas Indonesia PITTA B Grant 2019, contract number: NKB-0751/UN2.R3.1/HKP.05.00/2019.

Nomenclature

Logit function for heavy injury:

\[
P_1(x) = \ln \left( \frac{P}{P_0} \right|_x) = 1,451+(0,800)x_{4.1}+(0,054)x_{4.2}+(-1,162)x_{7.1}+(-1,660)x_{7.2}
\]

Logit function for Death:

\[
P_2(x) = \ln \left( \frac{P}{P_0} \right|_x) = 2,538+(-1,076)x_{4.1}+(0,396)x_{4.2}+(-3,292)x_{7.1}+(-2,027)x_{7.2}
\]

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