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Mathematical Model to Assess Motorcycle Accidents in Tanzania

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Abstract: Motorcycle accident has been one of the paramount road cases in Tanzania. However, when ensuring road safety rules in Tanzania it is important to assess the nature and causes of road accidents in the country. It is also necessary to find out the factors which lead to an obstacle of achieving road safety and regulations. This paper focuses on the assessment of motorcycle accidents in Tanzania and the associated factors such as driving experience, personal status like alcoholic, carelessness, wrong overtaking, speed, mechanical defect and road conditions. The models were formulated by using SPSS software program from the data collected from Kilimanjaro and Arusha regions. By applying multi-linear regression methods, the formulated model solutions were used to analyze the relationship between motorcycle accidents as the dependent variable and other factors such as driving experiences, speed, legal status, personal status, mechanical defects, wrong overtake and rough road, tarmac road as independent variables.

Keywords: Multi Linear regression method, Motorcycle accidents, Personal status and Road condition.

1. Introduction

Road traffic accidents are the most frequent causes of injury-related deaths worldwide (Astrom et al., 2006). According to the World Report on Road Traffic Injury Prevention (2004), traffic accidents account for about 3000 daily fatalities worldwide. Pierce and Maunder (1998), under the auspices of Road Research Laboratory in UK, found out that road accidents worldwide are estimated to a total of 20,000,000 victims for a time period, of which 70% occurred in developing countries due to the low income allocated to the implementation of road safety measures.

Akinlade (2000), while looking at the same subject matter from the public health point of view, noted that road traffic accidents have been recognized as a serious health problem in both developed and developing countries. He observed that road traffic accidents have been increasing in developing countries like Nigeria and Tanzania while there is a noted decrease of road accidents in developed countries like Australia.

Several studies have been done on motorcycle injury protection (Chang and Yeh, 2006; Hung, Stevenson and Ivers, 2008; Brown et al., 2009). This is due to the reason that motorcyclists are more at risk of sustaining injury than motor vehicle drivers. According to the USA National Highway Traffic Safety Administration (2007), motorcycle riders have 34 times risk of death and are 8 times more likely to be injured than the drivers of other types of vehicles per mile travelled. A 2009 study from Nigeria found that Road Traffic Incidence (RTI) rated to be 41.2 per 1000 persons a year, considerably higher, and this was comparable to Srilankan and Uganda population based study, which found an incidence of 49 and 38.9 per 1000 persons a year respectively (Moshiro et al., 2005; Labingo et al., 2009). Using exactly the same methodology, and focusing exclusively on the testimonials "worst" area of Accra, a 2009 study by Guerrero et al. (2009) found a similar rate of 33.0 per 1000 persons a year. However, when these statistics were compared to country wide estimates from developed countries such as the United Kingdom (UK) it was found that the rates were 4.3 per 1000 persons a year. From these views it is clear that road traffic injury in developing countries pose a major public health risk.

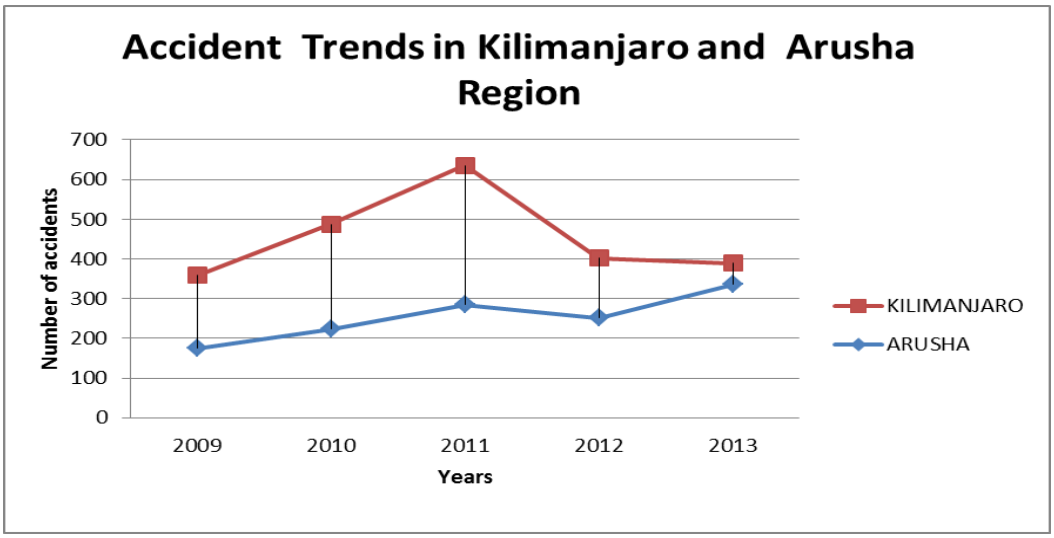
In middle and low-income countries especially in Africa, motorcycle is a common means of transport (WHO, 2006). Motorcyclists form a significant proportion of people who are affected by road traffic accidents; for example, 181 lives were claimed in Tanzania due to motorcycle accidents during the first quarter of 2010 (Nkwame, 2010). Furthermore, according to Tanzania Traffic police at least 3,642 people were killed and another 18,813 were injured between June and November 2013 following 21,691 accidents in Tanzania blamed on massive increase of vehicle traffic in recent years. According to Mohammed Mpinga, the Commands Officer Traffic Police (DCP) of Tanzania said that from January to June 2012 Tanzania mainland recorded 11,163 road accidents that killed 1,808 people and left 9,155 others injured (Mpinga, 2012). According to the DCP, it is estimated that the total number of road casualties on Tanzania roads is about 20,000 to 25,000 accidents per year.

Mpinga also said that a big increase of motorcycle taxis (bodaboda) has largely been attributed to the increase of death. The traffic reports show that motorcycle accidents were the leading cause of death since motorcyclists were allowed to operate commercially in the country from 2009. In 2011 there were 5384 motorcycle accidents compared to the figure 4,363 that occurred in 2010, which is an increase of about 20 percent. However, these figures show that motorcyclists are more vulnerable to road accidents than drivers of other means of transport.

Motorcycle accidents affect the quality of life and have major social and economic consequences. However, one hospital based study done by C. Musem (2002) found that 67.8% of parents believed that accidents were unpreventable often quoting the Swahili saying of "ajali haina kinga" which can make a fate the determining factor for road traffic injuries in Tanzania. Additionally, after realizing motorcycle accidents today as a serious problem in Tanzania, hospitals such as Kilimanjaro Christian Medical Center and Muhimbili referral hospitals as well as other hospitals have introduced special ward(s) for people who are injured in the motorcycle accidents.

As noted from the above observations, motorcycle accidents appear to be a threat to the lives of people in a developing country like Tanzania. Therefore, it is of interest to assess the main causes of motorcycle accidents in Kilimanjaro and Arusha regions of Tanzania. The trend of motorcycle accidents in Kilimanjaro and Arusha regions from 2009 to 2013 is shown in Figure 1.

Figure 1: Accident trends in Kilimanjaro and Arusha regions



Motorcycle taxi operation has brought new form of employment to jobless Tanzanian youth; however drivers of those motorcycles face a very high danger of road traffic accidents. In 2004, the total number of reported motorcycle road accidents was 4,136 while in 2009 it had increased to 16,293 accidents; an increase of about 400%. The National Road Safety Council of Tanzania in 2010 reported that the problem of road traffic accident was on the increase for the last five years. This problem has not only caused loss of peoples' lives, but also leaves behind devastated families, untold misery to the respective families, loss of income to the nation and caused permanent disabilities to accident victims. This paper aims to formulate multiple regression models that will incorporate driving experience and personal status factor (alcohol or drugs intake) in assessing motorcycle accidents in Tanzania.

2. Observation from literatures

Generally, the literature agree that motorcycle accident is a severe problem and in order to solve it one should consider multiple factors that are key causes of the motorcycle accidents for effective establishment of countermeasures to solve the problem. Studies have been developed to assess motorcycle accidents by considering several factors most of them being age, driving behavior and junction type. However, none of these studies had considered mathematically the factor of driving experience and a personal status factor (alcohol or drug intake).

Therefore, this justifies the importance of developing the multiple regression models that assess motorcycle accidents in Tanzania by considering nine factors which are high speed, rough road, tarmac road, wrong overtaking, legal status not own license, legal status own license, mechanical defect, driving experience, and a personal status factor (alcohol or drugs intake), for the aim of coming up with the suggestion that will yield effective solution for the problem.

3. Design and Methods

The research methodology was divided into four stages which included both quantitative and qualitative approaches. The first stage was the feasibility study, where surveying approach with detailed on-site observation was conducted in order to investigate the existing relationship between road accidents caused by alcoholic or drug use behavior and its impact to the society. The second stage was the objective formulation, the third stage dealt with data collection, and the last stage was the validation of the model.

3.1. Model Development

The model was formulated from the data obtained from Kilimanjaro and Arusha regions and analyzed. The kind of data collected includes: wrong overtaking, mechanical defects, speed, experience of drivers, accident time (day or night), roads conditions, and personal factors such as alcoholic behavior or use of drugs. In this paper multiple regression models was used to observe the response of the factors incorporated in the defined equations as reported by Ezequal (2013). The model formulation was done by following the procedure as described by Nancy et al. (2005).

3.2. Model Formulation and Mathematical Analysis

The models were developed using SPSS software program from the data collected in Kilimanjaro and Arusha regions. The used variables in the models with their corresponding descriptions were as in Table 1.

Table 1.Variables and their Description

Variable	Description
X_1	Wrong overtaking
X_2	Legal status not own license
X_3	Rough road
X_4	Legal status own license
X_5	High speed
X_6	Personal status
X_7	Experience of drivers
X_8	Tarmac road
X_9	Mechanical defect

4. Mathematical Analysis

As most of the data in this work were obtained from the real sources such as district traffic police offices and motorcycle drivers we have assumed that some of the motorcycle accidents are not reported. From this assumption, the work with the data used can lack exactness with precision due to the way they are needed to be presented. Therefore, we consider them as approximated data which can give us a full overview of motorcycle accidents in Tanzania. Since the data collected can be analyzed by multiple linear method the SPSS software program was used to formulate the multiple linear equations as described in equations 3 and 4. The multiple linear regression models was used to analyze multivariate data as reported by Fajaruddin et al. (2011) and Ezequal (2013).

4.1. Mathematical Model

The SPSS software program was mainly used to describe the data by formulating the models depending on the type of data entered. With reference to the collected data, two models were presented as in equations 3 and 4 for Kilimajaro and Arusha regions respectively. A similar approach of model formulation has been used in road accidents as reported by Akhigbe (2010).

4.1.1. Analysis of accidents in Kilimajaro region

Table 2: Coefficients for motorcycle accidents and contributing factors in Kilimanjaro region

Coefficients[a] for Kilimanjaro Region						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	181.022	.000		.	.
	Experiencex7	-.213	.000	.106	.	.
	Not_own_licensex2	3.513	.000	.326	.	.
	Rough_roadx3	-3.838	.000	-.735	.	.
	Personal_statusx6	15.098	.000	1.529	.	.
a. Dependent Variable: Number of accident						

From Table 2, the formulated model for Kilimanjaro region was presented as equation **1:**

$$Y_1 = 181.02 + 3.513x_2 - 3.838x_3 + 15.098x_6 - 0.213x_7$$

4.1.1.1. Effect of individual variable in the model

For variable X2 (legal status of not having own license), when we hold fixed the number of drivers who have personal status, rough road condition and experience of a driver; we observe that as the number of drivers who do not own license is increased by one unit, the number of motorcycle accidents will be increased by 3.513 units.

For variable X3 (rough road) holding fixed the number of drivers who have taken in alcohol, legal status of not having own license and experience of a driver, if the number of drivers who are using rough road increased by one unit, the number of motorcycle accidents will be reduced by 3.838 unit.

From the formulated model for the variable X6, (personal status) when we hold fixed the drivers who have legal status of not own licenses, rough road condition and experience of a driver, then as the number of people who are taking drugs and alcohol increased by one unit, the number of motorcycle accidents will be increased by 15.098 units.

For variable X7 (driver with experience), when holding fixed the number of drivers who have personal status, legal status of not having own license and condition of the rough road, if the number of people with experience is increased by one unit, the number of motorcycle accidents will be decrease by 0.213 unit

Figure 2: Accident projection by factors in the model

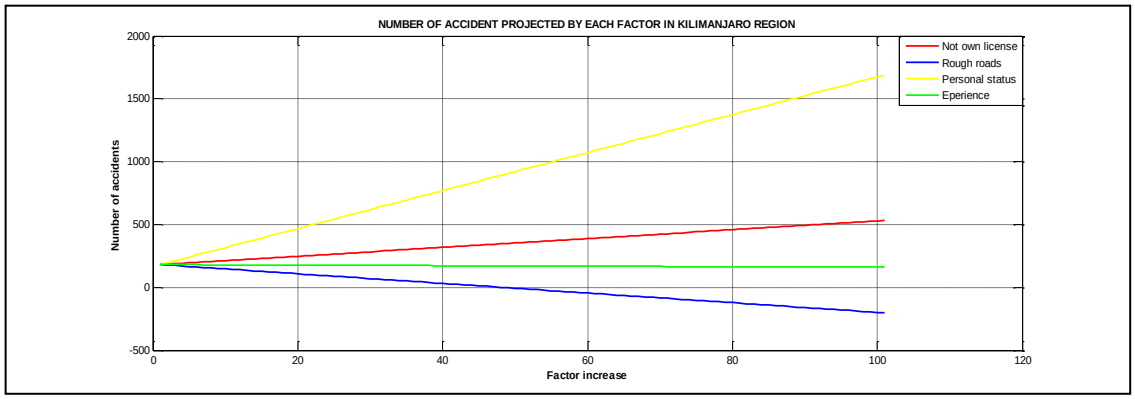
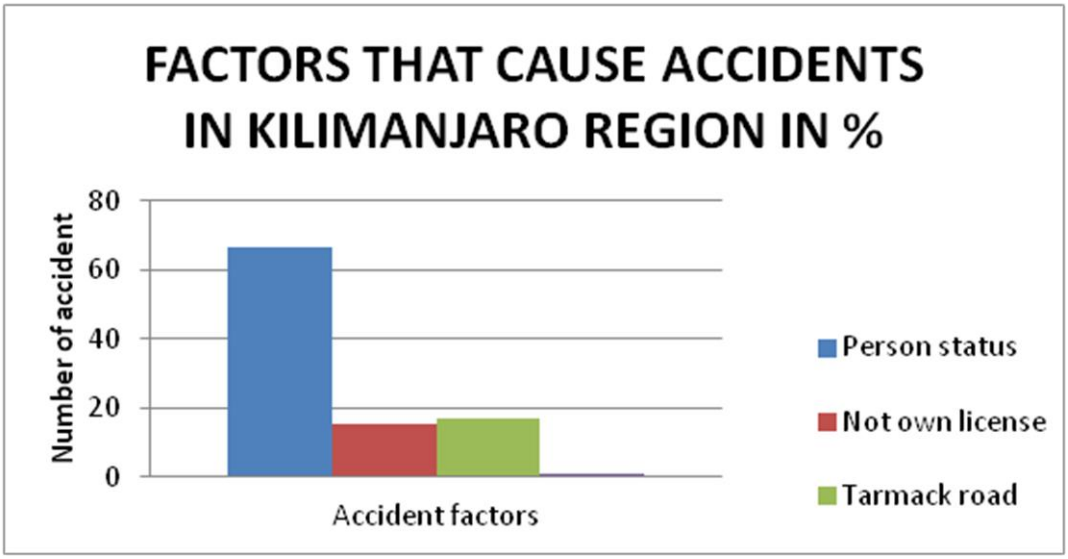


Table 3: Correlation coefficients between variables in Kilimanjaro region

Correlations											
		number of motocycle accidents	experience of drivers in years	wrong overtaking	legal status not own licence	day accident	night accident	high speed	rough road	tarmac road	personal status
Pearson Correlation	Number of motocycle accidents	1	-0.996	0.0167	0.66	-0.04	0.071	0.007	0.527	-0.003	0.899

From Table 3, it can be seen that the numbers of motorcycle accidents have strong relationship with experience of drivers, rough roads, person status and legal status of not owning license in a year with values of 0.996, 0.527, 0.899 and 0.66 respectively. However, the relationship between the number of motorcycle accidents and day and night, high speed, tarmac road, and personal status have shown a small effect with values of -0.04, 0.071, 0.007, -0.003 and 0.0167 respectively

Figure 3. Factors that mostly lead to motorcycle accidents in Kilimanjaro Region



Furthermore, from Table 3 it can be observed that the significant level is at 0.094 for wrong overtaking and 0.06, 0.056 and 0.07 for not own license, rough roads, and experience respectively. This strongly agreed with Table 2 which revealed that motorcycle accidents are mostly caused by personal status, not own license, rough roads, and experience. However, similar findings have been reported by Zhang (2010).

4.1.2. Analysis of accidents in Arusha region.

Table 4. Coefficients between variables in Arusha region.

Coefficients[a] for Arusha Region						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	134.263	.000		.	.
	Experiencex7	-1.530	.000	-.282	.	.
	wrong_overtakingx1	1.913	.000	1.049	.	.
	High_speedx5	.628	.000	.874	.	.
	Personal_statusx6	8.421	.000	1.056	.	.
a. Dependent Variable: Number of accident.						

From the Table 4, the formulated model for Arusha region was presented as equation **2**:

$$Y_2 = 134.263 + 1.913x_1 + 0.628x_5 + 8.421x_6 - 1.530x_7$$

4.1.2.1. Effect of individual variable in the model

When we consider all factors (wrong overtaking, experience, high speed and personal status) as zero, the number of accidents in Arusha region will be constant of about 134 accidents.

For variable X5 (high speed), holding fixed the number of drivers who have wrong overtaking, person status and experience of a driver, then as the number of drivers who drive at a very high speed is increased by one unit, the number of motorcycle accidents will be increased by 0.628 units.

For variable X1 (wrong overtaking), holding fixed the number of people who have taken in alcohol, experience of a driver and high speed, if the number of drivers who are using rough road is increased by one unit, the number of motorcycle accidents will increase by 1.913 units.

For variable X6 (personal status), when holding fixed the number of drivers with wrong overtaking, experience of a driver and high speed, if the number of people who have experience is increased by one unit, the number of motorcycle accidents will be increased by 8.421 units.

For variable X7 (experience of a driver), holding fixed the number of drivers with wrong overtaking, high speed, and personal status, then if the number of drivers who have experience is increased by one unit, the number of motorcycle accidents will decrease by 1.530 units.

Figure 4: Accident projection by factors in the model

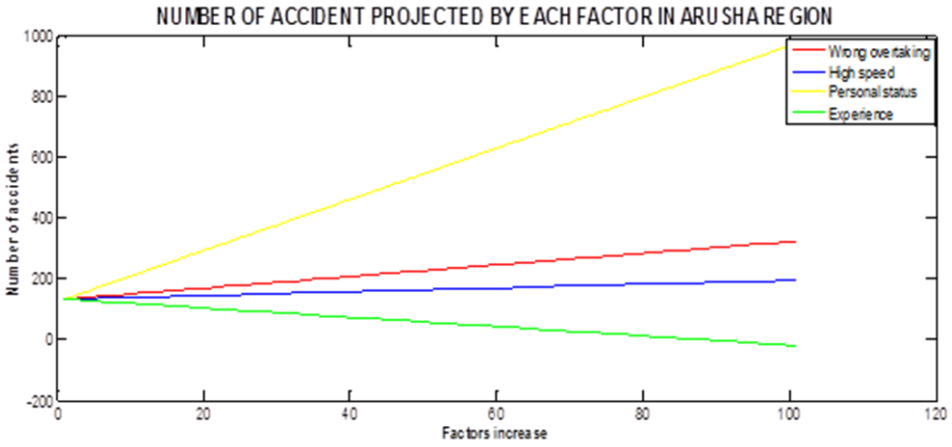
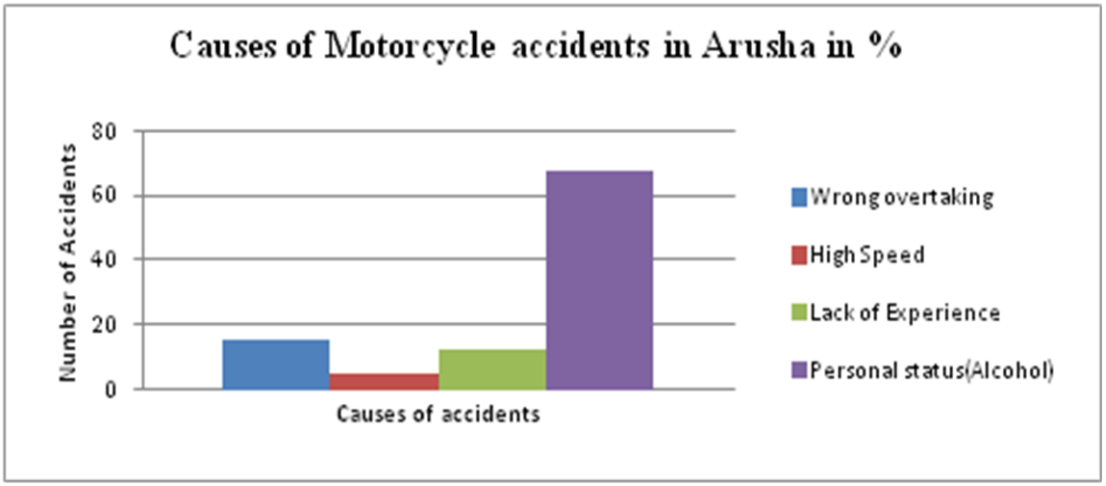


Table 5. Correlation coefficients between variables in Arusha region

Correlations											
		number of motocycle accidents	experience of drivers in years	wrong overtaking	legal status not own licence	day accident	night accident	high speed	rough road	tarmac road	personal status
Pearson Correlation	number of motocycle accidents	1	0.715	0.897	0.003	-0.015	0.005	0.79	0.001	-0.003	0.901

From Table 5, it can be seen that the number of motorcycle accidents have strong relationship with high speed, experience of drivers, personal status (alcohol) and wrong overtaking in a year with values of 0.79, -0.715, 0.901 and 0.897 respectively. However, the relationship between the number of motorcycle accidents and day and night, rough roads, tarmac road and legal status have shown a small effect with values of -0.04, 0.005, 0.001, -0.002 and 0.003 respectively. From Table 3 and Table 5 it can be observed that, there is negative relationship between number of motorcycle accidents and experience of a driver by the value -0.996 and -0.715 which means that as the number of people with experience increases the motorcycle accidents decrease. From these observations it can be said that the drivers with experience do not commit some minor mistakes that those with no experience commit and thus lead to accidents. One of these mistakes is wrong overtaking. Rough roads increase accident at a very low rate but in most cases it decrease the number of accident cases; the possible reason may be drivers normally drive at a very low speed when they are driving in rough roads as a result signifies the rarely occurrence of accidents. People with no license also increase the number of accident in the region this may be attributed by the fact that most of drives in this category are youngsters who in most cases lack experience and thus it is easy for them to commit several mistakes like wrong overtaking and the like, thus lead to accident

Figure 5. Factors that mostly lead to motorcycle accidents in Arusha Region



5. Recommendation and Conclusion

5.1. Recommendations

From the results and discussion, it was observed that a motorcycle accident in rough road was high in Kilimanjaro region; 10% than in tarmac roads with only 4% with percentage difference of 6%. From this observation, it can be seen that the formulated models can be used by the ministry of infrastructure to construct good roads in order to reduce the rate of accidents. Furthermore, this implies that the formulated models can be used to give a full caution to the society to avoid these personal status behaviors (alcohol or use drugs) as most of them occur in rough roads side way streets. It is also recommended that the ministry of home affairs under the department of traffic police

should put more effort in educating motorcycle drivers through providing seminars and workshops concerning road regulations so as to reduce the habit of alcoholism as well as carelessness when riding motorcycles.

5.2 Conclusion

The multiple regression models were used to assess the impact of driving experience and alcoholic behavior in relation to motorcycle accidents. The formulated models have shown a strong relationship between personal status such as alcoholism and driving experiences. These factors contribute to motorcycle accidents as shown in Figure 3 and Figure 5 as well as the formulated models. From the formulated models it can also be noted that in Kilimanjaro and Arusha regions the personal status factors and drivers without experience have large impact to motorcycle accidents. Therefore the formulated multiple regression models that incorporated many factors such as driving experience, high speed, wrong overtaking, and alcoholic or drug use can be used to assess the causes of motorcycle accidents in Tanzania.

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