Modelling of severity level causes factors in the traffic accident victims in the province of West Nusa Tenggara

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Abstract. Traffic accidents have always been one of the common causes of injuries or even deaths in the world. Traffic accidents do not always occur only because of human error, but sometimes the state of nature or poor infrastructure are often the cause of accidents. NTB Province itself is a province that has just been audited after major road construction was carried out. So in this study the causes of the accident will be used as a part of the factors in determining the severity of victims in traffic accidents. With three severity levels, namely minor injuries, severe injuries, and death, the variables will be analyzed statistically.

1. Introduction
Accidents are a problem that happens every time and every time, especially traffic accidents. Traffic accidents are one of the biggest killer factors in Indonesia and in the world. This requires a treatment so that victims of accidents do not peak [5]. Based on the National Police Correspondent report in 2017 alone there were 98,414 accidents and in 2016 there were 105,374 which decreased by 7%. Road accidents often cause casualties, whether minor, severe, or even fatal. According to the Indonesian Republic Police Traffic Corps data each year there are approximately 18,000 to 38,000 deaths due to traffic accidents in Indonesia, in 2017 alone there were 24,213 fatalities caused by traffic accidents which tend to decrease by around 6% from 2016 which is a figure his death reached 25,859. The number of wounded victims of self-injury in 2017 reached 16,410 people, down from the previous year which amounted to 22,939. The proportion of disability and case fatality rate due to traffic accidents is still high (25%). Injury due to traffic accidents is a major cause of disability and mortality in developing countries [10]. Based on the WHO report in terms of the number of Indonesia ranked fourth in the world in terms of deaths due to accidents traffic [8]. Many things cause the severity of the people involved in an accident, such as personal problems, vehicle problems, road problems, problem conditions, and much more. Therefore there needs to be a way to estimate the severity of the consequences of the accident.

West Nusa Tenggara or hereinafter referred to as NTB is a province in Indonesia which is in the western part of the Nusa Tenggara Islands. NTB is a province whose capital city is Mataram, NTB houses ten cities or districts including Lombok and Sumbawa regencies. Based on data from Korlantas in 2013, NTB was ranked 18th in the number of accidents, quite low but high enough if compared to the total population, not much different if compared to East Java as the province with the highest number of accidents in Indonesia. In addition, in 2013 alone there was a lot of rejuvenation and
construction of roads in NTB that were audited and had quality which is a PRIM project, as known as Provincial Road Improvement and Maintenance which focused on the quality of maintenance work, better management and governance for regional roads

2. Methodology

With an output target in the form of an accident rate decision in the form of minor injuries, serious injuries, and death, it is necessary to do a regression with variables, then the best methodology is the logit regression methodology or logistic regression. Where logit regression is also divided into sequential binary logit models (binomial), sequential logit models, and multinomial logit models. Of the three logit regression forms that are most suitable to use is a multinomial logit model because of the wide distribution of data and requires many value options for each variable, also because the Severity form sought has more than two options. Forms of use other than logit do exist but little is known about the relative benefits of these alternative models. This regression is carried out on factors that are considered to influence the severity that occurs in an accident in the form of statistical data.

Before processing logistical multinomial, several tests such as multicollinearity and correlation tests need to be carried out. The multicollinearity test is part of the classic assumption test.

Multicollinearity test in a study aims to test the correlation between independent or independent variables. A good regression model should not occur multicollinearity on the variable. The basis for decision making in this test is the value of VIF and tolerance where when the tolerance value has a value below 0.1 then multicollinearity occurs but when the VIF value is above 10 a meal occurs multicollinearity. The value of both will definitely produce the same result and no opposite result will occur.

The bivariate correlation test does not take into account the independent and dependent variables, because in fact the correlation test looks at the correlation between the two variables. The strength of a linear correlation can be described as follows:

\[
 r_{xy} = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{N\Sigma X^2 - (\Sigma X)^2} \sqrt{N\Sigma Y^2 - (\Sigma Y)^2}} \ldots \ldots (1)
\]

Decision making in this test is based on the significance value of the crossing of two variables, where when there is a significance value below 0.05, the two variables are considered correlated.

Multinomial logistic regression or also called polytomous logit model is a regression model used to resolve regression cases with the dependent variable in the form of qualitative data in the form of multinomial (more than two categories) with one or more independent variables.

The general equation for multinomial logistic regression is as follows:

\[
g_j(x) = \beta_{j0} + \beta_{j1}x_1 + \beta_{j2}x_2 + \ldots + \beta_{jp}x_p \ldots \ldots (2)
\]

\( g \) = Dependent variable
\( x \) = Independent variable
\( \beta \) = Parameter

The dependent variable in this study covers the severity which is categorized in three categories: death, serious injuries, and minor injuries. The independent variables in this study include gender, light, age, weather, usage, class, lane, geometry, road condition, vehicle type, accident type, damaged part, driving license, safety equipment, alcohol, distraction, and location
3. Collinearity test

Collinearity test is a test conducted to ascertain whether in a regression model there are intercorrelations or colinearities between independent variables.

Table 1. Collinearity test

| Coefficients | Model | Unstandardized Coefficients | Standardized Coefficients | t | Sig. | Collinearity Statistics |
|---------------|-------|-----------------------------|---------------------------|---|-----|-------------------------|
| B | Std. Error | Beta | Tolerance | VIF |
| 1 (Constant) | 3.769 | 0.905 | 4.164 | 0.000 | |
| Gender | 0.007 | 0.140 | 0.003 | 0.048 | 0.962 | 0.835 | 1.198 |
| Light | -0.223 | 0.096 | -0.132 | -2.328 | 0.021 | 0.851 | 1.176 |
| Age | -0.143 | 0.112 | -0.070 | -1.273 | 0.204 | 0.904 | 1.106 |
| Weather | 0.109 | 0.144 | 0.043 | 0.757 | 0.450 | 0.865 | 1.156 |
| Usage | -0.050 | 0.077 | -0.039 | -0.645 | 0.519 | 0.750 | 1.333 |
| Class | 0.027 | 0.076 | 0.022 | 0.355 | 0.723 | 0.713 | 1.402 |
| Lane | 0.145 | 0.118 | 0.066 | 1.226 | 0.221 | 0.945 | 1.058 |
| Geometry | -0.035 | 0.067 | -0.030 | -0.519 | 0.604 | 0.837 | 1.195 |
| Condition | -0.673 | 0.514 | -0.070 | -1.308 | 0.192 | 0.948 | 1.055 |
| Vehicle type | 0.268 | 0.085 | 0.186 | 3.160 | 0.002 | 0.794 | 1.259 |
| Accident type | 0.057 | 0.042 | 0.080 | 1.342 | 0.181 | 0.767 | 1.304 |
| Damaged part | -0.126 | 0.054 | -0.146 | -2.333 | 0.020 | 0.703 | 1.422 |
| Driving license | -0.213 | 0.082 | -0.156 | -2.601 | 0.010 | 0.765 | 1.307 |
| Safety equipment | -0.217 | 0.131 | -0.107 | -1.662 | 0.098 | 0.667 | 1.500 |
| Alcohol | 0.085 | 0.271 | 0.017 | 0.313 | 0.754 | 0.881 | 1.135 |
| Distraction | 0.027 | 0.027 | 0.055 | 1.013 | 0.312 | 0.915 | 1.093 |
| Location | 0.042 | 0.021 | 0.122 | 2.013 | 0.045 | 0.748 | 1.337 |

a. Dependent Variable: Severity

Collinearity test aims to see whether the variables studied have indications of multicollinearity or not. Multicollinearity itself occurs when there are variables that tend to be equally distributed. Example: Age in years, Age in months; both have a tendency to have the same distribution and do not need to include both because they will not form a targeted model. When the data has a VIF value of more than 10 then collinearity occurs in the related variable, when the data has a VIF value of less than 1 then the data is declared to be scattered too randomly to be calculated in the model.

4. Correlation test

Correlation is a statistical technique used to test the presence / absence of a relationship and the direction of the relationship of two or more variables.
Table 2. Correlation test

| Variables | Severity | Correlation Coefficient | Y | Gender  | Light | Age | Weather | Usage |
|-----------|----------|--------------------------|---|---------|-------|-----|---------|-------|
|           |                      | 1.000                     | -0.092 | -0.086 | 0.042 | -0.012 | -0.136** |
| Sig. (1-tailed) |        | 0.051                     | 0.062  | 0.229  | 0.416  | 0.007 |
| N         |          | 321                       | 321    | 321    | 321    | 321    |

| Variables | Severity | Correlation Coefficient | Class | Lane | Geometry | Condition | Vehicle type | Accident type |
|-----------|----------|--------------------------|-------|------|----------|------------|--------------|--------------|
|           |                      | -0.077                    | 0.050 | 0.025 | -0.056   | .362**     | .096*        |
| Sig. (1-tailed) |        | 0.083                     | 0.186 | 0.329 | 0.158    | 0.000      | 0.044       |
| N         |          | 321                       | 321    | 321    | 321    | 321    |

| Variables | Severity | Correlation Coefficient | Damaged part | Driving license | Safety equipment | Alcohol | Distraction | Location |
|-----------|----------|--------------------------|--------------|-----------------|------------------|---------|-------------|----------|
|           |                      | -0.082                    | -.253**      | -.238**         | 0.021            | .143**  | .209**      |
| Sig. (1-tailed) |        | 0.071                     | 0.000        | 0.000           | 0.353            | 0.005   | 0.000       |
| N         |          | 321                       | 321          | 321             | 321              | 321     |

Correlation testing is used in a bivariate way to see the relationship between two variables, namely severity and factors. In this test significance values of 0.05 (5%) and 0.01 (1%) were taken to determine the level of correlation calculated high. Calculations use a calculation system for 1-tailed data to adjust the shape of the data. From the above table it can be concluded that the data are (Road Function (F)), (Vehicle type (J)), (Accident type (K)), (Ownership of Driving License (S)), (Use of safety equipment drive (A)), (Distraction of the driver (D)), and (Location of the accident (L)) have a correlation with the variable (Severity of the victim).

5. Parameter estimation

Parameter estimation is estimation of population characteristics (parameters) using sample characteristics (statistics).

Table 3. Parameter estimation for death

| Parameter estimation | Severity | \( \beta \) | df | Exp(\( \beta \)) |
|----------------------|----------|------------|----|----------------|
| Death                | Intercept| 19,786     | 1  |                |
| Road Function        | [F=1.00] | -0.345     | 1  | 0.708          |
|                      | [F=2.00] | -0.912     | 1  | 0.402          |
|                      | [F=3.00] | 0b         | 0  |                |
| Vehicle type         | [J=1.00] | -35.687    | 1  | 3.174E-16      |
|                      | [J=2.00] | -40.931    | 1  | 1.675E-18      |
|                      | [J=3.00] | -39.103    | 1  | 1.042E-17      |
|                      | [J=4.00] | 0b         | 0  |                |
| Accident type       | [K=1.00] | 17.821 | 1     | 54889758.502 |
|--------------------|----------|--------|-------|---------------|
|                    | [K=2.00] | 17.660 | 1     | 46744064.925  |
|                    | [K=3.00] | 17.192 | 1     | 29268321.609  |
|                    | [K=4.00] | 17.426 | 1     | 36970351.183  |
|                    | [K=5.00] | -1.066 | 1     | 0.344          |
|                    | [K=6.00] | 0\textsuperscript{b} | 0     |                |
| Ownership of driving license | [S=1.00] | -2.656 | 1     | 0.070          |
|                    | [S=2.00] | -1.945 | 1     | 0.143          |
|                    | [S=3.00] | 0\textsuperscript{b} | 0     |                |
| Use of safety equipment drive | [A=1.00] | -1.644 | 1     | 0.193          |
|                    | [A=2.00] | 0\textsuperscript{b} | 0     |                |
| Distraction of the driver | [D=1.00] | 1.130  | 1     | 3.097          |
|                    | [D=2.00] | -17.064| 1     | 3.884E-08      |
|                    | [D=3.00] | 16.866 | 1     | 21132473.957  |
|                    | [D=4.00] | 1.981  | 1     | 7.250          |
|                    | [D=5.00] | 0\textsuperscript{b} | 0     |                |
| Location of the accident | [L=1.00] | 2.201  | 1     | 9.030          |
|                    | [L=2.00] | 0.750  | 1     | 2.117          |
|                    | [L=3.00] | -0.536 | 1     | 0.585          |
|                    | [L=4.00] | 0.749  | 1     | 2.115          |
|                    | [L=5.00] | 1.345  | 1     | 3.837          |
|                    | [L=6.00] | -14.011| 1     | 8.221E-07      |
|                    | [L=7.00] | 3.028  | 1     | 20.647         |
|                    | [L=8.00] | 1.771  | 1     | 5.876          |
|                    | [L=9.00] | -0.015 | 1     | 0.986          |
|                    | [L=10.00]| 0\textsuperscript{b} | 0     |                |

Table 4. Parameter estimation for serious injury severity

| Severity                  | Parameter estimation | \(\beta\) | df | \(\text{Exp}(\beta)\) |
|---------------------------|----------------------|-----------|----|-----------------------|
| Serious injury            | Road Function        | Intercept | -1.941 | 1          |
|                           | [F=1.00]             | -1.446    | 1     | 0.236                |
|                           | [F=2.00]             | -0.123    | 1     | 0.884                |
|                           | [F=3.00]             | 0\textsuperscript{b} | 0     |                       |
| Vehicle type              |                      | [J=1.00]  | 0.559  | 1         | 1.750 |
|                           |                      | [J=2.00]  | -20.821| 1         | 9.068E-10 |
|                           |                      | [J=3.00]  | -20.231| 1         | 1.637E-09 |
|                           |                      | [J=4.00]  | 0\textsuperscript{b} | 0     |                       |
| Accident type             |                      | [K=1.00]  | 5.103  | 1         | 164.484 |
|                           |                      | [K=2.00]  | 3.847  | 1         | 46.849  |
|                           |                      | [K=3.00]  | 3.196  | 1         | 24.439  |
|                           |                      | [K=4.00]  | 2.456  | 1         | 11.663  |
|                           |                      | [K=5.00]  | 5.262  | 1         | 192.942 |
Table 5. Parameter estimation for minor injury severity

| Parameter estimation                                      | Severity  | β          | df | Exp(β)    |
|----------------------------------------------------------|-----------|------------|----|-----------|
| Ownership of driving license                              | Minor injury | 0<sup>b</sup> | 0  |           |
|                                                          | [K=6.00]  | 1.0<sup>b</sup> | 3.344 | 1.0535   |
|                                                          | [S=1.00]  | -3.684 | 1  | 0.0025    |
|                                                          | [S=2.00]  | 0<sup>b</sup> | 0  |           |
|                                                          | [S=3.00]  | 0<sup>b</sup> | 0  |           |
| Use of safety equipment drive                             | Minor injury | 0<sup>b</sup> | 0  |           |
|                                                          | [A=1.00]  | -0.417 | 1  | 0.659     |
|                                                          | [A=2.00]  | 0<sup>b</sup> | 0  |           |
| Distraction of the driver                                 | Minor injury | 0<sup>b</sup> | 0  |           |
|                                                          | [D=1.00]  | 0.476 | 1  | 1.609     |
|                                                          | [D=2.00]  | -17.948 | 1  | 1.604E-08 |
|                                                          | [D=3.00]  | 15.500 | 1  | 5389346.791 |
|                                                          | [D=4.00]  | 1.452 | 1  | 1.4274    |
|                                                          | [D=5.00]  | 0<sup>b</sup> | 0  |           |
| Location of the accident                                  | Minor injury | 0<sup>b</sup> | 0  |           |
|                                                          | [L=1.00]  | 5.487 | 1  | 241.534   |
|                                                          | [L=2.00]  | -14.954 | 1  | 3.202E-07 |
|                                                          | [L=3.00]  | 1.566 | 1  | 4.787     |
|                                                          | [L=4.00]  | -1.683 | 1  | 1.86      |
|                                                          | [L=5.00]  | 0.344 | 1  | 1.410     |
|                                                          | [L=6.00]  | -14.524 | 1  | 4.926E-07 |
|                                                          | [L=7.00]  | 3.571 | 1  | 35.544    |
|                                                          | [L=8.00]  | 4.314 | 1  | 74.761    |
|                                                          | [L=9.00]  | -0.437 | 1  | 0.646     |
|                                                          | [L=10.00] | 0<sup>b</sup> | 0  |           |
5.1. Road function ($F$)

At the severity level, arterial roads have a 0.708 times less chance of death than local / environmental roads and collector roads are 0.402 times less than local and environmental roads, so it can be concluded that local / environmental roads are the safest road designs because motorists who pass through local / environmental roads tend not to use safety equipment such as SNI helmets or seat belts so they tend to die.

At the severity of major arterial road injuries is 0.236 times less likely than local / environmental collector roads, 0.884 times less likely to be seriously injured. This indicates that local / environmental roads are the road designs that are most likely to be seriously injured when accidents occur, this is related to the age of drivers who cross local / environmental roads tend to be young and tend to drive at high speeds in contrast to arterial roads whose designs are inadequate for used at high speed due to crowded.

At the severity of minor injuries, arterial roads are 0.486 times less likely than local / environmental and collector roads are 0.45 times less likely than local / environmental. It can be concluded that local roads / environments are the most contributor to minor injuries compared to others because they are inadequate for use at high speeds but are often misused. At the severity level, arterial roads have a 0.708 times less chance of death than local / environmental roads and collector roads are 0.402 times less than local and environmental roads, so it can be concluded that local / environmental roads are the safest road designs because motorists who pass through local / environmental roads tend not to use safety equipment such as SNI helmets or seat belts so they tend to die.

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5.2. **Vehicle type (J)**

At the death far vehicle users have a lower probability of dying than pedestrians. According to research that proves beyond crashing vehicles (especially two-wheeled vehicles), pedestrians are far more likely to die than the driver of the vehicle [11].

At the severity of severe injuries motor vehicle users have a 1.750 greater possibility than pedestrians, when on the other hand the type of vehicle has a much smaller possibility, this is due to the large percentage of motorists who do not wear helmets when driving (71.3%).

At the severity of minor injuries, light vehicles and heavy vehicles have almost the same possibility for minor injuries where two-wheeled and pedestrian vehicles have a greater likelihood of injuries, respectively. light and heavy indicating safe driving with closed vehicles, especially heavy vehicles.

5.3. **Accident type (K)**

At the death, side-side accidents are the least likely to occur where death, in contrast to severe injuries, side-type accidents are most likely to cause serious injuries, but the value of side-side accidents in minor injuries has the smallest possibility of accident the side causes big only in severe injuries because light vehicles do not have a good safety system when dealing with accidents from the side.

In front-of-the-road accidents the largest cause of death, the second largest serious injury, and the largest minor injury as well, indicates almost certainly that in the event of a front-injury accident or even death by overriding other factors.

5.4. **Driving license ownership (S)**

Based on the regression model that has been formed people who drive without a driver's license have the possibility of dying approximately two times greater than people who have a driver's license, this is related to the ability of drivers in driving that have been tested when having a driver's license. However motorists who have a driver's license are more likely to suffer serious injuries than motorists who do not have a driver's license.

At the severity of minor injuries the possession of a driver's license is not too different for the driver, but at all levels of severity the passenger / pedestrian has a much greater possibility than the driver.

5.5. **Safety equipment (A)**

The results of multinomial logistic regression showed that people who used driving safety equipment in a row at the death, serious injuries, and minor injuries amounted to 0.193; 0.659; and 0.47 smaller than people who do not use any driving safety equipment. People who don't use driving equipment are more than five times more likely to die than people who use driving equipment.

5.6. **Distraction (D)**

At all levels the severity of the driver's distraction which causes the most injury or death is a driving skill that tends to be reckless however, what is quite surprising is that fatigue causes injuries and dies the least compared to other distractions even when the driver has no distraction. Because fatigue causes people to have reflexes or vehicle movements that are late and are commonly experienced by light and heavy class motorists whose vehicles have a high level of security. But unskilled happens a lot in two-wheeled vehicles where many underage drivers force to drive.

Disordered motorists also have a high likelihood of injury and death which proves that traffic policies clearly exist to create driving safety.
5.7. Location (L)
In Bima District, the severity with the greatest probability was serious injuries and was quite significant at 95%. In contrast to Dompu Regency the probability of serious injury is almost 0% followed by the probability of death 45% as the highest probability in Dompu Regency. Whereas in West Lombok Regency the severity with the highest probability was severe injury (73%) and Central Lombok District had the highest probability at the death with 57%. Whereas in East Lombok Regency there was no lame percentage although it was dominated by the death (44%). In the area of North Lombok Regency there is a very large imbalance which is dominated by the severity of minor injuries (91%) and severe injuries with death approaching 0%. Sumbawa Regency has the highest probability in serious injuries although it is not too dominant (48%). West Sumbawa Regency is dominated by serious injuries at 78%. Kota Bima has a different pattern because it has the highest probability in the severity of no injuries (35%) which is slightly different from death (34%).

6. Conclusion
Based on research that has been carried out using multinomial logistic regression it can be concluded that after conducting the correlation test to reduce variables as needed and based on the distribution of data, seven variables were drawn that had a p-value of less than 0.05 (5%). Variables that have a p-value correlation below 0.05 are (Road Function (F)), (Vehicle type (J)), (Accident type (K)), (Ownership of Driving License (S)), (Use of safety equipment drive (A)), (Distraction of the driver (D)), and (Location of the accident (L)) have a correlation with the variable (Severity of the victim).

The equations resulting from multinomial logistic regression are:
For death severity:
\[ y1(x) = 19.786 - 0.345F_1 - 0.912F_2 - 35.687J_1 - 40.931J_2 - 39.103J_3 + 17.821K_1 \\
+ 17.660K_2 + 17.192K_3 + 17.426K_4 - 1.066K_5 - 2.656S_1 - 1.945S_2 \\
- 1.644A_1 + 1.130D_1 - 17.064D_2 + 16.866D_3 + 1.981D_4 + 2.201L_1 \\
+ 0.750L_2 - 0.536L_3 + 0.749L_4 + 1.345L_5 - 14.011L_6 + 3.028L_7 \\
+ 1.771L_8 - 0.015L_9 \]

For serious injury severity:
\[ y2(x) = -1.941 - 1.446F_1 - 0.123F_2 + 0.559J_1 - 20.821J_2 - 20.231J_3 + 5.103K_1 \\
+ 3.847K_2 + 3.196K_3 + 2.456K_4 + 5.262K_5 - 3.344S_1 - 3.684S_2 \\
- 0.417A_1 + 0.476D_1 - 17.948D_2 + 15.500D_3 + 1.452D_4 + 5.487L_1 \\
- 14.954L_2 + 1.566L_3 - 1.683L_4 + 0.344L_5 - 14.524L_6 + 3.571L_7 \\
+ 4.314L_8 - 0.437L_9 \]

For minor injury severity:
\[ y3(x) = 19.570 - 0.721F_1 - 0.799F_2 - 15.914J_1 - 21.496J_2 - 21.505J_3 + 2.028K_1 \\
+ 1.005K_2 + 0.963K_3 + 0.548K_4 - 0.286K_5 - 2.892S_1 - 2.802S_2 \\
- 0.756A_1 + 0.435D_1 - 1.192D_2 + 15.776D_3 + 1.424D_4 + 0.430L_1 \\
- 0.445L_2 - 1.670L_3 - 0.915L_4 + 0.905L_5 + 2.301L_6 + 2.844L_7 + 2.6228 \\
- 1.448L_9 \]

The value for the condition of the severity of no injuries is 1 as a permanent comparison. Misclassification resulting from multinomial logistic regression modelling is 26.8%.

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