KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, GHANA

FACULTY OF SCIENCE

DEPARTMENT OF MATHEMATICS

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ORDINARY LEAST SQUARES AND POISSON REGRESSION ANALYSIS OF ROAD TRAFFIC ACCIDENTS IN THE VOLTA REGION OF GHANA FROM 2006 TO 2010

BEATRICE ANANI

A Thesis Submitted To the Department of Mathematics Kwame Nkrumah University of Science and Technology-Kumasi In Partial Fulfillment of Award of Master's of Science Degree in Industrial Mathematics

OCTOBER 2012

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DECLARATION

I hereby declare that this thesis is as a result of my own original research work and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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NYANSAPƆ WɔSANE NO BADWENMA

DEDICATION

I sincerely dedicated this project to my father

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ABSTRACT

This research seeks to provide ordinary least squares and Poisson regression analysis of road traffic accidents in the Volta region of Ghana from 2006 to 2010. Road accident is a worldwide problem (but more pronounce in the developing world) robbing such countries of valuable human and material resources. The objectives of the study are; to perform comparative analysis for various road traffic accident variables, and model the relationship between road traffic accidents and degree of road traffic accidents in the Ho municipality of the region. Ordinary least square regression models were converted to Poisson regression since the data are mostly counts and contingency tables with the assumption that the conditional means equal the conditional variances. The main conclusions of the study are that; accident cases (fatal, serious or minor) has not been declining over the years with, January, May, June, July and December appearing to record more cases. It was also found that, the number of vehicles involved in accident is a significant factor in determining number of reported cases of road traffic accident. The degree of injuries becomes extremely high when road accidents occur. That is, there is very high probability of having people injured when accidents occur irrespective of which type of accident that occurs.

ACKNOWLEDGEMENT

My ultimate appreciation goes to the Almighty God my source of strength, knowledge and wisdom.

This project could not have been completed without the assistance of many individuals. In actual fact it could be difficult to enumerate all of them.

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I would be very ungrateful if I do not mention the enormous encouragement and support from Mr. Lawrence Yevudoko.

Once again I say than you to all loved ones and God richly bless you.

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LIST OF ABBREVIATIONS

RTA	Road Traffic Accident
RAI	Road Accident Injuries
MTTU	Motor Traffic Transport Unit
WHO	World Health Organization
GDP	Gross Domestic Product
NRSC	National Road safety Commission
GNP	Gross National Product

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CHAPTER ONE

RESEARCH SETTING

1.0 Introduction

Road accident cases in Ghana become topical issues for discussion anytime it occurs. This is because it normally comes along with lots of losses to both families and the state. Knowledge of the trend and causative factors could go a long way in providing some level of prevention; prevention, they say, is better than cure. This research seeks to provide some statistics of road traffic accident in the Volta Region of Ghana. These statistics are intended to add to the already existing ones from the MTTU unit of the police service in the country; so that, as a country, we can have facts and figure backing our call to end the carnage on our roads.

1.1 Background Study

Road Traffic Accident (RTA) according to (Ohakwe *et al.*, 2011), is when a road vehicle collides with another vehicle, pedestrian, animal or geographical or architectural obstacle. The RTAs can result in injury, property damage and death. RTA results in the deaths of 1.2million people worldwide each year and injures about 4 times this number (WHO, 2004). In this study, road traffic accident is defined to mean the collision between a vehicle and another vehicle, a vehicle and a pedestrian, a vehicle and motor cycle, a vehicle and bicycle, or any collision involving two or more of these.

Road accident is a worldwide problem. Every year more than 1.17 million people die in road crashes around the world. The majority of these deaths, about seventy (70) percent occur in developing countries. Sixty-five (65) percent of deaths involve pedestrians and thirty five (35) percent of pedestrian deaths are children. Over ten

(10) million are crippled or injured each year. It has been estimated that at least six (6) million more will die and sixty (60) million will be injured during the next ten (10) years in developing countries unless urgent action is taken, according to a World Bank report (http://www.worldbank.org/transport/roads/safety.htm).

The rapid motorization in many developing countries and newly industrialized countries has invariably led to an increase in the number of accident over the past many decades now. Since the invention of the wheel people have thrived for fast and comfortable travel. Automotive industry started with the invention of an internal combustion engine serial manufacturing of Ford model-T made automobiles accessible to lower income classes. In this way, automobiles became a necessity rather than luxury goods. Beside obvious advantages there are many disadvantages of automobiles. The most important negatives are pollution and road accidents (http://www.worldbank.org/transport/roads/safety.htm).

The first pedestrian died in 1896, while the first driver died in 1899 (http://www.straightdope.com/columns/read/2844/who-was-the-first-person-to-be-hit-by-a-car) as quoted by Gfactor, Straight Dope Science Advisory Board, and this has continued ever since with devastating effect on the economy of countries, especially developing countries. The annual cost of road accident equals one percent (1%) of the worlds GDP (Mujkic' and Rovan, 2003). Over one million people every year are killed in road accident; 20-25 million are injured. Road Accident Injuries (RAIs) are growing as the vehicle use of developing countries rise. This trend, if not checked, might result in RAIs becoming one of leading causes of death and disability worldwide. When this happens, resident of developing countries would obviously be of higher risk of death when an accident occurs with its accompanying inadequate trauma systems to care for accident victims (Mujkic' and Rovan, 2003).

According to the 2004 World Health Report, countries sub-Saharan Africa alone with only four percent (4%) of the global vehicles registered accounts for ten percent (10%) of the total fatalities, and economic, social and health consequences are grave. Conversely, the high income nations with sixty percent (60%) of the total global vehicle fleet contribute only fourteen percent (14%) of the annual road deaths. Human error, road, environment and vehicle factors are reported by the traffic police as the main cause of road accident. Two countries, South Africa and Nigeria, account for most of the reported deaths in sub-Sahara Africa. The South Africa figure of over nine thousand (9,000) has been consistent over time, while Nigeria with six thousand, one hundred and eighty five (6,185) deaths has declined from a high of over nine thousand two hundred (9,200) in the early 90s. Ethiopia, Kenya, Uganda, Tanzania and Ghana are the other countries that experience high number of road accident deaths.

Roads accidents continue to be a major problem in Ghana, from both public health and socio-economic perspectives. In the period 1991-2000, 85,867 road accidents were recorded and this resulted in 107,780 casualties, of which 25,340 were fatal. These figures may be much higher if it was possible to account for short falls in reporting. On the average, the total costs of road accidents, including an economic valuation of lost quality of life, were estimated to about 2.5% of the gross national product. Excluding the valuation of lost quality of life, road accident costs on the average amounted to 1.3% of the gross national product. When valuation of lost quality of life is included, costs ranged from 0.5 to 5.7% of GNP (Gross National Product). When valuation of lost quality of life is disregarded, costs ranged from 0.3 to 2.8% of GNP (http://www.ncbi.nlm.nih.gov/pubmed/10994613).

In Ghana, according to National Road Safety Commission (NRSC), the country loses up to 1.6 percent of its Gross Domestic Product (GDP) to road traffic accident annually. Between 2000 and 2010, it recorded 125,857 road accidents, which led to death of 20,503 and injury to 63,384 people (http://www.ghananewsagency.org/details/Social/Retro-Reflective-Tape-launched-to-reduced-night-crashes/?ci=4&ai=16164).

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Solution to this canker becomes more needed in Ghana particularly because Road transport appears to be the major overall national delivery of people and goods. So road safety is a vital prerequisite for economic progress of Ghana and everything must be done to reduce accidents to the barest minimum. Improving safety on Ghana's roads is therefore a pressing national concern that has already found expression in the setting-up of National Road Safety Commission (NRSC). The commission has the task to initiate and oversee the implementation of more proactive and structured programs of accident reduction. The initial effect in this direction has culminated in the National Road Safety, strategy and action plan both of which underscore the need for data led interventions and innovative approaches to understanding the occurrence in mechanisms and determining factors of road accident devising factors to reduce the incidence of accidents. It is in furtherance of this strategic approach that this study is been undertaken with the express objective of developing accident prediction model using Poisson regression that can be used to investigate the relationship between the causes of road accident, its reported cases and the effect of road accident.

In this thesis, a safety model based on national accident database frequencies will be presented. The statistical accident rate model developed will include benchmark estimates of national rates of absolute crash risk by crash type and fatality. Traffic accident is the result of multiplicity of factors and it is often the interaction of more than one variable that leads to the occurrence of accident. Accidents occur as a result of the interaction of many different factors among which are road and traffic characteristics.

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1.1.1 Types of Accidents

Car accidents fall into several major categories (whose names are self- explanatory):

1. Rear-end collisions
2. Side collisions
3. Rollovers
4. Head-on collisions
5. Single- car accidents
6. Pile-ups

A traffic accident is defined as any vehicular accident occurring on a public highway (i.e. originating on, terminating on, or involving a vehicle particularly on the highway). These accidents therefore include collisions between vehicles and animals, vehicles and pedestrians, or vehicle and fixed obstacles. Single vehicle accidents, in which one vehicle alone (and no other road user) was involved, are included. All fatality and injury totals include pedestrians, motorcyclist unless otherwise noted.

1.1.2 Causes of Accidents

Many factors result in car accidents, and sometimes multiple causes contribute to a single accident. The factors include the following:

(i) Driver distraction, including fiddling with technical devices, talking with passengers or on the mobile phone, eating or grooming in the car, dealing with children or pets in the back seat, or attempting to retrieve dropped items;

(ii) Driver impairment by tiredness, illness, alcohol or drugs, both legal and illegal.

(iii) Mechanical faults, including flat tire or tires bursts, brake failure, axle failure, steering mechanism failure;

(iv) Road conditions, including foreign obstacles or substances on the road surface; making the roads glossy; road damage including pot holes, arbitrary speed hump;

(v) Speed exceeding safe conditions, such as the speed for which the road was designed, the road condition, the weather, the speed of surrounding motorists, and so on.

1.1.3 Fatality Rates

There is no single accepted indicator that accurately describes the overall road safety situation in a particular country (Africa Road Safety Review Final Report, 2000). The number of fatal crashes per million vehicles per kilometers travelled per annum, as a measure of exposure to motor vehicle traffic, is the most common method often used in highly motorized countries. However, because of the absence of accurate data on

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vehicle usage in most African countries, it is not possible to apply this method. Instead, fatality rates, the number of reported fatalities per 10,000 registered motor vehicles, are normally used. Fatality risk, calculated as the number of deaths per 100,000 populations per annum, which is also the indicator commonly used by the World Health Organization (WHO) and the ministries of health sector to report diseases and causes of death. It should be noted that both rates are subject to several errors, including variations in the definition of road deaths; under-reporting of crashes, the resulting injuries and deaths; lack of uniform definition of a vehicle; inaccurate record of the total number of registered vehicles; and lack of accurate data for the year of reporting. There are wide variations in fatality rates: from 270 in Central African Republic to 8 in Chad. The highest rates, all in excess of 100, are reported in Ghana, Malawi, Tanzania, Uganda and Ethiopia.

1.1.4 Risk Factors

It is a common believe in countries like Ghana, Uganda, Ethiopia, Tanzania, Kenya, South Africa and Zimbabwe that most of the road crashes are largely due to a range of human error, as well as road and vehicle factors that include:

(i) Over speeding, perilous overtaking;

(ii) Alcohol and drug abuse;

(iii)Driver negligence, poor driving standards;

(iv)Vehicle overload; Overloading of vehicles

(v) Poor maintenance of vehicles;

(vi)Bad roads and hilly terrain;

(vii) Negligence of pedestrians;

(viii) Distraction of drivers (e.g. speaking on cell phone).

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These findings need to be taken with caution as the single causes usually reported by the police oversimplify the reality. Also, traffic police are often more inclined to cite the driver as being at fault than a pedestrian or cyclist because of the rules and guiding principles existing at this moment in time in Ghana, special investigation teams are needed to assess the contribution of the various risk factors at the time of a crash. Special investigation teams are needed to assess the contribution of the various risk factors at the time of a crash.

Although the factors cited above are the most commonly reported in routine police statistics, there might be other underlying inter-related factors contributing to the rising magnitude and burden of road traffic injuries in Ho Municipality in particular. Some of these factors the researcher believes are contributing factors include;

(i) Rapid growth in motorization and human population;

(ii) increased spatial interaction of road traffic, in terms of the volume and direction of movement;

(iii) Deficiencies and problems in road-user behavior;

(iv) Conditions and environment of work in the public transport sector, with special reference to buses and minibuses;

(v) Social and economic conditions prevailing in Ghana;

(vi) Serious deficiencies in the road network development and maintenance; and deficiencies in road safety planning, management, enforcement and interventions.

To adequately address these social, economic and developmental issues firm political commitment and resources are needed at the national and international levels.

1.1.5 Road Safety Initiatives

Like in other developing nations, many African countries have road safety agencies in the form of National Road Safety Commission or Road Safety Committee since the early 1980s, mostly within Ministries of Transport and Roads, with the aim of preventing road "accidents". They are inter-sectorial in composition, with membership derived from both governmental and non-governmental sectors, and operate mainly at the national level. Their roles and capacity to effectively function, however, vary from country to country. Their activities, in many jurisdictions, include the following;

(i) Ensuring law enforcement
(ii) Collecting road accident statistics,
(iii)Revising traffic legislation,
(iv)Promotion of road safety education,
(v) Ensuring adequate provision of medical facilities for traffic injury victims,
(vi)Undertaking research in road safety, and co-ordination of all road safety activities.

In general, in Ghana, organizations have largely been ineffective, as they do not have the capacity to function effectively due to inadequate funding, lack of sufficient human and material resources, as well as lack of authority to fully discharge their duties. A more effective central agency for road safety, with adequate resources and trained personnel, is needed in this and other municipalities.

1.2 Statement of Problem

At all levels whether at national or international level road traffic accidents continue to be a growing problem. In connection with this according to the world health organization/world bank report, deaths for non communicable diseases are expected to grow from 28.1 million a year in 1990 to 49.7 million by 2020, which is an increase in absolute number of 77%. Traffic accidents are the main cause of this rise. Road traffic injuries are expected to take higher place in the rank order of diseases burden in the near future.

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Similarly, the rate of road accident in the Ho municipal goes up together with the increase of motor vehicles and population size. The rise in automobile ownership together with the poor condition of the roads has resulted in the high level of road accident problem. In Ghana, national road safety commission (NRSC) lost up to 1.6% of its gross domestic products (GDP) to road traffic accident annually between 2000 and 2010. It recorded 125,857 road accidents, which led to 63,384 people. Nowadays, Ho municipal is experiencing around 600 reported cases per annum resulting in various level of injury (Ministry of transport, the motor traffic and transport unit of the Ghana police service 2012).

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Records at the Ho municipal ministry of transport, the motor traffic and transport unit of the Ghana police service, shows that, the amount of road accident that occur on roads with good conditions and during good weather conditions, accordingly for the Ho municipal, it could be assumed that the road and weather conditions have no significant impact on the accident. But the driver may have significant role in causing accident especially resulting in injuries. The consequences of road accidents are categorical as: death, serious injuries and fatal injuries, minor injuries and fatal injuries. Most of the time, serious injuries may result in death of the injured person and minor injury may result in disability. Thus in this study the term "injury" will be used to refer to any of these incidents on human life. Road accidents in Ho municipal have serious negative effects on the country as enumerated below:

(i) The human resources of the country is reduced drastically as most of our future leaders and prominent men and women lost their lives or become disabling.

(ii) Economically, the government uses money to organize road safety campaigns, building hospitals and importing more drugs for accident victims.

(iii) Socially more police have to be trained to check drivers and control over speeding on our roads.

1.3 Objective of the Study

The objectives of the thesis are:

(i) to perform comparative analysis for various road traffic accident variables from 2006 to 2010.

(ii) to model the relationship between accidents and their causes using Ordinary Least Squares and/or Poisson regression analyses in Ho Municipality.

(iii) to model the relationship between accidents and degree of accident using Ordinary Least Squares and/or Poisson regression analysis in Ho Municipality.

1.4 Methodology

The models used in this study are Ordinary Least Squares and Poisson regression model. The Poisson model assumes that the mean and variance are equal. But usually

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in practice the variance is larger (or sometimes smaller) than the mean. When the variance is larger than the mean the alternative is a negative binomial model. The negative binomial distribution is a form of Poisson distribution in which the distribution parameter itself is considered as random variable. The SPSS and Excel application softwares were the analytical tool used for the study. The secondary data for this study were collected from the Motor Transport and Traffic Unit (MTTU) of the Ghana Police service. The data contain records of road accidents and number of injuries (which includes fatalities) in each accident. The observations are information about the number of accidents, effects and causes of the accidents that occur within the period from 2006 to 2010. Information on the following variables was collected for analysis.

(i) Number of accidents by month.

(ii) Number of vehicles involved in accidents for the same period.

(iii)The type accidents and cases of severity.

(iv)Causes of accidents.

(v) Number of persons killed and injured.

1.5 Justification

The road accident Poisson regression analysis can be used at different levels. At national level, it can be used to help government formulate road safety policies. At the regional level, it can be used to help regional authorities to make appropriate decisions. The regression analysis can be used by local engineers to determine problem areas on their network and indeed can be used in identification of accident prone areas. In general, the thesis will help the researcher, and indeed the general public, to forecast the trend of future road accidents.

1.6 Limitations of The Study

The following may constitute some limitations of the study;

(i) Unavailability of data on traffic density and traffic flow,

(ii) Unavailability of data on persons who were safe (as in not injured or killed) for modeling survival rates,

(iii)Modeling would have been enhanced were the data subjected to a negative binomial distribution in addition.

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1.7 Thesis organization

The thesis is organized into five chapters. Chapter one presents the background, statement of problem, objectives, methodology and justification of the study. The limitations of the study was also put forward. Chapter three presents the conceptual framework, overall study design and a detail description of the methodology. This includes a description of the Poisson regression analysis was used to find the relationship between road accident and the causes of the road accident. It was also used to estimate and predict outcome of the road accident in this study. Chapter four focuses on data collection and analysis. In Chapter five, we shall put forward the conclusions and recommendations of the study.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

A number of road traffic models have been constructed in the past by various people at different times. The goal of these models was to provide mathematical equation that is fit (line of best fit) to predict and hence control accident cases in various countries or jurisdictions. According to Hauer (1996) some researchers ranked locations by accident rate (accidents per vehicle-kilometres or per entering vehicles), some use accident frequency (accidents per km-year or accidents per year) and some use a combination

of the two. According to (http://doclib.uhasselt.be/dspace/bitstream/1942/1507/1/Ranking.pdf,) "a number of statistical models have been used to estimate accident rates and/or accident frequencies at a specific location over a given interval of time. The underlying assumption is that road accidents can be treated as random events with an underlying mean accidents rate for each accident location. To account for this probabilistic nature of accident occurrence compelling arguments can be found to support the assumption that accidents counts follow the Poisson probability law."

2.1 Accident Regression Analysis in Road Safety Research

Information from road accident regression analysis is imperative for road safety research to inform road safety policies. Road accident regression analysis would help in the formulation of road safety policies and counter measures that are needed to reduce the incidence and severity of road accidents. A scientific approach to advance accident knowledge base on statistical methods in analyzing road accidents can help

Speeding is a key contributing factor in road accident and injuries in Africa, regardless of the variation of policy investigation and reporting in different countries. Speeding is a contributing factor in 75% of the traffic fatal crashes in South Africa (Satchwell, 2002).

According to (Barengo et al., 2006) as sited by (Greg, 2009), speeding is a contributing factor in more than 25% of all traffic crashes in Dar-Es-Salam in Tanzania between 1999 and 2001. Higher speed reduces the response time of the drivers of motor vehicles and increases the severity of the injuries, due to the large amount of energy to be dissipated at contact/impact. Arguably, every road accident is speed related, and speed management is apparently one of the top issues for safety improvement in African countries. In Ghana, pedestrians were the main victims of road accident injuries. The dominant driver error assigned by traffic police was toss of control with the underlying factors being excessive vehicle speeds. The speed factors alone accounted for more than 50% of all Ghanaian road accident between 1998-2000 (Afukaar, 2003).

Drink driving may also be considered another key factor contributing to road accidents and injuries. Driving while either intoxicated or drunk is dangerous and drivers with high blood alcohol content or concentration (BAC) are at greatly increased risk of car accidents, highway injuries and vehicular deaths. Possible prevention measures examined here include establishing Driving While Intoxicated (DWI) courts, suspending or revoking driver licenses, impounding or confiscating vehicle plates, impounding or immobilizing vehicles, enforcing open container bans, increasing penalties such as fines or jail for drunk driving, and mandating alcohol

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education. Safety seat belts, air bags, designated drivers, and effective practical ways to stay sober are also discussed;(http://www2.potsdam.edu/hansondj/DrinkingAndDriving.html/).

The lack of enforcement has been cited in many literature as reason for concern. In Tanzania for example, lack of identification of drinking and driving as contributing factor has been specifically attributed to the lack of technology, logistic and culture, as well as reluctant in enforcing driving laws (Museru et al., 2002). Lack of devices on the road side, the police has to take the drivers to medical centers where doctors may or may not be available for blood concentration test in the name of law enforcement (Bekibele et al., 2007).

Human incapacitation rendered somewhat heightened status in transportation in present Africa where private vehicle ownership is still low and most people take private transportation that is, buses and mini-buses operated primarily by private companies. Two key issues stand out in this concern, the driver visual acuteness and driver fatigue. A study of drivers in public institutions found that older drivers with lower level of eye sighted to have likelihood to be involved in road accident. Lack of examination of eye sight, especially for older drivers who drive buses or trucks, is therefore policy relevance for decision makers, given the significant role that commercial transportation plays in these nations and economies (Adeoti, 2007).

Driver fatigue, especially truck and bus driver fatigue is considered a major issue, threatening transportation safety in the world, including Africa (Adams-Guppy and Guppy, 2005: Davis et al., 2003) obtained via (http://www.utrc2.org/research/assets/168/

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FinalRept-Traffic-Safety1.pdf). This issue is exacerbated by the overcrowding of passengers and lack of maintenance of buses and trucks. In Kenya, for example, most accidents in rural areas involve public transportation vehicles, including buses and matatus, a smaller vehicle used for personal transportation often owned and operated by private companies in Africa. The long distance driving and lack of fatigues contributed to the accidents and the resulting injuries and fatalities (Odero et al., 2003).

Fatigue affects road users who lack protection especially. A Nigerian study shows that rider fatigue contributes to 13% of motor cycle accident in Nigeria (Oginni et al., 2009).

Another major category of contributing factors relates to vehicles. Vehicles road-worthiness is a concern in Africa, although it account for a smaller percentage of accidents, between 5% and 6% of total road accidents as the sole contributing factor (Odero et al., 2003). However, combine with other factors, human and road and vehicles are involved in more than 10% of all road accident (Schoor et al., 2001).

Given the present economic condition and lack of car manufacturers in this region, many African countries import older second hand vehicles. Lack of regulation and inspections at boarder entry point, imported vehicle may have varying road worthiness in the first place. This is furthered by the lack of maintenance, in terms of neglect and replacement using low quality substitute, especially for safety components, such as tires and brakes. This issue may not be improved without economic recovery coupled with policy initiative to control, import and regulate fleets on public roads. Road infrastructure is another category of factors that contribute to road accident in African countries. Although bad roads account for less than 5% of the causes that contribute to road accident in Africa countries (Baguley and Jacobs 1999), the consequence in human and economic terms could be equally devastating.

Specific factors include potholes and sharp-slip bends (Oduro et al., 2003). A number of reasons has been advance as explanations for current road conditions in the African context. Imported by war political instability and economic stagnation, roads in many African countries are often badly maintained. More often they are not being considered in the design of new high ways nor was safety not being considered as priorities in highway. Maintenance not being cited as the key contributing factors in majorities of road accident, unsafe road in combination with human error and vehicle malfunction does in fact increase the frequency and severity of road accidents, injuries and fatalities (Baguley and Jacobs, 1999).

Road accident regression analysis can be used at three different levels. At the macro or national level it can be used to help government formulate road safety policies e.g. compulsory belt wearing or motor cycle helmet wearing. At a regional level it can be researched to help regional authorities make appropriate decisions regarding road safety e.g. on local police campaigns on deink-driving, child safety education. The most beneficial use of road accident data is at the local macro level where the Poisson regression analysis can be used by local engineers to determine problems areas on their network and indeed, can be used in the identification of accident-prone areas on their network and indeed, can be used in the identification of accident- phone areas.

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2.2. Modelling Variation of Accident Frequencies

2.2.1 Statistical Models

A number of statistical model have been used to estimate accident rate and /or accident frequencies at a specific location over a given interval of time (Geurts and Wets, 2003). Some have used simple model using mean and variance to study variations in accident rates for different levels of exposure. These models are not able to incorporate the effect of risk factors on accident involvement. Multiple regression models were also used where the dependent variable (either number of accidents or accident rate) is a function of a series of independent variables such as speed or traffic volume. Many other persons might have seen the need to use time series (ARIMA models) regression models to try to find the possibility of identifying independent variables of accident cases.

Poisson regression analysis is a technique which allows to model dependent variables that describe count. It is often applied to study the occurrence of small number of counts or events as a function of a set of predictor variables, in experimental and observational study in many disciplines, including Economy, Demography, Psychology, Biology and Medicine. The Poisson regression model may be used as an alternative to the Cox model for survival analysis, when hazard rates are approximately constant during the observation period and the risk of the event under study is small. Poisson regression model usually replaces Cox model, which cannot be easily applied to aggregated data. Poisson regression model has often been applied to estimate standardized mortality and incidence ratios in cohort studies and in ecological investigations. Finally, some variants of the Poisson regression model have been proposed to take into account the extra-variability (over dispersion) observed in actual data, mainly due to the presence of spatial clusters or other sources of autocorrelation. Details of the Poisson regression model are found in the next chapter of this work.

2.2.2. Risk Factors

Risk factors are used to explain accident involvement and accident severity. Risk factors in road accident models play two roles (Nassar, 1996). Improve overall model fit and reduce the amount of unexplained variation. Care must be taken that these models are not over-specified. The following risk factors have been elaborately adopted in the literature for explaining factors can be found in Nassar (1996):

(i) Course of the accidents: vehicle maneuver, driver action

(ii) Traffic conditions: traffic volume, dynamics, speed regulation

(iii) Environmental conditions: light condition, road surface condition, road geometry

(iv) Human conditions: driver age, occupant age, driver sex, driver condition(alcohol, fatigue, illness), seating position, sear belt use

(v) Vehicle conditions: vehicle mass, vehicle size and road worthiness

In (Geurts and Wets, 2003) an association algorithm is used to identify accident factors that frequently occur together at high frequency accident locations. Furthermore, these patterns are anal used and compared with frequently occurring accident characteristics at low frequency accident locations. The strength of this approach lies within the identification of relevant variable that make a strong

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contribution towards a better understanding of accident circumstance and the discerning of descriptive accident patrons from more discriminating accident circumstances to profile black spots and black zones. In general, risk factors related to traffic and road section characteristics were found to be essential in analyzing accident injury severity. Risk factors such as accident dynamics/ speed, seat belt used, and occupant age could be most important in explaining accident severity.

Recently, identification of black zones has been considered in the literature, as arising from the awareness of the evident spatial interaction existing between contiguous accident locations. The existence of black zones reveals concentrations and hence may suggest spatial dependence between individual occurrences. Spatial concentrations may be due to one or several common causes (s). The following review is described in more details in The most appropriate level of spatial aggregation for road accidents is the road section, but in most studies its length is not justified and not controlled (Geurts and Wets, 2003). No clear indication exists of what the best length of a dangerous road segment should be, nor or whether an optimal length can be defined (Geurts and Wets, 2003).

According to (Geurts and Wets, 2003), Deacon et al., (1975) mde a distinction between 'short' and 'large' highway segments, respectively called spots and sections. The lengths are chosen in order to limit the heterogeneity within each road segment, but the authors recommend the use of a constant length because the interpretation of accident data would be more complicated for sections of variable length.

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Okamoto and Koshi (1989 as quoted by (Geurts and Wets, 2003)) proposed seven ways of defining road segments: some are based on fixed lengths are other on variable length.

Michelle and Michael (2011) cited Stern and Zehavi (1990) as also dividing the road studied into 1-kkm-long sections, without any particular justification for this length.

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In Flahaut et al., (2002), as cited by (Geurts and Wets, 2003), the concept of black zone is used to tackle the problem of the length as well as the location of road sections, taking into account the contiguity structure of the basic individual spatial units. A black zone is here defined as a set of contiguous of the basic individual spatial units taken together and characterized by a high number of accidents, or which countermeasure should be taken to reduce their number. The research focused on an exploratory spatial data analysis problem: defining the location and the length of black zones. Two methods are compared: the use of local spatial autocorrelation indices (a decomposition of the global Moran index) and generate a smoothing of the empirical process. Although each method starts from different conceptual approaches, both may provide quit similar results under a specific choice of parameters and lead to a definition of non-contiguous black zones.

Vistisen (2002), as cited by (Geurts and Wets, 2003), pointed out that Poisson-gamma hierarchical generalized linear models better describe the variation in accident counts on the Danish roads and accordingly provide better estimates of site safety than the models currently at use in Denmark. The proposed accident models are disaggregated on time periods of one year, which assures that yearly changes in traffic as well as in other traits may be accounted for. In these models not only general trends in accident represent the site-specific conditions not included, but also the so-called dispersion effects. These effects represent the site-specific conditions not included as traits in the model. In addition, a dispersion effect models interdependence between yearly accident counts at the same location. Since this dispersion effect expresses who the expected accident frequency at a location deviates from the expected accident frequency at locations with similar traits, it may be used for targeting black spots in the road network. In general, this results in a marginally higher sensitivity than the method used on the Danish road network today.

Vistisen (2002) proposed a new method for estimating the effect of hot spot treatment work. The model is based on the site safety estimates provided by the accident models, and takes into account the regression to the mean effect as well as changes in traffic flow and other traits. The proposed method is found to give better estimates of the effect of treatment than the method currently used in Denmark. In addition, the authors claimed that it outperforms the methods as yet suggested in the international literature. The improve estimates of treatment effect will improve the foundation for prioritizing of black spots and safety measures.

For over a decade, the Federal Government of Australia has operated programs to improve the physical condition or management of hazardous locations with a history of crashes involving death or serious injury. This evaluation relates to the Capital

Funding for Black Spots Roads Programme, more generally known as the Federal Road Safety Black Spot Program, which commenced in 1996-97 and is scheduled to concluded in 2001 -02.

In total, 983 black spot projects had been implemented under the Program as at 30 June 1999. The Australian Transport Safety Bureau (2001) administered the Program. A sample of 608 black spot project around Australia undertaken between 1 July 1996 and 30 June 1999 was analyzed. The total cost of these projects was approximately $59.5 million. The study adopted a before and after treatment approach. This methodology was chosen because to its compatibility with the nature of the data available for analysis. The evaluation compared the number and severity of crashes that would have been expected with no treatment. The expected crash history was estimated using the actual crash history of the black spots after before treatment and data on other variables expected to affect crashes at black spots after treatment. A Poisson regression model was used to determine whether black spots treatment had a statistically significant effect. Overall, the evaluation provides very strong evidence that the Program achieved its aim of improving safety at locations with a history of crashes involving death or serious injury. Nevertheless, the Program was not uniformly effective in reducing the number of casualty crashes. Not all road engineering treatments had a statistically significant effect to accrue over the life of the black spot treatment that was applied.

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2.3 Summary

In this chapter, adequate and relevant literature on accidents, Poisson and linear models were presented. In the next chapter, we shall put forward the research methodology.

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CHAPTER THREE

RESEARCH METHODOLOGY

3.0 INTRODUCTION

This presents the theoretical approach to the tools and procedures used in the analyzing the data obtained for the study. Properties and procedures of the Poisson regressive analysis and regression, in general, shall be reviewed under the following sections.

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3.1 Regressive Model

The difference between data generated for regression and that for time series is; while in regression, data on variables are collected without considering time, those for time series are collected with time as an independent variable. In many statistical works, data are collected on two or more variables. At times the researcher would want to study the inter-relation between the variables, in other words, a particular variable made of interest and the remaining ones are measured on the degree of relation with the first. A typical regressive model includes:

The responds (variable): it is also called the variable of interest normally denoted by y. It is the variable whose dependency is tested on others and so, called the dependent variable.

The Independent variable: These are variable on which the responds variable depends. They are denoted normally by x_i.

The Error term (ε): this represents a random deviation of the typical responds variable from the mean responds. In other words, it's the difference between the actual responds value and the predictor responds values. Lists of errors are also called the residuals.

3.1.1 *Estimation of Regression Coefficients*

Given a simple linear regression model, $y = \beta_o + \beta_1 x_1 + \varepsilon$, the expected value for the dependent variable is $E(y) = \hat{y} = \beta_0 + \beta_i x_i$. To estimate β_0 *and* β_1, which are the regression coefficient, the least square method is used.

<u>The Method of Least Squares:</u> This method is used to estimate the parameters by choosing β_0 *and* β_1 so as to minimize the total sum of square error

$$\sum_{i=1}^{n} \varepsilon^2 = \sum_{i=1}^{n} (y_i - \beta_o - \beta_1 x_i)^2$$

The use of the principle becomes valid if the response variance $Var(y_i) = \sigma^2$ for all x_i, that is we choose β_o, β_1 so as to minimize the sum of squares error.

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To minimize β_o, β_1, we take the partial derivative, so

$$\frac{\partial}{\partial \beta_o} \sum_{i=1}^{n} \varepsilon^2 = \frac{\partial}{\partial \beta_o} \sum_{i=1}^{n} (y_i - \beta_o - \beta_1 x_i)^2 = -2\sum_{i=1}^{n} (y_i - \hat{\beta}_o - \hat{\beta}_1 x_i) = 0 \qquad (3.1)$$

$$\frac{\partial}{\partial \beta_1} \sum_{i=1}^{n} \varepsilon^2 = \frac{\partial}{\partial \beta_1} \sum_{i=1}^{n} (y_i - \beta_o - \beta_1 x_i)^2 = -2\sum_{i=1}^{n} (y_i - \hat{\beta}_o - \hat{\beta}_1 x_i)x_i = 0 \qquad (3.2)$$

From equations (3.1) and (3.2), we have the following:

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$$\sum_{i=1}^{n} y_i = n\hat{\beta}_o + \hat{\beta}_1 x_i \qquad (3.3)$$

$$\sum_{i=1}^{n} x_i y_i = \hat{\beta}_o \sum_{i=1}^{n} x_i + \hat{\beta}_1 \sum_{i=1}^{n} x_i^2 \qquad (3.4)$$

The equations (3.3) and (3.4) are called normal equations. In the matrix notation, the two becomes

$$\begin{pmatrix} \sum_{i=1}^{n} y_i \\ \sum_{i=1}^{n} x_i y_i \end{pmatrix} = \begin{pmatrix} n & \sum_{i=1}^{n} x_i \\ \sum_{i=1}^{n} y_i & \sum_{i=1}^{n} x_i^2 \end{pmatrix} \begin{pmatrix} \hat{\beta}_o \\ \hat{\beta}_1 \end{pmatrix}$$

From this we obtain the estimates

$$\hat{\beta}_o = \frac{1}{n}\sum_{i=1}^{n} y_i - \beta_1 \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$= \bar{y} - \beta_0 \bar{x}$$

$$\therefore \hat{\beta}_o = \bar{y} - \hat{\beta}_0 \bar{x} \qquad (3.5)$$

$$\hat{\beta}_1 = \frac{\sum_{i=1}^{n} x_i y_i - \frac{\left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right)}{n}}{\sum_{i=1}^{n} x_i^2 - \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n}} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} = \frac{SS_{XY}}{SS_{XX}} = \frac{cov(x, y)}{s_x^2} \qquad (3.6)$$

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Hence the regression model, $\hat{y} = \beta_o + \beta_1 x + \varepsilon$ is fitted. Note that if the data were collected with time as the independent variable, then the model becomes,

$$\hat{y} = \beta_o + \beta_1 t + \varepsilon(residual) \qquad (3.7)$$

The error term or the residual, ε in equation 3.7 above, needs to satisfy certain condition for the regression model to be deemed to be fit for prediction. These conditions are;

(i) The residuals must be normally distributed.

(ii) The mean of the error distribution must be close to 0; that is $E(\varepsilon) = 0$

(iii)The variance σ^2 of the residual should be constant regardless of the value of x .

(iv)The errors are independent of each other.

3.2 Autoregressive Model

Autoregressive occur whenever the errors (residuals) are not independent of each other; which means there is a strong correlation between consecutive residuals. When this occurs, the model may not be accurate for use in predicting future values, using time as the independent variable. However, autocorrelation also provides the opportunity to develop another forecast model. If there is no obvious trend or seasonality and it is believed that there is a correlation between consecutive residuals, the autoregressive model below becomes most effective.

$$y_t = \beta_o + \beta_1 y_{t-1} + \varepsilon$$

3.3 Poisson Regressive Model

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In statistics, Poisson regression is a form of regression analysis used to model count data and contingency tables. Poisson regression assumes the response variable Y has a Poisson distribution, and assumes the logarithm of its expected value can be modeled by a linear combination of unknown parameters. A Poisson regression model is sometimes known as a log-linear model, especially when used to model contingency tables. Poisson regression models are generalized linear models with the logarithm as the (canonical) link function, and the Poisson distribution function.

3.3.1 Assumption of Poisson Regression

(i) Poisson regression is used to model count variables with the assumption that the conditional means equal the conditional variances.

(ii) Poisson regression - It has a very strong assumption that is the conditional variance equals conditional mean. Data appropriate for Poisson regression do not happen very often. Nevertheless, Poisson regression is often used as a starting point for modeling count data and Poisson regression has many extensions.

3.3.2 *Regression Models*

If $x \in R^n$ is a vector of independent variables, then the model takes the form

$$\log(E(Y|x)) = a'x + b,$$

Where $a \in R^n$ and $b \in R^n$. Sometimes this is written more compactly as

$$\log(E(Y|x)) = \theta'x,$$

where x is an $(n+1)$ - dimensional vector consisting of n independent variables concatenated to some constant, usually 1. Here θ is simply a concatenated to b. Thus, when given a Poisson regression model θ and an input vector x, the predicted mean of the associated Poisson distribution is given by

$$E(Y|x) = e^{\theta' x},$$

If x_i are independent observations with corresponding values Y of the predictor variable, then θ can be estimated by maximum likelihood. The maximum-likelihood estimates lack a closed-form expression and must be found by numerical methods. The probability surface for maximum-likelihood Poisson regression is always convex, making Newton-Raphson or other gradient-based methods appropriate estimation techniques.

3.3.3 *Maximum likelihood – based parameter estimation*

Given a set of parameters θ and an input vector x, the mean of the predicted Poisson distribution, as stated above, is given by

$$E(Y|x) = e^{\theta' x}$$

and thus, the Poisson distribution's probability mass function is given by

$$p(y|x;\theta) = \frac{e^{y(\theta' x)}e^{-e^{\theta' x}}}{y!}$$

Now suppose we are given a data set consisting of m vectors $x_i \in R^{n+1}, i = 1,2,3,\dots,m$, along with a set of m values $y_1, y_2, y_3, \dots, y_m \in R$. Then, for a given set of parameters θ, the probability of attaining this particular set of data is given by

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$$p(y_1,\dots,y_m|x_1,\dots,x_m;\theta) = \prod_{i=1}^{m} \frac{e^{y_i(\theta' x_i)}e^{-e^{\theta' x_i}}}{y_i!}$$

By the method of maximum likelihood, we wish to find the set of parameters θ that makes this probability as large as possible. To do this, the equation is first rewritten as a likelihood in terms of θ:

$$L(\theta|X,Y) = \prod_{i=1}^{m} \frac{e^{y_i(\theta' x_i)}e^{-e^{\theta' x_i}}}{y_i!}$$

Note that the expression on the right hand side has not actually changed. A formula in this form is typically difficult to work with; instead, one uses the *log-likelihood*:

$$l(\theta|X,Y) = logL(\theta|X,Y) = \sum_{i=1}^{m} (y_i(\theta' x_i) - e^{\theta' x_i} - \log(y_i!))$$

Notice that the parameters θ only appear in the first two terms of each term in the summation. Therefore, given that we are only interested in finding the best value for θ we may drop the $y_i!$ and simply write

$$l(\theta|X,Y) = \sum_{i=1}^{m} (y_i(\theta' x_i) - e^{\theta' x_i})$$

To find a maximum, we need to solve an equation

$$\frac{\delta l(\theta|X,Y)}{\delta\theta} = 0,$$

which has no closed-form solution. However, the negative log-likelihood, $-l(\theta|X,Y)$ is a convex function, and so standard convex optimization or gradient descent techniques can be applied to find the optimal value of θ.

3.3.4 Over-dispersion

A characteristic of the Poisson distribution is that its mean is equal to its variance. In certain circumstances, it will be found that the observed variance is greater than the mean; this is known as over-dispersion and indicates that the model is not appropriate. A common reason is the omission of relevant explanatory variables, or dependent observations. Under some circumstances, the problem of over dispersion can be solved by using a negative binomial distribution instead.

Another common problem with Poisson regression is excess zeros: if there are two processes at work, one determining whether there are zero events or any events, and a

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Poisson process determining how many events there are, there will be more zeros than a Poisson regression would predict. An example would be the distribution of cigarettes smoked in an hour by members of a group where some individuals are non-smokers. Other generalized linear models such as the negative binomial model may function better in these cases.

3.4 Summary

This chapter considered the research methodology of the study. In the next chapter, we shall put forward the data collection and analysis of the study.

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CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.0 Introduction

This chapter presents the data obtained and the analyses of the data. The original data were subjected to Statistical Package for Social Sciences (SPSS) and Microsoft Excel analyses, outputs generated and results interpreted statistically. The analyses of data were done in two parts; the preliminary analysis, where data descriptive features were found; and the further analysis, where the Poisson regression analytical methods were followed for interpretation.

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4.1 Preliminary Analysis

Under this section the raw annual accident cases together with some descriptive data features were provided for initial assumption to be made concerning the accident cases, the number of vehicles involve, fatal cases, serious cases and minor cases. The rest of the variables are; the number killed, number injured, driver causes, vehicle causes, road causes and pedestrian causes. The presentation was a comparative analysis from 2006 through to 2010.

4.1.1 Comparative Analysis of Accident Cases

The research seeks to perform simple comparative analysis of the data obtained for accident cases from 2006 to 2010. This would provide insight into the trend of cases and year that have had the worst case, as well as the year with relatively low cases over the twelfth-month period within a year.

Table 4.1: Annual Accident Case

Month	2006	2007	2008	2009	2010	Mean
January	48	52	37	42	61	48
February	37	29	24	34	48	34
March	26	38	26	37	54	36
April	43	49	20	52	56	44
May	51	55	34	50	68	52
June	42	61	42	34	71	50
July	36	63	39	42	60	48
August	38	59	31	33	66	45
September	27	28	19	26	52	30
October	18	32	25	23	55	31
November	14	45	22	13	37	26
December	20	53	36	62	62	47
Total	400	564	355	448	690	
Mean	33.3	47.0	29.6	37.3	57.5	
Variance	147.2	156.4	62.4	181.3	87.7	

The floating means and variances suggest that there hasn't been any definite trend associated with this time series; it therefore, as it stands, not provide any reliable forecast values when modelled with raw figures. Table 4.1 shows that 2010 recorded the highest mean cases of accident (with relatively low variance) over the period under study. It could generally be seen that accident cases has not been declining with year, while January, May, June, July and December appear to record more cases.

4.1.2 Comparative Analysis of Number of Vehicles Involved in Accident Cases

The number of vehicles involved in accidents may be a contributing factor to determining the casualty and/or injury cases. This section also seeks to compare yearly and monthly cases with respect to the number of vehicle involve in accidents as shown in Table 4.2.

Table 4.2: Number of Vehicles Involved in Accident

Month	2006	2007	2008	2009	2010	Mean
January	56	73	49	47	78	61
February	43	33	27	39	57	40
March	34	56	30	42	73	47
April	53	70	25	58	80	57
May	70	69	46	57	103	69
June	47	78	50	38	98	62
July	46	95	45	49	88	65
August	51	81	37	38	93	60
September	32	49	25	30	74	42
October	25	34	28	28	73	38
November	17	51	27	16	59	34
December	31	70	51	14	89	51
Total	505	759	440	456	965	
Mean	42.08	63.25	36.67	38.00	80.42	
Variance	220.27	357.84	115.52	200.36	206.63	

The means and variances are unstable and not uniform; hence one cannot determine a predictable trend. This notwithstanding, could be seen that 2010, no doubt, has recorded more vehicle involvement than other years. This shows that number of vehicles involved in accident might be a significant factor in determining the number of reported cases of accident.

4.1.3 Comparative Analysis of Fatality Cases

Fatality rate has over the years been the prime concern of authorities and stakeholders in road traffic sector; and in fact, the general public. Reducing accidents also mean that the fear of losing the manpower needs of the country would be allayed.

Table 4.3: Fatality Cases

Month	2006	2007	2008	2009	2010	Mean
January	10	9	10	10	9	10
February	9	6	5	6	5	6
March	5	5	6	7	7	6
April	9	8	3	13	8	8
May	16	11	9	11	16	13
June	11	7	6	7	13	9
July	6	8	4	6	9	7
August	12	5	3	4	8	6
September	4	2	5	2	7	4
October	4	3	2	6	8	5
November	2	5	1	4	7	4
December	4	13	10	8	12	9
Total	92	82	64	84	109	
Mean	7.7	6.8	5.3	7.0	9.1	
Variance	17.3	10.2	9.2	9.8	9.5	

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The fatality level is also a deduction from the previous two indicators. This shows that number of vehicles involved in accident might be a significant factor in determining the number of reported cases of accident hence high fatality rates, especially in 2010.

4.1.4 *Comparative Analysis of Serious Accident Cases*

Serious cases could be those accidents cases that lead to serious incapacitation of victims thereby rendering the individual, and for that matter the nation, of certain level of activity in critical sectors of the economy.

Table 4.4: Serious Accident Cases

Month	2006	2007	2008	2009	2010	Mean
January	16	19	11	19	30	19
February	10	13	8	15	22	14
March	12	10	8	18	25	15
April	14	17	6	20	18	15
May	18	20	13	18	29	20
June	12	18	16	15	31	18
July	15	21	12	22	23	19
August	17	16	15	13	30	18
September	9	11	6	10	19	11
October	5	6	10	11	19	10
November	1	19	9	3	14	9
December	4	26	13	10	23	15
Total	133	196	127	174	283	
Mean	11.1	16.3	10.6	14.5	23.6	
Variance	29.7	30.2	11.0	29.0	30.6	

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Table 4.4 shows that, the more accidents are recorded, the more cases of "serious" ones we would have on our hands to deal with. This obviously would drain portions of the purse of the individuals, families and the nation as a whole, since serious accidents requires more money to cater for disabilities and losses.

4.1.5 Comparative Analysis of Minor Accident Cases

Minor cases might be described by many as "lucky ones" but may not be well with that too.

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Table 4.5: Minor Accident Cases

Month	2006	2007	2008	2009	2010	Mean
January	22	24	16	12	22	19
February	18	10	11	13	21	15
March	9	23	12	12	22	16
April	20	24	11	19	30	21
May	17	24	12	21	23	19
June	19	36	20	12	27	23
July	8	34	23	14	28	21
August	13	38	13	16	28	22
September	14	15	8	14	26	15
October	9	23	13	6	28	16
November	9	21	12	6	16	13
December	12	31	13	10	27	19
Total	170	303	164	155	298	
Mean	14.2	25.3	13.7	12.9	24.8	
Variance	24.2	68.9	17.2	20.1	16.3	

From Table 4.5, it can be seen that 2007 and 2010 appear to have recorded the highest mean minor accident cases.

4.1.6 *Comparative Analysis of Number of Persons Killed*

This section presents actual number of persons killed in the cases presented above.

Table 4.6: Number of Persons Killed

Month	2006	2007	2008	2009	2010	Mean
January	21	14	14	11	12	14
February	19	9	9	14	8	12
March	13	6	10	9	57	19
April	13	10	6	8	20	11
May	17	11	14	10	29	16
June	7	15	10	6	28	13
July	8	14	8	7	14	10
August	13	13	8	9	17	12
September	7	15	8	3	8	8
October	6	9	5	6	16	8
November	2	4	4	3	12	5
December	4	15	16	7	21	13

Total	130	135	112	93	242
Mean	10.8	11.3	9.3	7.8	20.2
Variance	37.1	13.8	13.9	10.0	181.1

Table 4.6, together with those seen earlier have suggested that 2008 and 2009, were years that recorded least cases of accident and its accompanying deaths. Could it be that some measures were put in place then? Or was it as a result of low/reduction in residual causes.

4.1.7 Comparative Analysis of Number of Persons Injured

Injury cases over the periods under study are also presented below. When injuries are high, the possibility of losing parts of the body and resultant pains would also be high.

Table 4.7: Number of Persons Injured

Month	2006	2007	2008	2009	2010	Mean
January	54	48	51	31	77	52
February	47	32	39	24	50	38
March	48	53	33	23	59	43
April	39	52	41	40	63	47
May	53	64	52	37	93	60
June	39	80	55	47	90	62
July	71	78	38	35	64	57
August	50	83	40	28	61	52
September	44	45	24	29	56	40
October	24	48	32	23	57	37
November	13	57	35	27	45	35
December	19	87	46	29	83	53
Total	501	727	486	373	798	
Mean	41.8	60.6	40.5	31.1	66.5	
Variance	267.8	310.3	83.9	54.4	243.4	

From Table 4.7, it can be seen that, the mean numbers of injuries are relatively higher than those other numbers found under previous section.

4.1.8 Comparative Analysis of Driver Causes

Causes of accident are arguably the most aspect of road accident that would trigger solutions and policies. When we know the major causes of accidents, then we are one step up to solving he canker. This section, and the next three, presents data on the cases of accidents, recorded over the periods under study, with respect to the various causes; driver cause is presented in Table 4.8.

Table 4.8: Driver Caused Cases

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Month	2006	2007	2008	2009	2010	Mean
January	19	25	14	15	23	19
February	16	9	10	17	18	14
March	12	17	20	10	24	17
April	20	25	7	22	20	19
May	26	30	28	25	28	27
June	12	21	20	16	30	20
July	10	33	19	12	27	20
August	12	29	17	10	36	21
September	17	14	11	14	20	15
October	5	17	5	13	25	13
November	7	21	3	5	17	11
December	14	29	14	17	30	21
Total	170	270	168	176	298	
Mean	14.2	22.5	14.0	14.7	24.8	
Variance	34.2	53.0	52.5	29.2	32.0	

2007 and 2010 appears to ~~record the~~ highest mean numbers for driver causes with 2006, 2008 and 2009 recording close to equal numbers for driver causes. This might be suggesting that driver causes appear to be paramount or constant throughout the period under study.

4.1.9 Comparative Analysis of Vehicle Causes

Next to driver causes is vehicle causes.

Table 4.9: Vehicle Caused Cases

Month	2006	2007	2008	2009	2010	Mean
January	15	17	13	12	14	14
February	12	11	7	10	10	10
March	10	12	6	14	11	11
April	12	12	7	15	18	13
May	14	6	5	10	19	11
June	20	30	12	7	20	18
July	15	16	11	20	17	16
August	14	20	9	17	14	15
September	6	6	5	8	15	8
October	9	8	18	6	14	11
November	4	11	7	6	9	7
December	3	19	16	10	15	13
Total	134	168	116	135	176	
Mean	11.2	14.0	9.7	11.3	14.7	
Variance	25.1	47.3	18.8	20.0	12.1	

Table 4.9 seems to suggest that driver causes and vehicle causes are related. More so, the mean numbers for driver causes are greater than those for vehicle causes, which make vehicle-causes the next causative factor after driver causes.

4.1.10 Comparative Analysis of Road Causes

Road causes cannot also be overlooked in our quest to have reduction in accident cases in the country.

Table 4.10: Road Caused Cases

Month	2006	2007	2008	2009	2010	Mean
January	10	10	5	13	18	11
February	9	6	3	5	15	8
March	3	7	0	13	12	7
April	10	9	5	14	13	10
May	11	15	1	13	12	10
June	7	10	7	10	16	10
July	11	14	9	8	10	10
August	10	9	4	5	8	7
September	4	6	3	3	10	5
October	2	6	1	3	9	4
November	3	9	10	2	6	6
December	2	2	5	0	11	4
Total	82	103	53	89	140	
Mean	6.8	8.6	4.4	7.4	11.7	
Variance	14.0	12.8	9.7	25.4	11.9	

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From Table 4.10, it can be seen that road causes appear to be the next causative factor after vehicle. It could also be seen that the road factor does not related to driver or vehicle factors, since the means of the values of the three factors differ greatly.

4.1.11 Comparative Analysis of Pedestrian Causes

The negligence of some pedestrians could also result in road accidents leading to deaths, injuries (whether minor or severe).

Table 4.11: Pedestrian Caused Cases

Month	2006	2007	2008	2009	2010	Mean
January	4	0	5	2	6	3
February	0	3	4	2	5	3
March	1	2	0	0	7	2
April	1	3	1	1	5	2
May	0	4	0	2	9	3
June	3	0	3	1	5	2
July	0	0	0	2	6	2
August	2	1	1	1	8	3
September	0	2	0	1	7	2

October	2	1	1	1	7	2
November	0	4	2	0	5	2
December	1	3	1	1	6	2
Total	14	23	18	14	76	
Mean	1.2	1.9	1.5	1.2	6.3	
Variance	1.8	2.3	2.8	0.5	1.7	

From Table 4.11, it is obvious that pedestrian causes are among the least among all the factors that cause road traffic accidents, since the pedestrian factor produced the least values.

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4.2 Further Analyses

This research focuses on the application of the Ordinary Least Squares and Poisson Regression analyses to fit model(s) that might be existing between the variables being studied here. The two models are used whenever possible. Data collected for this research are count data on cases of accidents in the Ho municipality. Poisson distributed data is intrinsically integer-valued, which makes sense for count data. Ordinary Least Squares (OLS, which you call "linear regression") also assumes that true values are normally distributed around the expected value and can take any real value, positive or negative, integer or fractional, whatever. Poisson distribution and regression assume that the mean and the variance are equal, while OLS can deal with unequal means and variances. Thus, a Poisson Regression model would be useful when;

(i) The data are counts,

(ii) The data are non normal,

(iii)The mean is assumed to be equal to the variance (very rare cases).

All data collected are already count; the following table provides values for the mean and variances for the indicators that affect accident cases, as well as their skewness, which tells of the normality of the data. Values in Table 4.12 would provide clue to the authenticity of the modeling tools used, hence paving way for using the models or improving the models for future use in tracking and managing accidents cases to reduce its accompanying negative effects. The values were obtained from performing a simple descriptive statistics using the Microsoft Excel software.

Table 4.12: Mean, Variance and Skewness of Data

Indicator	*Skewness*	*Mean*	*Variance*	*Remark*
Number of Vehicles	0.4	52	503	Not normal
Fatal Accidents	0.5	7	12	Not normal
Serious Accidents	0.3	12	47	Not very normal
Minor Accidents	0.6	18	60	Not normal
Number Killed	3.0	12	67	Not normal
Number Injured	0.6	48	358	Not normal
Driver Causes	0.2	18	60	Quite normal
Vehicle Causes	0.6	12	27	Not normal
Road Causes	0.1	8	19	Quite normal
Pedestrian Causes	1.0	2	6	Not normal

4.2.1 *Regression Model for Accident Cases and Effects*

Here the researcher seeks to establish a model that explains the contribution a type of accident (fatal, serious or minor) on the cases reported within the period. The analysis would be done in two parts; first using ordinary least squares regression model, and secondly using the Poisson regression model to determine the rate of accident considering these indicators.

Table 4.13: Regression Model for Accident Cases and Effects

Regression Statistics	
Multiple R	0.94
R Square	0.89
Adjusted R Square	0.89
Standard Error	5.02
Observations	60.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3.00	11705.53	3901.84	155.04	0.00
Residual	56.00	1409.32	25.17		
Total	59.00	13114.85			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.50	1.89	1.86	0.07	-0.28	7.28
Fatality	1.03	0.24	4.22	0.00	0.54	1.52
Serious	0.94	0.15	6.42	0.00	0.65	1.24
Minor	0.86	0.11	7.99	0.00	0.65	1.08

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Table 4.13 suggests that, the effects of accident cases in the municipality over the five year period cuts across fatality, serious and minor. This means that all the three categories have claimed significant proportion of the cases reported within the period. This is why all the p – values for the coefficients are 0.00. The value for the coefficients, 1.03, 0.94 and 0.86 are very close to 1, meaning there almost equally share the accident cases in the municipality. By this result, we cannot say that only one category of accident type is the case in the region. There have been fatal accidents as well as serious ones, as is the case is for minor ones. This is why accident cases should be declared a canker and stringent measures be put in place to forestall the menace.

If we let f represent fatal accident cases, S, serious ones, and m, minor, then the regression model is;

$$Accident\ Cases = 3.50 + 1.03f + 0.94S + 0.86m$$

The Poisson regression model is now;

$$\log(Accident\ Cases) = 3.50 + 1.03f + 0.94S + 0.86m$$

$$\therefore Accident\ Cases = e^{3.50} \times e^{1.03}f \times e^{0.94}S \times e^{0.86}m$$

The degree of fatality of accident cases = $33.12 \times 2.80 = 92.77\%$

The degree of serious accident cases = $33.12 \times 2.56 = 84.79\%$

The degree of minor accident cases = $33.12 \times 2.36 = 78.27\%$

The degree of accident cases seeks to suggest that, when the present incidences of accidents are not checked, then going forward, there is likely to be a 92.77% chance of having fatal accidents cases, 84% of having serious accident cases and 78.27% change of having minor accident cases.

4.2.2 *Regression Model for Persons Killed and Effects*

The obvious outcome of having continuous fatality cases is the increase in the number of persons killed. It is important to note that whichever type of accident have the potential of killing a person. The rate however would be higher whenever the accident is declared fatal.

Table 4.14: Regression Model for Persons Killed and Effects

Regression Statistics	
Multiple R	0.58
R Square	0.34
Adjusted R Square	0.30
Standard Error	6.84
Observations	60.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3.00	1322.40	440.80	9.43	0.00
Residual	56.00	2616.54	46.72		
Total	59.00	3938.93			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.08	2.57	-0.03	0.98	-5.22	5.07
Fatality	0.46	0.33	1.39	0.17	-0.20	1.13
Serious	0.44	0.20	2.21	0.03	0.04	0.84
Minor	0.10	0.15	0.71	0.48	-0.19	0.40

From Table 4.14, the multiple R value of 0.58 shows that the independent variables; fatality, serious and minor type of accidents do have some relation with the number of persons killed over the years. However, these only accounts for about 30% of the reasons why people die during accidents. Additionally, the coefficients of the regression, 0.46, 0.44 and 0.10; for fatality, serious and minor respectively, also suggests that the number of people killed increases when fatality increases, serious accidents also increasing and minor ones too increasing.

The regression model is;

$$Persons\ Killed = -0.08 + 0.46f + 0.44S + 0.10m$$

The Poisson regression model is now;

$$\log(Persons\ Killed) = -0.08 + 0.46f + 0.44S + 0.10m$$

$$\therefore Persons\ KIlled = e^{-0.08} \times e^{0.46}f \times e^{0.44}S \times e^{0.10}m$$

The degree of Persons killed when accident is fatal = $0.92 \times 1.58 = 1.46\%$

The degree of Persons killed when accident is serious = $0.92 \times 1.55 = 1.43\%$

The degree of Persons killed when accident is minor = $0.92 \times 1.11 = 1.02\%$

The degrees show number of persons killed increases by 1.46% whenever the accidents type is fatal. The number of persons killed also increases by 1.43% whenever the accident type is serious. At this point, it is worth mentioning that the numbers increases much more whenever the accident type is both fatal and serious. Minor accident types are also likely to increase number of persons killed by 1.02%.

4.2.3 *Regression Model for Persons Injured and Effects*

The degrees of injuries would also be needed when the accident type is fatal, serious or minor. The regression model and the subsequent Poisson model are below.

Table 4.15: Regression Model for Persons Injured and Effects

Regression Statistics	
Multiple R	0.83
R Square	0.69
Adjusted R Square	0.67
Standard Error	10.84
Observations	60.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3.00	14564.23	4854.74	41.33	0.00
Residual	56.00	6578.35	117.47		
Total	59.00	21142.58			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.54	4.07	1.60	0.11	-1.63	14.70
Fatality	0.74	0.53	1.41	0.16	-0.31	1.80
Seriousness	0.87	0.32	2.74	0.01	0.23	1.50
Minor	1.27	0.23	5.42	0.00	0.80	1.73

From Table 4.15, the multiple R value, 0.83, is high indicating that fatal accidents, serious and minor accidents have great potential of causing high numbers of injuries during accidents. The adjusted R suggests that 67% of accident cases (fatal, serious or minor) are likely to result in high injuries.

The regression model is;

$$Persons\ Injured = 6.54 + 0.74f + 0.87S + 1.27m$$

The Poisson regression model is now;

$$\log(Persons\ Injured) = 6.54 + 0.74f + 0.87S + 1.27m$$

$$\therefore Persons\ Injured = e^{6.54} \times e^{0.74}f \times e^{0.87}S \times e^{1.27}m$$

The degree of Persons Injured when accident is fatal = $692.29 \times 2.10 = 1451.0\%$

The degree of Persons Injured when accident is serious = $692.29 \times 2.39 = 1652.4\%$

The degree of Persons Injured when accident is minor = $692.29 \times 3.56 = 2465.1\%$

The values have shown that the degree of injuries become extremely high when accidents occur. That is, there is very high probability of having people injured when accidents occur, and it does not matter which type of accident that occur; even if the accident type is rated minor its degree or probability is very high.

4.2.4 *Regression Model for Persons Killed and Number of Vehicles Involved*

It is common sense to deduce that the number of persons killed in any accident would be mathematically more when more vehicles are involved in the accidents. This section seeks to find the regression model and degrees associated with persons killed and number of vehicles involve.

Table 4.16: Regression Model for Persons Killed and Number of Vehicles Involved

Regression Statistics	
Multiple R	0.59
R Square	0.35
Adjusted R Square	0.33
Standard Error	6.67
Observations	60.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	1360.67	1360.67	30.61	0.00
Residual	58.00	2578.27	44.45		
Total	59.00	3938.93			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.71	2.19	0.33	0.75	-3.68	5.10
Cases of Veh.	0.21	0.04	5.53	0.00	0.14	0.29

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From Table 4.16, the output has shown that indeed the number of vehicles involved in an accident do cause the casualty level to be high. This however can only be responsible for about 33 to 35% of that; suggesting that high casualties could also come as a result of other factors, that might be the type or degree of accident (fatal, serious or minor, as seen earlier) or the number of persons being carried in the vehicle, etc.

Let n, represent the number of vehicles involved in accident. Then the regression model is;

$$Persons\ Killed = 0.71 + 0.21n$$

The Poisson regression model is now;

$$\log(Persons\ Killed) = 0.71 + 0.21n$$

$$\therefore Persons\ Killed = e^{0.71} \times e^{0.21}n$$

The degree of Persons Killed when accident is fatal = $2.03 \times 1.23 = 2.50\%$. Hence the degree is not as high, 2.50%.

4.2.5 *Regression Model for Persons Injured and Number of Vehicles Involved*

A similar model might be needed for number of injuries too.

Table 4.17: Regression Model for Persons Injured and Number of Vehicles Involved

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Regression Statistics	
Multiple R	0.84
R Square	0.71
Adjusted R Square	0.70
Standard Error	10.29
Observations	60.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	15001.25	15001.25	141.67	0.00
Residual	58.00	6141.33	105.89		
Total	59.00	21142.58			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	11.05	3.38	3.27	0.00	4.28	17.82
Cases of Veh.	0.71	0.06	11.90	0.00	0.59	0.83

Table 4.17 shows that it is ~~more likely~~ to have the number of injuries high when more vehicles are involved in the accident. In fact, more vehicles involved in accidents could account for about 70 to 71% of injury cases.

4.2.6 *Regression Model for Cases of Accidents and Causes of Accidents*

Addressing the canker of road traffic accidents cannot be complete without finding and addressing causes of road accidents. In this research data was collected on the

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cases of driver causes, vehicle causes, road causes and pedestrian causes. Similar regression model would be applied here to find relationships and further find degree of associations.

Table 4.18: Regression Model for Cases of Accidents and Causes of Accidents

Regression Statistics	
Multiple R	0.96
R Square	0.92
Adjusted R Square	0.91
Standard Error	4.40
Observations	60.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4.00	12051.76	3012.94	155.88	0.00
Residual	55.00	1063.09	19.33		
Total	59.00	13114.85			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.41	1.75	0.80	0.42	-2.10	4.92
Driver Cause	1.06	0.09	12.02	0.00	0.89	1.24
Vehicle Cause	1.03	0.12	8.28	0.00	0.78	1.28
Road Cause	0.71	0.16	4.53	0.00	0.40	1.03
Pedestrian Cause	0.96	0.27	3.51	0.00	0.41	1.51

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From Table 4.18, it is obvious to have high values for Multiple R, 96%, and R adjusted, 91%. All the causative factors too are highly significant in the model. However, the Poisson regression model would give a more accurate degree of association.

Let D, represent Driver cause, V, Vehicle cause, R, Road cause and P, Pedestrian cause. Then the regression model is;

$$Accident\ Cases = 1.41 + 1.06D + 1.03V + 0.73R + 0.96P$$

The Poisson regression model is now;

$$\log(Accident\ Cases) = 1.41 + 1.06D + 1.03V + 0.73R + 0.96P$$

$$\therefore Accident\ Cases = e^{1.41} \times e^{1.06}D \times e^{1.03}V \times e^{0.73}R \times e^{0.96}$$

The degree of Accident when accident is caused by driver = $4.10 \times 2.89 = 11.85\%$

The degree of Accident when accident is caused by vehicle = $4.10 \times 2.80 = 11.48\%$

The degree of Accident when accident is caused by road = $4.10 \times 2.08 = 8.53\%$

The degree of Accident when accident is caused by Pedestrian = $4.10 \times 2.61 = 10.7\%$.

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The figures have shown that it is more probably to have accidents when it is caused by the driver, followed by when it is caused by the vehicle. Additionally, it is more highly probably to have accidents when the fault is coming from a pedestrian than when it is the cause of the road.

4.3 Summary

In this chapter, we forward the data collection and analysis of the study. The next chapter presents the conclusions and recommendations of the study.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The data collected for the analysis has been applied to finding answers to the objectives of this study. After analyzing the data, the following conclusions were made;

(i) That accident cases (fatal, serious or minor) has not been declining with year, while January, May, June, July and December appear to record more cases. It would therefore be dangerous to allow this trend to continue.

(ii) That the number of vehicles involved in accident is a significant factor in determining number of reported cases of accident.

(iii) That 2007 and 2010 have recorded the highest mean minor accident cases than those for fatal and serious accidents cases, hence most of the accidents cases recorded over the years under study were fatal and serious ones.

(iv) 2008 and 2009, were years that recorded least cases of accident and its accompanying deaths. So going forward might need to study carefully some of the policies and programmes put in place in those years.

(v) Persons injured are more than those killed over the years.

(vi) 2007 and 2010 appears to record the highest mean numbers for driver causes; with 2006, 2008 and 2009 recording close to equal numbers for driver causes.

(vii) Driver causes appear to be paramount or constant throughout the period under study, make vehicle-causes the next causative factor after driver causes, road and then pedestrian in that order.

(viii) There have been fatal accidents as equal as serious one as the case is for minor ones.

(ix) When the present incidences of accidents are not checked, then going forward, there is likely to be a 92.77% chance of having fatal accidents cases, 84% of having serious accident cases and 78.27% change of having minor accident cases.

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(x) Number of persons killed increases by 1.46% whenever the accidents type was fatal. The number of persons killed also increases by 1.43% whenever the accident type was serious. The numbers increase much more whenever the accident type was both fatal and serious. Minor accident types are also likely to increase number of persons killed by 1.02%.

(xi) The degree of injuries becomes extremely high when accidents occur. That is, there is very high probability of having people injured when accidents occur, and it does not matter which type of accident that occur; even if the accident type is rated minor its degree or probability is very high.

(xii) Number of vehicles involved in an accident does cause the casualty level to be high. This however can only be responsible for about 33 to 35%.

(xiii) That it is more probably to have accidents when it is caused by the driver, followed by when it is caused by the vehicle. It is also more highly probably to have accidents when the fault is coming from the pedestrian than when it is the cause of the road.

5.2 RECOMMENDATIONS

Based on the data analyses, we want to put forward the following recommendations:

(i) Since Accident cases do not seem to be declining or increasing, there is a need to holistically tackle issues concerning safety on our roads.

(ii) Critical among the solution seeking for safety on roads might be to address qualification of drivers, aside the driving license to reduce the driver causative effect.

(iii) Since driver causes are high, it would be very helpful if driver education be considered as top priority; drivers should be made to have formal education to some appreciable level before allowed to drive.

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