Linking Road Traffic Accidents to Vehicle Population; Empirical Evidence from Ghana.

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Abstract

Several road accidents in Ghana in the past have resulted in road fatalities leading to loss of lives, property, broken homes, thus leaving behind shattered families and communities, among others despite the indispensable role the road transport sector plays in the economy. This paper examined the relationship between road traffic accidents and vehicular population in Ghana using linear regression model based on time series data relating to the two variables covering a twenty (20) year period from 1991 to 2010. Empirical results showed the existence of relationship between the two variables with R=0.855 indicating a very strong positive association between them, with vehicular population accounting for 73.098% of the changes in the annual road traffic accidents in Ghana and models the relationship as \( Y = 7166.33 + 0.00521X \), where \( Y \) is the total number of accidents and \( X \) being the number of registered vehicles. The study concludes that vehicular population should form part of policy formulation in dealing with road traffic accidents in Ghana based on the results and finally recommend among others that a legislation should be passed and strongly enforced as a matter of agency by stakeholders to deal with all over-aged vehicles, broken down and racketeering vehicles to remove them from the roads to help manage the vehicle population in the country.

Keywords: road transport; road accidents; regression model; correlation coefficients, vehicular population
INTRODUCTION

Vehicular accidents in Ghana have become one of the worrying and growing concerns to most Ghanaians in recent times. This is as a result of the tremendous negative effects of road traffic accidents on human lives, properties and the environment. The National Road Safety Commission (NRSC) was therefore established by an Act of Parliament (Act 567) in 1999 with the mission of promoting best road safety practices for all categories of road users through the vision of making Ghana a country with the safest road transportation system in Africa.

Despite the existence of these powerful institutions and regulatory bodies, statistics relating to road traffic accidents are very disheartening. For instance, globally, at least 1.3 million people are killed every year through road crashes, with some 20-50 million suffering from various forms of disability; 90% of these road casualties are in low and middle income countries; at current rates, it is estimated that road traffic crashes will be the 3rd leading cause of death worldwide by the year 2020 if rigorous actions are not taken (WHO, 2010).

Furthermore, 1,800 lives are lost in Ghana annually through road crashes with 14,000 injuries from an average of 11,000 road traffic crashes; road traffic crashes cost the nation 1.6% of GDP which translates to US$ 165 million in 2006 and US$ 288 million in 2009; 42% of these crash victims are pedestrians; 60% of all crash victims are people within the productive age group (NRSC, 2010).

According to a World Health Organization (WHO) & World Bank (1999) report on "The Global Burden of Disease", deaths from non-communicable diseases are expected to climb from 28.1 million a year in 1990 to 49.7 million by 2020 (an increase in absolute numbers of 77%). Road traffic crashes will contribute significantly to this rise. According to the report, road traffic injuries are expected to move from ninth place to take third place in the rank order of disease burden by the year 2020.

In assessing the magnitude of the problem of road traffic crashes, according to WHO, 1.2 million people die through road traffic crashes annually. On the average, in the industrialized countries, and also in many developing countries, one out of every ten hospital beds is occupied by a road traffic crash accident victim (NRSC 2010).

The 1999 WHO publication on "Injury: A Leading Cause of the Global Burden of Disease," reports that road traffic crashes are the major cause of severe injuries in most countries and the leading injury-related cause of death among people aged 15-44 years. Globally, the WHO reports that 38,848,625 people were injured through motor vehicle crashes in 1998. Out of the 5.8 million people who died of injuries, 1,170,694 (20%) died as a direct result of injuries sustained in motor vehicle crashes. The above facts reveal unacceptable levels of road traffic accidents and casualties and therefore have global, national, social and economic burden, especially in Ghana as quite a substantial amount of the nation’s GDP is channelled into the management of road traffic accidents rather than real investments and development. There is
therefore the need for interventions and strategies to deal with the menace especially by reducing it by 50% by the end of 2020 as recommended in the United Nations (UN) Global Plan for the Decade of Action for Road Safety 2011-2020.

To best of our knowledge, enough work has been done on road traffic accidents globally and especially in Ghana, however, none of the researches addressed the issue of vehicular population in relation to road traffic accidents in Ghana.

This paper therefore attempts to consider vehicular population growth and road accidents and its impact on human lives and property in Ghana with the following specific objectives:

- To identify the trend of vehicular population and road traffic accidents in Ghana;
- To ascertain whether there exist a relationship between road traffic accidents and vehicular population in Ghana;
- To establish the nature of the relationship between road traffic accidents and vehicular population in Ghana;
- To derive a model for the relationship between road traffic accidents and vehicular population in Ghana; and
- To forecast the road traffic accidents based on a given vehicular population in Ghana.

LITERATURE REVIEW

Ramakrishnan, T. (2013), revealed a relationship between vehicle population and fatal accident with results indicating that the state, which saw a whopping increase in vehicle population during 2006-2011, also experienced an alarmingly high rate of fatal accidents and even as vehicles grew by 66 per cent in the five years, the rate of accidents went up by about 43 per cent and persons killed by 40 per cent.

The increase in the number of accidents therefore calls for the need to statistically justify if these accidents on the other hand could be attributed to the growth in vehicular population in the country over time. Vehicular population here is defined as the aggregation of vehicles registered in the country plus those that are already in the system at any period of time. Statistically or mathematically, the total vehicular population growth can be said to be a function of both the past registered number of vehicles and the current registered number of vehicles, but most importantly depends on the current registered number of vehicles.

Both the World Bank and the World Health Organization, in independent studies, have calculated that, worldwide, there are around 500,000 fatalities and 15 million injuries per annum as a result of road accidents. Earlier estimates also suggest that about sixty percent of these deaths and injuries take place in those countries of Africa
and Asia which are classified by the World Bank as low or middle income World Bank, 1990 and Yerrell, 1992).

To assess the validity of these estimates, and whether there has been any change, the number of global fatalities by region have been calculated using 1992/93 data. Using data from a number of detailed studies, it has been suggested that the level of under-reporting of road accident fatalities in LDCS is at least twenty percent (Sayer and Hitchcock, 1984). Similar studies by James (1991) discovered that under-reporting in industrialized countries is in the order of 6 percent. The data on fatalities have been adjusted to take into account underreporting. This relationship is statistically significant at the one per cent level, showing a strong correlation between vehicle ownership and per vehicle fatality rates; the higher the levels of vehicle ownership, the lower the per vehicle fatality rate. Comparing this result with that obtained by Jacobs (1982), it appears that the line has now rotated anticlockwise relative to 1978. This suggests that the situation deteriorated between 1965 and 1978, but has improved slightly between 1978 and 1990, at least in so far as the fatality rate relative to vehicle ownership is no longer worsening.

One way of assessing the importance of road accidents as a cause of death is to compare death rates from road accidents with those of other causes. Using data provided by the World Health Organisation (WHO) Jacobs and Bardsley (1977) discovered that for a sample of 15 developing countries, road accident deaths were the tenth most important cause of death behind such causes as bronchitis, circulatory, parasitic and infectious diseases); and for the age-group 5-44 years they were second only to deaths due to other accidents, suicides and homicides combined.

According to Valli P. P (2005), while the alarming increase in road accidents has become a major concern in India, available statistics indicated that it takes away more than 90,000 lives every year, a significant share of it coming from the major cities and as a result attempted to develop models by analyzing the road accident data at an all India level as well as for major metropolitan cities using data for the 25 year period from 1977 to 2001 to build models to understand the nature and extent of the causes of accidents using the concept of Smeed’s formula and Andressen’s equations. The study concluded on the basis of population and motor vehicle growth rates and the predicted road accidents for the years 2007 and 2010 that in order to minimize accidents, major policy may be evolved to reduce the growth of personalized vehicles and simultaneously to encourage the use of public transport vehicles.

Abledu, et al (2013) concluded in their study that there exists a strong positive correlation \( r = 0.853 \) between road traffic accidents and population in Ghana, and that specifically, population growth accounts for 72.9% of the changes in the number of accidents in the country as indicated by the value of the coefficient of determination. This implies that as the vehicle population grows, the number of accidents will also increase.
The problem at hand is the fact that the substantial amount of money that is channelled into the management of road traffic accidents in the country every year alternatively could be invested into provision of social amenities and other infrastructure such as provision portable water, electricity, healthcare, physical infrastructure such as roads, building schools and hospitals, among others.

In conclusion, the impact of some road accidents that have occurred in the past and even in recent times have led to lost of innocent lives, property, torn many homes apart thereby rendering many citizens in a condition of rejection and dejection. Road traffic accidents occurrences have enormous negatives consequences on the citizens, resources, economy and as well as the country at large and as a result a holistic approach spearheaded by empirical research is therefore required to deal with this menace from our part of the world.

**METHODOLOGY**

The type of data used in this research was purely quantitative obtained from secondary sources. The data specifically relates the set of observations on the two main variables that are being studied. These are road traffic accidents and vehicular population in Ghana covering a twenty (20) year period from 1991 to 2010. Fay, (1997) concluded that the key point of secondary data is that it should be relevant, accurate and available. For this reason and purpose, the time series data relating to road traffic accidents and vehicular population covering the period 1991 to 2010 were collected respectively from National Road Safety Commission of Ghana.

Exploratory data analysis, descriptive and inferential data analysis were performed using Minitab 16 software. The exploratory analysis involved the use of graphical displays of the data to help identify and analyse trends and patterns in the data. These included line graphs and frequency polygons. Where the two variables were looked at concurrently, scatter plot was used to establish the relationship between them.

With respect to the descriptive analysis, correlation coefficients, standard errors, have also been computed and interpreted. Linear regression model which attempts to model the relationship between two variables by fitting a linear equation to observed data was subsequently developed. Finally, with regard to the inferential analysis, hypothesis tests were performed using the computed p-values in which decisions and conclusions were arrived at.

In regression analysis, it is important that we go beyond the fitting of an equation to data and making inferences about the population from which the data were drawn. There are some underlying conditions that must be satisfied, at least approximately, before any statistical inference can be considered reasonable.
These conditions are:

1. In the underlying population, the relationship between the response variable, \( Y \), and the predictor variable of \( X \) is or must be linear. That is \( Y = \beta_0 + \beta X \).
2. For each value of \( X \), there is a group of \( Y \) values, and these \( Y \) values are normally distributed.
3. The \( Y \)-values are statistically independent. That is, the \( Y \) values chosen for a population value of \( X \) do not depend on the \( Y \) values for any other value of \( X \).
4. For each value of \( X \), the variance, \( \sigma^2 \), of \( Y \) about the regression line (i.e. the amount of variation in the population of \( Y \) values) is the same.

**Model adequacy checking (diagnostics)**

The model diagnostics is done using graphical displays of the residuals as shown in figure 1 below.

![Residual Plots for Accidents(Y)](image)

**Figure 1:** Residual plots of the data

The Figure 1 above is four in one plot residuals of the data which clearly shows that all the four (4) diagnostic residual plots do not show any anomalies for a hypothetical fitted regression model. These plots are used in the preliminary analysis to ensure that the assumptions underlying the use and development of such models are met before a regression model is fitted to a given data.

The first plot which is the probability plot of the residuals is used to verify the assumption of normality. In this case it is expected that the individual probabilities of the residuals are normally distributed if all the points are near or closer to one another with the plotted points forming an approximately straight line. Any points that tend to deviate from this pattern may be termed as an outlier.

The second plot which is a plot of the residuals verses the fitted values must clearly show that the residuals appear to be randomly scattered about zero, thereby satisfying the assumption of constant variance.

The third plot which is the time plot of the residuals is used to check the assumption of statistical independence of the dependent variable. The residuals must appear to be randomly distributed without showing any clear visible pattern. Finally, the...
histogram plot of the residuals is also used to check the same normality assumption in which the histogram plot of the residuals must appear to be normal in order to satisfy the normality assumption. However, a slight deviation from normality is allowed.

**RESULTS AND DISCUSSIONS**

The data

The data for this analysis is a twenty (20) year annual data on road traffic accidents and the number of registered vehicles in Ghana obtained from the Ghana Road Safety Commission. For the purposes of the flow of the analysis, the data is presented in Appendix I.

Exploratory data analyses

Trend Analysis of Total Accident in Ghana

![Trend Analysis Plot for accident](image)

**Figure 2**: Trend of total accidents in Ghana, 1991 - 2010

Figure 2 above is the trend and actual plot of the road traffic accident data from 1991 to 2010. It can be seen from the actual plot that the accident situation over the has not remained constant but rather varied from year to year. Some years saw significantly high occurrences whilst others saw low growths or occurrences. 1993 and 1994 recorded the least occurrences and has since been steadily increasing over the period.

The plot of trend equation exhibit a linear or a straight line which is continuously increasing as shown in the figure 2. the total number of accident for the country was 8370 which decline through 1992 to 1994. The specific linear trend model is given as; \( Y_t = 7073 + 282t \) where \( Y_t \) is the total number of accidents and \( t \) is the time period.
Trend Analysis of Vehicular Population in Ghana

It is clear from figure 3 that the vehicular population or the number of registered vehicles has continuously increased over the period. The plot of the fitted trend equation also display a good fit which is specifically given by \( Y_t = -5583 + 52964t \), which depicts a perfect situation of a linear trend steadily increasing.

Relationship between road traffic accidents and vehicular population in Ghana

The relationship between road traffic accidents and vehicular population is depicted by the figure 4 above. There appears to be a positive correlation between the two variables. It is clear from the figure that as the number of registered vehicles grew, the number of road traffic accidents also grew along with it, thereby resulting in the movement in the same direction by the two variables and for that matter the positive association between them. The exact strength of the relationship would be more enhanced by the calculation of the correlation coefficient and other important statistics in the subsequent analysis.
Model development and analysis of relationship

Table 1 Summary of Regression coefficients

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7166.33469.517</td>
<td>15.2632</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Vehicles (X)</td>
<td>0.005209</td>
<td>0.00007448</td>
<td>6.9935</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The Table 1 above report the regression coefficients and other vital statistics such as regression coefficients, standard errors of the coefficients, the t values and the p values. The regression model, which establishes the relationship between total yearly accidents and number of registered vehicles is thus given as $Y = 7166.33 + 0.00521X$, where $Y$ is the total number of accidents in a year and $X$ being the total number of registered vehicles in a year.

From the regression model obtained, the value of 7166.33 is interpreted to be the total number of yearly accidents when the total number of registered vehicles is set to zero and all other factors are held constant, whilst the coefficient of $X$ of 0.005209 is the rate or magnitude of change in the number of accidents as a result of a unit change in the number of registered vehicles. Its positive sign is an indication of the fact that there is a positive association between road traffic accidents and the number of registered vehicles as already established by the scatter plot in the preliminary analysis above.

Again, the errors associated with these coefficients are minimal as displayed by the standard errors of the coefficients. The p-values indicate that the constant terms as well as that of the predictor variable ($X$) are statistically significant since it is less than the chosen alpha level of 0.05.

Table 2 Summary of Model statistics

<table>
<thead>
<tr>
<th>Model statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>0.8549</td>
</tr>
<tr>
<td>R-square</td>
<td>73.098%</td>
</tr>
<tr>
<td>R-square (adj)</td>
<td>71.603%</td>
</tr>
<tr>
<td>Standard error</td>
<td>1022.94</td>
</tr>
</tbody>
</table>

Furthermore, Table 2 presents summary of model statistics which indicate that the exact nature of the relationship between the road traffic accidents and the vehicular population is a strong positive one as given by the correlation coefficient value of 0.8549. The coefficient of determination (R-sq) which is a measure of the explanatory power of the model indicate that vehicular population or number of registered
vehicles is able to account for or explain 73.098% of the changes in the number of road traffic accidents in Ghana. This also imply that there are other variables or factors that have effect on road traffic accidents and are in the neighbourhood of about 26.902%.

Test of hypothesis
It has earlier on been claimed that there is no significant relationship between road traffic accidents and the number of registered vehicles in Ghana or otherwise. This claim is been investigated at this moment by the test of hypothesis with the aid of the analysis of variance table below in order to draw valid conclusions.

Table 3 Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1</td>
<td>51179201</td>
<td>51179201</td>
<td>48.91</td>
<td>0.000</td>
</tr>
<tr>
<td>Residual Error</td>
<td>18</td>
<td>18835299</td>
<td>1046405</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>70014500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The analysis of variance table is used here to test the hypothesis for the study:

Null Hypothesis (Ho): There is no significant relationship between road traffic accidents and vehicle population growth in Ghana.

Alternative Hypothesis (H1): There is a significant relationship between road traffic accidents and vehicle population growth in Ghana.

The p-value of 0.000 as reported in the analysis of variance table indicates that the test is significant at 0.05. Therefore, we fail to accept the null hypothesis and conclude that indeed there is a significant relationship between road traffic accidents and vehicle population growth in Ghana as stated alternatively.

Forecasts
A forecast is a probabilistic estimate of a future value. Both current and future decisions are based on forecast values provided the forecasts are reliable. With regard to the last objective, the study sought to make some forecasts given some levels of registered number of vehicles based on the model that would be developed. It is clear from the test of hypothesis that there is a strong significant relationship between road traffic accidents and number of registered vehicles in Ghana, and as a result the model developed can be applied in making forecast as displayed in the Table 4 below.
Table 4 Road Traffic Accident Forecast for some hypothetical number of registered vehicles in Ghana.

<table>
<thead>
<tr>
<th>Year/Period</th>
<th>Estimated vehicular Population</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1123800</td>
<td>13021</td>
</tr>
<tr>
<td>2015</td>
<td>1020002</td>
<td>12481</td>
</tr>
<tr>
<td>2016</td>
<td>1539020</td>
<td>15185</td>
</tr>
<tr>
<td>2017</td>
<td>2000000</td>
<td>17586</td>
</tr>
</tbody>
</table>

From the Table 4 above, it can be seen that a higher projected number of forecast resulted in a higher road traffic accident forecast. This implies that in Ghana and with regard to this model, the higher the number of registered vehicles in a year, the higher the road traffic accidents that would be recorded in Ghana. There is therefore the need to control the importation of vehicles in the country.

FINDINGS

This research was intended to identify the trend of vehicular population and road traffic accidents in Ghana; ascertain whether there exist a relationship between road traffic accidents and vehicular population in Ghana; establish the nature of the relationship between road traffic accidents and vehicular population in Ghana; derive a model for the relationship between road traffic accidents and vehicular population in Ghana; and finally forecast the road traffic accidents based on a given vehicular population in Ghana.

Based on the above objectives, and subsequent to the analysis of the appropriate data, the following are the findings of the study:

Firstly, the study revealed that the road traffic accidents in Ghana over the period under study exhibited a fluctuated pattern with a linear trend indicating a steady increase. The specific linear trend model is given as; \( Y_t = 7073 + 282t \).

Secondly, the annual vehicular population or the number of registered vehicles on the other hand exhibited a steady increase with a well fitted trend given as \( Y_t = -5583 + 52964t \).

Also, the study found out that there is a relationship between road traffic accidents and registered number of vehicles in Ghana based on the past years with specific reference to 1991 to 2010. The specific relationship can be said to be strong positive with a correlation coefficient of 0.855. This was further corroborated the conclusion drawn from the test of hypothesis.
Furthermore, the relationship between road traffic accidents and the number of registered vehicles is modelled by the relation as $Y = 7166.33 + 0.00521X$, where $Y$ is the total number of accidents in a year and $X$ being the total number of registered vehicles in a year and that this model is statistically significant with the explanatory variable having about 73.098% explanatory power in terms of the coefficient of determination.

Finally, the study projects from the forecasts that higher number of registered vehicles will result in a higher road traffic accidents. This implies that in Ghana and with regard to this model, the higher the number of registered vehicles in a year, the higher the road traffic accidents that would be recorded in Ghana.

CONCLUSION
Based on the findings of the study, it desirable to draw the following conclusions:

Firstly, there is a steady pattern and linear trend in both the numbers of road traffic accidents and registered vehicles in Ghana on the basis of the analysis.

Secondly, it can be concluded that with regard to road traffic accidents and vehicular population in Ghana there exist a strong statistically significant positive relationship between them.

Finally, it can be concluded that the model developed that established the relationship between the road traffic accidents and vehicular in Ghana is also statistically significant at 5% level of significance and therefore can be used for estimation and forecasting purposes and should subsequently form the basis of decision and policy formulation regarding road traffic accident management, all other factors held constant.

RECOMMENDATION
The paper recommends among others the following for consideration based on the results and conclusions.

Legislation should be passed and strongly enforced as a matter of agency by stakeholders such as the National Road Safety Commission (NRSC), Motor Traffic and Transports Unit (MTTU) of the Ghana Police Service, Driver and Vehicle Licensing Authority (DVLA) to deal with all over-aged vehicles, broken down and racketeering vehicles to remove them from the roads to help manage the vehicle population in the country.

The National Road Safety Commission and other stakeholders must also intensify public education and also develop a proactive intervention on road safety to help minimize the spate of accidents in the country.

Increased police presence on our roads especially officers from the Motor Traffic and Transports Unit of the Ghana Police Service to help as a proactive means of curtailing some avoidable road traffic crashes on our roads.
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