UNIVERSITY FOR DEVELOPMENT STUDIES



# IE SERIES ANALYSIS OF NRSS II ON ROAD ACCIDENTS IN GHANA: A ROAD SAFETY INTERVENTION ANALYSIS

ZAMANAH, ERNEST

Thesis submitted to the Department of Statistics, Faculty of Mathematical Sciences, niversity for Development Studies in partial fulfillment of the requirements for the award of Master of Science Degree in Biometry

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# TIME SERIES ANALYSIS OF NRSS II ON ROAD ACCIDENTS IN GHANA: A ROAD SAFETY INTERVENTION ANALYSIS

BY

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Thesis submitted to the Department of Statistics, Faculty of Mathematical Sciences, University for Development Studies in partial fulfillment of the requirements for the award of Master of Science Degree in Biometry

NOVEMBER, 2011

## Declaration

**Student**

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere:

Candidate's Signature:........................ Date: 22 – 11 – 2011

Name: IAMANAH ERNEST

**Supervisors'**

I hereby declare that the preparation and presentation of the dissertation/thesis were supervised in accordance with the guidelines on supervision of dissertation/thesis laid down by the University for Development Studies.

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## Abstract

Over the years, the National Road Safety Commission of Ghana together with various road safety stakeholder organizations in the country has embarked on various activities to safeguard the road. The National Road Safety Strategy II (NRSS II) was conspicuously introduced in 2006 as an intervention technique to bring a desired change in reducing the number of road accidents in the country. This project work therefore considered the innovative time series analysis methods and its applications to investigate the impact of the NRSS II on the reduction of road accidents in Ghana. The aim was to develop an intervention model to assess the impact of the NRSS II in terms of the extent to which its introduction contributed in significantly reducing the number of road accidents in the country. The road accident data was found to be homogeneous non-stationary and Autoregressive Integrated Moving Average (ARIMA) models which are used for describing various homogeneous non-stationary time series were therefore applied to the issue of road accidents in Ghana. The tentative ARIMA (0, 1, 1) noise model given by $(1 - B) N_t = (1 - \theta_1 B) a_t$ was developed for the pre-intervention season to adequately fit the incidence of road accidents in Ghana. The method of moments was then used to estimate the unknown parameter, $\theta_1$ in the model. $\theta_1$ was estimated to be 0.117. Consequently, the intervention model was developed by introducing a step function for the component of the intervention introduced. This was obtained as;

$$Z_t = \omega_o I_t + \frac{(1-\theta_1 B)a_t}{(1-B)}.$$

A test of hypothesis was carried out on the significance of the NRSS II intervention defined by $I_t$ in the above model at 0.05 level of significance. The estimation results of the intervention analysis revealed that the intervention parameter, $\omega_o$ was not statistically significant ($p > 0.05$)

indicating that the introduction of the NRSS II did not result in a significant change in the reduction of road accidents in Ghana.

The research work concluded by indicating that, apart from the introduction of road safety interventions in the country, a lot more is required in terms of the level of commitment from all stakeholder organizations, concerned parties and individuals (road users) in order to achieve desired results of controlling the alarming rate of the incidence of road accidents in Ghana.

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## Dedication

I dedicate this work to my dad and mum, Mr. and Mrs. W. S. Zamanah for their special love, care and support which gave me the strength and courage to get this far.

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## List of Acronyms

HOD- Head of Department

UDS- University for Development Studies

NRSS II - National Road Safety Strategy II

ARIMA - Autoregressive Integrated Moving Average

DTU - Technical University of Denmark

DALYS - Disability Adjusted Life Years

GNP - Gross National Product

GDP - Gross Domestic Product

GRSP -Global Road Safety Partner

RTA - Road Transport Authority

TRL - Transport Research Laboratory

UNCHS -United Nations Center for Human settlement

UNDP -United Nations Development Program

UNTACDA -United Nations Transport and Communication Development for Africa

WHO -World Health Organization

UN - United Nations

EU - European Union

USA - United States of America

BRRI - Building and Road Research Institute

PSV - Public Service Vehicles

TRP - Transport Rehabilitation Project

GHA - Ghana Highway Authority

VELD - Vehicle Examination and Licensing Division

DUR - Department of Urban Roads

MTTU - Motor Traffic and Transport Unit

UTP - Urban Transport Project

MRH - Ministry of Roads and Highways

MOT - Ministry of Transportation

ACF - Autocorrelation Function

PACF - Partial Autocorrelation Function

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background

Transport is indispensable for mobility and economic growth of any society (DTU, 2010). This assertion through Taoana (2005) is supported by the fact that, transportation is considered a major generator of employment and plays a vital role in the distribution of essential goods and services from place to place (Meket, 1997). Road transport plays a key role in the national traffic flow of developing countries and accounts for more than 95 percent of inter-urban transport of goods and passengers in different African countries (UNTACDA, 2000).

Clearly, road transport has an important role in economic, social and cultural functioning of cities. But in many cities today it is also generating significant social and economic costs (Shefer, 1997). These costs arise from the external effects of traffic system, particularly road accidents among others (WHO, 2000).



The World Health Organization (2000) statistics reveal that in developing countries road accident is the major factor that brings about death next to those caused by natural factors; one death per annum is recorded for every 50 to 500 motor vehicles, whereas the corresponding range in developed countries is 2000 to5000 motor vehicles.

The total economic costs are also the highest when the productivity loss and expenses incurred because of road traffic accidents are measured. TRL (2000) estimated that the social cost of road accidents in 1999/2000 was in excess of 500 billion US dollars and the cost in the developing world was estimated to be about 65 million US dollars.

A road accident referred to as traffic collision, traffic accident, motor vehicle collision, motor vehicle accident, car accident, Road Traffic Collision (RTC) or car crash, occurs when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or utility pole (Wikipedia, 2010).Road accident can also occur when a vehicle fails o negotiate a curve and runs into a gutter or any other object. Traffic collisions may result in njury, death and property damage (Wikipedia, 2010).

\ news article on road accidents by the Ghanaian chronicle in August 2008 indicated that the nost common known causes of road traffic accidents in Ghana include: gross indiscipline on the 'oad, over-loading, fatigue driving, drunk driving and over-speeding.

\ccording to statistics from the officials at the headquarters of the Motor Traffic and Transport Jnit of the Ghana Police Service, 2008, it was revealed that 60% of road accidents are caused by lrunk driving and over-speeding. The latter alone constitutes about 50% of road accidents in the :ountry. The poor nature of some of our roads, poor maintenance of vehicles, disregard for raffic regulations by most drivers and indiscriminate use of the road by some pedestrians are ;ome of the other causes of motor accidents in the country.

The same chronicle in September 2010 indicated another school of thought, the palm-wine theory to be another cause of road accidents in the country. This school of thought as captured by the chronicle is steeped in tradition, blame – culture, curses and downright idiocy. For example, commercial drivers will blame their grandmothers and curses for accidents and therefore not bother to maintain their vehicles. Any rational discussion will be thrown out of the window because the gods, deities, jealous neighbor, aunties are to blame. This view as stated by the chronicle has led to many accidents and is not worth exploring further as it is simply bunkum and irrational.

Owing to the global and massive scale of the issue of road accidents, with the predictions that by the year 2020, road traffic deaths and injuries will exceed HIV/AIDS as a burden of death and disability (WHO, 2004), the United Nations and its subsidiary bodies have passed resolutions and held conferences on road safety. In 1999, the International Red Cross first warned of an epidemic on the roads in its World Disasters Report published that year. In the same year the World Bank, through its Business Partners for Development program launched the Global Road Safety Partnership (GRSP) with a strong emphasis on multi-sector collaboration. Then in 2003 the United Nations General Assembly passed the first in a series of resolutions on road safety sponsored principally by the Sultanate of Oman.

In 2004, on the initiative of its former Director General Dr Gro Harlem Brundtland, the World Health Organization made road safety the theme of its annual World Health Day, the first time the issue had gained such global recognition. In the same year, WHO and the World Bank published the World Report on Road Injury Prevention which was the first global assessment of the scale of road traffic death and injury occurring especially in developing countries. And also the UN General Assembly had its first major debate on road safety and authorized the creation of the UN Road Safety Collaboration which began work on developing best practices in reducing the main road safety risk factors, such as non use of helmets and seat belts, drink driving and speeding.

In 2005, the World Bank established its Global Road Safety Facility as the first dedicated funding mechanism for road injury prevention. The World Day of Remembrance for Road Traffic Victims was also declared in 2005. In 2006, the FIA Foundation launched the

Commission for Global Road Safety, chaired by Lord Robertson and which called for a global Ministerial Conference. In 2007 the first ever global road safety week was organized by the UN Road Safety Collaboration and featured a global youth assembly held in the Palais des Nations in Geneva. In 2008, the UN General Assembly unanimously supported a further resolution that nandated the first ever global Ministerial conference and accepted the generous offer of the government of the Russian Federation to host the event in Moscow. Finally in 2009, the first high level ministerial conference on global road safety was held in Moscow.

A large body of knowledge has been amassed through the conferences held by the United Nations and its subsidiary bodies and also through research on how to prevent car crashes, and reduce the severity of those crashes that do occur (WHO, 2009). The knowledge base covers institutional responsibility of road safety, the development of a road safety action plan, raising awareness and understanding of road safety problems, road crash data systems, road safety education and training, traffic safety legislation, and enforcement of traffic laws (WHO, 2009).

Considering the level of property damage, the lives that are lost and the total economic cost of road accidents in Ghana on annual basis, the National Road Safety Commission and the seven key road safety stakeholder institutions in the country; Ghana Highway Authority (GHA), Department of Urban Roads (DUR), Driver and Vehicle Licensing Authority (DVLA), Motor Traffic and Transport Unit (MTTU) of the Ghana Police Service, National Ambulance Service (NAS) and Ghana Red Cross Society (GRCS), introduced the 2006 – 2010 road safety intervention called the National Road Safety Strategy II (NRSS II). Under the NRSS II, the country aimed at systematically reducing the number of road accidents in the country (NRSC, 2007).

As the aim of the NRSS II intervention was to reduce the number of accidents, investigation on the extent of the effectiveness of the intervention is needed to reveal the full benefit in terms of the number of road accident reduction in Ghana and this is the main focus of this research work. As a result, an intervention model is sought to be developed in this work to assess the impact of he NRSS II on the reduction of road accident cases in Ghana using Time Series Analysis.

## l.2 Problem Statement and Justification

Research has shown that, the development of the human resource capital is the surest way for the development of every nation and the generality of humankind (Oppapers, 2008). However, not only do road accidents lead to the destruction of capital resources but also to the depletion of the human resource base. The negative repercussions of road accidents on the economy cannot therefore, be over emphasized.

According to a report by WHO (2004), 1.2 million people die through road traffic crashes annually and 50 million injured on the roads around the world each year. The report also noted road accidents as the leading cause of death among children 10 – 19 years of age (WHO, 2004). The report as well noted that the problem is more severe in developing countries.

The majority of road crash victims (injuries and fatalities) in developing countries are not the motorized vehicle occupants, but pedestrians, motorcyclists, bicyclists and non-motorized vehicles (NMV) occupants according to WHO (2009). Historically, many of the measures put in place to reduce road traffic deaths and injuries are aimed at protecting car occupants. However, as this report shows, nearly half of those killed each year around the world are pedestrians, motorcyclists, cyclists and passengers in public transport: this figure is even higher in the poorer countries and communities of the world.

The Global Burden of Disease study undertaken by the World Health Organization (1996), Harvard University (1996) and the World Bank (1996) showed that, traffic crashes were assessed to be the world's ninth most important health problem in 1990. The study also indicated that by the year 2020, road crashes would move up to third place in the table of leading causes of death and disability facing the world community.

Road crashes cost approximately 1 to 3 percent of a country's annual Gross National Product (GNP). These are resources that no country can afford to lose, especially those with developing economies (Kanitpong et al., 2008).

It is estimated that developing countries lose in the region of $100 billion every year. This is almost twice as much as the total development assistance received worldwide by the developing countries. These losses are noted to undoubtedly inhibit the economic and social development of developing countries (World Bank, 2002).

In Ghana for instance, statistics from the National Road Safety Commission (NRSC) in February, 2009 indicate that, not only do road accidents claim more lives than malaria every year but also road accidents, apart from claiming human lives and leaving others injured, cost the nation US$165 million, representing 1.6 per cent of the nation's Gross Domestic Product (GDP), every year.

The huge losses that are incurred as a result of road accidents in Ghana over the years necessitated the government through the National Road Safety Commission, and the seven key road safety stakeholder institutions in the country to introduce the NRSS II to counter the various causes of road accidents and consequently contribute in significantly reducing the number of road accidents in Ghana (National Road Safety Commission, 2007).

However, the success of the NRSS II in addressing the problem of road accidents in the country in terms of the extent of accident reduction remains a question yet to be answered. This research work is therefore deemed necessary as it seeks to assess the impact of NRSS II in the quest to reducing the number of road accidents in Ghana.

## 1.3 Study Objective

The primary objective of this research is to develop an intervention model to assess the impact of the National Road Safety Strategy II (NRSS II) on the reduction of road accidents in Ghana.

### 1.3.1 Specific Objective

The specific objective is to develop a minimum mean square error forecast time series pre-intervention model that describes the noise series of the quarterly road accident cases in Ghana.

## 1.4 Outline of Study

The thesis is comprised of five chapters. The first chapter comprises of an introduction and background of the study. Chapter two is a review of related literature whilst chapter three consists of the research methodology. Chapter four consists of results and discussions and chapter five embodies the conclusions and suggestions and recommendations.

## 1.5 Limitation of Study

The variable under study is the quarterly observations of road accidents in Ghana from 1993 to 2010. The NRSS II intervention technique was introduced to help contribute in significantly reducing the number of road accidents in the country. The study is therefore strictly investigating the success or otherwise of the intervention technique based on the data available within the stated period of 1993 to 2010. The study variable could be affected by other factors outside of the available data that was used in this work within the study period. This is therefore a limitation to this work.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Road Traffic Accidents and its effects in the world

Road traffic crashes present serious challenges all over the world. Road Traffic Accidents (RTAs) are a major cause of death and disability globally, with a disproportionate number occurring in developing countries (Murray and Lopez, 1997). RTAs ranked ninth globally among the leading causes of disability adjusted life years lost in 2003 was projected to rank third by 2020 (Abdulbari, 2003). About 90% of the disability adjusted life years lost worldwide due to road traffic injuries occur in developing countries (Krug, 1999). When comparing European countries, Belgium is seen as having one of the worst road safety records; 502 road traffic casualties per 100 000 inhabitants and 14 fatalities per 100 000 population (Czech Republic Transport Yearbook, 2001).

In 1998, road traffic crashes in higher-income countries were already among the top ten leading causes of disease burden as measured in disability-adjusted life years (DALYs) (Abdulbari, 2003). In less developed countries, road traffic crashes were the most significant cause of injuries, ranking eleventh among the most important causes of lost years of healthy life (Abdulbari, 2003).

According to a World Health Organization (1999) and 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 as the report indicated. 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 a report by WHO ( 2004), 1.2 million people die through road traffic crashes annually and 50m injured on the roads around the world each year. The report also noted road accidents as the leading cause of death among children 10 – 19 years of age. The report as well noted the problem to be most severe in developing countries and that simple prevention measures could halve the number of deaths. 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 accident victim (WHO, 2004). Studies show 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 (WHO, 1999). 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.

Over 50% of deaths are shown to be among young adults of between 15 - 44 years and among both children between 5 - 14 years and young people of between 15 - 29 years young (WHO, 2004), and traffic injuries are the second behind HIV/AIDS, as a leading cause of premature death and ill health globally (FIA Foundation, 2005). The direct economic costs of global road accidents is estimated at around US$ 518 billion, and US$ 65 billion for the low income countries (WHO, 2004). In the US, road traffic injuries cost US$ 230 billion per year, the cost to the EU 15 is 180 billion Euros per year (FIA Foundation, 2005). Road traffic deaths and injuries absorb massive financial resources, about 1% of the GDP in the developing countries, 1.5% in the transitional countries and 2% in highly motorized countries (WHO, 2004). Road Traffic casualties are shown worldwide to be predominantly economically active persons, that is, between 1-40 year olds and this has a ripple effect on the affected dependents causing emotional suffering and poverty (WHO, 2004).

### 2.1.1 Causes of road accidents

Four factors have been shown to significantly contribute to vast majority of road traffic accidents (Smart Motorist, 2010). These include: Equipment Failure, Roadway Design, Poor Roadway Maintenance and Human factors.

1. **Human Factors**

Human factors in vehicle collisions include all factors related to drivers and other road users that may contribute to a collision. Examples include driver behavior, visual and auditory acuity, decision-making ability, and reaction speed.

A 1985 report by Rumar K. based on British and American crash data found driver error, intoxication and other human factors contribute wholly or partly to about 93% of crashes.

A study conducted by Smart Motorist in Chicago, USA 2010 indicated that over 95% of motor accidents in the USA or road traffic accidents in Europe involve some degree of driver behavior combined with one of the other three factors. It was discovered in the study that drivers always try to blame road conditions, equipment failure, or other drivers for those accidents. However, the behavior of the implicated driver in the study was found to be the usual primary cause of road accidents as most of the accident cases were shown to be caused by excessive speed or aggressive driver behavior.

**2. Equipment Failure**

Manufacturers are required by law to design and engineer cars that meet a minimum safety standard. As reported in the study carried out by the Smart Motorist in USA 2010, computers, combined with companies' extensive research and development have produced safe vehicles that are easy and safe to drive. However, the most cited types of equipment failure that contribute to road accidents according to the study included the following: loss of brakes, tire blowouts or tread separation, and steering /suspension failure.

**3. Road Design**

A 1985 US study on road accidents by Rumar showed that although about 34% of serious crashes had contributing factors related to the roadway or its environment, most of the crashes also involved a human factor. The road or environmental factor was either noted as making a significant contribution to the circumstances of the crash, or did not allow room for recovery. In these circumstances, the study indicated that it is frequently the driver who is blamed rather than the road even though those reporting the accident have a tendency to overlook the human factors involved, such as the subtleties of design and maintenance that a driver could fail to observe or inadequately compensate for.

**4. Poor Roadway Maintenance**

Another factor that could be responsible for road accidents is the maintenance or lack of maintenance of the roadway (Rumar, 1985). The study found roadway maintenance to contribute to some motor vehicle accidents, but not to the extent that drivers use it as an excuse. Unfortunately, maintenance schedules and procedures vary greatly from city to city and state to state. In most cases, nationwide standards don't exist as reported by Smart Motorist in USA in a study on road accidents in 2010. Debris on the roadway, faded road signs and signs obscured by foliage as well as potholes occasionally contribute to accidents as reported by Smart Motorist in USA in a study on road accidents in 2010.



### !.2 Road accidents in Ghana

n 1996, among 29 African countries, Ghana was ranked ninth in terms of fatalities per 10,000 ehicles (Ghana Road Safety Policy Document (GRSPD, 2008). Ghana's fatality rate of around i6 per 10,000 vehicles in 1996 dropped to 18.76 per 10,000 vehicles in 2006 (GRSPD, 2008). )ver the years, the vehicle/population ratio in Ghana has been growing steadily BRRI, 2008). From a vehicle/population ratio of around 31 vehicles per 1,000 population in !002, the ratio continued to climb to around 44 vehicles per 1,000 population in 2008 (BRRI, !008 ). The report by BRRI (2008) also indicated that absolute fatalities were rising. Within the '-year period from 2002 to 2008, the number of people killed on Ghana's roads averaged around ,883 annually. Specifically, in 2008, about 19 people per 10,000 vehicles were killed. The tatistics showed that within the same 7-year period, out of the total of 13,166 people who were :illed through road traffic crashes on Ghana's road network, over 41% were pedestrians, 33% were passengers in Public Service Vehicles (PSVs) that constitutes passengers in cars and buses, 14% were occupants of Heavy Goods Vehicles (HGVs) and pick-ups and about 11% were riders and passengers of motorcycles and bicycles (BRRI, 2008). Close to 1% of the fatalities were users of other forms of non-motorized transport such as push carts.

In 2001, Ghana was rated as the second highest road traffic accident-prone nation in West Africa with 73 deaths per 1,000 accidents (Obeng, 2008). According to the records of the NRSC between

1991 and 2006,154,348 road accidents were recorded in the country. During the same period 189,000 casualties were recorded. A detailed analysis of the road accident statistics of the NRSC from 1991 to 2006 showed that 42% killed annually were pedestrians, over 60% were economically active in the age group 18-55 years and 70% were males (BRRI, 2008).

### 2.2.1 Effects of road accidents on life in Ghana

Every life is precious and Ghana needs all its human resource and talents to develop. Many Ghanaians of all ages have lost their lives through reckless driving and almost every Ghanaian has experienced a death in the family through motor accident or knows of a friend, neighbor, colleague at work or community member who has lost a loved one through the actions of mad drivers (Obeng, 2008).

Beyond the enormous suffering they cause, traffic crashes drive families into poverty as crash survivors and their families struggle to cope with the long term consequences of the event including the cost of medical care and rehabilitation and all the funeral expenses and the loss of the family breadwinner.



### 2.2.2. Economic cost of road accidents in Ghana

There is the human and economic cost to this carnage- the young ones who will never see their parents, widows, loved ones and young people whose lives have been cut short and the tragic consequences of whole communities losing precious members. The carnage on our roads is also a direct threat to foreign direct investment as no investor would like to invest in a nation where roads are death traps and some drivers have a pact with the devil (Obeng, 2008).

In February 2009, the National Road Safety Commission (NRSC) reported that road accidents, apart from claiming human lives and leaving others injured, cost the nation $165 million, representing 1.6 per cent of the nation's Gross Domestic Product (GDP), every year. It added that the cost ranged from medical cost, property damaged, human cost, administrative cost and lost output.

### 2.3 Global View on Road Safety.

According to a report by ROSEBUD (2006), it is a challenge to develop effective measures for improving road safety – especially when resources are scarce and economic means are limited. Nevertheless, a major target for European policy as well as for national, regional and local decision makers is to improve road safety significantly.

In order to help meet this challenge, ROSEBUD was funded by the European Commission as a thematic network to support users at all levels of government (European Union, national, regional, local) with information about road safety related efficiency assessment solutions. To this end, ROSEBUD brought together researchers, policy makers, decision makers and other relevant stakeholders into a co-operative network.



The European Union had the objective of halving the number of deaths on European roads by 2010 (ROSEBUD, 2006). Implementing a range of effective road safety measures to the fullest extent according to ROSEBUD report on road safety 2006 was necessary to achieving the said objective. According to ROSEBUD (2006), implementing the following general measures among others is key to enhancing safety on the road.

1. **Reforming and improving basic driver training, education and licensing**

Although basic driver training and testing has been widely established, the number of accidents caused by novice drivers world-wide is still high (ROSEBUD, 2006). Different approaches to reform and improve driver training, education procedures and licensing systems are required. For example, basic driver training can be improved (e.g. requirement to undertake more practical driving lessons) and new pre or post licensing measures can be introduced (e.g. license for novice drivers on probation, second phase training after licensing). Moreover, the age at which lriver training is permitted could be reduced by one or two years to allow accompanied driver raining in earlier years.

**2. Road safety campaigns**

Road safety campaigns complement other activities aimed at improving road safety. Important asks of road safety communication according to ROSEBUD (2006) include raising the public ıcceptance for road safety measures (e.g. enforcement measures) and decreasing the public ıcceptance of risky behaviors. The media can influence attitudes e.g. by informing about rules, explaining consequences of risky behavior, informing about police enforcement and about possible punishments. Since the target of the campaigns are people or groups of people, and as heir behavior may differ from one country to another, the specific messages addressed to the arget group chosen for a campaign may vary from country to country and even within a single country.

**3. Hazard warning**

Safety, hazard and warning signs ensure that road users and emergency staff have adequate information concerning specific dangers related to this road section. Hazard warning signs have to be consistent. A hazard warning should indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury. Confusion among the road users should be avoided by using standardized patterns, phrases, colors, shapes and pictograms. The installation of utility poles with flashing lights could increase drivers attention in dangerous road sections. The hazard warning sign should be used beside the road when it is needed to indicate the presence of a specific danger.



**4. Traffic safety education and information for children and adolescents**

Traffic safety education and information aims at ensuring that children and adolescents travel safely to and from school. They should be well prepared for their active participation in traffic by walking, riding a bicycle, using a bus or a car as passenger. Therefore, comprehensive education programs are necessary to build road safety awareness among school children and adolescents. These programs should be developed by road safety professionals together with teachers. Furthermore, traffic safety education should take place on all school levels to reduce the number of accidents with children of all ages.

**5. Increasing construction site security**

Construction firms could be obliged to provide a specific safety policy for their construction sites to reduce the number of road accidents at the work zone. Road work zone related safety measures should be developed and applied to mitigate the adverse safety effects on workers and road users. Measures to reduce such accidents could include using more message signs to warn motorists, scheduling work when traffic is lighter and putting specific barriers between workers and the cars and trucks driving past.

**6. Physical examination of vehicle drivers**

Especially for elderly drivers, medical examinations could be required. The driving licensing practice for elderly drivers could include various combinations of age-dependent requirements for re-licensing such as road tests, medical reports or vision testing. A physical examination of elderly drivers is an alternative to rigorous age limits for driving and should allow people to drive as long as they can do so safely and effectively. Compulsory periodic testing of drivers' eye sight should reduce the number of crashes caused by drivers with poor eye sight. If the test shows that the eye-sight is not adequate for driving, the driver should be obliged to wear a seeing aid. This duty should be noted in the driving license. If the bad eyesight is not correctable, the driving license should be withdrawn.

**7. Prohibiting the use of external two-way communication devices in cars and on motorcycles**

External two-way communication devices in vehicles and on motorbikes can be harmful for road safety. They distract the driver from his driving task if used while driving and consequently increase the risk of an accident. A driver is not sufficiently able to control the vehicle while using a mobile phone and driving at the same time. To reduce accidents caused by the use of two-way communication devices (e.g. handheld mobile phones) during driving, their use could be banned while the vehicle is in motion or the engine is running.

**8. Randomly scheduled and enhanced police enforcement**

Traffic law enforcement is a factor that contributes significantly to normative road user behavior and road safety. Randomly selected sites and times of day for enforcement achieve good results.

Traffic rules are usually enforced by traffic police forces whose activity and success are generally limited by the resources than can be applied and by established priorities. Nevertheless, many studies have shown that increased police enforcement effort would have a major impact on road safety.



### 9. Road lighting

At night, visual capabilities are impaired and visibility is reduced. In order to drive safely on roads at night drivers must be aware of the conditions around their vehicles and see other road users adequately far away from them. Road lighting is a potential countermeasure to reduce the number of night-time accidents at locations with inadequate illumination. These locations, especially junctions, intersections, access roads and tunnels, should be redeveloped regarding their road lighting equipment.

### 10. Seat belt enforcement

Seat belts are intended to reduce the incidence and severity of personal injuries when an accident occurs. According to most national traffic laws, car occupants and all children above a specific age anywhere in the vehicle must be secured by a seat belt (and younger children by special child restraint systems). Low levels or decline of safety belt use in some regions are worrying. Enforcement of seat belt laws should raise seat belt wearing rates. Intensive police enforcement efforts are a major component of seat belt enforcement and education programs designed to reduce avoidable traffic fatalities and injuries. Visual surveys have often shown that seat belt use has risen following police enforcement campaigns.

**11. Combined enforcement and publicity campaigns**

In order to increase the acceptance of a road safety measure by the public and thereby render it more successful, road safety campaigns should be launched simultaneously with enforcement programs. The public should be extensively informed about the road safety problem that is addressed. Mostly, the costs for the campaign are paid by local or national authorities whereas the control costs have to be borne by the police authorities.

**13. Cycle helmet related campaigns and legislation**

Head injury is known to be a major cause of disability and death resulting from cycle accidents (e.g. fractures of vault or base of skull or intracranial injuries). Increasing helmet wearing should help to reduce the number of head injuries. To reduce head injuries to cyclists in all forms of accidents, including those involving a motor vehicle, every cyclist could be required to wear a helmet, and violations would be punished. Additionally, such an obligation could be accompanied by an information campaign. Moreover, it is sometimes assumed that campaigns are a potential alternative and could replace an obligation.

**14. Safety inspections of heavy vehicles**

To reduce the number of crashes attributable to fatigued drivers and the number attributable to mechanical defects or unsafe equipment in commercial vehicles, vehicle safety inspections could be undertaken to ensure that vehicles are well maintained for safe operation. Technical inspections of vehicles should be carried out several years after the first registration, and then repeated periodically. Licensed inspection technicians should perform these inspections, familiar with all the regulations required for the technical inspection of motor vehicles. Vehicle equipment should be inspected to ensure that vehicle related safety standards and regulations are met. Roadside inspections of trucks should include checks of the driver's requirements, the presence of hazardous materials, the sides and the front of the tractor, the steering axle, all sides of the trailer, brake adjustment, wheels etc. Violations which could be detected by roadside inspections of trucks comprise for example driver's records of duty status violations (e.g. regarding driving hours and rest periods) or technical problems like brakes out of adjustment or inoperable lamps. The inspections could be carried out by the police or by authorized staff.

### 15. Daytime running lights (DRL)

To reduce the number of daytime multiparty accidents that occur when a driver or rider fails to see another vehicle in time to avoid a collision, some countries already require vehicle running lights to be illuminated in day time. A compulsory rule for lights to be switched on when the vehicle is in motion could be considered, also a campaign to inform the public. As an alternative to a compulsory rule for the driver, one might consider the equipping of all new cars with a device which automatically switches the lights on when the vehicle's engine is started. Another option is the mandatory installation of dedicated daytime running lamps which turn on automatically when the ignition is started and are overridden when regular headlights are activated. Because of their characteristics, dedicated daytime running lamps have the advantage of consuming less fuel than conventional low beam headlights and therefore lead to lower levels of air pollution.

**16. Pedestrian and bicycle visibility enhancement**

Pedestrians and bicycle riders are sometimes difficult to be identified by motorized road users. The accident rates of bicyclists and pedestrians could be reduced if more would be done to make these vulnerable road users as visible as possible. Lights and reflectors are essential for their visibility. With reflective devices cyclists and pedestrians could improve their own conspicuity and thereby make themselves easier to be detected and identified by other road users. Every bicycle should be equipped with reflective material of sufficient size and reflectivity to be visible from both sides when directly in front of a motor vehicle's head lamps. Reflective materials on clothes could also make pedestrians more visible to motorized road users.

**17. Truck visibility enhancement**

Retro-reflective material could increase the conspicuity of trucks at nights and in bad weather. The sides and rear of the trailers can be equipped with retro-reflective tape or reflex reflectors to reduce side and rear impacts into heavy trucks, the retro-reflective material brightly reflects other motorists headlights, especially in the dark, and warns them that they are closing on a heavy trailer. Additionally, it is easier for the other road users to assess the distance to and the speed of the truck. Because of the enhanced visibility of heavy trucks and trailers, a large-scale introduction of retro-reflecting contour marking could reduce the probability of side and rear impacts by other vehicles.

**18. Variable message signs**

Variable message signs are infrastructure related facilities which could supply traffic related and safety relevant information to the road user. Variable message signs include simple prism displays as well as fully graphic-enabled display boards. For example, traffic signs, lane signals or textual displays can be brought rapidly to the attention of the road user. The importance of variable message signs for road safety depends on the messages that they convey. Variable message signs can have at least a short term effect on driving behavior but messages must not be overloaded.

### 19. Road Safety Audits (RSA)

A road safety audit is a systematic examination of the safety standard of a road, usually at the design stage, but sometimes also immediately before the road is opened to traffic. The idea of the road safety audit was first developed in Great Britain and is applied now in many other countries. The two main potential benefits from the Road Safety Audit process are to reduce the frequency of accidents and casualties and to reduce the need to redesign a scheme after it has been implemented. Audits are performed by independent auditors and are based on detailed checklists listing the items to be examined. The independent auditor or an auditor team is commissioned by the owner of the infrastructure (federal, regional and local authority, private owner). The Auditor should have experiences with road safety and construction. Road safety audits are often described as a first step to implement a complete quality management system for roads. The aim of the safety audit is to put a value, from the standpoint of traffic safety, on all new road construction projects and major road maintenance works on existing roads, so that any shortcomings in road safety could be detected in time.

**20. Black spot management**

Black spot" is a colloquial term for points, sections or junctions in the road network that show a regional higher-than-average density of fatalities and severe injuries. Black spot treatment makes use of the accident record and other information to identify the measures that are likely to be most effective; these are then implemented in those places where they should have the greatest effect on accidents. Black spot treatment is an iterative procedure with a regional scope based on accident reporting, accident analysis, data storage and presentation. In detail, black spots are identified with the help of information on the precise accident location and on the accident scenario of fatal and severe accidents – displayed on a map. Experts on road safety should then visit those sites, discuss and identify remedial measures. As to the type of measure, low cost measures can be distinguished from major repair works or even a reconstruction for the medium to long run. For each measure an accident reduction potential should be identified and costs estimated. With these data, a benefit cost ratio is calculated. A ranking of the measures for the entire region according to the benefit cost ratio and the time frame, will then allow to define a work program.

**21. Traffic calming**

The purpose of traffic calming is to improve traffic safety for vulnerable road users. Traffic calming is the combination of mainly physical measures to alter driver behavior and improve conditions for vulnerable road users. Driving speed has a major influence on the probability of becoming involved in an accident and on the severity of injuries. A common problem for example in school zones is excessive vehicle speed and traffic volume in areas where children must cross streets and where they are picked up and dropped off. To avoid conflicts, traffic calming devices should be simple, self-enforcing and easy to modify to accommodate emergency and other service vehicles. Speed humps are frequently chosen as a typical solution when there is a need to reduce travel speeds on a local street and to provide the street with a calmer and safer character. The main advantage of speed humps are in their self-enforcing nature and in creating a visual impression that the street is not designated for high speeds or for passing traffic. The length is usually larger than the distance between the wheels of vehicle (usual length 3.6 m), their height oscillates between 7.5 – 10 cm and the recommended distance between successive humps varies from 60m to 100m.

### 22. Signal control at road junctions

A road junction presents a natural point of potential conflict between different traffic streams. As traffic volumes increase, the probability of conflict increases too, and traffic delays worsen. Traffic signal control at intersections separates traffic streams and improves the flow. Traffic signal control can be achieved by using lights, which may be either time-controlled (phases change after a given time irrespective of the amount of traffic) or vehicle-actuated (the length of the phases is adapted to the amount of vehicles up to a given maximum phase length).

### 23. Roundabouts

The roundabout is a common form of intersection control used throughout the world. An increasing number of intersections are being converted into roundabouts. These have a traffic calming effect and help limit the severity of any collision that might occur. Modern roundabouts can be used at a wide variety of intersections. An advantage of roundabouts is the reduced number of conflict points compared with uncontrolled intersections. Decision-making is simple combined with a lower level of conflicts. Furthermore, roundabouts slow down all vehicles. The tighter the curve the lower the speed, which means that it is easier to stop or at least a possible impact would be relatively minor. Consequently, roundabouts reduce the number and severity of accidents. On the other hand, especially in the beginning, roundabouts can be unfamiliar to the verage driver which could lead to more accidents. Nevertheless, crashes at roundabouts are rimarily rear end or low speed merge crashes.

The above measures as earlier stated by Umar et al. (1996) are also noted to enhance safety on he road if properly implemented and enforced (WHO, 2009).

## .4 Road Safety Efforts in Ghana

ccording to a National Road Safety Policy document (NRSPD) in 2008, the year 1988 was the urning point with the organization and management of road safety activities in Ghana. In that ear, the Ghana Road Safety Project (GRSP) was launched under the World Bank financed ransport Rehabilitation Project (TRP). The primary objective of the GRSP was to increase the nowledge, skills and capabilities of key Ghanaian organizations and professionals to tackle the ountry's road safety problems more effectively.

The GRSP was designed around 5 mini-projects that bordered on strengthening the National Road Safety Committee, the Vehicle Examination and Licensing Division (VELD), the Ghana Highway Authority (GHA), the Department of Urban Roads (DUR) and the Motor Traffic and Transportation Unit (MTTU) of the Ghana Police Service (GPS). The project was complemented with the establishment of an improved data system on road traffic crashes.

A key recommendation of the report on the GRSP according to the Policy document was the proposal to transform the National Road Safety Committee into the National Road Safety

Commission (NRSC) with the requisite legislation, staffing and funding to enable the Commission promote and coordinate road safety activities in Ghana (NRSPD, 2008).

The Policy document indicated that, from 1991 to 1994, the second phase of the TRP was implemented. The principal objective of the road safety component of TRP 2 was to provide continued assistance in order to consolidate the achievements of the road safety program of TRP 1. It provided support in the form of training, equipment, materials and budgetary support to the National Road Safety Committee, the Building and Road Research Institute (BRRI), GHA, DUR, MTTU and VELD.

Since 1994 when the TRP ended, two phases of Urban Transport Project (UTP) were subsequently implemented in the country with road safety components (NRSPD, 2008). In 1997, the merger of the then Ministry of Roads and Highways (MRH) and the Ministry of Transport and Communications (MOTC) into the Ministry of Road and Transport (MRT) brought the principal road safety stakeholder agencies namely the GHA, DUR, VELD and the NRSC under a single Ministry. The merger presented the greatest opportunity for the coordination of road safety activities in the country (NRSPD, 2008).

Currently, the major stakeholders namely the GHA, DUR, VELD (which is now the Driver and Vehicle Licensing Authority) and the NRSC are under the Ministry of Transportation (MOT). In 1999, an act of parliament (Act 567) established the National Road Safety Commission (NRSC). Presently, a Chairman, the Executive Director and 18 representatives from 6 Ministries and 12 organizations constitute the membership of the Commission. The Commission executes its day-to-day functions through a Secretariat that is headed by the Executive Director.

Since its establishment in 1999, the NRSC, with the collaboration of stakeholders, has been designing and coordinating the implementation of data-led road safety programs and activities in

Ghana (NRSPD, 2008). The first of such programs according to the NRSPD (2008), was the National Road Safety Strategy 1 (NRSS 1) covering the period 2001-2005. NRSS I provided a broad framework for coordinated efforts with the view to reversing the upward trend in road traffic crashes and casualties. The implementation of the strategy led to significant enhancement n the institutional, technical, regulatory and enforcement capabilities of the NRSC and its key stakeholders.

During 2006, one significant event that was undertaken by the NRSC was the review and evaluation of NRSS I (NRSPD, 2008). In spite of the achievements of NRSS I, emerging road safety challenges coupled with the ever-increasing vehicular fleet in the country necessitated the need for a new strategic direction. In response to these challenges, the NRSC in collaboration with its key stakeholders designed NRSS II for implementation from 2006 to 2010 to address emerging challenges and build on the gains of NRSS I (NRSPD, 2008) to ultimately contribute n significantly reducing the number of road accidents thereby making the road safe for use.

## 2.5. The Success and Failure of Road Safety Efforts in the World

According to ROSEBUD (2006), roads and road transport play a central role in Western and all societies. Most of the goods needed for everyday life are transported by road, and the current generation has far greater opportunities for travel in the course of work and leisure than earlier generations (ROSEBUD, 2006). These advantages according to ROSEBUD (2006) have, however, come at a cost. In addition to the obvious costs of building roads and vehicles and providing fuel, there are various less obvious costs: human and environmental. The costs to society that are as a result of road accidents include human pain, grief and suffering and material costs according to the ROSEBUD report. These costs are not acceptable to society and so measures are usually being introduced in an attempt to reduce the number of accidents - or ideally to eliminate them. These efforts have achieved great success in most European countries, with the number of fatal or serious accidents falling at a time when the volume of traffic has grown rapidly (ROSEBUD, 2006). Nevertheless, the level of risk on the roads is still unacceptable, even in the safest countries, so much remains to be done to improve road safety, the ROSEBUD (2006) report indicated.



### 2.5.1 The success and failure of road safety efforts in Ghana

In Ghana for instance, road safety measures that are put in place through the National Road Safety Commission over the years to combat the incidence of road accidents have made some gains (GRSPD, 2008). For example, Ghana's fatality rate of around 36 per 10,000 vehicles in 1996 dropped to 18.76 per 10,000 vehicles in 2008. In spite of the achievements however, road safety challenges coupled with the ever-increasing vehicular fleet in the country have resulted in an upward trend in the number of road accidents in the country according to statistics from MTTU 2010.

### 2. 6 Time Series Analysis

According to Box et al. (2008), time series is a sequence of observations ordered in time. Mostly, these observations are collected at equally spaced, discrete time intervals. When there is only one variable upon which observations are made then we call them a single time series or more specifically, a univariate time series. A basic assumption in any time series analysis or modeling according to Ramasubramanian (2007) is that some aspects of the past pattern will continue to remain in the future. Also under this set up, often the time series process is assumed to be based only on past values of the main variable but not on explanatory variables which may affect the variable or system. So the system acts as a black box and we may only be able to know about what will happen rather than why it happens (Box et al., 2008). So if time series models are put to use, say, for instance, for forecasting purposes, then they are especially applicable in the short erm. Here it is tacitly assumed that information about the past is available in the form of ıumerical data. Ideally, at least 50 observations are necessary for performing time series analysis ›r modeling as propounded by Box and Jenkins who were pioneers of time series modeling ıccording to Brockwell et al. (2002).

Time series models have advantages in certain situations. They can be used more easily for orecasting purposes because historical sequence of observations upon study variables are readily ıvailable from published secondary sources (William, 2005). These successive observations are ıtatistically dependent and time series modeling is concerned with techniques for analyzing such lependencies (Makradakis, 1998). Thus in time series modeling, the prediction of values for the uture periods is based on the pattern of past values of the variable under study but not generally ›n explanatory variables which may affect the system (William, 2005). There are two main easons for resorting to such time series models. First, the system may not be understood, and even if it is understood it may be extremely difficult to measure the cause and effect relationship, second, the main concern may only be to predict what will happen and not to know why it happens. Many a time, collection of information on causal factors (explanatory variables) affecting the study variable(s) may be cumbersome or impossible and hence availability of long series data on explanatory variables is a problem (Chatfield, 1996). In such situations, the time series models are a boon for forecasters (Ramasubramanian, 2007).

### 2.6.1 Background to time series analysis

Decomposition models were among the oldest approaches to time series analysis albeit a number of theoretical weaknesses from the statistical point of view (Ramasubramanian, 2007). These according to Ramasubramanian (2007) were followed by the crudest form of forecasting methods called the moving averages method and as an improvement over this method which had equal weights, exponential smoothing methods came into being which gave more weights to recent data. Exponential smoothing methods had been proposed initially as just recursive methods without any distributional assumptions about the error structure in them, and later, they were found to be particular cases of the statistically sound Autoregressive Integrated Moving Average, ARIMA models (Box et al. 2008).

In early 1970's, Box and Jenkins according to Box et al. (2008) pioneered in evolving methodologies for time series modeling in the univariate case often referred to as the Univariate Box-Jenkins (UBJ) ARIMA modeling. In course of time, various organizations and workers in India and abroad have done modeling and forecasting based on time series data using the different methodologies viz. time series decomposition models, exponential smoothing models and ARIMA models (Ramasubramanian, 2007).



### 2.6.2 Time series analysis and road safety interventions

According to Bijleveld (2008), road safety is usually measured in terms of the number of accidents or the number of victims. Although in practice the situation is more complicated, some road safety interventions may affect either accident occurrence or accident severity. When a study is performed measuring the effect of a policy intervention on road safety that should mainly affect accident occurrence, the development of the number of accidents of a relevant kind is studied (Bijleveld, 2008).

Road safety analyses aim to describe and explain variation in road safety outcomes (road accidents and casualties), either in time or in space, as well as to forecast future developments on the basis of existing experience (Dupont et al., 2009). Such analyses which concern the description, explanation and forecasting of overall or particular (e.g. motorcyclists') road safety rends are grouped into time series analyses (Martensen et al. 2008). In this case, the data equired concern series of measurements over time (Dupont and Martensen, 2007). The development of time series modeling by Box and Tiao (1975) resulted in applications of ntervention analysis in various fields. For example, Box and Tiao (1975) developed an ntervention model with the application to economic and environmental problems. More pecifically, time series intervention analysis is used when exceptional external event, called ntervention, affects the variable to be forecasted (Bowerman and O'Connel 1987).

n road accident modeling application, there are many traffic safety studies that successfully ıpplied the Box and Tiao intervention analysis methodology. For example, Bhattacharyya and Layton (1979) used the intervention analysis to study the effect of seat belt legislation ntroduced in the state of Queensland on road death and concluded that the intervention had ignificant effect on the volume of deaths.

Hilton (1984) also used the intervention analysis to investigate the impact of changes in California drinking and driving laws on fatal accident levels during the first post intervention year. However, he found that the change in that law did not indicate a different impact occurred in reductions of fatal accident levels.

The same intervention analysis methodology was used to study the impact of an anti-drinking and driving advertising campaign on highway accident data (Murry *et al*., 1993). The result suggested that four models demonstrated a decreased proportion of fatal and incapacitating accidents during the campaign intervention period.

Noland *et al*. (2008) also investigated the effect of a congestion charge on traffic casualties for motorists, pedestrians, cyclists and motorcyclists, both within the charging zone and in areas of London outside the zone using intervention analysis. They adopted the Box-Tiao intervention analysis in the study. The result showed that there was no significant effect for the total causalities, but within the charging zones the motorist causalities and cyclist causalities had been a statistical significant effect.

Yaacob et al. (2010) again used the time series intervention analysis to study the effect of a road safety intervention (OPS Sikap) on road accident reduction in Malaysia and concluded that there was a significant reduction of road accidents during OPS Sikap VII and XIV.

In the case of Ghana, the National Road Safety Strategy II was introduced in 2006 to offset the road accident figure thus making the road safe for use at all times. In effect, the NRSS II is expected to have influenced the pattern of road accident occurrences over the period. This work therefore uses the time series intervention analysis to investigate the impact made in significantly reducing the number of road accidents in Ghana.

# CHAPTER THREE

## 3.0 METHODOLOGY

This research work considers the innovative time series analysis methods and its applications to the issue of road accidents in Ghana. To this end, the impact of road safety intervention, NRSS II ıtroduced in 2006-2010 to significantly contribute in the reduction of road accidents is ıvestigated. The quarterly observations of road accidents collected nationwide in Ghana from anuary 1993 to September 2010 are used in this study. These quarterly total number of road ccidents used in this study referred to the total figure of their occurrences on public or private oads due to the negligence or omission by any party concerned (on the aspect of road users onduct, maintenance of vehicle and road condition), environmental factor (excluding natural lisaster) resulting in a collision which involved at least one moving vehicle whereby damage or njury was caused to any person, property, vehicle, structure, or animal. These data series were ›btained from the headquarters of the Motor Traffic and Transport Unit (MTTU) of the Ghana ›olice Service 2010 in Accra. The data series are contained in the appendix.

\scertaining the impact of the NRSS II on the reduction of road accidents is done using the ollowing form of intervention model.

$Y_t = f(I,X) + N_t$

where, t is the discrete time (in this case quarter of a year), $Y_t$ is the dependent variable for a particular time (the quarterly total number of road accident cases), f(I,X) is the dynamic part of the model that contains the intervention component (I) and $N_t$ is the noise component (season before intervention was introducded) (Box and Tiao 1975; Bowerman and O'Connel 1987).

The hypothesis statement for testing the impact of the road safety intervention, NRSS II is given below.

### 3.1 Hypothesis Statement

The hypothesis stated here is tested at the 0.05 level of significance.

$I_0$ : The introduction of the NRSS II in 2006-2010 made no significant effect on road accident reduction in Ghana.

$I_1$: The introduction of the NRSS II in 2006-2010 made a significant effect on road accident reduction in Ghana.

The statistical softwares that are used for the analyses include R and Excel.

### 3.2 Description of Variables

The total number of road accident cases recorded over an interval of every three months in Ghana from January 1993 to September 2010 is the variable under study in this work using the time series analysis. This variable is coded as $Y_t$ where the subscript, t is the time representing quarter of a year.

The NRSS II intervention component under investigation is contained in f(I,X), the dynamic part of the model stated above.

### 3.3 The NRSS II intervention

The NRSS II, an integrated road safety intervention introduced in 2006-2010 was carried out by the National Road Safety Commission and other road safety stakeholder organizations in the country (NRSPD, 2008). The NRSS II intervention plan was aimed at reducing the number of road accidents in Ghana. The intervention entailed the promotion of education, publicity, research and monitoring to create awareness and improve knowledge and understanding of road safety. It also involved enforcement of road traffic laws and regulations to enhance discipline on the road to help in crash prevention and to ensure compliance of Driver and Vehicle Standards and Traffic Laws and Regulations. The NRSS II was also designed to minimize road accidents associated with road conditions by improving road infrastructure development (in terms of the echnology employed-engineering) (NRSC, 2007).



### .4 Methodology of the time series analysis

'o carry out the analysis in examining the effect of the NRSS II intervention, the modeling rocess is divided into two phases. The first phase of the analysis is the pre-intervention analysis vhich covers the period from 1993 to 2005 before the NRSS II intervention was introduced in Ghana. This period is referred to as the noise season and the series known as noise series.

The time series analysis methodology applied in the first phase in identifying the pre-ntervention univariate model describing the 52 observations of road accidents in Ghana before he NRSS II intervention, is the Box- Jenkins time series methodology. The Box-Jenkins time eries methodology makes use of the following models; the autoregressive models, moving average models and Autoregressive-moving Average (ARMA) models (Yaacob et al., 2010).

The Autoregressive (AR) model denoted AR(p) is defined by:

$$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \varepsilon_t$$

where, $Y_t$ is the actual value of the series at time t (actual number of road accidents observed at time t), $Y_{t-i}$ is the actual value of the series at the time t–i, φ is the autoregressive parameter for $Y_{t-i}$ and $\varepsilon_t$ is the irregular fluctuation at time t, not correlated with past values of the $Y_t$'s (Makridakis and Hibon, 1997).

The Moving Average (MA) model denoted by MA(q) is expressed as shown below:

$$Y_t = \theta_0 + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \dots - \theta_q\varepsilon_{t-q}$$

where, $Y_t$ is as defined above, $\theta_q$ is the moving average parameter for $\varepsilon_{t-i}$, $\varepsilon_t$ is the error term at time t, $\varepsilon_{t-i}$ is the error term at time t–i (Makridakis and Hibon, 1997).

In 1938, World combined both AR and MA schemes and showed that ARMA process could be sed to model a large number of stationary time series as long as the appropriate order of p, the umber of AR term and q, the number of MA term, are appropriately specified (Makridakis and Iibon, 1997). This means that a general series $Y_t$ can be modeled as a combination of past $Y_t$ nd/or past $\varepsilon_t$ which is:

$$Y_t = \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \dots + \varphi_p Y_{t-p} + \varepsilon_t + \theta_0 - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \dots - \theta_q\varepsilon_{t-q}$$

f differencing is required to achieve stationarity, then the series will eventually have to be ndifferentiated or integrated before forecasting resulting in the case of the Integrated ARMA ARIMA) model. This model combines the Autoregressive (AR) and Moving Average (MA) nodels with a differencing factor that removes trend or seasonal pattern in the data. The letter I, etween AR and MA, stands for Integrated and reflects the need for differencing to make the eries stationary. The ARIMA model equations are the same as ARMA equations except that $Y_t$ s replaced by the different series $Z_t$ and it can be defined as:

$$Z_t = \varphi_1 Z_{t-1} + \varphi_2 Z_{t-2} + \dots + \varphi_p Z_{t-p} + \varepsilon_t + \theta_0 - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \dots - \theta_q\varepsilon_{t-q}$$

where, $Z_t = \Delta^d Y_t = (1-\beta)^d Y_t$ with $\beta$ as the backward shift operator and d is the number of differencing being performed.

The above model is an ARMA (p, q) process for $Z_t$ in the form $\varphi(\beta)(1-\beta)^d Y_t = \theta(\beta)\varepsilon_t$, the model is an ARIMA of order (p, d, q) for $Y_t$.

After identifying the best Box-Jenkins model, the second phase is to incorporate the intervention analysis. This is usually done when there is the need to examine the impact of an external event introduced into a system at specific time periods such as festive occasions (Yaacob et al., 2010).

In the case of Ghana, the National Road Safety Strategy II was aimed at offsetting the road accident figure by having a lasting effect on road accident reduction from 2006-2010. Thus, a step function is to be introduced after identifying the best Box-Jenkins model to account for the NRSS II intervention component in the model.

In order to model the effect of the NRSS II, the Box-Jenkins model found in the first section is used to hypothesize the effect of the intervention using a special kind of dummy variable called step function. The general type of intervention analysis in this work can be described as:

$$Z_t = I_t + \frac{\theta_q(B)\theta_Q(B^L)a_t}{\phi_p(b)\phi_P(B^L)}$$

In which, $I_t$ is the step function as described by the pattern of NRSS II. $a_t$ is the error term and

$$\frac{\theta_q(B)\theta_Q(B^L)a_t}{\phi_p(b)\phi_P(B^L)}$$

is a univariate model obtained by Box-Jenkins methodology (Chang and Lin, 1997).

The step function, $I_t$ which represents the implementation of NRSS II in 2006-2010 is defined as follows:

$$I_t = \begin{cases} 0 & t < January, 2006 \\ 1, & t \geq \text{January, 2006.} \end{cases}$$

### 3.4.1 Identification of the model

Model identification refers to the methodology in identifying the required transformations such as variance stabilizing transformations and differencing transformations, the decision to include the deterministic parameter $\theta_0$ and the proper orders of p and q for the model (William, 2005).

n the identification process according to Box et al. ( 2008), a plot of the time series data is ıbtained and a careful examination of the plot done to get a good idea about the presence of a rend, seasonality, non-constant variances and other nonnormal and nonstationary phenomena. 'his understanding often provides a basis for postulating a possible data transformation. Then, he sample ACF and PACF are computed and examined. If the sample ACF decays very slowly ınd the sample PACF cuts off after lag 1, then it indicates that differencing is needed (William, !005).

### ı.4.2 Stationarity of a time series process

\ time series according to Ramasubramanian, (2007) is said to be stationary if its underlying ;enerating process is based on a constant mean and constant variance with its autocorrelation 'unction (ACF) essentially constant through time. That is, if different subsets of a realization time series 'sample') are considered, the different subsets will typically have means, variances and autocorrelation functions that do not differ significantly.

### 3.4.3 Autocorrelation Functions

#### (i) Autocorrelation

Autocorrelation refers to the way the observations in a time series are related to each other and is measured by the simple correlation between current observation ($Y_t$) and the observation from p periods before the current one($Y_{t-p}$). That is, for a given series $Y_t$, autocorrelation at lag p is the correlation between the pair ($Y_t$, $Y_t$-p) given by

$$\gamma_p = \frac{\sum_{t=1}^{n-p}(Y_t - \overline{Y})(Y_{t+p} - \overline{Y})}{\sum_{t=1}^{n}(Y_t - \overline{Y})^2}$$

nd it ranges from -1 to +1 (Ramasubramanian, 2007). Box and Jenkins has suggested that naximum number of useful $\gamma_p$ is roughly N/4 where N is the number of periods upon which nformation on $Y_t$ is available (Ramasubramanian, 2007).

ii)**Partial Autocorrelation**

'artial autocorrelations are used to measure the degree of association between $Y_t$ and $Y_{t-p}$ when he Y-effects on other time lags 1, 2, 3, …, p-1 are removed (Ramasubramanian, 2007).

iii) **Autocorrelation Functions (ACF) and Partial Autocorrelation Functions (PACF)**

Theoretical ACFs and PACFs (autocorrelations versus lags) are available for various models chosen for various values of orders of autoregressive and moving average components, that is, p and q respectively. Thus, comparing the correlograms (plot of sample ACFs versus lags) obtained from the given time series data with these theoretical ACFs and PACFs enhances the identification of one or more tentative ARIMA models (Ramasubramanian, 2007) The general characteristics of theoretical ACFs and PACFs according to William (2005) are shown in table 1 below.

TABLE 1: Characteristics of theoretical ACF and PACF

| Process | ACF | PACF |
|---|---|---|
| AR(p) | Tails off as exponential decay or damped sine wave | Cuts off after p |
| MA(q) | Cuts off after lag q | Tails off as exponential decay or damped sine wave |
| ARMA(p, q) | Tails off after lag(q - p) | Tails off after lag(p - q) |

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSIONS

## 4.1 RESULTS

A plot of the noise series in figure 1 below indicates a phenomenon of nonstationarity. It also epicts an element of a trend where high road accident cases are always recorded in the last uarter of the year which can also be said to be seasonal.

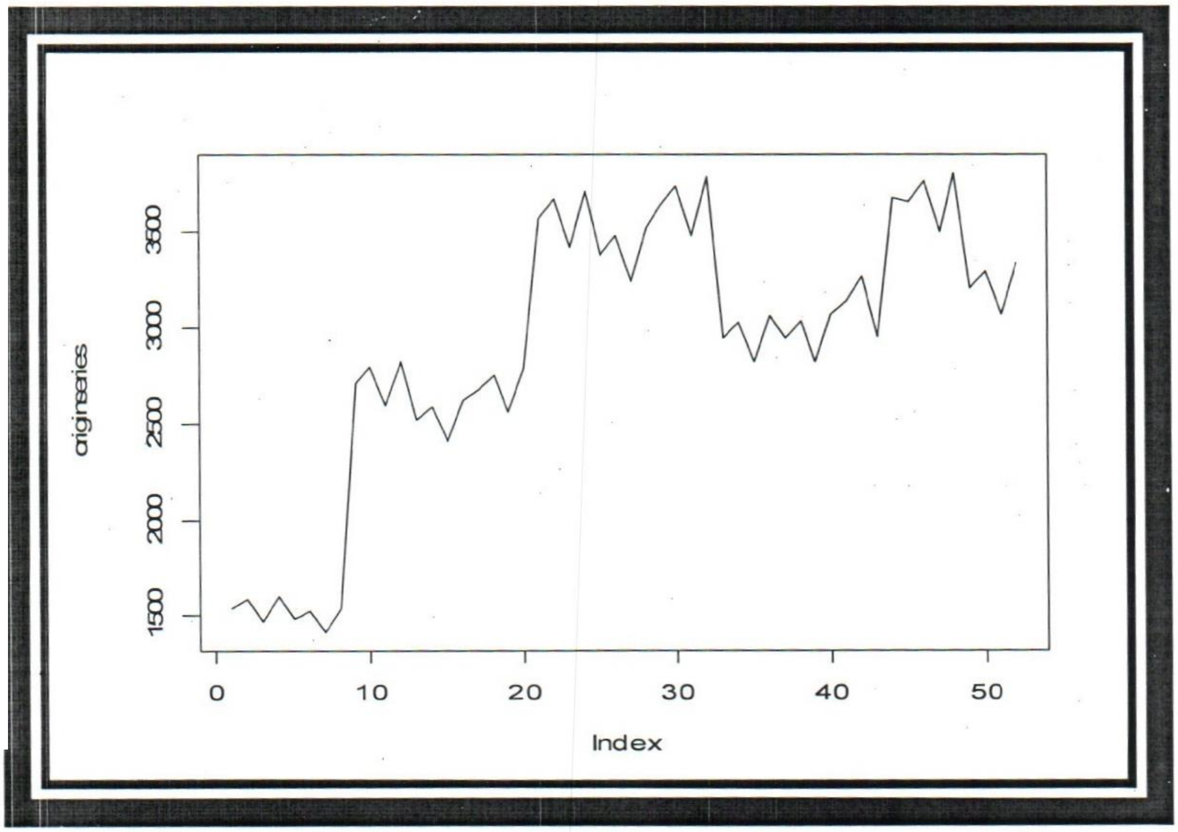


**FIGURE 1: Plot of original series (Quarterly road accident cases before intervention)**

**Index as contained in the plot refers to the time within which observations are made.**

The required transformation for variance stabilization is therefore investigated by using a power transformation analysis. Table 2 below shows the residual mean square errors in the power transformation analysis.

**TABLE 2: Residual mean square errors in the power transformation**

| λ | Residual mean square error . |
|---|---|
| 1.0 | 203.10 |
| 0.5 | 203.52 |
| 0.0 | 204.95 |
| -0.5 | 652.00 |
| -1.0 | 649.17 |

ower transformation analysis enhances the selection of a transformation that has the least or ıinimum mean square error (William, 2005). This in turn leads to the identification of a ːntative model that has the ability to produce forecast values with the minimum error possible.

'he results from the power transformation analysis given in Table 2 suggest that no variance tabilizing transformation is needed and thus, the series is stationary in the variance. The tationarity in variance as indicated by the power transformation analysis however suggests a onstationarity in the mean. Hence, differencing is needed to achieve stationarity in order to apply any further analysis. A plot of the differenced series shown in figure 2 below indicates a stationary process.

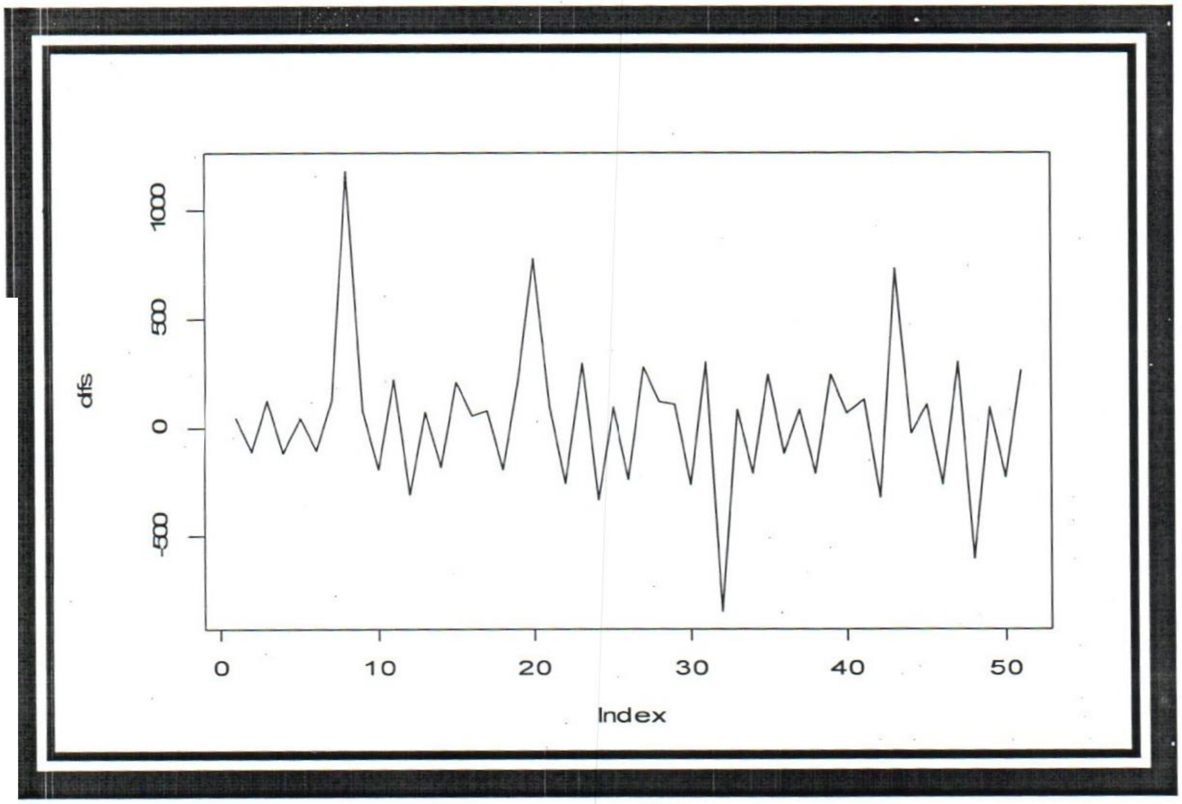


FIGURE 2: A plot of the differenced noise series.

The sample ACF and PACF of the differenced series are therefore respectively plotted as shown in figures 3 and 4 to enhance the identification of a tentative noise model for the stationary differenced series.

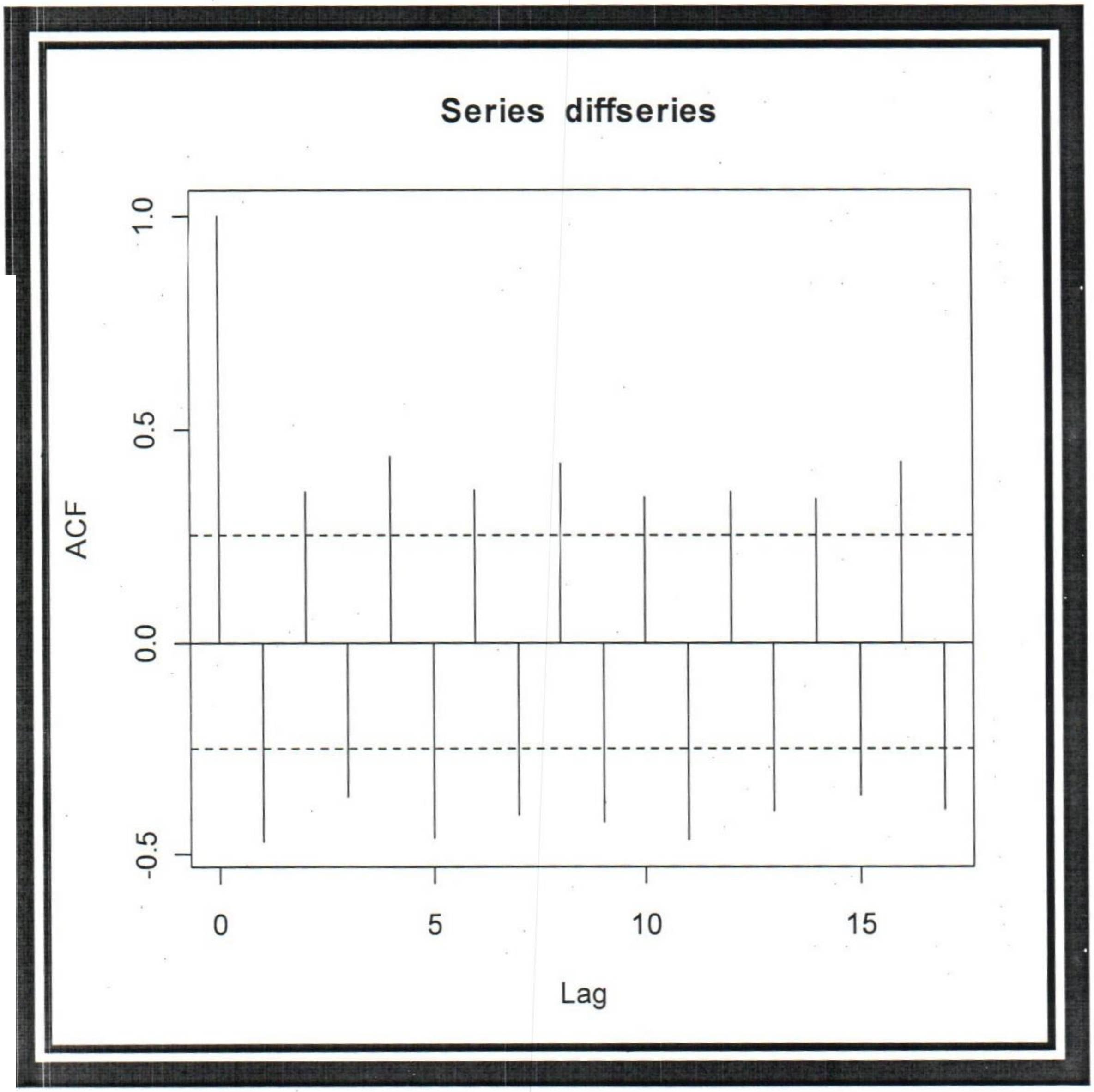


**FIGURE 3: Sample ACF of the differenced noise series.**

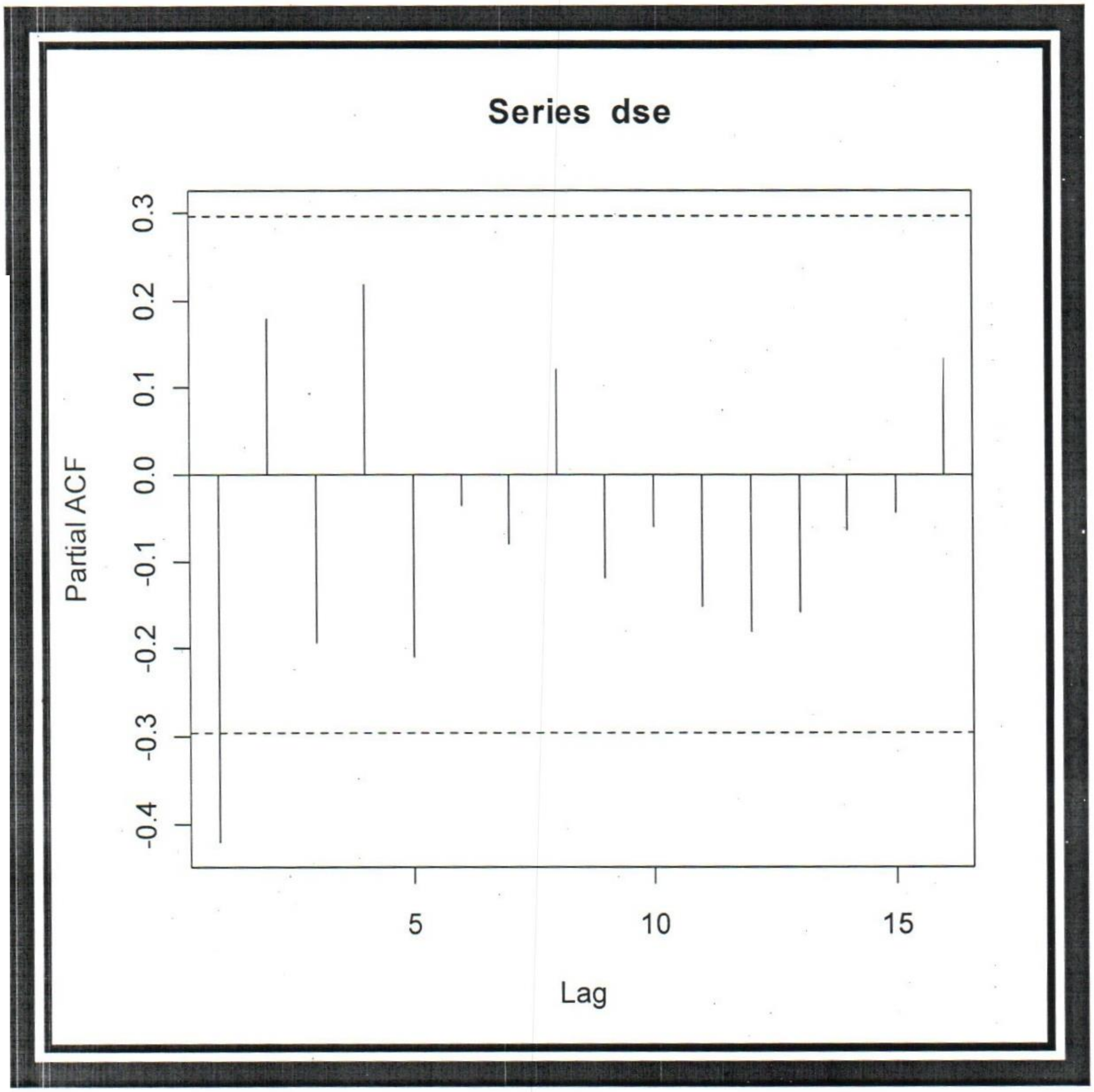


**FIGURE 4: Sample PACF of the differenced noise series**

In figures 3 and 4 above, the sample ACF cuts off after lag 1 whilst the sample PACF tails off as a damped sine wave suggesting an MA(1) model of the differenced series and consequently a tentative model of ARIMA(0, 1, 1) or IMA(1, 1) of the original series.

Table 3 below gives the results of the correlation coefficients of the pre-intervention differenced series. These correlation coefficients describe how the observations are related to each other. For example, the correlation coefficient at order 1 denoted $\rho_1$, is the correlation between a present observation and the next or past immediate observation.

**TABLE 3: Correlation coefficients of differenced series**

| | Order | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **coefficient** | -0.1154 | 0.0092 | -0.0192 | 0.10.0172 | -0.1987 |

### 4.1.1 Results of Diagnostic Checking

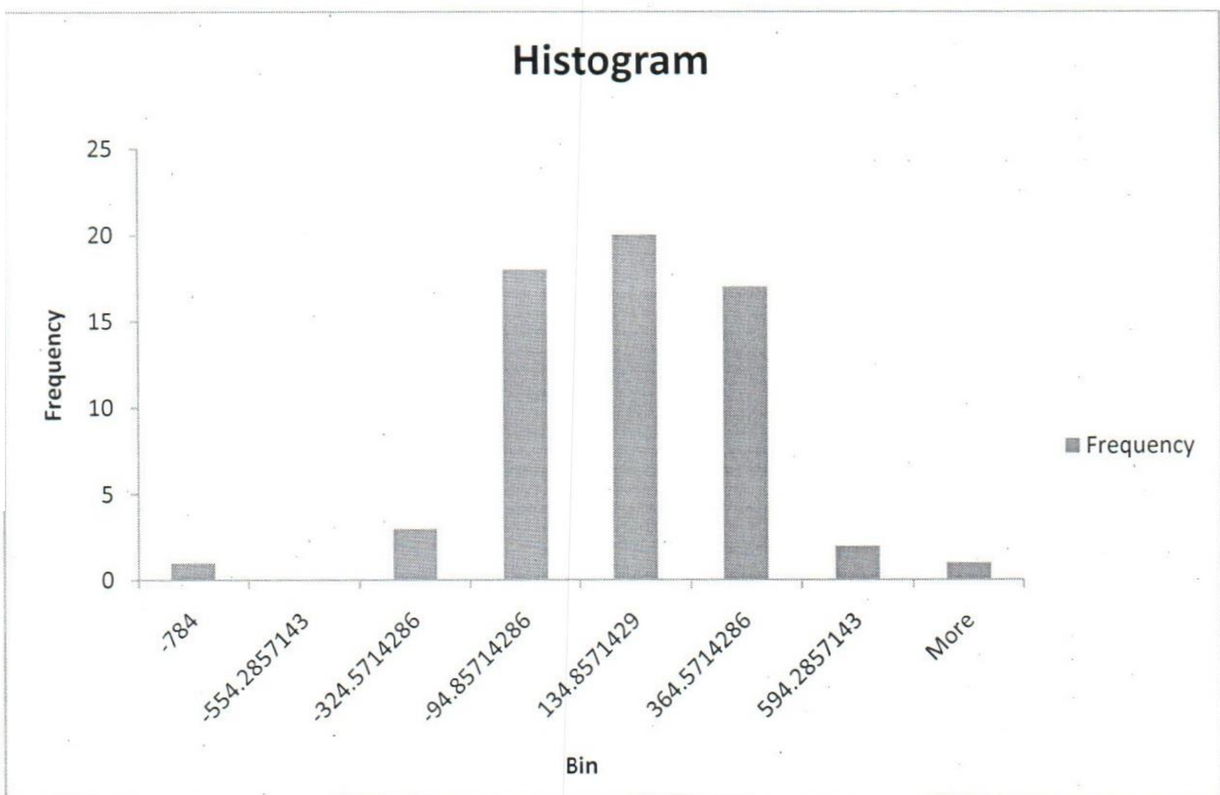


**FIGURE 5: Histogram of standardized residuals**

The histogram of the standardized residuals shown above is used to identify the distribution of the residuals.

The plot of the residuals shown in figure 6 below is used to identify the state of variability of the residuals.

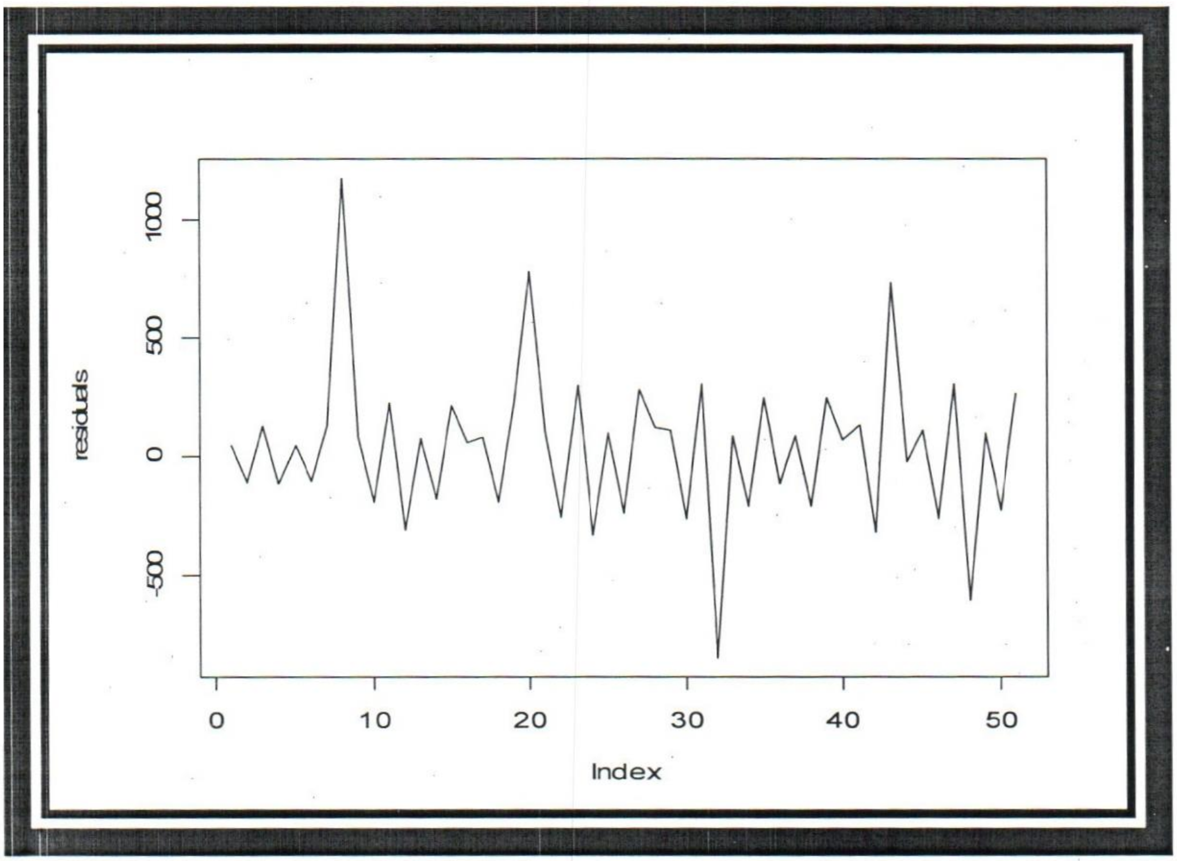


**FIGURE 6: Plot of residuals**

The plot of the sample ACF of the residuals shown in figure 7 below together with the sample PACF plot of the residuals shown in figure 8 are used to identify whether or not a different model apart from the already identified tentative ARIMA(0, 1, 1) model is possible.

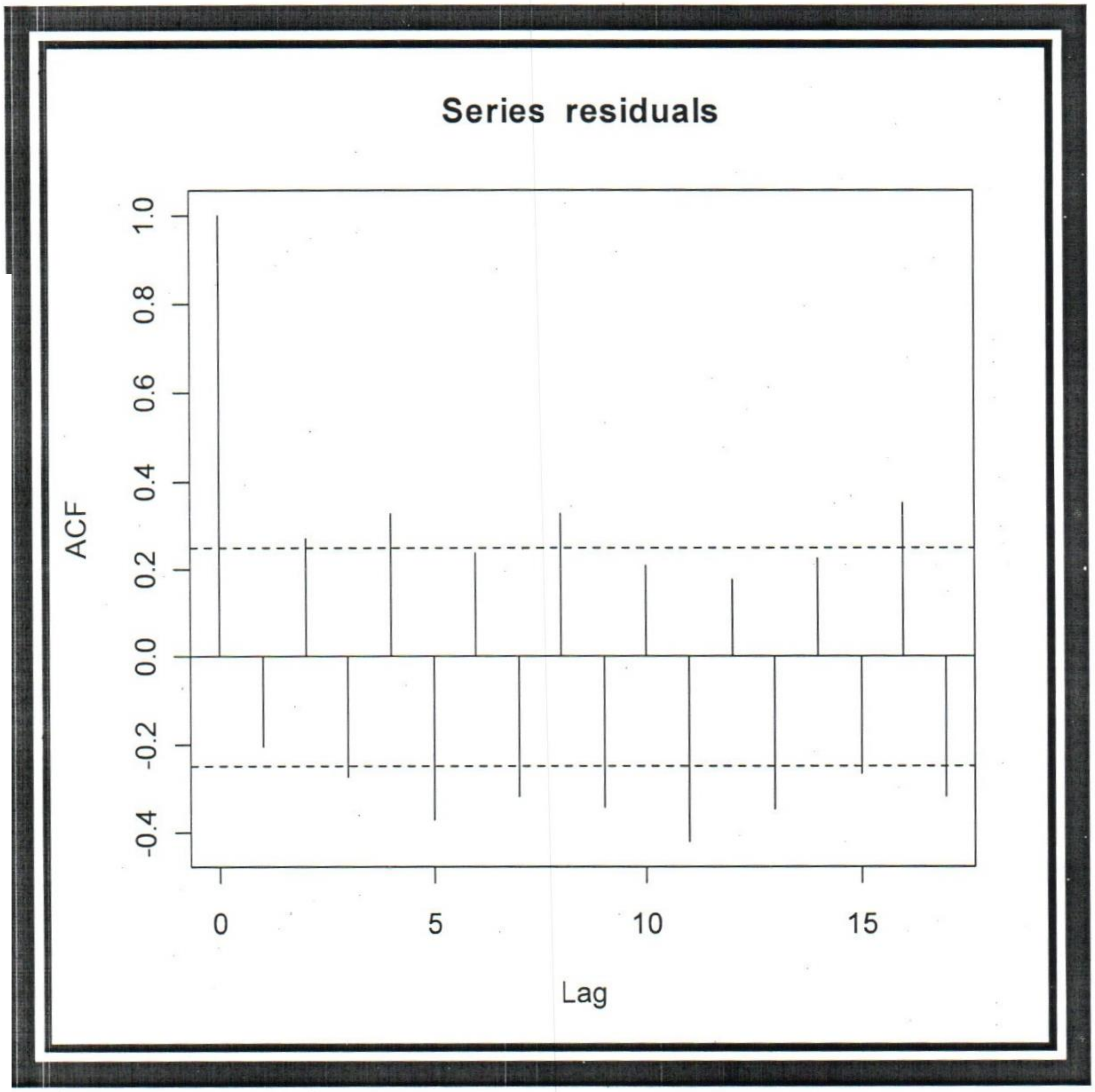


**FIGURE 7: ACF of the residuals**

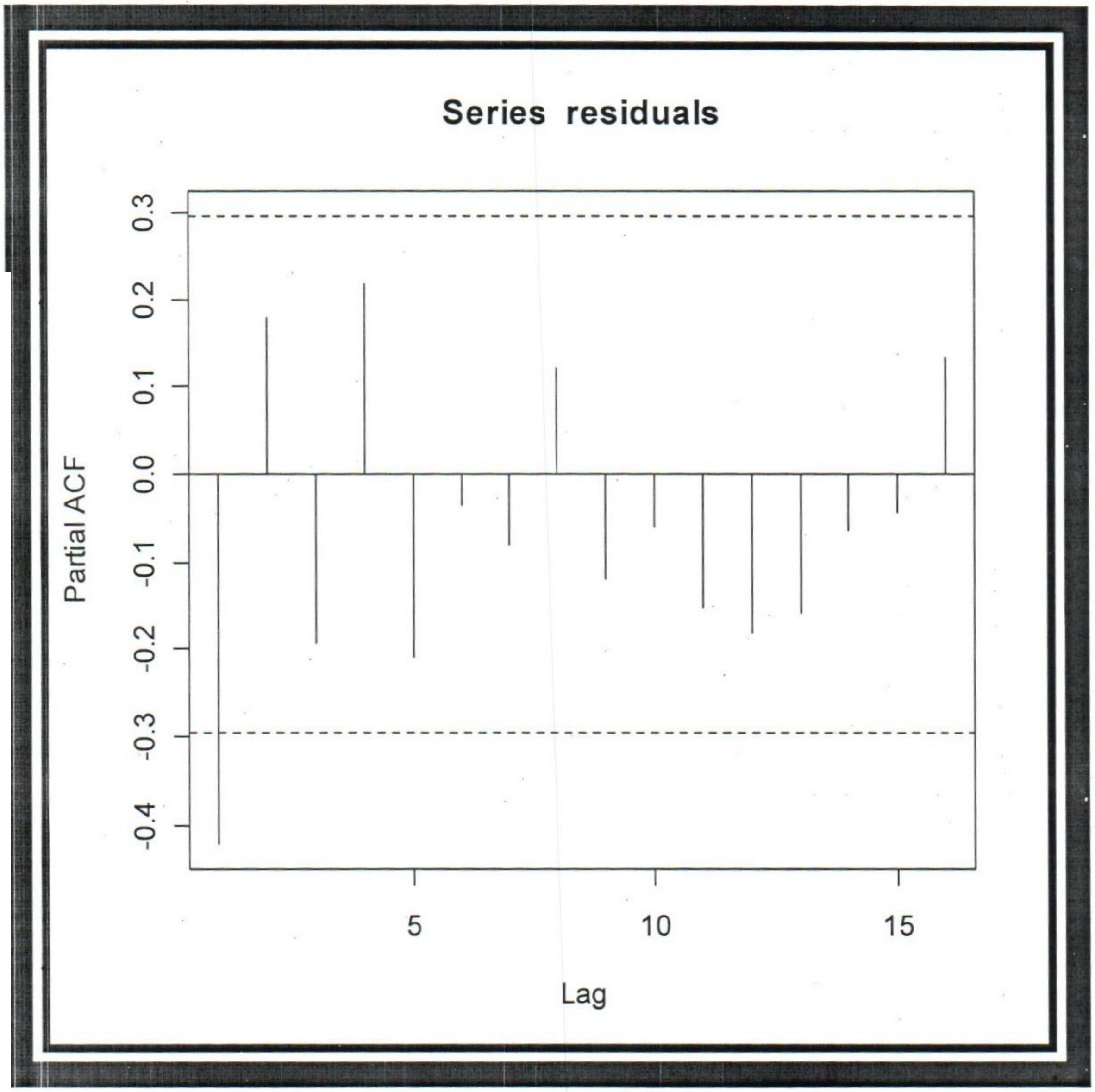


**FIGURE 8: PACF of residuals**

The sample ACF and PACF of the residuals as shown above have significantly indicated a pattern thereby suggesting a non zero mean of the residuals.

The results of the sample ACF and PACF plots however does not indicate the possibility of any model other than the already identified ARIMA(0, 1, 1) model. This therefore enhances the incorporation of the intervention analysis. The ARIMA(0, 1, 1) identified represents the noise model (model describing the quarterly road accident cases before intervention period) given by

$\varphi_0(B)(1 - B)N_t = \theta_0 + \theta_1(B)a_t$ (Wei, 2005).

That is, $(1 - B)N_t = \theta_1(B)a_t$ since $d \geq 1$.

Thus;

$(1 - B)N_t = (1 - \theta_1 B)a_t$

The parameter, $\theta_1$ in the model represents the amount of contribution of the error term to the total number of road accidents recorded within an interval of every three months in Ghana before the intervention period.

### 4.1.2 Parameter Estimation

The method of moments is employed for the estimation of the noise model parameters. The parameter in the noise model to be estimated is $\theta_1$. $\theta_1$ is estimated by solving the quadratic equation below after replacing $\rho_1$ by $\hat{\rho}_1$ (William, 2005).

$$\rho_1 = \frac{-\theta_1}{1+\theta_1^2}$$

The result of the above solution leads to

$$\hat{\theta}_1 = \frac{-1 \pm \sqrt{1 - 4\hat{\rho}_1^2}}{2\hat{\rho}_1}$$

Also, the moment estimator for $\sigma_a^2$ is given as

$\hat{\sigma}_a^2 = \frac{\hat{\gamma}_0}{1 + \hat{\theta}_1^2}$ where $\hat{\gamma}_0$ is the variance of the original series (William, 2005).

According to William (2005) as well as Box et al. (2008), the method of moments is not recommended for use if the process is noninvertible, however, if $|\hat{\rho}_1| < 0.5$, there exist two listinct real-valued solutions and so choosing the one that satisfies the invertibility condition nakes the method of moments worthy of use.

rom the analysis results shown in table 3 above, $\hat{\rho}_1$ = -0.1154.

Ience;

$$\hat{\theta}_1 = \frac{-1 \pm \sqrt{1 - 4\hat{\rho}_1^2}}{2\hat{\rho}_1}$$

$$\hat{\theta}_1 = \frac{-1 \pm \sqrt{1 - 4(-0.1154)^2}}{2(-0.1154)}$$

That is, $\hat{\theta}_1$ = 0.117 or 8.549

The process is invertible if the roots of θ(B) = 0 lie outside of the unit circle, that is, if B > 1 according to Brockwell et al. (2002).

Now, for $\theta_1$ = 0.117, we have

θ(B) = (1- 0.117B) = 0

That is, B = 1/0.117

= 8.547 > 1.

Therefore, the process is invertible for $\theta_1$ = 0.117.

For $\theta_1 = 8.549$, we have

$B = 1/8.549 < 1$ and so noninvertible.

The parameter estimate is therefore $\hat{\theta}_1 = 0.117$.

Having identified the best pre-intervention model, the intervention model then becomes

$$Z_t = \omega_o I_t + \frac{(1-\theta_1 B)a_t}{(1-B)}$$

where $\omega_o$ is the intervention parameter representing the amount of contribution of the NRSS II intervention on the reduction of road accidents in the country. The impact of the NRSS II is therefore revealed by the statistical significance or otherwise of $\omega_o$. $I_t$ is the intervention variable defined as;

$$I_t = \begin{cases} 0 & t < January, 2006 \\ 1, & t \geq \text{January, 2006.} \end{cases}$$

The results of the intervention analysis shown below is used to assess the impact of the NRSS II introduced in 2006-2010 on the reduction of road accidents in the country.

**TABLE 4: Results of the intervention analysis**

| | *Coefficient* | *St. Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| $\omega_o$ | 91.00404858 | 167.6526 | 0.542813 | 0.589008 |

## 4.2 DISCUSSIONS

### 4.2.1 Diagnostic Checking

Model diagnostic checking is done to assess the adequacy of the model (Brockwell et al., 2002). This according to Ramasubramanian (2007) is done by checking whether the model assumptions ıre satisfied. The basic assumption is that the $\{a_t\}$ are white noise. That is, the $a_t$'s are ıncorrelated random shocks with zero mean and constant variance. For any estimated model, the esiduals, $\hat{a}_t$'s are estimates of these unobserved white noise, $a_t$'s. Therefore, the model liagnostic checking is done through a careful analysis of the residual series $\{\hat{a}_t\}$ as indicated elow (William, 2005).

A histogram of the standardized residuals $\hat{a}_t / \hat{\sigma}_a$ is constructed and compared with the standard ıormal distribution to check whether the errors are normally distributed. To check whether the variance is constant, we examine the plot of residuals. To check whether the residuals are approximately white noise, we compute the sample ACF and sample PACF of the residuals to see whether they do not form any pattern and are all statistically insignificant.

A histogram of the standardized residuals shown in figure 5 above gives an indication that the errors are approximately normally distributed. A plot of the residuals shown in figure 6 also gives an indication of a constant variance.

A plot of the sample ACF and sample PACF of the residuals respectively shown in figure 7 and figure 8 produces an MA(1) residual series instead of a white noise series, that is,

$b_t = (1 - \theta_1 B)a_t$. This result however suggests that an ARIMA(0, 1, 1) model may be appropriate which is already the entertained model (William, 2005).

The significant pattern of the residuals indicated by the sample ACF and PACF plots of the residuals gives an indication of a nonzero mean of the residuals violating the basic assumption of a white noise.

The results emanating from the model diagnostic checking is very much expected because a tationary process resulting from a properly differenced series is not necessarily white noise William, 2005). The ARIMA(0, 1, 1) model developed is a stationary process resulting from a roperly differenced series which is not necessarily a white noise and so it will not fully satisfy he basic assumption of a white noise. Therefore, the violation of the basic assumption of the vhite noise is not an indication of an inadequate model and so the ARIMA(0, 1, 1) noise model s maintained.

To ideally identify a reasonably appropriate ARIMA model according to Box (1994) and 3rockwell et al. (2002) as well as Ramasubramanian (2007), a minimum of n = 50 observations s needed and the number of sample lag-k autocorrelations and partial autocorrelations to be calculated should be about n/4. On this basis, it suffices to indicate that the tentative ARIMA(0, 1, 1) noise model obtained in this work is reasonably appropriate since the number of observations used for the model identification is n = 52 and the number of sample lag-k autocorrelations and partial autocorrelations is greater than the required 50/4 lags.

The estimation results shown in table 4 above of the intervention model indicate that the parameter estimate of $\omega_o$ is not statistically significant ($p > 0.05$). This therefore gives no sufficient evidence to reject the null hypothesis and consequently gives the conclusion that the intervention analysis of the NRSS II in Ghana does not show a significant reduction in road accident occurrences.

# CHAPTER FIVE

## 5.0 CONCLUSIONS, SUGGESTIONS AND RECOMMENDATIONS

### 5.1 Conclusions

This study attempted to evaluate the effect of the NRSS II intervention introduced in Ghana within the period of 2006-2010 by developing an intervention model. The intervention model with step function was adopted to model the interrupted effect of the intervention on the number of road accidents in Ghana. A test of hypothesis was carried out to examine the significance of the NRSS II intervention at the 0.05 level of significance.

The residual ACF showed no evidence of model inadequacy. However, the parameter estimate of the NRSS II intervention, $\omega_o$ was not statistically significant ($p > 0.05$). This result therefore gave no enough evidence of rejecting the null hypothesis, $H_0$. On the other hand, it provided sufficient evidence to conclude that the introduction of the NRSS II intervention did not significantly result in the reduction of the number of road accidents in the country.

This outcome is however not explicit since other factors outside the available data used within the study period could have affected the studied variable.

Studies have shown that, "road safety is the collective responsibility of all" (http://www.transport.gov.za/comm-centre/pr/2002/pr0314.html). On this basis it suffices to indicate that, apart from the introduction of a road safety intervention, a lot more is required in terms of the level of commitment from all stakeholder organizations, concerned parties and individuals (road users) in enforcing the intervention among other road safety issues in order to win the battle against road accidents in the country.

## 5.2 Suggestions

It is an undisputable fact that, preventing the occurrence of road accidents is by far a better option than reducing the severity of road accidents (WHO, 2009). In this regard, concerted efforts are made by various bodies such as the National Road Safety Commission and other road afety stakeholder organizations in attempts to combat the incidence of road accidents in the ountry (NRSPD, 2008). As a result, a lot more information on the parameters or characteristics f road accidents is needed to enhance research in the area of road accidents in the country. tatistics on road safety measures for example could be taken over time to enhance research nvestigations into which measures contribute in significantly reducing the number of road ccidents in Ghana.

## .3 Recommendations

very comprehensive documentation and proper records keeping of road accident occurrences n the country is required to enhance more research and better understanding of the nature of oad accidents.

onsidering the peculiar case of gross indiscipline on road usage in the country, effective traffic aw enforcement is a significant tool to reducing the alarming rate of traffic crashes.

The participation of many different organizations and sectors in the country in the quest to improving safety on the road is very commendable since no one sector working alone can effectively reduce the number of road accidents. However, a lot more is required in terms of the level of commitment from all stakeholder organizations, individuals and concerned parties in enforcing road safety interventions in order to achieve desired results.

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## APPENDIX

### MOTOR ACCIDENT RETURNS FROM 1993-2010

| | YEAR | | | | | |
|---|---|---|---|---|---|---|
| **QUARTER** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** |
| **1st** | 1536 | 1479 | 2712 | 2516 | 2676 | 3566 |
| **2nd** | 1583 | 1523 | 2791 | 2590 | 2755 | 3670 |
| **3rd** | 1471 | 1416 | 2597 | 2410 | 2563 | 3415 |
| **4th** | 1599 | 1540 | 2823 | 2620 | 2786 | 3713 |
| **TOTAL** | **6189** | **5958** | **10923** | **10136** | **10780** | **14364** |

| | YEAR | | | | | |
|---|---|---|---|---|---|---|
| **QUARTER** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** |
| **1st** | 3380 | 3637 | 2943 | 2947 | 3137 | 3658 |
| **2nd** | 3478 | 3743 | 3028 | 3034 | 3270 | 3765 |
| **3rd** | 3237 | 3483 | 2818 | 2823 | 2950 | 3503 |
| **4th** | 3518 | 3787 | 3064 | 3068 | 3682 | 3808 |
| **TOTAL** | **13613** | **14650** | **11853** | **11872** | **13039** | **14734** |

| | YEAR | | | | | |
|---|---|---|---|---|---|---|
| **QUARTER** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
| **1st** | 3203 | 2904 | 2892 | 2845 | 3051 | 3132 |
| **2nd** | 3297 | 2990 | 2976 | 2820 | 3094 | 3516 |
| **3rd** | 3068 | 2781 | 2769 | 2517 | 3154 | 3349 |
| **4th** | 3335 | 3023 | 3011 | 3027 | 3266 | |
| **TOTAL** | **12903** | **11698** | **11648** | **11209** | **12565** | |

Source: MTTU of the Ghana Police Service, Accra-2010.