The influence of road safety culture on driver behaviour: a study of Nigerian drivers

Chinebuli Chiderah Uzondu

Submitted in accordance with the requirements for the degree of
Doctor of Philosophy

The University of Leeds
Institute for Transport Studies

November 2019

The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

1) Chapter 5: “Phase 1: On-road observation of traffic behaviour and conflicts in Nigeria” partly based on the publication: Uzondu, C.C., Jamson, S., & Lai, F. (2018). Exploratory study involving observation of traffic behaviour and conflicts in Nigeria using the traffic conflict technique. Safety Science, 110 (part a), 273-284.

2) Chapter 5: “Phase 1: On-road observation of traffic behaviour and conflicts in Nigeria” partly based on the publication: Uzondu, C.C., Jamson, S., & Lai, F. (2018). Uzondu, C.C., Jamson, S., & Lai, F. (2019). Investigating unsafe behaviours in traffic conflict situations: An observational study in Nigeria. Journal of Traffic and Transportation Engineering, https://doi.org/10.1016/j.jtte.2018.06.002

The work attributable to the candidate comprises the literature review, planning and conducting experiments, data analysis, writing and creation of graphics.

The contributions of the co-authors consisted of supervision, critique and advice during the whole process, proof-reading and commenting.

Acknowledgements

To God
…from whom all blessings flow

To my Father, Sir Christian Chukwuocha (1940-2015)
Who laid this beautiful solid foundation

I wish to express my sincere gratitude to my supervisors, Prof. Samantha Jamson and Prof. Greg Marsden, for their invaluable insights and immense support. Thank you, Sam, for becoming my PhD supervisor at a critical juncture. Your keen interest and consistent guidance led to the successful completion of this research. I am grateful for the trust and confidence you showed in letting me work independently and giving this work your full attention. Thank you, for your patience and for giving me time whenever I needed it. Your open-door policy was much appreciated as were the times you spent carefully reviewing my thesis chapters. You were always there whenever I got confused especially from reading and understanding your insightful comments, needed a chat or had a question about my research or writing. You trusted me even at points when I doubted myself. Thanks a lot, Sam! Thank you, Greg, for your support in phase 3 of my PhD, when I needed guidance on the policy aspect of my research. In spite of your very busy schedules, you provided thought-provoking suggestions and valuable guidance in the design of the study and in writing up the thesis.

I am also indebted to my former supervisors- Dr Darly Hibberd and Dr Frank Lai for their support at different phases of my PhD research. Thank you Daz for your support in phase 2 of my research. Daz was very helpful during the design of the driving simulator experiments, carrying it out and writing up that phase. Thank you to Frank who sadly passed away on 24 November 2017. Frank was my first supervisor and patiently provided me with valuable guidance through the difficult initial stage of my research. His advice, encouragement and contribution especially in phase 1 helped shape this PhD and is very well appreciated. This research relied on a lot of work and support of the University of Leeds Driving Simulator team. I appreciate the help of Michael Daly, Anthony Horrobin, Andrew Tomlinson, Abert Solernou and Jukic Hrvoje. Particularly Anthony Horrobin, who did an amazing job, setting up the road layouts for the experiments and was always available when I got stuck with the simulator data.

Many thanks to the Federal University of Technology Owerri (FUTO) which their Tertiary Education Trust Fund (TetFund) scholarship provided initial funding, and the Institute for Transport Studies (ITS), University of Leeds, for part funding my studies. Prior to beginning my PhD, Prof. C. Ibe from FUTO, who was my MSc supervisor, encouraged me to undertake this PhD, helped me to shape the initial ideas of my PhD proposal and continued to create supportive engagements throughout. Thank you to my colleagues in the department of Transport Management Technology, FUTO for all their encouragement. I am grateful to all the field surveyors who helped in data collection in phase 1; participants, who took the time and effort to volunteer and take part in the driving simulator experiments in phase 2 and the facilitators and participants from the Federal Road Safety Corps (FRSC) involved in the focus group study in phase 3, enabling me to complete this study. My appreciation goes to the Corps Marshal of FRSC, Dr B. Oyeyemi and Deputy Corps Marshal Mrs O. Ewhrudjakpor who ensured the focus group study was a success. Many thanks to the supportive and kind staff at ITS, Ms. Deborah Goddard, Mr Mattew Armstrong, Mr. Paul Adams, Ms. Jo Moran, Ms Natalia Ainsworth and Ms. Jennifer Cleaver. Special thanks to Paul, who made sure I had all the equipment I needed at each stage of data collection.

I thank my friends and fellow PhD students David, Tony and Bashiru for listening, inspiring, challenging and also encouraging me. Thanks, Dr Mojtaba, Dr Anderson and Dr Tatjana for all the intelligent conversation and valuable suggestions. Thanks to Onyii and Chii for cheering me up in low times. Thank you to OJ, Chimmy and the beautiful family in Wolverhampton for providing the much needed get away from the PhD and for hosting me especially during the Christmas holidays.

My deepest gratitude goes to my family for their unwavering love and support. To my mum, Lady Mercy Chukwuocha, I will remain indebted for your constant prayers, support and taking care of the Kids all this while. My brothers, Uche and Ikechukwu; my go-to-girls, Adanna, Chinwe and Ezinne, who have given me unequivocal support throughout, I cannot say how thankful I am. To my foster daughter Anuri, you have been very helpful. To Ven (Dr.) A.C. Chukwuocha, thank you for always being there. The entire Chukwuocha and Uzondu families, I am very grateful for your support.

Finally, to my husband, Uzondu, words cannot describe how much I value your love, care, understanding and support during this period. Thank you, for taking good care of the kids all these years. To the strongest kids I know, Nmeso, Esom, Somto and Kamsy, you make me proud and you mean everything to me. Just to let you know that we did it!

Abstract

Unsafe driver behaviour is regarded as the most significant contributory factor in road traffic crashes in Nigeria, and the prevailing road safety culture in the country is one aspect which sustains the high crash rate. This research used a problem-oriented approach with the intention to recommend research-based solutions to road safety problems in Nigeria while considering cultural and environmental factors that provoke different driving styles and behaviours. It aims to identify which, among culture and road environment, has a stronger influence on drivers' behaviour and how behavioural changes can be achieved. To achieve this, a multi-method approach was adopted in different phases. **Phase 1,** an exploratory study involved on-road observation of traffic behaviour and conflicts in Nigeria using the Traffic Conflict Technique (TCT). It provided an understanding of the general traffic behaviour of various road users, showed the effect of various factors on conflict severity and helped to identify the most prevalent unsafe behaviours found in this environment. Based on the results of this study, a driving simulator experiment was designed and carried out in **Phase 2**, comparing the driving style of three groups of drivers in varying road conditions. These were Nigerians with no experience of driving in the United Kingdom (UK), Nigerians with some experience of driving in the UK and UK drivers. The conditions varied depending on how much regulation was provided (low or high infrastructure). A short road safety awareness-raising intervention for Nigerian drivers with no experience of driving in the UK was also evaluated. It was hypothesised that those Nigerian drivers with no experience of driving in a highly regulated UK road system would not be encouraged to adopt a safe driving style. This would have implications for the use of road safety interventions in Nigeria that have been developed outside the Nigerian context. In addition, participants completed the Driving Behaviour Questionnaire (DBQ) to compare reported behaviour and objectively measured driving behaviour in various traffic scenarios (overtaking, lane changing, car following etc.). Since many road safety measures could not evaluated for Nigerian drivers in phase 2, a focus group study was conducted in **Phase 3** with the lead road safety agency in Nigeria-the Federal Road Safety Corps (FRSC). The study investigated the perceived effectiveness and ease of implementation of a wide range of road safety measures on drivers' behaviour including those that were evaluated in **Phase 2** (simple engineering measures and awareness-raising campaigns).

Results provided a greater understanding of the road safety situation in Nigeria. Some of the unsafe behaviours identified in Phase 1 are distinct and can only be found in a particular cultural environment like Nigeria because of the traffic conditions and vehicle fleet. Investigating some of these behaviours in Phase 2 and comparing them with the behaviour of drivers from other cultures showed that there were distinct differences in behaviour between all the groups in most of the traffic scenarios. Nigerian drivers with no experience of driving in the UK were more likely to engage in unsafe driving behaviours compared to other groups. Improvements in the road environment did not bring about any significant changes in the behaviour of this group of drivers. However, small changes were observed after the awareness-raising intervention. The results indicate that the behaviour of drivers are interpretable in relation to their traffic safety culture, and are only partly influenced by their driving environment. Specifically, drivers' traffic safety culture has a greater influence on their behaviour compared to changes in the road environment. Findings from the focus group study in phase 3 revealed that road safety measures such as education and information campaigns are perceived to have the potential to be very effective and easy to implement in Nigeria compared to other measures. The research findings provide an innovative approach to defining the key safety-critical behaviours which are prevalent in Nigeria as well as starting to understand how features of the road environment and/or training could be used to improve the road safety record in Nigeria. It also has implications for the design of road safety interventions in developing countries, particularly with respect to the non-portability of infrastructure measures from developing countries.

List of abbreviations

ABS: Anti-locking Braking System
ANDS: Australian 400-car Naturalistic Driving Study
ANOVA: Analysis of Variance
BRT: Brake Reaction Time
CG: Centre of Gravity
DBQ: Driver Behaviour Questionnaire
FA: Factor Analysis
FRSC: Federal Road Safety Corps
GDP: Gross Domestic Product
GNP: Gross National Product
GNCAP: Global New Car Assessment Programme
GPS: Global Positioning System
HBM: Health Belief Model
HICs: High Income Countries
HP: Hazard Perception
IRAP: International Road Assessment Program
LMICs: Low and Middle Income Countries
NaRSAC: National Road Safety Advisory Council
NCAP: New Car Assessment Programme
NDS: Naturalistic Driving Studies
NG: Nigerian drivers
NG/UK: Nigerian/UK drivers
UK: UK drivers
PCA: Principal Component Analysis
PDAS: Percentage distance travelled above the speed limit
RSPA: Royal Society for the Prevention of Accidents
RT: Reaction Time
RTC: Road Traffic Crashes
RTI: Road Traffic Injury
SD: Standard Deviation
SHRP: Strategic Highway Research Program
SPSS: Statistical Package for Social Sciences
TCT: Traffic Conflict Technique
TH: Time Headway
TPB: Theory of Planned Behaviour
TTC: Time to Collision
TTJ: Time to Junction
UAE: United Arab Emirates
UDRIVE: European naturalistic Driving and Riding for Infrastructure & Vehicle safety and Environment

UNECE: United Nations Economic commission for Europe
VTTI: Virginia Tech Transport Institute
WHO: World Health Organization

Table of contents

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Overview

Road Traffic Crashes (RTCs) constitute a major problem worldwide, accounting for an estimated 1.35 million fatalities annually (WHO, 2018). These numbers are higher in Low and Middle Income Countries (LMICs) compared to the High Income Countries (HICs). This highlights the importance of understanding factors that influence driving behaviour and how behavioural changes can be achieved especially in the LMICs. This research investigates the influence of road safety culture on driver behaviour. Section 1.2 describes the motivation for the research. The research rationale is presented in Section 1.3 while the aims and overview of the thesis are presented in sections 1.4 and 1.5 respectively

1.2 Motivation for research

This thesis is motivated by the poor road safety culture in most LMICs which has contributed to the continuing increase and high incidence of RTCs in these countries.

The frequency of road fatalities is declining in high-income countries despite traffic growth, because of improvements in vehicles, roads, traffic management, law enforcement, education, emergency services, and medical treatment. However, fatalities are rising in the developing world, especially where motor vehicle use is growing rapidly. According to Peden et al. (2004), rapid motorisation, poor road and traffic infrastructure, as well as the behaviour of road users, have all contributed immensely to increases in road traffic crashes and fatalities in LMICs. Additionally, as motorisation levels increase, the need for proper research becomes even stronger. Past studies and research are needed to keep track of improvements and to evaluate performance but this is scarce in developing countries. According to Downing (1991), there may be 20 person-years of research effort each year in developing countries compared with over 500 in developed countries.

Data on traffic crash causation are also important for the targeting and monitoring of road safety interventions; such data could help in defining the extent of the road safety problem by comparing it with other causes of death in order to make informed decisions (WHO, 2015). The available road safety data in most developing countries is inadequate and generally under-reported which could be as a result of data collection methods used. The most common method of collecting data in LMICs is with the use of self-reports (see section 4.4.1 for more information) which is associated with limitations such as underreporting as opposed to the use of other methods that enable actual observation of behaviour.

On the other hand, most data collection methods were developed in Western countries. These methods and intervention measures developed and successfully used in these countries may not be readily applied in developing countries because of the differences in traffic safety culture, road environment, traffic conditions and traffic systems (Baguley & Jacob, 2000; Warner et al., 2009). Therefore there is a need to improve and modify data collection methods developed and applied in developed countries, by taking into consideration local conditions before being used in developing countries. Hence, it is imperative to carry out research and evaluation studies, which accommodate country-specific conditions and suggest appropriate interventions accordingly. This will enable prioritisation of measures or interventions so that the limited resources are allocated to measures which have been proved to be effective in improving the road safety system of specific countries where they had been developed. Carrying out adequate research would go a long way in providing evidence-based measures which can be used in designing effective policies to improve the road safety culture in developing countries.

1.3 Rationale for the research

This section provides an overview of the rationale for the research based on gaps identified from the literature review.

1.3.1 Lack of road safety research and data in Nigeria

Many Studies (see chapter 4 for a review) have established the relationship between driving behaviours and crashes. To improve drivers' behaviour, it is important to have a clear idea of the reality of the situation by understanding the issues to be tackled. This could be achieved by looking at past studies, research and evaluation reports, crash data and documents related to these issues. Unfortunately, there is lack of adequate empirical research related to road safety in Nigeria and as a result, data is scarce and not readily available. The available data are inadequate and not enough to tackle the road safety problems. As shown in the literature, road traffic crashes are grossly under-reported and may not reflect actual numbers. Improving the road safety situation in Nigeria requires more information than could be elicited from the available crash data. Most studies have relied on crash data both in the developed and developing countries, to provide countermeasure programs for road safety problems. On the other hand, many studies have resorted to the use of crash surrogates or otherwise called near misses. This has the advantage of happening more often and data can be collected within a short time rather than waiting for crashes to happen (which is rare and takes a long time). Most of these studies have taken place in developed countries and very few have been conducted in developing countries (Almqvist & Hyden, 1994). Data from this type of study and other behavioural observations could provide baseline information on risk factors on the behaviour of road users. Combining it with the limited available crash data could provide rich data needed for road safety assessment in developing countries and can be used to design intervention measures targeted at identified behaviours**. Therefore, the first study in this thesis adopted the TCT as an exploratory method to understand the road safety situation in Nigeria.** In addition to the advantages of using this method in Nigeria, it is also a proactive method of road safety assessment and provides more information especially on pre-crash situations to complement the inadequate crash data. It also provides a low-cost method of road safety assessment especially in the developing countries where research funding is limited.

1.3.2 Need to improve and modify data collection methods

Nearly all methods of data collection were developed in the western countries and parameters related to driver characteristics were determined based on driver behaviour as observed in those countries. It would be unknown if research methods developed in the western countries or better-performed countries in terms of road safety would be applicable (transferable) to other regions of the world where traffic culture and vehicle mix are different. In developing countries, the traffic infrastructure, driving culture and driving experience all distinctly differ from those in western countries. These discrepancies can influence driver behaviour in one way or the other. If research methods are applied in practice without modification for the specific environment, results obtained may not reflect the exact road safety problems in that particular environment. Subsequently, inappropriate safety measures would be implemented based on some unrealistic results. Therefore, it is important to develop and modify methodologies that could be directly applied to different countries considering their different profiles and traffic conditions.

For example, the TCT and DBQ developed and used in developed countries may not be used directly on Nigerian drivers and needed a slight modification in this study. These methods have been widely adapted to several international studies (both developed and developing countries) as shown in the literature but researchers have also stressed the importance of considering cultural factors while applying the instrument in other countries. Research being conducted in developing countries should fulfil research deficits and needs and not to directly transfer methods from developed countries which may not be applicable to the environment. For example in a cross-cultural study Lajunen et al. (2004), they emphasised the importance of thorough knowledge of the countries and cultures involved and also great care in translation procedure where applicable. In this study, it was very relevant to incorporate local factors specific to the Nigerian traffic environment into the TCT and the DBQ, so that research findings will be readily applicable to the environment. **Consequently, to observe general traffic situation in Nigeria and measure self-reported behaviour of different groups of drivers, this thesis used the TCT and DBQ with slight modifications to take into account local aspects of the environment (Nigeria) where the instruments were not originally developed**. As it also provides the first application of modified versions of the TCT and DBQ in Nigeria, it also assesses the acceptability and applicability of these methods in the country.

1.3.3 Use of Objective data

Self-reports are the most commonly used methods of identifying unsafe behaviours of drivers in Nigeria and most developing countries. Self-reports are associated with issues such as reliability of subjective data, could be biased and should not be taken as the only measure of driving behaviours. This is because the self-reported behaviour of drivers may differ from their actual performance and can generate over or under-reported sets of data. **Therefore, in addition to self-reports, this thesis goes one step further and observed behaviour of drivers using (i) the TCT in real traffic situation in Nigeria and (ii) the University of Leeds Driving simulator.** These techniques have emerged as successful tools for recording the actual behaviours of drivers.

1.3.4 Understanding the influence of road safety culture and road environment

Evaluating driver behaviour could be a challenging task, especially in developing countries due to the lack of reliable behavioural data and the absence of effective data collection techniques. Very few studies have been able to analyse driving behaviour data of different groups of drivers with their activity data (speed, overtaking, lane changing behaviour etc.) across cultures. General investigation of driver behaviour and skills have been the basis of most research, but this study will attempt to investigate driving in actual circumstances, and how prevalent it is across cultures using the reliable and flexible conditions of the University of Leeds driving simulator. **While most cultural studies have focused on two or more different cultures, it is not yet known if any study has been able to investigate the influence of road safety culture and road conditions on drivers' behaviour. This was investigated in this thesis by comparing three distinct groups of drivers**. This is to assess how these conditions contribute to changes in driving behaviour and how drivers from high-risk countries adapt to environmental conditions in low-risk countries. To achieve this, three distinct groups of drivers (NG, NG/UK and UK drivers) were compared under different environmental conditions in this thesis. There has been little work to uncover the mechanisms or factors that account for the observed changes in behaviour following the implementation of tests, training and environmental changes. According to Comte (2001), behavioural adaptation may be as a result of the secondary effect of a system and so it is crucial while carrying out this type of study to look into a wide range of variables that might be responsible for this change in behaviour. This has not been thoroughly investigated in studies trying to uncover behaviour change and adaptation in new environments. This thesis provided the opportunity to observe these groups of drivers and to investigate factors that could influence behaviour.

1.3.5 Need for adequate driver education and training

Research have highlighted the effect of driver education and training on driver behaviour. Unfortunately, driver education and training is not adequately implemented in Nigeria as most drivers do not do the adequate tests and training needed before obtaining a driver's license. This could affect knowledge and understanding of basic road rules, regulations and legislation for safe driving. In order words, drivers may not understand what certain road rules mean and may need some form of additional periodic training to improve their knowledge and understanding. This would also provide an opportunity for drivers to have a proper understanding of what driving behaviours are safe and unsafe. **Therefore, this thesis also examined the effect of simple training in the form of an awareness-raising intervention on the behaviour of Nigerian drivers.** This was found very important because engineering measures could sometimes be very expensive and may be ineffective in bringing about behavioural change if they are applied alone.

1.3.6 Need to prioritise road safety measures based on effectiveness and ease of implementation

It is apparent from the literature that road safety measures such as engineering measures, driver education and training and vehicle inspection could be used to improve road safety. On the other hand, countries such as Nigeria have limited funding allocated to road safety. It becomes very important that adequate research needs to be carried out to be able to prioritise road safety measures so that the limited available resources are allocated in order of importance to measures that are very effective and easy to implement in the country. **Therefore a focus group study was carried out in this thesis with the lead road safety agency in Nigeria (the Federal Road Safety Corps, FRSC). As the agency directly responsible for road safety activities in the country, this study was needed to gain a better understanding of current road safety practices and measures which have proved effective and easy to implement in Nigeria**. This is so that the limited available resources are allocated to measures which are very effective in improving the road safety profile of the country.

1.3.7 Formulation of evidence-based road safety policies imperative to improving the Nigerian road safety culture

Finally, adequate data for road safety assessment is scarce and not available in Nigeria. This makes it very difficult to design effective road safety interventions. Adequate data is needed to develop evidence-based measures which are needed to make recommendations for effective road safety policies in Nigeria. **Based on the findings of the studies carried out in this thesis, recommendations for future policies, schemes and measures vital for improving the road safety culture in Nigeria are made.**

1.4 Main aim of the research

The preceding discussion of the burden from traffic crashes, the lack of knowledge about factors affecting risk on the roads, and the need for a multidisciplinary approach encompassing the interactions between the components of the road system and the broader social and physical environment, led to the aims of the research presented in this thesis.

The aims of the research are to:

1. Gain a better understanding of the road safety situation and identify the most prevalent unsafe driver behaviours in Nigeria.
2. To examine the similarities and differences between self-reported and actual behaviour of different groups of drivers.
3. To investigate the influence of traffic safety culture and road environment (simple engineering measures) on driver's behaviour.
4. To evaluate the effect of some simple awareness-raising intervention on the behaviour of Nigerian drivers.
5. To examine effective evidence-based road safety measures imperative to improving the road safety culture in Nigeria.
6. To assess stakeholders' perception of the effectiveness and ease of implementation of a range of road safety measures on the behaviour of Nigerian drivers.
7. Based on the findings from the studies carried out in different phases of this thesis, to make evidence-based recommendations for future policies, schemes and measures imperative to improving Nigerian road safety culture.

These are broken down into the following research questions which were investigated in three phases.

1.4.1 [1]Research questions

Phase 1:

RQ1: What unsafe (bad) driving behaviour(s) are most prevalent among drivers in Nigeria?

Phase 2:

RQ2: Are there differences in reported and observed behaviour among different groups of drivers (NG, NG/UK and UK drivers)?

RQ3: Do drivers exhibit different behaviours across different scenarios?

(a) Are there significant differences in behaviour between the driving activity patterns of drivers (NG, NG/UK and UK drivers) in different scenarios?

(b) Is poor driving behaviour a function of the influence of culture and are drivers with a history of unsafe driving culture more likely to commit road traffic violations or exhibit the greatest risky behaviour?

---

[1]To explore these research questions, specific hypotheses were developed and tested in the relevant chapters.

RQ4: Do drivers adjust or change unsafe behaviours when they move to a better-disciplined driving environment with clear regulations and strict policies?
RQ5: Can a simple awareness-raising intervention affect driver behaviour?

Phase 3:
RQ6: What road safety measures are perceived to be effective and easy to implement in Nigeria?
RQ7: How could the evaluated road safety measures be effectively implemented in Nigeria to improve the road safety culture?

1.5 Phases of the study

The different phases adopted in this research are summarised below.

1.5.1 Phase 1

This study represents a practical application of the TCT in the Nigerian road environment. It is directed at assessing the capabilities and limitations of the technique as a predictor of traffic safety at selected locations in a major city in Nigeria. The road safety situation in Nigeria is very poor and despite this, very few studies have demonstrated the causes and effects of the safety situations in the country. Most of these studies are based solely on crash data which is not enough to tackle the menace. With the increasing volume of vehicles and a large number of vulnerable road users (pedestrians, tricyclists and sometimes cyclists), traffic safety has become a major concern. Considering this, an exploratory study involving observation of traffic behaviour and conflicts was applied to complement the available crash data in order to thoroughly examine the current situation.

1.5.2 Phase 2

Based on the results obtained from Phase 1, a driving simulator experiment was designed and carried out. The experiment was divided into two- Experiments 1 and 2. Experiment 1 investigated the cross-cultural differences in driving behaviour using different groups of drivers. Experiment two examined whether drivers' unsafe driving behaviours could be modified by simple engineering measures and awareness-raising campaign. In addition, participants completed the Driver Behaviour Questionnaire (DBQ) which was used to compare self-reported data to actual driving behaviour data.

1.5.3 Phase 3

Because a range of road safety measures could not be examined and evaluated in Phase 2, a focus group study was designed and carried out in phase 3. This was to examine the perceived effectiveness and ease of implementation of a range of road safety measures (including those evaluated in phase 2) in Nigeria and to find ways to improve the road safety profile of the country.

1.6 Overview of the thesis

The thesis is divided into nine chapters:

- *Chapter One* presents the motivation for the research including the rationale, research aims, research questions and an overview of different phases of the research.

- *Chapter Two* presents the Nigerian road safety profile including the causes of RTCs and measures adopted to reduce the high number of crashes.

- *Chapter Three* presents the current global road safety situation, regional differences in road safety and the comparison of the Nigerian and UK road safety profile.

- *Chapter Four* provides a review of the relevant literature on the understanding of driver behaviour. This includes the determinants of driver behaviour, measurement of driver behaviour and methods for improving driver behaviour.

- *Chapter Five* is the methodological approach. It outlines and elaborates the different stages of the research and data collection methods at different phases.

- *Chapter Six* reports the first study (phase 1), an exploratory quantitative investigation of the road safety situation in Nigeria using the Traffic Conflict Technique (TCT). This inspired further investigation of the driving behaviour of Nigerian drivers in chapter six (phase 2).

- *Chapter Seven* reports a quantitative cross-cultural investigation of drivers' self-reported and actual driving performance carried out on a driving simulator (phase 2). This led to more investigation of measures that can be used to improve road safety especially in developing countries in phase 3.

- *Chapter Eight:* A focus group discussion (phase 3) with the lead road safety agency in Nigeria enriched the knowledge gained on road safety measures. The result is reported and the effectiveness and ease of implementation of certain road safety measures in Nigeria examined. Finally, ways of improving the road safety situation in the country are presented.

- *Chapter Nine* provides a discussion of the significance and implications of the research as well as making recommendations for improving Nigerian road safety culture and suggestions for future studies.

Chapter 2 Road safety profile in Nigeria

2.1 Overview

This chapter explores the road safety profile of Nigeria. It highlights the road safety problems in Nigeria and compares the situation with other developing and developed Countries. The causes of road traffic crashes are also examined including past and current measures adopted to improve road safety in Nigeria.

2.2 Road safety profile of Nigeria

Road transport accounts for over 90% of the subsector contribution to the gross domestic product in Nigeria. With a total of 193,200km of roads [Paved: 28,980km and Unpaved: 164, 220km] (KPMG, 2014), Nigeria has the largest road network in West Africa and the second largest south of the Sahara. According to the WHO (2013a), there are approximately 12 million registered vehicles using Nigeria's roads, at 85 cars per 1000 people. It has a population-road ratio of 860 persons per square kilometre, indicating intense traffic pressure on the available road network (Ukoji, 2014).

With an estimated population of 190 million (NBS, 2017), Nigeria is Africa's most populous nation and the seventh most populous country in the world. It shares borders with Niger in the north, Chad in the northeast, Cameroon in the east, and Benin in the west. Its coast in the south is located on the Gulf of Guinea in the Atlantic Ocean. It has a land mass of 923,768km^2 and comprises of 36 states and 1 Federal Capital Territory, where Abuja, the capital is located. As of 2017, Nigeria's gross domestic product (GDP) stood at an estimated $375.77 billion (World Bank, 2018).

RTCs have been identified as a major public health problem in Nigeria and as such requires urgent attention as not much success in tackling this problem has been achieved. The Federal Road Safety Corps (FRSC) is the lead agency in charge of road safety in Nigeria. It is tasked with the responsibility of ensuring a safe motoring road environment in Nigeria. This is achieved by its programmes on road safety administration, road safety educational campaigns by government agencies and charities, promotion of stake holders' cooperation etc. The number of RTCs keeps increasing despite the programmes the Federal Road Safety Commission has implemented in the past. Nigerians depend majorly on the road transport system as a means of transportation as cycling and walking are not common, and the rail system is not developed. Most movements are on the road, that is why the road transport system in Nigeria should be made safer than it is today for every road user. Figure 1, shows the trend in traffic crashes in Nigeria from 2000 - 2017 depicting a lot of variation in the pattern. For example, between 2003 and 2004, there was a significant drop in total casualty and persons even though the crash rate remained high. The same pattern was also observed between 2009 and 2010 but with a significant reduction in the number of crashes. The Figure also shows that the number of fatalities has remained fairly stable from 2000 up to 2017 compared with the other crash types. Despite the variation in most of the crash types, generally the casualty rate has remained very high.

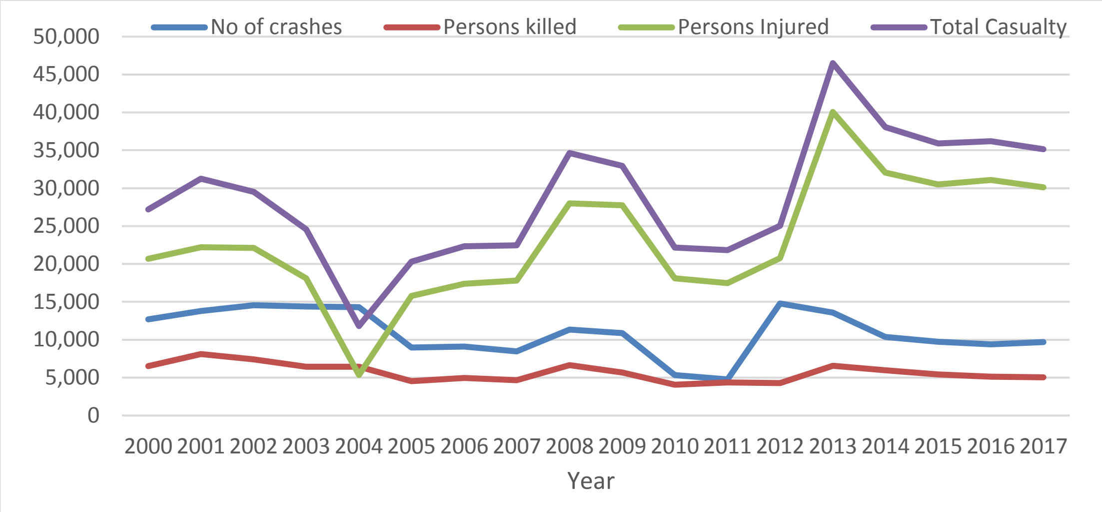


Figure 1: Trend in road traffic crashes, persons killed, injured and total casualty 2000-2017 (FRSC, 2018)

The differences in statistics provided by the FRSC and WHO has revealed the under-reporting and unreliability of crash data in the. Studies have consistently pointed these out for developing countries (Ameratunga et al. 2006), and Nigeria is not an exception (Figure 2). In the year 2015, the WHO estimate of fatalities (39, 802) was seven times higher than those reported by the FESC (5, 053). The reason for the differences in numbers is because the WHO adjusts for under-reporting which is not done by the FRSC.

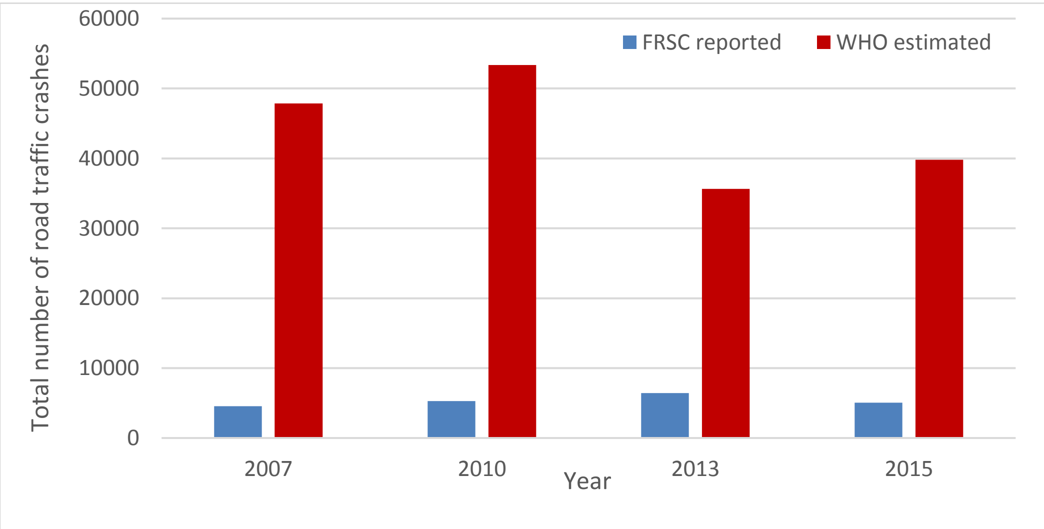


Figure 2: Reported and estimated number of road traffic fatalities for selected years in Nigeria (WHO, 2010; 2013; 2015, 2018)

While there has been a downward trend in road traffic fatalities in some HICs, the situation is different in LMICs such as Nigeria, where limited resources and attention has been given to road safety. For example HICs such as Sweden, the US and the UK have reduced road traffic fatality rates per 100, 000 population from levels varying between 0.47 and 1.26 in 2013 to rates of 0.46 and 1.25 in 2016. Road traffic fatalities in LMICs like Nigeria, Pakistan, and Uganda are still very high. (WHO, 2018). Figures 3a & 3b shows these numbers and compares the data with other HICs and LMICs.

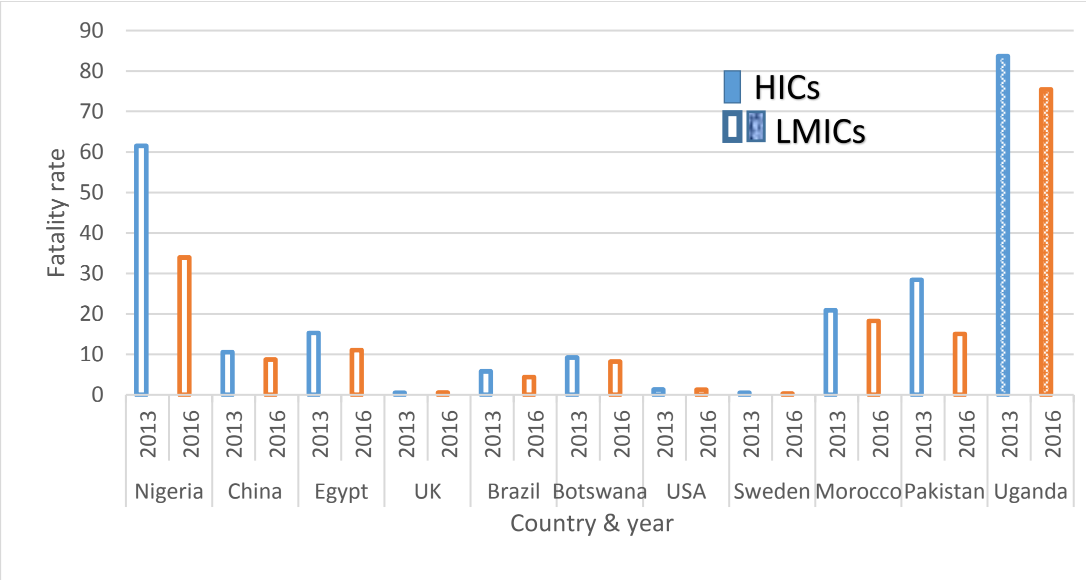


Figure 3 (a): Road traffic fatality rate per 10,000 vehicles (Adapted from WHO, 2015 & 2018)

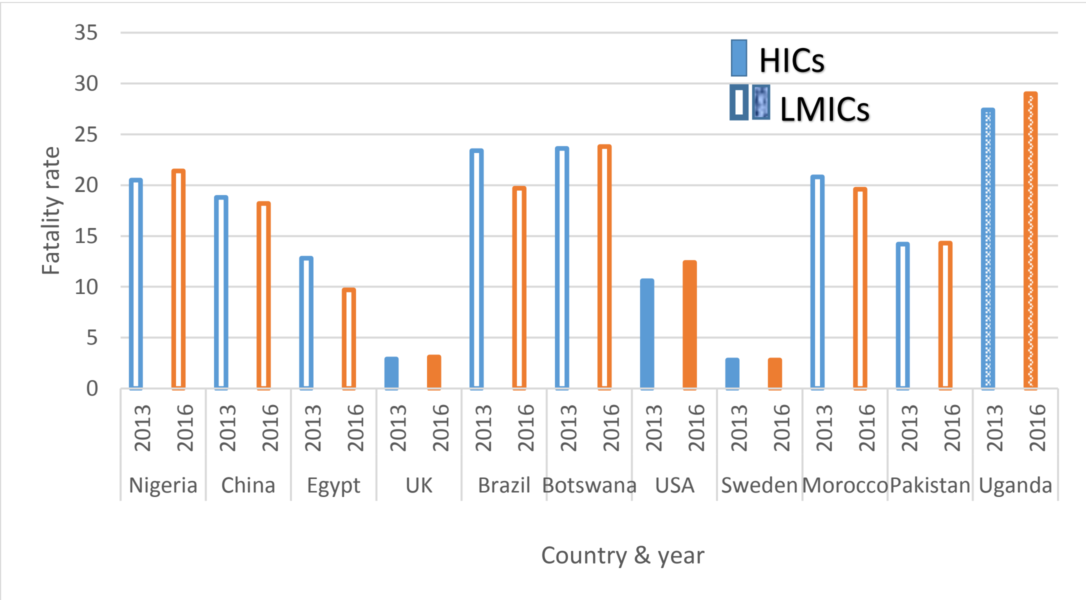


Figure 3 (b): Road traffic fatality rate per 100,000 population (Adapted from WHO, 2015 & 2018)

The socio-economic cost of road traffic crashes in Nigeria is devastating. According to Adekunle (2012), the loss is best presented in terms of the labour lost to the nation's economy, which consequently results in reduced productivity. WHO (2013a) reveals that Nigeria loses about US$20 Billion yearly (4% of its GDP) to RTCs, giving an idea of how dangerous Nigerian roads are. Table 1 provides a better understanding of the situation in Nigeria when compared with other HICs and LMICs in terms of fatality rate, level of motorisation etc. With a much smaller number of registered vehicles in 2016, Nigeria reported the highest fatality per 10,000 vehicles compared with China, the UK, Brazil, U.S.A, Iran and Turkey which had higher number of registered vehicles (Table 1).

A report by the Federal Ministry of Works (2013) compared most developing countries of the world with Nigeria in terms of the availability and quality of road network and showed that Nigeria has a considerable number of good roads and cars. Even though traffic density is not high when compared with many European countries, the incidence of road crashes, in terms of frequency and severity index is very high. Therefore, it could be seen that neither improvements of the road network nor increased sophistication of cars will, by themselves, lead to a significant reduction in road crashes in Nigeria, much more needs to be done.

Table 1: Comparison of fatality and motorisation level for selected developed and developing countries (WHO, 2015; 2018)

Country	Year	Person killed (Reported)	Person killed (Estimated)	GNI per capita in $US	Income level	Number of registered vehicles	Deaths/10,000 vehicles	Deaths/100,000 population	National population
Nigeria	2013	6, 450	35, 641	2, 710	Middle	5, 791, 446	61.54	20.5	173, 615, 345
	2016	5, 053	39, 802	2, 450		11, 733, 425	33.92	21.4	185, 989, 632
China	2013	58, 539	261, 367	6, 560	Middle	250, 138, 212	10.49	18.8	1, 385, 566, 537
	2016	58, 022	256, 180	8, 260		294, 694, 457	8.69	18.2	1, 411, 415, 375
Egypt	2013	6, 700	10, 466	3, 140	Middle	7, 037, 954	15.24	12.8	82, 056, 378
	2016	8, 211	9, 287	3, 460		8, 412, 673	11.04	9.7	95, 688, 680
UK	2013	1, 770	1, 827	41, 680	High	35, 582, 650	0.50	2.9	63, 136, 265
	2016	1, 804	2, 019	42, 390		38, 388, 214	0.53	3.1	65, 788, 572
Brazil	2013	41, 059	46, 935	11, 690	Middle	81, 600, 729	5.75	23.4	200, 361, 925
	2016	38, 651	41, 007	8, 840		93, 867, 016	4.37	19.7	207, 652, 864
Botswana	2013	411	477	7, 770	Middle	520, 793	9.16	23.6	2, 021, 144
	2016	450	535	6, 610		653, 274	8.19	23.8	2, 250, 260
USA	2013	32, 719	34, 064	53, 470	High	265, 043, 362	1.26	10.6	320, 050, 716
	2016	35, 092	39, 888	56, 180		281, 312, 446	1.25	12.4	322, 179, 616
Sweden	2013	260	272	6,1 760	High	5, 755, 952	0.47	2.8	9, 571, 105
	2016	270	278	54, 630		6, 102, 914	0.46	2.8	9, 837, 533
Morocco	2013	3, 832	6 870	3, 020	Middle	3, 286, 421	20.91	20.8	33, 008, 150
	2016	3, 785	6, 917	2, 850		3, 791 ,469	18.24	19.6	35, 276, 784

Pakistan	2013	7, 636	25, 781	1, 380	Middle	9, 080, 437	28.39	14.2	182, 142, 594
	2016	4, 448	27, 582	1, 510		18, 352, 500	15.03	14.3	193, 203, 472
Uganda	2013	2,851	10, 280	550	Low	1, 228, 425	83.68	27.4	37, 578, 876
	2016	3 503	12 036	660		1594 962	75.46	29	41 487 964

2.2.1 Causes of road traffic crashes in Nigeria

Several factors contribute to RTCs in Nigeria. Compared with the traffic in Nigeria, traffic flows in most HICs are smooth because the majority of drivers behave in a consistent and predictable way (Li & van Zuylen, 2014). Obedience to the traffic rules and driving in a disciplined way can help drivers to know and predict each other's movement. To drive a vehicle safely requires that one must possess specific skills that must be learnt properly. When one drives with the right skills, there is a higher chance that the person will be safe and getting into a crash is reduced to an extent. To improve the safety performance of drivers, training and education are very important. Most drivers in Nigeria are inexperienced and unqualified, do not understand and obey simple road rules and as a result, crash rate is high. They are unqualified in that drivers do not do the necessary training and tests stipulated as a prerequisite for obtaining a licence and driving. Analysis of the 2012 casualty rates in the country showed that unlicensed drivers had a fatality rate which was twice as high as those drivers with formal training (FRSC, 2013). More than 80% of respondents on a 1991 Gallup Poll Survey in the UK supported compulsory driver training for learner drivers (Quimby et al., 1991) and according to Kinnear (2009) pre-training serves the purpose of shaping driver attitudes and requires the new driver to take ownership of his behaviour before being granted the privilege of driving without restrictions.

Research (Akpoghomeh, 1998; Obinna, 2007; Atubi & Onokala, 2009) has identified Nigeria as having the highest RTC rates in Africa. According to Obinna (2007), the percentage of all deaths as a result of road traffic crashes in Nigeria increased from 38.2% to 60.2% in ten years between 1999 and 2009. Table 2 shows the most recent data on probable causes of RTCs in Nigeria in 2017.

Table 2: Probable causes of road traffic crashes in Nigeria in 2017 (FRSC, 2018)

Probable causes of road traffic crash	Number of crashes caused (%)
Speed Violation	44
Loss of Control	12
Dangerous Driving	8
Wrong overtaking	7
Tyre burst	6
Brake failure	5
Routes violation	5
0thers	11

Driver factors account for up to 90% of crashes in Nigeria: this includes inappropriate speeding and speed-related factors, poor knowledge of traffic regulations including road signs and markings, drink driving, driver fatigue, wrongful overtaking etc. (Ukoji, 2014). The first four which are linked to driver behaviour have consistently been the highest probable causes of road traffic crashes in Nigeria in a long time. These are speed violation, loss of control, dangerous driving and wrong overtaking, Figure 4. This indicates that efforts need to be intensified in the area of driver behaviour in the country. A study conducted by Atubi (2010) to examine the variation patterns of road traffic crashes in Lagos state Nigeria, with the use of secondary data from the FRSC and Nigerian Police, found that more than 90% of road traffic crashes in Lagos could be attributed to over speeding and recklessness on the part of drivers.

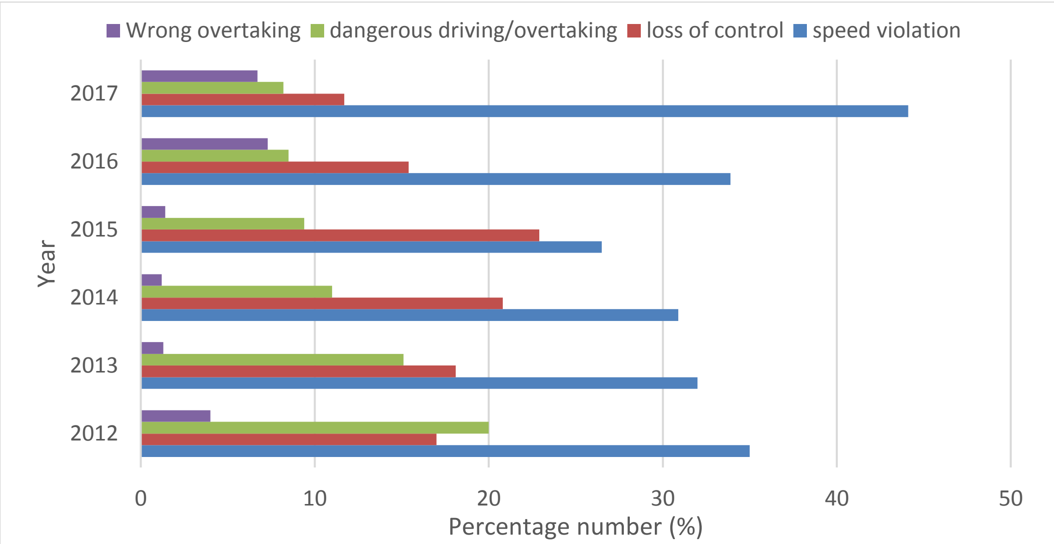


Figure 4: Top four probable causes of road traffic crashes in Nigeria (FRSC, 2018)

Apart from these, driving behaviour could also be influenced by the environment. The environment in which a driver operates can affect behaviour in a lot of ways, for example, poor road designs, roads with potholes, traffic mix, weather conditions (rainy, dry), time of day, traffic layout and traffic laws (Dixit et al., 2012; Kilpelainen & Summala, 2012; Hao et al., 2016). Generally, the Nigerian road environment lacks the basic road furniture needed to improve safety operations on the roads. Hills & Baguley (1992), have shown that most roads and road systems in developing countries are being built and upgraded with little consideration given to road safety. According to Almqvist & Hyden (1994), some road design measures dramatically reduce the number of mistakes that lead to risks and crashes, by reducing opportunities for road users to make errors; and if errors do occur, making the environment more forgiving. Similarly, factors related to the vehicle such as un-roadworthy vehicles, tyre blowouts and poor vehicle lighting also affect road traffic crashes.

2.2.2 Road safety measures

In Nigeria, the FRSC is mostly responsible for developing these measures. In response to the UN decade of action for road safety, FRSC launched “safe road in Nigeria” with the aim of reducing road crash deaths and injuries by 50% by 2020. It is based more on changing driving behaviour than advocating for good road infrastructure. The FRSC has stepped up the campaign in Nigeria to ensure that these objectives are met by strengthening legislation and enforcement in the following areas:

(i) **Drink- driving**

This is universally believed to be unacceptable and a serious threat to traffic safety (Taylor & Rehm, 2012; DfT, 2018). The maximum authorised blood alcohol content (BAC) in Nigeria is 0.5 g/l. FRSC (2013) shows that driving under the influence of alcohol accounted for an estimated 1% of the total cause of vehicle crashes in the country in 2012. Recently there have been efforts to amend the maximum BAC to 0.2 g/l for novice drivers (less than one year driving experience) and 0.01g/l for commercial drivers. The dangers inherent in driving under the influence of alcohol include impaired vision, poor sense of judgement, indulging in excessive speed etc. The FRSC has been organising and running publicity campaigns against drink-driving with private sector support, but enforcement of the law is still very weak and needs to be strengthened.

(ii) **Speeding**

Speed violation and inappropriate speed have been identified as a major contributor to road traffic crash in Nigeria (FRSC, 2017). Current national speed limits on Nigerian roads are as follows: Urban roads: 50km/h, Rural Roads: 80km/h and Expressways: 100km/h. Ironically, only very few Nigerian drivers are aware of the different speed limits because most of them do not do the required training and tests before obtaining a driver's licence and will not on their own go through the highway code. In addition to these, most roads have no speed limit signs at all.

In 2014, the FRSC carried out a study to investigate the motive behind inappropriate speeding among Nigerian drivers. In this survey, the average speed of various categories of vehicles on five major routes was investigated. A total of 7,339 vehicles were captured during the exercise of which 68% of them violated the legal speed limits on the routes studied (FRSC, 2014). As a result enlightenment campaigns, public awareness, education and enforcement intensified to increase awareness of speeding and its associated risk of road traffic crashes. FRSC reported a downward trend in speed-related crashes from 2013 to 2015 but this started increasing again from 2016 as depicted in Figure 5. The reason for the increase could be because there are no proper enforcement and infrastructure, effect of the campaigns may have gone away with time and drivers reverted to former speed. Even though it remains the highest probable cause of road traffic crashes in Nigeria, the decline in the years prior to 2016 showed that the programmes and efforts targeted at speed control in Nigeria had some effect (FRSC, 2017). Consequently, in 2016 the compulsory installation and use of speed limiting devices were introduced to commercial vehicles in the first instance, although enforcement and compliance began in 2017. There is a plan to extend this to private vehicles pending success with the commercial drivers.

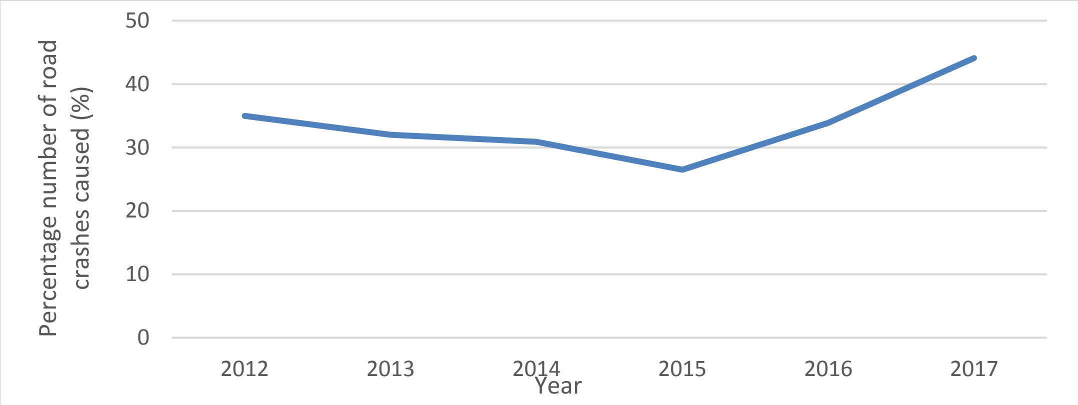


Figure 5: Trend in speed violation in Nigeria from 2012-2017 (FRSC, 2018)

(iii) **Seatbelt use**

Seat belts are highly effective in protecting vehicle occupants and significantly reducing their risk of being fatally or seriously injured in the event of a crash (Cummings et al., 2003; Evans, 2004). In developed nations, the use of seatbelts is one of the most effective ways of reducing fatalities (Green, 1994; Evans, 1996). Seat belts prevent certain types of injuries to vehicle occupants or reduce their severity when a crash occurs (Shibata & Fukuda, 1994; Arajaevi, 1998).

The seatbelt policy was made compulsory in Nigeria in 2003, which makes it an offence for front seat occupants of vehicles not to wear seatbelts (Sangowawa et al., 2010) while the enforcement for rear seat occupants started in 2015. The law is exclusively enforced in Nigeria by the FRSC. Table 3 shows the reported seatbelt wearing rate by car occupants before and after enforcement. OECD/ITF (2015), reports that 80% of front seat occupants wear a seatbelt while less than 5% of rear seat occupants do. The reason for the low compliance rate could be related to the standard of some vehicles in Nigeria. For example, most vehicles in Nigeria do not have seatbelts installed in the rear. According to ITF (2018), in 2014 the UK recorded a 98% and 91% compliance in seatbelt wearing rate for front and rear seat occupants respectively. This means that enforcement of seatbelt, fitment and use by rear seat occupants needs to be intensified in Nigeria.

Table 3: Seatbelt wearing rate by car occupants in Nigeria (OECD/ITF, 2015)

Front Seat	2000	2013
General	<5%	80%
Urban Roads	<5%	90%
Rural Roads	<2%	60%
Rear Seat		
Adults	<1%	<5%
Children	<1%	<1%

Chapter 3 Road traffic safety

3.1 Overview

In this chapter, the global problems associated with road traffic crashes, their over-representation in LMICs and factors contributing to these crashes are reviewed. Cross-cultural comparison of the two cultures investigated in chapter six of this thesis is presented.

3.2 Global road safety

Road traffic crashes (RTCs) are a big problem everywhere in the world. Deaths and injuries as a result of this have been acknowledged as a global phenomenon with authorities in virtually all countries of the world expressing serious concern about the growth in the number of people killed and seriously injured. Road traffic crashes now represent the eighth leading cause of death globally. It has been estimated that annually an estimated 1.35 million people die worldwide and up to 50 million are injured as a result of RTCs (WHO, 2018). The impact of road crashes, however, is not only limited to the death of individuals involved in crashes, the families of victims and the society at large also suffer the aftermath of road crashes, and so do surviving victims who may suffer long and short term physical injuries (WHO, 2009). In addition to human misery and suffering, the total cost of road accidents, including the economic value of lost quality of life, cost governments about 3% of their gross national products (WHO, 2015). The over-representation of young people in road traffic crashes is a serious cause for concern. WHO (2018) reports that road traffic injuries are currently the major cause of death for children aged 5-14 years and young adults between 15-29 years of age. Additionally, a greater percentage of these road traffic deaths are among vulnerable road users- pedestrians, cyclists and motorcyclists.

The cost of road traffic crashes is disproportionately borne by some countries, as a greater percentage occur in LMICs[2]. Fatality rates per population in these countries are more than twice that in the HICs considering that the motorisation level is lower in LMICs compared to HICs. Transport systems have increased and developed rapidly in the developing countries but little success has been achieved in reducing the crash

[2] The World Bank classification of economies is based on their Gross National Income (GNI). Low Income: less than $1,005; Lower-middle income: $1,006 – 3,955; Upper-Middle Income: $3,956 - $ 12,235; High Income: Greater than $12,235. According to classification, high-income countries are equated as developed countries whilst the countries with low or middle levels of GNI per capita are equated as developing countries (WHO, 2011). Nigeria belongs to the Lower-middle income class with a GNI/capital of $2,450.

severity, preventing them and improving the road safety situation (Peden et al., 2004; WHO, 2015). In addition, these countries do not have sufficient resources to take care of the injured and help those with disabilities. In 2015, LMICs had a higher road traffic (crash) fatality rate per 100,000 population compared to HICs. The African region had the highest road traffic fatality rate at 26.6, while the European region had the lowest rate at 9.3, this is as compared with the global average of 17.4 death per 100,000 population. Figure 6 shows road traffic fatality rates per 100,000 population by WHO region (WHO, 2018).

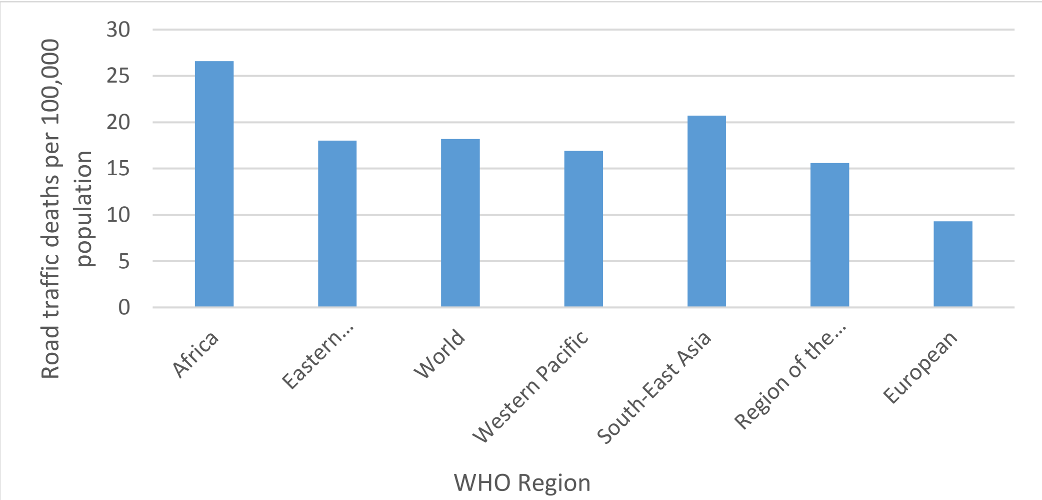


Figure 6: Rate of road traffic deaths per 100,000 population by WHO region (WHO, 2018)

3.3 Regional differences in road safety

Regional differences in traffic safety are quite considerable. The nature of road safety issues in developing countries is significantly different from that in developed countries. In addition, the associated economic loss is enormous. According to the World Bank (2017a) reducing road traffic injuries by half could translate into an additional 15% to 22% of GDP per capita income growth over 24 years. This practically means that failure to meet the UN Sustainable Development Goal target to halving road deaths by 2020 accrues to about 2-3 per cent points in unrealized per capita GDP growth for LMICs. Those affected most are the working-age population and represent a substantial percentage of the workforce. Peden et al. (2002) have shown that road traffic injuries are a major cause of Disability-Adjusted Life Year (DALY)[3] losses in developing countries because a greater number of children and men in their productive ages suffer these injuries, and according to Bishai et al. (2008), the fatality

[3] DALYs: This is World Health Organization summary measure used to give an indication of overall burden of disease in a population. It is expressed as the number of years lost due to ill-health, disability or early death. Numerically this is the sum of years of potential life lost due to premature mortality and the years of productive life lost due to death and disability.

rates in these countries is estimated to increase by 80% from 1990 to 2020, unless appropriate measures are taken. While there has been a decrease in road traffic fatalities in some high-income countries as a result of various countermeasures put in place, the situation is different in developing nations as RTCs do not get the attention it deserves. Countries such as Norway, Sweden, and the UK have recorded reductions in road traffic fatality rate while it continues to rise in most developing countries. Reducing road traffic injuries has a positive effect on national income growth (World Bank, 2017b).

Traffic safety records are much worse in Africa than in Northern and Western Europe. In its Global status report on road safety 2018, the World Health Organisation (WHO) reports that the highest road traffic fatality rates are in the LMICs (Figure 7), particularly the African and South-East Asian regions. Although the African Region is the least motorised (2%) of the world, 16% of all recorded deaths as a result of road crashes is found there (Figure 7). Nigeria and South Africa have the highest fatality rates (33.7 and 31.9 deaths per 100,000 population, respectively) in the region which is above the regional average of 24 deaths per 100,000 population (WHO, 2013b). Road traffic crashes are preventable especially if the right intervention measures are put in place to counter them. Strong policies and enforcement, smart road design, and good public awareness campaigns are a few examples and can save millions of lives over the coming decades if implemented appropriately.

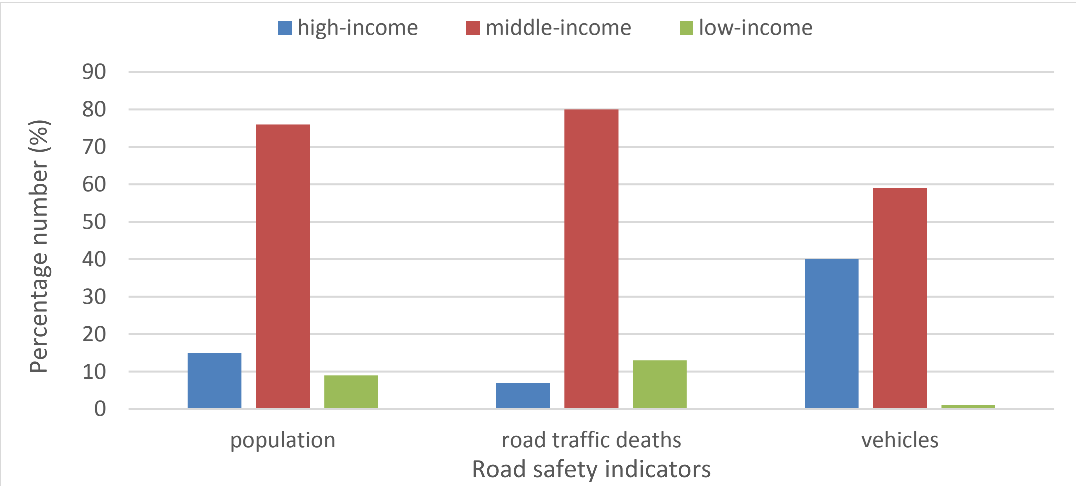


Figure 7: Population, road traffic deaths and registered motor vehicles by country income category, 2016 (WHO, 2018).

3.4 Contributing factors to road traffic crashes

Traditionally, factors responsible for road traffic crashes were classified into three- the driver (human factor), the road environment and the vehicle (Evans, 1996). Although human factors are at the top of the list (Rumar, 1985; Evans, 1996; Christ et al., 1999; UNECE, 2008), crashes could also be caused as a result of other factors related to the vehicle and road environment. Consequently, any shortcoming in one of the three factors increases the potential of road crashes because each factor has a different level of impact on road crashes. The contribution of human factors to crashes means that it is very crucial to understand driving behaviour and performance. For example, the way drivers choose to drive and what motivates drivers to drive the way they do.

The road environment is also very important for safety. It contributes to the risk of crashes as a several variables affect the performance of both the driver and the vehicle. Research has shown that road design/layout characteristics (Mayora & Robio, 2003; Noland & Oh, 2004), light and weather conditions (Kim, 2001; Daniel et al., 2002), traffic flow (Kononov & Allery, 2004) etc. all affect driver performance. In addition to this, the influence of various factors including road geometry (width, straight or curved, flat or sloping), objects next to the road (posts, guardrail, vegetation etc.), road signs and pavement markings, transient factors such as night or day, weather conditions, parked cars and the presence of other road users all have significant effects on the performance of both the driver and the vehicle. The road environment should provide instructions, warning and information about the safest way to use it.

The vehicle itself also plays a role in road crashes. A vehicle can malfunction as it is being driven, resulting in a crash. According to WHO (2018) vehicle standards are now being developed to ensure that design protects car occupants and road users outside the vehicle. Some of these can also prevent crashes and reduce crash severity. Research (WHO, 2015 and Erke, 2008), shows that improved vehicle design has been responsible for a substantial proportion of the safety improvement in the UK and Europe in the last 20 years. The Global Status Report on Road Safety 2018 highlights that while vehicles in HICs are increasingly safe, only 40 of 175 countries (23%) have adopted the priority vehicle safety standards as recommended by the United Nations (WHO, 2018).

However, the safe system approach building on Haddon's insights (Table 4) recognises that all system must all work together as a whole to reduce injury risk to road users to an acceptable level. Haddon's matrix identifies both the components of the road system and the stages at which countermeasures can be targeted in order to prevent injuries. It is, therefore, an appropriate framework to apply when attempting to identify and understand the factors that influence crash and injury risk. Thus, the safe system approach encourages a better understanding of the interaction between the key elements of the road system- road user, roads, vehicle and also travel speeds. While the system makes room for human errors, its effectiveness also depends on the travelling speed of drivers. Controlling drivers' speeding behaviour is very critical to the system approach. It considers not only the underlying factors but the role of different agencies and actors in preventing crashes. Sweden and the Netherlands are the two earliest countries to adopt a safe system approach to road safety. Sweden launched "Vision Zero" in 1994, and summarised it by one sentence "No loss of life is acceptable". Vision Zero became law in 1997, setting an ultimate target of no deaths or serious injuries on Sweden's roads. It is based on the fact that humans make mistakes and that the road system needs to be designed to protect humans at all times (OECD/ITF, 2008). The Netherlands developed its Sustainable Safety approach in 1995, followed by a full start-up programme in 1997. It relied on large scale infrastructure changes. It differs slightly from Sweden's Vision Zero approach in that it does not assume that road users will obey the rules, and it considers public information and education to be a vital part of the safe system (Wegman & Aarts, 2006). This system does not only consider the factors listed above, but it also looks into the role different agencies and governments play in crash prevention. A key objective of this approach is that in the event of a crash, injury or fatality rate will remain at a minimum level. The obligation to comply with rules is also a core part of Vision Zero and Safe Systems.

Table 4: Haddon's matrix including targets for countermeasures as applied to road safety

Factors	Pre-event	Event	Post-event
Human factors	Education & licensing Driver impairment Enforcement	Use of restraints Impairment Sitting properly in restraint	Response to emergency services
Vehicle	Crash avoidance equipment & technology (lights, tires, collision avoidance) Vehicle design Roadworthiness	Functioning of safety devices (seatbelts, airbags, child restraint) Speed of travel Energy absorption of vehicle	Ease of extraction from vehicle Safe design of fuel tank to prevent rupture and fire
Physical environment	Road design & layout Speed limit Road signs and markings Weather and road surface conditions	Forgiving roadsides, e.g. crash barriers	Quick rescue facilities
Social/economic	Enforcement activities Social norms Appropriate use of safety equipment	Laws concerning the use of safety equipment	Trauma system equipment, personnel, training Information sharing

Source: Haddon Jr, W. A. (1972)

The terms used in this table are modified versions of the terms originally used by Haddon.

Similarly, in 2011, the United Nations (UN) developed the decade of action for road safety to provide an opportunity for long term and coordinated activities in support of regional, national and local road safety. The objective is to develop a road transport system that is better able to accommodate human error and take into consideration the vulnerability of the human body. It could be used by LMICs to accelerate the adoption of effective and cost-effective road safety programmes while HICs can use it to make progress in improving their road safety performance as well as to share their experiences and knowledge with others. The guiding principles underlying the Plan for the Decade of Action are those included in the "safe system" approach and calls for action focuses on five pillars: road safety management; safer roads and mobility; safer vehicles; safer road users; and post-crash response (UN, 2011).

Pillar 1: Road safety management

This focuses on the need to strengthen institutional capacity to support national road safety efforts. Encourage the creation of multi-sectoral partnerships and establishment of lead agencies with the capacity to develop and lead the delivery of national road safety strategies, plans and targets, development of data systems to evaluate and monitor implementation and effectiveness.

Pillar 2: Safer roads

This focuses Highlights the need to improve the safety and quality of road networks for the benefit of all road users, especially the most vulnerable: pedestrians, bicyclists and motorcyclists. This will be achieved through the implementation of various road infrastructure agreements under the UN framework, road infrastructure assessment and improved safety-conscious planning, design, construction and operation of roads.

Pillar 3: Safer Vehicles

This addresses the need for improved vehicle safety technologies for both passive and active safety through the harmonization of relevant global standards, consumer information schemes and incentives to accelerate the uptake of new technologies. It includes activities such as implementing New Car Assessment Programmes (NCAP) so that consumers are aware of the safety performance of vehicles, and to ensure that all new motor vehicles are equipped with minimum safety features, such as seat belts. Others include promoting more widespread use of crash avoidance technologies with proven effectiveness, such as electronic stability control and anti-lock braking systems.

Pillar 4: Safer road users

Focuses on developing comprehensive programmes to improve road user behaviour. Sustained or increased enforcement of laws and standards, combined with public awareness/education to increase seat-belt and helmet wearing rates, and to reduce drink-driving, speed and other risk factors. It also calls for activities to reduce work-related road traffic injuries and promotes the establishment of graduated driver licensing programmes for novice drivers.

Pillar 5: Post-crash response
This focuses on increased responsiveness to post-crash emergencies and improve the ability of health and other systems to provide appropriate emergency treatment and longer term rehabilitation for crash victims.

3.5 Cross-cultural comparisons: Nigeria and the UK

The nature of road safety issues in developing and developed countries are significantly different (See section 3.3). This section provides an overview of the magnitude of the problem in Nigeria (developing country) and the UK, a highly motorized country (developed country). Table 1, provided a cross-cultural comparison of development and road safety related indicators. It can be seen that the level of motorization in all of the developing countries is far less than the developed countries. However, road safety related indicators demonstrate the adverse safety profile of low-income countries. For instance, in 2016 Nigeria had 21.4 fatalities per 100, 000 vehicles. This was far higher than the UK (3.1) with a very low number of fatalities. In 2016, the UK had a population of 65, 788, 572 with about 38 million registered vehicles and has a far better traffic safety situation compared to Nigeria with a population of 185, 989, 632 and an estimated 11 million registered vehicles (WHO, 2018). In the same year, there was a total of 2,019 traffic fatalities on British roads and 39, 802 traffic fatalities in Nigeria (WHO 2013). In other words, the road fatality rate in Nigeria is about seven times higher than what is obtainable in the UK. These statistics of the number of road incidents in both countries, with their populations and registered vehicles, indicate that the UK is better than Nigeria in road safety (Table 1).

Vehicle composition varies considerably between the two countries, which is roughly reflected in the categories of road user deaths. For instance, in the UK, four-wheeled vehicles account for over 90% of registered vehicles, while powered two and three-wheelers account for about 4.6%. In Nigeria on the other hand, the proportion of four-wheeled vehicles is 57.4%, and powered two- and three-wheelers make up about 12% of vehicle traffic (WH0, 2018). The higher number of two- and three-wheelers may be one contributor to Nigeria's higher crash rate. Furthermore, most two and three wheeler vehicles in Nigeria are found in rural areas and most crashes in these areas go underreported because of the lack of FRSC officials in those areas. This means that there may be an underestimation of the number of RTCs involving these groups of road users in Nigeria.

The poor public transport system in Nigeria combined with low cost of using a private car as compared to the UK is another important point. Paying the capital cost of the vehicle itself is the main cost of owning and using a private vehicle in Nigeria. In addition, the Nigerian government subsidises fuel for motorists. This encourages the use of private transport and makes the population drive more.

The current driver licensing process in Nigeria requires a hazard perception test and forms of video-based testing. Prospective drivers must first pass a written and practical on-road test of road rules to obtain a learner's permit which could be exchanged for a licence after three months. But most drivers do not go through this process. They would rather pay bribes and go through third parties to obtain the license. This is different in the UK, where novice drivers must first apply for a provisional driving licence, start driving lessons (must be 17 years and above) and then do the tests. A driving test consists of three sections: theory, hazard perception and a supervised driving examination. A driver holds the provisional licence until these tests have been passed. These and many more such as the economic situation of the countries (UK is a high-income country with GNI of $ 42, 390 and Nigeria is a middle-income country with GNI of $ 2, 450), road safety legislation, enforcement etc. all contribute to the differences in the traffic safety records of the two countries.

The rate of recording incidents differs in both countries. Crash data in Nigeria is collected at the scene by road safety staff on patrol or called to the scene via the toll-free emergency call centre or by other means. The police also collect crash data during investigations. Currently, the FRSC has digitised the data collection process with computers and hand-held tablets at the scene of a crash, and data arrives directly into the FRSC data portal. The portal is designed to accommodate inputs from other data collection agencies such as the Vehicle Inspection Officers (VIOs), State Traffic agencies and hospitals. The National Crash Report Information System (NCRIS) was inaugurated in April 2014 to harmonise all traffic crash data in Nigeria from the different agencies including the police, the Ministry of Health (hospital data), the vehicle inspection unit and state traffic agencies. Gaps still exist in the data as not all crashes are recorded, especially in locations not regularly covered by the patrol teams of the FRSC and the police. To address this issue, data information officers regularly visit these areas and collect missing data, but this is expensive. On the other hand, road traffic crash data in the UK come from STATS19. While all fatal crashes are reported by the police, data from hospitals, surveys and compensation claims indicate that a considerable proportion of non-fatal casualties are not known to the police. The best current estimate derived primarily from the National Travel Survey data and produced in 2017, is that the total number of road casualties in Great Britain each year, including those not reported to the police, is within the range of 590, 000 to 760, 000 with a central estimate of 670, 000. Linking the data from hospitals and police data for England gives a better understanding of injury severity and outcomes. Around 47% of the police-reported seriously injured casualties for England alone are matched to the hospital records. As part of this linkage, the DfT has been working with the Maximum Abbreviated Injury Scale (MAIS) to rate the severity of injury crashes. In 2016, police forces changed their reporting system for severe injuries and it is likely that the recording of serious injuries is more accurate for police forces using the new reporting systems. This has had a large impact on the number of serious injuries reported in

2016, which can therefore not be directly compared with previous years. This shows that the UK has a more thorough and standardised road crash recording system compared with Nigeria.

Previous cross-cultural studies have compared the behaviour of UK drivers with drivers from other nationalities such as Iran (Özkan et al., 2006), Korea (Son et al., 2016) and Malaysia (Lee et al., 2015). In contrast, there are relatively no cross-cultural studies comparing the driving behaviour of drivers from Nigeria and the UK or Nigeria with any other culture. Considering this, comparing Nigeria and the UK in this study revealed the differences in the road safety culture of both countries. The distinct differences between the two countries in traffic safety performance provided the second reason for choosing these two countries. As mentioned earlier Nigeria has one of the lowest traffic safety performances in the world while the UK is one of the countries with the best traffic safety performance (Table 1).

Using Nigeria and the UK as the sample countries, this study can provide more information on the differences between both sample groups' level of performance, perception of hazard and general driving behaviour in order to have more evidence-based strategies for improving the road safety profile in developing countries. Although Nigeria has one of the highest road fatality rates in the world, there are still very few studies carried out to address this issue. It is expected that this present study can provide some useful insights into the traffic safety situation in Nigeria. This comparison may help to understand the role road safety culture plays as a contributory factor to road safety performance in these countries.

In this study, Road safety culture is regarded as a general understanding of drivers' behaviour and attitudes within the traffic environment in a specific country. This encompasses the road infrastructure, vehicles, road user behaviour and general traffic safety management. Driver behaviour was investigated across two cultures- Nigeria and the UK. The terms "Nigerian driver" (NG), "Nigerian/UK driver" (NG/UK) and "UK driver" (UK) refers to a driver who learned to drive and whose driving behaviour was shaped from one (NG or UK) or two distinct (NG/UK) traffic environments.

Chapter 4 Driver behaviour

4.1 Overview

Investigating driver behaviour is a very important aspect of road safety. From the previous chapter, Global road safety was examined and differences in the road safety situation of Nigeria and the UK were explored. In this chapter, the literature on driver behaviour is reviewed by summarising a number of key studies. Section 4.3 discusses the determinants of driver behaviour by exploring the demographic characteristics, environmental and vehicle factors including traffic safety culture. Section 4.4 concentrates on the tools for measuring driver behaviour while section 4.5 concludes the review with various approaches for improving driver behaviour.

4.2 Introduction

Traffic conditions are the result of the interactions between vehicles, road environment and road users. The success of this interaction is made possible with the help of formal traffic rules that guide the proper way to behave in different situations. Driving requires complex control in a dynamic environment in which one of the driver's primary responsibilities is "avoiding a collision" (Fuller, 2000). Road users do not always comply with traffic regulations which in extreme circumstances may lead to critical situations which may cause traffic crashes (Panou et al., 2007). Road safety analysis aims to understand the causes of these crashes and take measures to prevent them from occurring. Safety can be determined through different approaches for e.g. the analysis of driving behaviour. The relationship between road crashes and driving behaviour has led to a wide range of studies focusing on investigating drivers' behaviour (Özkan et al., 2006). Driver behaviour has been identified as a determining factor in traffic safety as most studies have attributed traffic crashes to human factors as a contributory factor (Parker et al., 1995; Evans, 1996; Iversen & Rundmo, 2004). Considering this, it is crucial to study factors that shape drivers' behaviour so that drivers are aware of the safety implications of their behaviour in traffic.

Evans (1991) and Elander et al. (1993) have proposed that human factors are composed of two separate components: driving skill (performance) and driving style (behaviour). Driving skill is the information processing, motor and safety skills that are perceived to improve with practice and training. It reflects what drivers "can" do. While driving style (behaviour) refers to the way drivers choose to drive or usually drive including for example the choice of speed, driving for thrill or fun, attentiveness, lane changing, gap acceptance etc. (Elander, 1993). As reported by Evans (1996), driver behaviour has a much greater influence on safety than driver performance. Studies of driver behaviour are of great help for different tasks in transport safety as unsafe driving behaviour can cause crashes and injuries (Özkan & Lajunen, 2005; Taubman-Ben-Ari & Yehiel, 2012). In addition, it is also important to identify drivers who engage in unsafe driving practices, placing themselves and other road users at greater risk of involvement in a crash.

Drivers involved in crashes may be classified by age, gender, driving experience and social or occupational status. The driving behaviour (safe or unsafe) of these individuals can be influenced by temporary states such as those induced by alcohol or drugs, or by psychological factors such as mood, stress and fatigue as well as more permanent cognitive and attitudinal factors (Maycock, 1997). A considerable number of road safety research emphasises the importance of changing the attitudes and beliefs of drivers in order to improve and promote the safety culture (e.g. Parker, 2004; Glendon, 2007). Similarly, external factors such as the road environment, the design of vehicles, traffic rules and regulations and their traffic safety culture also mediate deviant driving behaviours. The WHO acknowledged that driver behaviour is governed not only by the individuals' knowledge and skills but also by the environment in which the behaviour takes place (Rumar, 2000 cited in WHO, 2004) and that indirect influences, such as road design and layout, nature of vehicles and traffic laws and enforcement affect driver behaviour (Peden et al., 2004).

Lonero & Clinton (1998), illustrated that a driver's current driving behaviour could consist of informal social norms, risk acceptance, habits, driving culture, time pressure, aggression, knowledge etc. Each of these consists of other components that explain it even further. Similarly, McNeely & Gifford (2007) and Shiraev & Levy (2010) state that behaviours are influenced by norms, roles, traditions, habits, and practices, which, in turn, are responsible, directly and indirectly, for the differences in driving behaviours. This substantiates the claim by Factor et al. (2007) that drivers from different cultures are regularly exposed to different points of view, values, norms, ways of life and communication. It is assumed that these would guide a range of behaviours including driving, as drivers would be expected to act or behave differently on the road. These differences may be as a result of influence in the culture and traffic environment of different drivers.

International comparisons show that countries differ in terms of traffic safety performance (Table 1). These performances cannot be explained solely by differences in the traffic environment. Instead, there is an assumed influence of culture on the generation of policies by transportation agencies and the acceptance of risk by users of the same transportation system (Ward & Ozkan, 2014). Cultural factors can possibly be more relevant in LMICs as a result of scanty regulations which are barely enforced, lack of training of law enforcement agents to deal with traffic regulations (as a result, most road users do not understand these regulations), and lack of resources to conduct enforcement (World Bank, 2002). Therefore, knowledge about features or characteristics of crash-involved or risky drivers can enhance countermeasure programs to improve road safety.

4.3 Determinants of driver behaviour

Given that risky driving is a major contributor to road crashes, reducing levels of risky driving would go a long way to reduce the incidence of crashes and injury on the roads. Doing this would require a good understanding of the factors that influence risky driving among drivers (Fernandes et al., 2006). From the evidence available in road safety research, it is obvious that several causal factors (which can be internal or external) can impact on the behaviour of drivers either in isolation or combination. In general, both behavioural factors related to the driver, and non-behavioural factors related to road geometry, traffic flow conditions, vehicle characteristics, environment and contextual conditions (cultural, social) all influence driving behaviour. Bener & Crundall (2005) indicated that a driver’s behaviour is influenced by personal, cultural and situational factors. McNeely & Gifford (2007) and Berry et al. (2011) found that behaviour is shaped by a wide range of features including attitudes, beliefs, values and norms. Zaidel (1992) and Björklund (2005) found drivers to be influenced by their social environment, other road users, and by formal and informal rules. Some of these factors are discussed below:

4.3.1 Influence of demographic characteristics

The literature argues that road safety is a social problem and that personal factors play a vital role in guiding and shaping driver behaviour. Research has found a close relationship between driver behaviour and demographic characteristics such as gender, age and experience (Ward & Lancaster, 2003; Iversen & Rundmo, 2004). This section briefly explores the influences of some demographic factors on the behaviour of drivers.

4.3.1.1 Gender

A large amount of research has been conducted to investigate the role of gender in drivers’ behaviour or driving safety. Most of these studies have shown that male drivers are more aggressive and more frequently involved in risky driving compared with females. Al-Balbissi (2003) pointed out in his study that males were more likely than women to be sensation-seekers and attention-seekers and so showed some reckless driving characteristics, while females adhered more closely to traffic laws. Laapotti et al. (2003) compared young male and female drivers’ attitude and self-reported traffic behaviour in Finland between 1978 and 2001, results revealed gender differences in traffic offences and violations. Compared with males, females had fewer offences and lower crash rates. In addition, results also showed that gender differences in traffic offences did not decrease over the years of driving (experience). In a study in Qatar, Bener et al. (2008) found that females committed fewer traffic violations than males, while United Arab Emirates (UAE) males and females showed similar behaviour in terms of traffic violations. De Craen (2010) found that young male drivers (aged 18-29 years) had a much higher probability of being involved in serious crashes than young female drivers in the Netherlands. Furthermore, Monárrez-Espino et al. (2006) found that the male drivers' crash rate was five times higher than that of female drivers.

On the other hand, some studies have not found any differences in crash rates or risky behaviour between male and female drivers. Munk et al. (2008) found that males and females retained a similar perception of seatbelt wearing in Qatar. Kweon & Kockelman (2003) drew a similar conclusion from the investigation of crash rates in the United States. A Driver Behaviour Questionnaire (DBQ) survey conducted by Bener et al. (2008) showed that only minimal differences existed between males and females in the DBQ item scores, indicating risky driving behaviour in samples of Qatar and United Arab Emirates drivers.

4.3.1.2 Age and experience

Age effects on driving behaviour have been widely investigated. A significant number of studies have shown that young drivers are overrepresented in road crashes (Reason et al., 1990; Aljassar et al., 2004; Bener & Crundall, 2008). Young drivers also appear to show a greater tendency towards risks compared with older drivers (Bener & Crundall, 2008). Boyce & Geller (2002) measured several variables (e.g., vehicle speed, following distance and seatbelt use) during an on-road test with an instrumented vehicle and found age (between 18 and 25 years old) to be one of the predictors of risky behaviours (speeding and following distance). Yan et al. (2007) studied driving behaviour related to left-turn gap acceptance in a simulator and found that older drivers (56 to 83 years old) displayed a conservative driving attitude compared with younger drivers.

Young drivers are often considered as novices with a lack of experience. Young novice drivers are usually more at risk of committing driving offences and getting into crashes compared with old experienced drivers. A conclusion made by de Craen (2010) is that young novices show more risky behaviours in driving compared with old experienced drivers, especially considering their frequency of involvement in traffic crashes. Driving requires drivers to have the right skills to process a variety of information and to make appropriate decisions. Machin & Sankey (2008) investigated the relationship between personality factors, risk perceptions, and driver behaviour of novice drivers; results showed that novice drivers underestimate the risks in many situations. Research also has shown that the crash risk of novice drivers decrease with increased driving experience (Mayhew et al., 2003; de Craen, 2010). According to Groeger (2006), age and inexperience should be associated together to explain the aggressive driver behaviour of young novices as there are indications that the lack of experience is more relevant than the young age. Similarly, Reason et al. (1990) and De Winter & Dodou, (2010), in different studies found that traffic violations decline with age and experience while errors were found to be proportional with age. Begg & Langley (2001) demonstrated that risky driver behaviour decreases rather quickly with the increase of driving experience, especially after the first year of driving as many novice male drivers become 'matured' and change their risky driving style. However, Maycock et al. 1991 attempted to disentangle the relationship between age and experience because they believe that experience on its own has an influence on crash risk. They used self-reported data from drivers and multivariate statistical modelling to determine the relative effects of age and years of licensure, after controlling for exposure. Results showed that crash risk is dependent mainly on exposure (total annual mileage), the driver's age and his or her driving experience measured as the number of years since passing the test. The relative importance of age and experience depended on the location of a driver on the age and licensure continuum. The proportional decline associated with increasing age or experience was larger for younger drivers than for older drivers. This was particularly true for experience; there was a steep learning curve.

4.3.2 Roadway and environmental factors

It has long been recognized that road infrastructure including road design and network have the potential to influence drivers' behaviour (Evans, 1991) because it determines how drivers use the road environment. This means that they can as well influence traffic safety as they provide instructions to road users on what to do. These include road geometries and roadside conditions (for example, well-designed curves and grades, wide lanes, adequate sight distance, clearly visible striping, flared guardrails, good quality shoulders, roadsides free of obstacles) and well-planned use of traffic signals (Drottenborg, 2002; Taylor et al., 2002; Sétra, 2006; Dixon & Wolf, 2007; Abele & Møller, 2011). Road geometry is often correlated to crash rates; for example, increases in crashes are seen along sharp curves with little to no shoulder compared to slight curves with adequate shoulder space. Research has shown that road widenings occur at the expense of safety, even after controlling for traffic volumes (Sawalha & Sayed, 2001; Noland & Oh 2004; Dumbaugh, 2005). According to Ewing & Dumbaugh (2009), eliminating lanes appear to improve traffic safety while intersections and driveways, the presence of horizontal curves and pedestrian sidewalks have been shown to increase drivers' perception of crash risk (Tarko, 2009).

In most countries, rural roads are the most dangerous types of road (DRSC, 2000; Abele & Møller, 2011) because they have a higher fatality rate than urban roads. This could be partly due to the higher speeds at which people travel in the rural areas and hence the increased injury severity when a crash occurs (Turner & Tziotis, 2006; DfT, 2014). According to Bell et al. (2012), in urban areas, speeds are generally constrained by legislation and /or congested conditions. However, despite the higher fatality rate on rural roads, the overall crash rate is significantly higher on urban roads (Turner & Tziotis, 2006; DfT, 2014).

Poor road design and roads with potholes could mislead a driver and directly trigger a crash. Safer roads and mobility is one of the five pillars of the UN Global Plan for the Decade of Action for Road Safety 2011-2020 (WHO, 2011). It emphasizes the need to raise the inherent safety and protective quality of road networks for the benefit of all road users. A road environment which provokes the right expectations would reduce potential errors. By improving road design, roads may become “self-explaining” in that their layout explains what driving behaviour is expected (see Theeuwes & Godthelp, 1992; Theeuwes, 1994; Kaptein & Theeuwes, 1996; Theeuwes, 2001). These studies emphasized that the traffic environment should provoke the right expectations concerning the presence and behaviour of other road users as well as the demands with regard to their behaviour. Unfortunately and especially in developing countries, current road design does not provide road users with a clear picture of which road belongs to what category. According to Reynolds et al (2009), roads are still being built and reconstructed without any consideration for the safety of road users, and therefore drivers do not know what to expect and what is expected of their own driving behaviour. These may lead to driving behaviours that are not appropriate for the traffic situation.

Successfully improving the safety of the road environment requires a clear understanding of how road users act or behave within the environment. The interaction between the road user and the road environment and the impact on crash risk is an essential aspect of road safety assessment. Therefore, in order to improve the safety of roads, there is a need to combine research methods to identify characteristics of the road and surrounding environment that impact crash risk and to further investigate why these factors influence risk (e.g. through changes in driver behaviour). Once these are determined, evidence-based countermeasures can be proposed and tested. It is, therefore, important to adopt an approach that combines the initial identification of risk factors and subsequent investigation of why risk keeps increasing.

Behavioural research methods can be used to investigate how driver behaviour changes in different road environments. Evidence from previous research on aspects of the road environment that increase crash rate and severity has been adopted to develop engineering measures and tools for identifying high-risk roads and prioritising treatments. It is very important to know whether the influence of environmental change on behaviour provides a route by which the environmental change can influence crash risk.

4.3.3 Vehicle factors

Vehicle type, engineering and the safety design standards for vehicle performance can affect driver behaviour and safety. Driver behaviour may vary between drivers with different types of vehicles. There is evidence linking certain vehicle types and characteristics to crash involvement and one possible mechanism behind this relationship is that these influence drivers' risk-taking behaviour (Jelenova, 2006). Wenzel & Ross (2005) studied the dependence of risk on vehicle type and found that the drivers of SUVs and pickup trucks behave more aggressively than the drivers of passenger cars. Aghabayk et al. (2011) found that the drivers of heavy vehicles behaved differently from drivers of passenger cars in lane changing behaviour, especially on arterial roads.

On the other hand, advancements in technology have led to an increased deployment of in-vehicle systems aimed at improving safety, such as navigation, guidance, and collision-avoidance systems. These systems aim at improving driver safety by providing drivers with warnings to avoid safety-critical events (Matthews & Desmond, 2001). For example, passenger protection systems in vehicles (i.e. airbags, safety belts), if used, can eliminate injuries or reduce their severity. These are found in developed countries where there is strict enforcement of vehicle safety standards.

The “New Car Assessment Programme” (NCAP) has contributed to improved safety of vehicles. This was created by the National Highway Traffic Safety Administration (NHTSA) in 1979 to improve occupant safety by developing and implementing meaningful and timely comparative safety information that encourages manufacturers to voluntarily improve the safety of their vehicles. The agency has improved the program by adding rating programs, providing information to consumers in a more user friendly format, and substantially increasing accessibility to the information. The Global NCAP (GNCAP) was founded in 2011 to encourage cooperation among all NCAP programmes, share best practices, and support vehicle testing in emerging markets. This program has strongly influenced manufacturers to build vehicles that consistently achieve high ratings, thereby increasing the safety of vehicles (GNCAP, 2017). On the other hand, most vehicles used in most developing countries are imported as second-hand vehicles from Japan, Europe and the United States. Most of these countries, for example, Nigeria have import standards, but enforcement of the standards is not strict. Even though most of the countries have laws for seatbelt use, these are not effectively enforced. Vehicle inspection regulations require cars to be inspected but the enforcement is also weak in most developing countries, Nigeria Included. Unsafe vehicles which include vehicles lacking simple safety design including the provision of seat-belts and other basic safety equipment and standards would not encourage drivers to adopt safe driving behaviour.

4.3.4 Traffic safety culture

Shared values within groups such as families, friends, organisations or society (e.g., the attitude towards unsafe driving among friends or the safety policies adopted in a society), affect drivers’ motives and hence influence driving behaviour. A study by Taubman-Ben-Ari et al. (2005) found significant associations between parents’ and offsprings’ driving style. Similarly, young drivers’ perception of speeding among their friends was the most important predictor of own speeding behaviour, compared to other possible predictors such as education, age, history of crashes and violations.

The term ‘culture’ is common in the social sciences and humanities. Hoebel (1966) described culture as an integrated system of learned behaviour patterns. Culture has been defined in many ways and under different contexts. According to Bealer et al. (1965), culture is the belief structure, shared ideas and directives for action that are embodied by a community. North (1990) citing the work of Boyd & Richerson (1985) defined culture as “transmission from one generation to the next, through teaching and imitation of knowledge, values, and other factors that influence behaviour.”

Culture strongly affects the way people live and behave. This may not be different in driving because it could influence the way people behave in traffic. It seems reasonable to assume that the relationship between safety culture and crash risk is mediated to a large extent by values related to or attached to road safety. Different people from diverse cultures interact and meet on the roadway and it is not wrong to argue that their beliefs will affect the way they drive. Warner et al. (2009) claim that an explanation for diverse violations and crash involvement could be as a result of cultural differences. Thus the road safety values associated with a society or country would be expected to have a significant influence on their driving behaviour.

Leviäkangas (1998) described traffic culture as the sum of all factors (skills, attitude and behaviour of drivers as well as vehicles and infrastructure) which either directly or indirectly influence a country’s level of traffic safety and as argued by Iversen & Rundmo (2004), societal norms and pressure contribute to shaping attitudes towards rule-breaking and risk-taking behaviour. A country’s traffic safety culture focuses on social norms, values and beliefs. This is formed and nurtured by formal and informal rules, norms and values of the society or environment. Formal rules which are mostly enforced by authorities may change overnight but informal rules are made as a result of constant interaction with other road users and traffic environment. These informal rules are usually embodied in the customs and traditions of the road users and are not easy to change. Özkan & Lajunen (2015) stated that the “traffic culture of a country could be redefined as the sum of all external factors (eco-cultural-socio-political, national, group, organisational, and individual factors) and practices (e.g., education, enforcement, engineering, emergency services) for the goals of mobility and safety to cope with internal factors (road users, roads, and vehicles) of traffic”. Understanding a country’s safety culture would be useful in developing effective interventions and countermeasures that could significantly reduce road traffic incidents.

The different choices drivers make during the driving task is often affected by their beliefs and values regarding the appropriate use of vehicles and what they think is right based on where they are coming. Road traffic conditions, situations, enforcement, legislation etc. vary across different countries and so some countries experience a much higher rate of traffic crashes than others. Comparing the cultural practices of one group to another will give a better idea of their safety culture. As noted earlier (see section 3.3), reports have shown road fatalities to be much higher in LMICs (e.g. Nigeria) than in the HICs (e.g. the UK). Drivers in LMICs have been reported to exhibit more risky behaviour than drivers from HICs (Lund & Rundmo, 2009; Bener et al., 2008). World Bank (2012) states that it is possible that cultural factors are more relevant in LMICs to account for high rates of traffic fatalities. These countries are characterised by scanty regulations which are not enforced, lack of training for the police to deal with traffic regulations and do not have the resources to conduct proper enforcement. High incidence of road traffic crashes in these countries can also be attributed to aberrant behaviour on the part of road users, unsafe vehicles, substandard road design and maintenance, little or no driver education and lack of enforcement of traffic safety laws.

Atchley et al. (2014) confirmed these national differences from a recent comparison of traffic safety culture between China, Japan and the United States. Although they do not explicitly discuss driving styles, they conclude that the different crash risk records of the three countries are related to different cultural values. As part of a simulator study carried out in ITERATE (2012), investigating how new technologies support different types of operators in different contexts, cultural differences were also investigated. This was achieved by examining results from the experiment, using five different countries (France, Israel, Italy, Sweden and the United Kingdom) and by administering a traffic culture questionnaire. The major result of the study was that country and gender were important factors for both car and train drivers. A self-report study by Nordfjærn et al. (2014) examined country cluster differences based on different culture framework in road traffic risk perception, attitude towards road safety and driver behaviour in samples from Norway, Russia, India, Ghana, Tanzania, Uganda, Turkey and Iran. Analyses were performed using Multivariate Analyses of Covariance (MANCOVA). Results showed that Norwegians reported overall safer attitudes towards traffic safety and driver behaviour but drivers from Africa (Ghana and Uganda) reported the highest risk perception. He further claims that contrary to the cultural theory, prediction models revealed that cultural factors were stronger predictors of driver behaviour than risk perception. Ozkan et al. (2006) used the DBQ to collect self-reported data from drivers across six countries (Finland, Great Britain, Greece, Iran, The Netherlands, and Turkey). Two hundred and forty-two drivers were chosen from each of the six countries, matched for age and sex. ANOVA results revealed differences between drivers from “safe” Western/Northern European and Southern European/Middle Eastern countries on DBQ items and scales. Results demonstrated that driving style mediates the relationship between traffic culture (i.e. country) and the number of crashes. Poisson and negative binomial regression analyses also showed that the importance of driver characteristics and behaviours in predicting the number of traffic crashes varies from country to country. Bener & Crundall (2005) used annual motor vehicle crash statistics on all fatal crashes that occurred in United Arab Emirates (UAE) from 1990-2000. Information such as the number of registered vehicles, number and nature of crashes, causes of road crashes, number of fatalities and casualties, age and gender of victims were retrieved. Multiple linear regression analysis was performed to determine predictor for fatalities per 10,000 vehicles. Results showed that despite the relatively low ratio of licensed vehicles to the number of inhabitants, the number of crashes have increased in the last ten years compared to the UK and the USA. Careless driving is the most important factor in RTAs over the period of study, accounting for over 35% of all incidents, while excessive speed was the second most common cause. Nordfjærn et al. (2011) investigated the cross-cultural differences in driver attitudes and behaviour, road traffic risk perception, risk sensitivity and risk willingness in Norway, Russia, India, Ghana, Tanzania and Uganda using a self-completed questionnaire. MANCOVA (multivariate analysis of covariance) analyses were performed and results showed that Norwegians reported safer attitudes regarding drinking and driving, seatbelt use and speeding in road traffic than the other sub-samples. Respondents from Sub-Saharan Africa reported higher road traffic risk perceptions and risk sensitivity than respondents from Norway, Russia and India. Respondents from Tanzania reported the highest willingness to take risks both in traffic and in general. Participants from Sub-Saharan Africa and India reported safer attitudes in regard to speaking out to an unsafe driver, rule violations and sanctions, attitudes towards pedestrians, and traffic rules and knowledge. Bener & Crundall (2005) and Nordfjærn et al. (2011) in their different studies concluded that differences in road safety among countries were attributed to differences in the behaviour of road users. Thus, measures that succeed in a particular culture might not succeed in other cultures.

Additionally, studies investigating differences in the behaviour of immigrant and native drivers also pointed out the cultural factor as a determinant for driving behaviour. Forward et al. (2009) carried out an extensive study investigating traffic safety among immigrants in Sweden. By reviewing literature, using crash data and a questionnaire based on the Theory of Planned Behaviour (TPB), and carrying out in-depth interviews, they concluded that immigrants' traffic behaviour is shaped and can be attributed to the traffic norms prevalent in the country in which they grew up. And went further to add that previous behaviour and the perception of how others behave in traffic could provide an explanation as to why people behave differently in traffic. Foreigners move into new environments with a pre-conceived or a mind-set of driving behaviour from their cultures where policies and enforcement may be different. Are they influenced by the new safety culture or do they try to adapt to the environment? Huang et al. (2006) used the focus group method to conduct a study on the effect of language on navigation and driving performance of drivers who had driving experience both in China and the USA. The major finding reported was that many highways and roads in China are named only with Chinese words which have complex characters that are not easily understood by foreigners. This has the potential to create safety problems for foreign drivers. Leviakangas (1998), investigated the crash risk of Russian drivers in

South-Eastern Finland. Crash rates were calculated for both groups (Russian and Finnish drivers) based on crash statistics collected by the police and origin-destination studies carried out at the Finnish-Russian border stations. Results showed that crash rates of foreign drivers (Russian) were higher than that of domestic drivers (Finnish). Shinar et al. (2003) examined the level of understanding of traffic signs in samples of drivers from Canada, Finland, Israel and Poland representing countries with moderate to high levels of motorization. They found differences among the different groups and concluded that this could be caused in part by cultural differences. Another study by Yannis et al. (2007) investigated foreign and native drivers in various road environments in Greece to determine the effect of driver culture, area type, junction and lighting conditions on accident risk. Using data from the national crash database of Greece and hierarchical log-linear analysis, it was concluded that foreign drivers in Greece are at an increased risk but immigrant permanent residents appear to have a lower risk compared to tourists, regardless of the road environment. A Spanish study by Claret et al. (2002) using data from the database of the General Traffic Directorate, found foreign drivers driving in Spain at a higher risk of causing a collision than are Spanish drivers.

Other studies in this area (e.g. Lajunen et al., 2004; Ozkan et al., 2006; Bener et al., 2008; Warner et al., 2009; Nordfjærn et al., 2011; Şimşekoğlu et al., 2012) etc. targeted differences across cultures using self-report data to compare road traffic risk perception, seatbelt use, aggressive driving, speed choice, attitudes towards road safety and driver behaviour. They all reported that drivers from countries with good road safety record exhibited better behaviour. The environment has a lot to do with the behaviour of drivers and also affects their compliance with policies regarding safety. This is evident in the studies cited above and can be endorsed by the high traffic fatalities in the LMICs.

In summary, the studies reviewed in this section indicate that drivers' behaviour is potentially influenced by a range of factors, from individual characteristics (gender, age, cognitive style, and lifestyle) to group/organisational values and national/regional culture. Thus, it seems clear that driving behaviours often develop through the joint influence of a large number of individual, socio-cultural, and technological factors.

4.4 Tools for measuring driver behaviour

Several methods have been used to measure driver behaviour and probably link them to crash risk and involvement. Conventional approaches include the use of a questionnaire, travel diaries, on-road observation while recent studies have adopted NDS, simulator experiment, GPS etc. As part of efforts to improve the understanding of driver behaviour, an increasing number of studies have employed improvements in technology to collect more detailed and richer data. These have led to substantially larger and more complex datasets of driver behaviour necessitating new methodologies to analyse them. In the literature, the most common methods used are observation, questionnaire survey and focus group (Huang et al., 2006; Yannis et al., 2007; Ozkan et al., 2011; Şimşekoğlu et al., 2012; Nordfjærn et al., 2014;). Some of these measures are described below:

4.4.1 Self-reports

One approach to eliciting behaviour are self-reported measures in which respondents are asked to report on their own behaviours, beliefs, attitudes, or intentions. Self-reported data provide a lot of information on factors related to crashes and crash risks. These techniques can include questionnaires, interviews, focus group discussions or travel diaries, and would require giving responses to pre-set questions. According to James et al. (1993), a major advantage derived from driver self-reports is that all crashes can be canvased (except those fatal to the driver). In this regard, minor, damage-only crashes can be included that would not appear in other records. Also, details of crashes and driver characteristics relevant to the study can be obtained. Self-reports allow participants to describe their own experiences rather than inferring this from observing participants.

Questionnaires are the most commonly used self-report measures. With the questionnaire, large amounts of data can be collected and analysed at a low cost and in a short time. In addition, it could be used for large scale national and international studies using representative driver samples. Questionnaires provide a means for studying driving behaviours, which could be difficult or impossible to study by using other methods like observations, interviews and analyses of national crash statistics. For example, reliable measurements of driving style as an established way of driving is required to record how a person drives across different traffic situations, not only when observed once or twice during a single trip. It is difficult to accurately measure infrequent phenomena, like deviant behaviours, by using other techniques than self-reports. In addition, attitudes and motives for deviant behaviour and other background information about the driver can be collected in the same form together with self-reports of driving behaviour. In this way, the questionnaire techniques can provide in-depth information about antecedents of certain driving behaviours.

Self-reports could also be in the form of qualitative measures. Among the various qualitative methods (interviews, case studies) of data collection, focus group discussion has become very popular and is being extensively used in social and behavioural research. It is a method in which the moderator, with the help of predetermined guidelines, stimulates free discussion among the participants on a particular subject of inquiry. It was originally used by social scientists to assist in understanding what people think about an issue (Rubin, 1996). Since being introduced in transport research, it has become a practical way to obtain information about people's opinions to identify the factors relevant to drivers' decision making and to explore effective measures for improvement. They focus on experience to gain information on motivations, attitudes and behaviour that cannot easily be obtained from quantitative methods alone. They are less time-intensive and cost relatively less than the other methods. Group interaction and non-verbal communication also benefits from focus group discussions as it may encourage participants to make connections to various concepts through the discussions. The focus group setting puts participants at ease and enables them to express their views freely considering that they may have a similar background.

Although self-report measures are widely used, it is important to note that their use is based on the assumptions that respondents understand and can answer the questions posed to them. On the other hand, self-reported data is sensitive to bias and is based on respondents' memories. Moharrer (2011) reported that studies based only on self-reports provide only a subjective measure of driver's skill without any objective measure for comparison. It is not to be ruled out that respondents may forget crashes or behaviours that have happened in the past. Maycock et al. (1991) in their study of accident liability of drivers, concluded that the rate of drivers forgetting their involvement in crashes was approximately 30% per year and this will likely be the same in reporting about driving behaviour. Self-reports can also present researchers with a variety of challenges such as validation of instrument. In focus group studies, for example, Khan et al. (1991) have also shown that a group setting is not always ideal for encouraging free expression. In addition, the samples are small and purposively selected, and therefore may not allow generalization to larger populations. The chances of introducing bias and subjectivity into the interpretation of the data especially during transcription are very high.

Although self-reports can be applied to investigate how road users behave in different road environments, self-report do not always represent actual behaviour. Technological advances have made other types of measures more plausible. For example, self-reported measures cannot be used to measure the behaviour of participants in a controlled environment or to measure physiological measures like galvanic skin response and eye movements. Measures of other variables, such as actual speed, Time to Collision (TTC), brake response time could be assessed without self-report by recording actual behaviour. For measuring actual behaviour, objective measurement methods are required. One of the ways to overcome the limitations and obtain a more reliable assessment of drivers' behaviour is by observing their actual driving performance. Some studies favour the utilisation of the observation measures to overcome these potential problems of self-reports (e.g. West et al., 1993; Hatfield et al., 2008; Merat et al., 2011). These can be used to objectively measure how road users behave within the road environment and how aspects of the environment affect behaviour. Sometimes self-report data are used in conjunction with these methods of behaviour to measure determinants of behaviour that are not amenable to being objectively measured. Some examples are self-report scales to measure constructs like mental workload or situation awareness, in which road users are asked to report what they are doing and thinking to elicit information about cognitive processes. Hence, observation of actual behaviour together with self-reports provide a more reliable measure of driver behaviour.

4.4.2 Observational studies

Observational studies have been applied in an attempt to investigate driver behaviour. In some of these studies, road users are observed without any intervention by the researcher as they travel through the road system. To explore behaviour and traffic situations, an observational study can focus on the behaviour of all road users at different locations and time periods. Read et al. (2014) observed how pedestrians and cyclists interacted with infrastructure at railway level crossings in Melbourne, Victoria and found that observed behaviour did not always match that expected by designers of the system, which has implications for the design of level crossings. These studies could be used to record how road users actually interact with particular environmental features and situations and are often used for evaluating the effects of countermeasures or interventions using before-after studies or quasi-experiments.

Driver behaviour could also be measured using trained observers. A typical example is the method of observation proposed by Wiener Fahrprobe (Chaloupka & Risser, 1995). This has been used in many road safety studies around the world and especially in Europe. Here the driver is accompanied by two observers - an independent observer who records whatever interactions the driver has with the driving environment without any standardised forms stating what should and should not be recorded and another who uses a standardized form for recording driver behaviour. The latter has an already defined list of behaviours to look out for. This method though widely adopted have been found to contain many lapses. There are concerns about drivers changing their behaviour because of the presence of observers or that observers may not record behaviours correctly and coherently. This is because observers may not be able to describe events adequately or may get distracted at some point. However, it also provides certain information which the driver may not want to report.

4.4.3 Naturalistic Driving Studies (NDS)

Naturalistic driving studies have been used to measure driver behaviour whereby cameras, sensors and other equipment are installed on participants’ vehicles and are used to continuously record details of the driver, vehicle and environment for a long period of time without any obstructions. Behaviour and performance of drivers are observed as it occurs in the context of the real world driving. NDS are similar to on-road studies in that they involve the in-depth recording of behaviour in the real world; however, unlike on-road studies, once the driver takes charge of the instrumented vehicle in a NDS, the researchers have no control over where or when the driver travels or how the driver behaves.

NDS involve precise measurements and observations of vehicles driving in the real world without any experimental interventions. Changes in behaviour and influence of certain factors such as road environment on driver behaviour can be investigated. According to Carsten et al. (2013), they have more of a diagnostic character, as they are used as an instrument to find out which factors are associated with crashes and conflicts and do not systematically investigate a countermeasure or other treatment that might prevent crashes from occurring. With the nature of NDS, they can be used to understand pre-crash or conflict conditions. This means that they can also provide information about precursors to conflicts and crashes.

Some examples are the 100-car NDS, conducted in 2003 by Virginia Tech Transport Institute (VTTI) to collect large scale naturalistic driving data of car drivers for over a year (Dingus et al., 2006); SHRP2 programme with objective to improve highway safety through an understanding of driving behaviour, was carried out with about 3,100 drivers, aged between 16-80 years for two years in six states of the United States (Hedlund, 2015); ANDS conducted in Australia aimed to understand what people do when driving under normal and critical conditions, it involved 360 volunteer drivers and lasted for 4 months (Regan et al., 2013); the UDRIVE which is the first large scale study to be conducted in Europe was used to collect data on about 500 cars, trucks and powered two-wheelers from six EU member states (Barnard et al., 2016). The purpose was to gain a better understanding of what happens on the road in everyday driving. Road user behaviour was studied with a focus on safety and the environment.

Even though these studies allow a more natural and richer data collection and their results are more generalizable for real-life settings in contrast to driving simulator experiments, they are very costly, time-consuming and requires a lot of effort to design and conduct. In NDS, vast amounts of data are recorded, and it could be challenging to decide the most appropriate study designs and analysis methods to answer research questions using the data. Some of the major methodological issues relate to how to effectively deal with repeated in-depth measurements on individuals and the potential for bias. Therefore NDS are appropriate for observing behaviour in a real-world context but may not be the most appropriate method for controlled investigation of the effect of a particular risk factor on driver behaviour.

4.4.4 Driving simulators

Another method is based on collecting data with the controlled environment of a driving simulator. Well-designed experiments conducted in a laboratory setting allow a high degree of experimental control over the independent variables and confounding factors. Measurement techniques can be used that are impractical in other settings. Well-controlled experiments provide strong evidence for a causal relationship between independent and dependent variables. Driving simulators provide control and the ability to compare driver behaviour safely across different experimental conditions and measure their driving performance in different road environments. According to da Silva (2014), performance measures are based on techniques of direct registration of driver ability to perform the driving task at a level considered acceptable and safe.

Investigation of complex driving scenarios that include many other road users and infrastructure is also possible. Collecting good quality data is more challenging in less controlled environments and it may be necessary to rely on observations by the researcher, which are prone to observer bias. Simulators provide a controlled environment in which to conduct experiments to safely measure the effect of various factors on tasks relevant for driving. Additionally, because of the high level of experimental control, it is easy to manipulate aspects of the environment safely and measure the resulting changes in behaviour within a realistic context (Vlakveld, 2005). For example, this could include placement of road signs, cones, day/night/dusk and weather conditions etc. It is the most appropriate method for the investigation of driver behaviour in response to changes in the environment and the development and evaluation of countermeasures. Driving simulators can measure performance accurately and efficiently and can be used to prepare trainees to handle unpredictable or safety-critical tasks that may be inappropriate to practice on the road, such as collision avoidance or risky driving (Hoeschen, 2001). The simulator records data of the drivers' actual behaviour, consciously or unconsciously controlled, and its consequences within the driving environment. Scenarios can be designed to closely represent the real-world road environment and events and conditions could be replicated for each driver. In contrast to on-road observations, complex physiological measurements and intrusive secondary task techniques can be used in simulators.

Simulation studies have greater face validity for investigating the effect of different aspects of the environment on behaviour. On the other hand, studies conducted in driving simulators are sometimes criticised because the road environment does not fully replicate the real world. In addition, participants have different motivators within a driving simulator experiment than they do in real life which can affect the behaviour they display. There is a possibility that drivers could be more disciplined than they would be when they feel they are not being observed (Ulleberg, 2002). Simulator sickness symptoms may undermine training effectiveness and negatively affect the usability of simulators. This is a serious concern, but fortunately, useful technological and procedural guidelines are available to alleviate it (Kolasinski, 1995). Nevertheless, driving simulation holds an important place as a valid method for conducting rigorously controlled experiments to investigate the effect of a small number of experimental manipulations on driver behaviour and for evaluating countermeasures prior to implementation on the road. The most critical characteristics that determine the reliability of a driving simulator, with respect to the degree to which it represents reality, are considered to be its technical fidelity (or physical validity) and its behavioural validity (Blaauw, 1982; Jamson, 1999). The Physical validity refers to the physical components and subsystem of a simulator and deals with how the simulator performs compared to a real world car. Jamson (1999) stated that physical validity measures the degree to which the simulator dynamics and visual system reproduce the vehicle being simulated. And that it deals with the extent to which the simulator replicates real world driving in terms of physical measurable characteristics (e.g. the actual resistance of brake pedal). According to Carsten and Jamson (2011), the physical validity can be divided into: (i) the accuracy of the underlying software representing vehicle dynamics (ii) the capability of the visual system in terms of brightness, contrast, resolution, field of view, and size of the projected world (iii) the fidelity and elements of the sound system e.g. road noise, engine noise, etc.(iv) the elaborateness of the physical vehicle controls and displays with which the driver interacts (more capable simulators generally use a real vehicle cab-and the accuracy with which pedal feel, steering wheel feel, and gearshift feel (where this is provided) are conveyed) (v)for a motion base simulator, the numbers of degrees of freedom (up to nine) provided, the scaling factor relative to real-world forces used for the direct motion cues (surge in the x axis, sway in the y axis, and heave in the z axis), the strategies used for tilt and the inertia and mechanical delays imposed by the motion platform. The physical validity is very important as a more elaborate environment will be more realistic and immersive. Behavioural validity is considered more important, due to their applicability to specific research hypotheses and the fact that in many cases high technical fidelity is not synonymous to maximum reliability in terms of results. While there are several types of behavioural validity, to use the driving simulator in place of a real vehicle for trials with users, it should be ensured that there will be meaningful results that will be directly transferable to real traffic conditions. Past research has shown similarities in behaviour in driving simulators and real-life settings, which supports the view that the use of a driving simulator is a reliable method (Palat & Delhomme, 2016). Carsten et al. (1997) evaluated the validity of the Leeds driving simulator by measuring speed and lateral position at 21 different locations along an 8km road section. 100 participants drove the real and simulated routes in three traffic conditions (none, light, heavy). Results of the comparisons made between the real and simulated routes showed no significant differences in mean speed at the ten data collection points for the three traffic conditions. For the lateral position, results showed that drivers adopted different lateral positions in the simulator which was linked to reduce Field of View (FOV) in the simulator. The rank order of the ten lateral position measurements was similar for both systems. The authors concluded that there was a great similarity between driving in the simulator and the real world.

Considerable effort is constantly being invested in enhancing simulator capabilities e.g. with multichannel projection, partial or complete vehicle cabins, working indicators, motion system to provide a replica of the acceleration forces in real-world driving and graphics performance (Carsten and Jamson, 2011).

4.5 Improving driver behaviour

The importance of influencing behaviour in order to achieve positive policy outcomes is increasingly being recognised. Influencing road user behaviour can be challenging and it is often unclear which behaviour change strategy will be most effective. Some studies have focused on behaviours relevant to specific contexts while others cover the use of behaviour change models (Darnton, 2008). What makes people behave in a certain manner may also determine to a large extent how behavioural change can be achieved. Goldenbeld et al. (2000) argue that the motivation underlying driver behaviour determines to a large degree how successful behaviour change strategies may be. Road user behaviours vary from new (planned) behaviour to habitual behaviour. Certain habitual road user behaviours can be altered by applying behaviour change strategies in such a way that seizes the underlying motive and therefore enables road users to detect the changes in the traffic situation but risky driving habits will not disappear overnight. When drivers become aware of unsafe driving habits and the associated safety risks, they can identify it themselves and correct it. Influencing attitudes can be done by convincing people of the consequences of behaviour and persuading them, for e.g. not to speed, to drive slowly in the vicinity of schools, to drive soberly, to use their seatbelt, and not to use a mobile phone. Interventions or strategies to modify driver behaviour may involve diverse activities such as road safety education and training, mass media campaigns, reward campaigns, enforcement and rehabilitation programmes. The transfer of knowledge and change of attitude plays a very crucial role in all these programmes. On the other hand, changing behaviour in the long-term poses a particular challenge, especially with regards to habitual behaviour. Habits are practised repeatedly without much thinking (Goldenbeld et al., 2000) and therefore relatively automated (Rasmussen, 1983). Although people can have access to information, and possess the knowledge enabling them to perform desired actions, automated habits can cause them to ignore information that conflicts with established behaviours (Nisbett & Ross, 1980). Approaches to change behaviour need to be sustainable. This means that they need to be ideally both cost-efficient and effective in the long-term.

4.5.1 Engineering measures

It is widely recognised that engineering measures have an important role to play in contributing to safer driving conditions. Engineering measures include mainly road design, construction, maintenance and management of the roads and roadside conditions. However, the costs associated with these are sometimes very high and as such, plans must be put in place to ensure they are effectively carried out to meet policy objectives.

Good road infrastructure improves traffic safety by contributing to forming behaviours which can be performed automatically. Forgiving roadside design should be adopted to reduce the road crash frequency and severity. When roads trigger the right expectations about which driving behaviours are appropriate, they allow drivers to perform those behaviours more or less automatically (Theeuwes & Godthelp, 1995). By influencing road users' observations of traffic situations, chances are that they may modify their behaviour accordingly (Lewis-Evans & Charlton, 2006; Martens, 2007; Mickie et al., 2013). More pro-actively, good road design and well-developed traffic management measures produce roads which are safer and are less likely to develop black spots, while road safety audit procedures can be used to attempt to ensure that both new and existing roads have potential safety problems removed before they lead to crashes. Road maintenance, on the other hand, is a fundamental feature of safe roads and includes a wide range of measures to improve the safety of the road environment for all road users. These measures can range from improvements to road surface condition, road alignment, drainage, road signs and markings, junction redesign, traffic calming schemes and improved shared space schemes. Traffic control devices are used for traffic regulation. This could be to give way, inform about regulations, warn drivers of dangerous situations and direct traffic distribution through appropriate signs. They can also be used to inform road users about congestion, estimated driving times, and alternative routes. Traffic control devices are usually used at intersections where chances of getting into conflicts are high. According to Elvik & Vaa (2004), the application, for instance, of traffic control signals at four arm junctions may generally lead to a 30% reduction in personal injury accidents, and 35% in property damage overall.

Low-cost engineering measures such as the application of rumble strips on rural areas has been associated with 20% to 60% of crash reductions, flattening of side slope could lead to a 40% accident reduction, a 25% to 30 % accident reduction is associated with the application of safety barriers on rural road medians, while a 20% to 60% accident reduction may be achieved with the construction of paved shoulders (Ogden, 1996; Elvik & Vaa, 2004).

4.5.2 Safe vehicles

Safe vehicles play a critical role in averting crashes and reducing the likelihood of serious injuries; thus they contribute substantially to road safety. Over the years, considerable improvements have been achieved in vehicle safety technology by helping drivers to prevent crashes from occurring (primary or active safety) and contributing to lowering the severity of injuries on vehicle occupants and impacted vulnerable road users (secondary or passive safety). Improvements in the functions of automobiles can improve driver behaviour. In-car systems can inform drivers at all times and places what is the proper driving behaviour or speed limit, and warn them when they are not showing the appropriate driving behaviour (such as driving within the speed limit). They enable drivers to react to their own violations and offer a measure of insight, comfort, and support. Some major contributions to reducing the effect of a collision have been made by air-bags and impact-absorbing vehicle bodies but these improvements cannot reduce the occurrence of traffic crashes themselves. Research (D'Elia, 2013; Bjurlin, 2014; Ernstberger, 2015) have shown that there is a significant reduction in injury severity in crashes when an airbag was available. Even though some studies show that an airbag can also cause injuries in specific situations, the measure consisting of the installation of a frontal airbag can be classified as effective in mitigating injuries.

Improvements such as antilock braking systems (ABS), vehicle stability and active control over the dynamic characteristics of vehicles have been made. These help to augment the driving capabilities of drivers and contribute to reducing the possibility of crashes. There are systems which involve installing sensors to detect the distance between vehicles and warn of collisions, systems which detect the white lane markings on roads and warn the driver when a vehicle strays out of the lane, and systems which detect vehicles on both sides and behind an automobile and warn of the dangers of changing lanes. Such systems are believed to contribute greatly to preventing traffic crashes (Jermakian, 2011; Kuasno et al., 2014). In addition, WHO (2017) restated the relevance of establishing and enforcing a minimum set of vehicle safety standard regulations (frontal and side impact, electronic stability control, pedestrian protection, seat-belts and seat-belt anchorage regulations, child restraint regulations).

However, it is not evident that this type of efforts are being implemented in developing countries. According to Broughton et al. (2000), as part of a study to develop a method to investigate the likely number of casualties in Britain, the effects of three policies (improved secondary safety for car occupants, reduced drink and driving, and road safety engineering) were assessed. Results showed that 14% more drivers would have died if they had been driving cars with the 1980-81 level of passive safety rather than their actual cars with the 1996 level. This method was further adapted to analyse data from Britain and Sweden as part of the SUNflower project. Results showed the overall estimated effect of vehicle safety improvements being calculated as a 15% to 20% reduction in occupant fatalities over the period 1998-2000 (Koornstra et al., 2002). Lie & Tingval (2001) supported this by ascertaining that a general reduction in the risk of severe or fatal injuries is expected for each star improvement in EuroNCAP car rating. Overall, the EuroNCAP procedure is internationally accepted by car manufacturers, car users and other stakeholders in most developed countries. NCAP star ratings have a beneficial effect in vehicle consumer choices, in factory design, and in automakers decisions regarding vehicle equipment provided as a standard (e.g. ABS, side airbags, etc.). Implementation of UN vehicle safety standards (UNECE, 2019) is expected to contribute significantly to road safety improvements, as well as the improvement of periodic inspection systems. However, many developing countries have not adopted these procedures and therefore manufacturers are not obliged to provide the same high safety standard quality of vehicles.

Interventions aimed at improving the safety of vehicles deal with factory design, construction issues, operation and maintenance relevant for car roadworthiness and crashworthiness. Roadworthiness and crashworthiness are primarily defined at factory design and construction stages; however, the owner's operation and maintenance care are also key determinants in the actual vehicle safety. Proper maintenance has to be ensured by vehicle owners and operators, through a network of mechanical workshops equipped with specialised equipment operated by professional mechanics. For example in the UK, there is an Ministry of Transport (MOT) test which is an annual test of vehicle safety and road worthiness for most vehicles over three years old used on any road in the UK. The test includes checks on the brakes, suspension, lights, bodywork and much more. It is designed to ensure that your car is roadworthy and safe to drive, to prevent any accidents or breakdowns. MOT testing centres are regulated and licensed by the Department of Transport (DfT) and Driver and Vehicle Standards Agency (DVSA). This is unfortunately not fully laid out in most developing countries where mechanic workshops are generally not equipped to deal with modern vehicle technology and electronics. In addition, there are older vehicles in developing countries which require periodic checks. In Nigeria, the FRSC stipulates that every vehicle must undergo a roadworthiness test before its papers are renewed. Free safety checks are conducted periodically and defects identified and brought to the attention of the owners for remedial action without the issuance of tickets. But this is rarely done as compliance rate is low and there is no form of enforcement.

4.5.3 Education and training

Driver education (and training) is a common approach to improving road safety as they aim to change the risky behaviour of the driver. The general premise of driver training is that lack of knowledge about safe driving and/or inappropriate attitudes are responsible for unsafe behaviours which often lead to road crashes. Therefore, the primary goal of driver training should be to increase knowledge and ensure that road users drive safely (Beanland et al., 2013; McDonald et al., 2015). There is substantial evidence that driving skills improve during training (Groeger & Clegg, 2007) and several studies have suggested that higher order skills such as risk-assessment, hazard perception, situational awareness and the development of a responsible attitude contribute more to reducing crash risk than advanced driving skills (Hatakka et al., 2003; Bates et al., 2014).

McKenna (2010) differentiates training (which is concerned with skills acquisition) from education (which is concerned with knowledge acquisition) in the driving field. Christie (2001) previously suggested a similar distinction stating that training tends to have a practical focus and concentrates on building specific skills and competencies, usually over a short time period while education is broad and intellectually based.

Training and education play a vital role in developing cultural values, beliefs, skills and legitimising safety-relevant enforcement and legislation but would not improve driver behaviour on its own. The value of driver training and education to society is probably not in direct prevention of crashes and casualties, but in developing a safety culture that can provide mechanisms that do reduce the risk of crashes and casualties. Driver training and education should occur within an evidence-based holistic and life-long driver licensing system, such as graduated driver licensing, with a developmental curriculum providing support and legitimacy for the things that do reduce risk (af Wåhlberg, 2018). Information-based training such as hazard perception training have been shown to have significant effects on driver behaviour. Katrakazas (2017) reported in their study that hazard perception training significantly improved the hazard perception skills of drivers as well as reducing speeds and crash rates. Katrakazas & Talbot (2017) showed that in general, safe driving behaviour of elderly drivers increased after training. Bener et al. (2007) argued that educating people about the benefits of complying with traffic laws might help improve compliance rates. However, if used alone, they would not be enough to reduce crash rates.

In addition to these, road safety campaigns are used as a means of influencing drivers to behave more safely in traffic. A road safety campaign, according to Delhomme et al. (2009), is defined as a purposeful attempt to inform, persuade and motivate a population (or subgroup of a population) to change its attitudes and/or behaviours to improve road safety. Many road safety campaigns aim to highlight the risks associated with certain road user behaviours (Snyder, 2001; Weber et al., 2006; Lewis et al., 2007) and can be delivered in different ways. However, there is little guidance on which method(s) is best. In designing a campaign, it is very important to consider effective ways to deliver the message to the target audience. If a campaign message is persuasive, it will only be effective in terms of behavioural change and crash reduction if it reaches the target audience.

There seems to be a belief that when a large number of people needs to be reached, mass media campaigns are the best methods. This is because, it is believed that almost everyone either watches television, listens to the radio or reads the newspaper or most recently uses social media. Therefore, the greater the reach of the media channel used to deliver the message, the greater the number of people who will receive that message. However, the effectiveness of mass media channels alone has been questioned in traffic safety (see e.g. Elliot, 1993; Vaa et al., 2004). This is partly because the audience is likely to be exposed to mass media at a time and place that is far removed from the context in which the targeted road user behaviour occurs. Additionally, some less educated people are less likely to be reached through media campaigns. This is because they may likely not pay attention to the message being passed by such campaigns (Weenig & Midden, 1997). Thus the best way to reach these people could be by personal contact (Elvik et al., 2009). Again, what works for a campaign aimed at seatbelt use may not work for a campaign aimed at speed reduction (Tay & Wastson, 2002; Tay, 2005). This implies that the nature of the behaviour determines whether or not a certain method will be effective. This could be determined by pre-testing a campaign.

Campaigns can inform, persuade and motivate people to change their behaviour (Rice & Atkin, 2002). Barkenbus (2010) and Cristea et al. (2012), recommended the use of social norms, related to environmental impacts because social norms define the behaviours that are acceptable in societies or groups. They are well suited for campaigns, for example by stating that other people would conduct and expect certain behaviours (Ajzen, 1991). Such a campaign could communicate that people similar to the addressee value their lives and drive safely.

Irrespective of message content or delivery method used, accompanying campaigns with strict enforcement has been found to be effective in reducing the number of road crashes (Elvik & Vaa, 2004). A meta-analysis by Elvik et al. (2009) showed that the effects of mass media campaigns alone are small, especially when compared to the effects of campaigns that were combined with other measures. Without enforcement and/or education a mass media campaign has virtually no effect in terms of reducing the number of road crashes. For example, the educational and awareness campaigns for seatbelt usage in Britain (MacKay, 1987) and the UAE (Bener et al., 1994; El-Sadig et al., 2002) did not result in reducing crash rates until compulsory seatbelt-wearing legislation was introduced. It is widely evident in the literature that awareness, educational and advertising campaigns will not succeed unless they are coupled with enforcement of practical, sound, and broadly accepted laws (El-Sadig et al., 2002; Afukaar, 2003; NCHRP, 2003; Nordfjærn et al., 2011; Stanojevic et al., 2013; James et al., 2014).

4.5.4 Enforcement

Enforcement is based on the principle that people try to avoid penalties. People have the impression that there is a high chance that they will be penalised when violating a rule. The subjective chance of apprehension is primarily affected by the actual level of enforcement which is affected by how much people see or hear about enforcement. Therefore, the chance of apprehension can be increased by applying enforcement, publicising specific enforcement activities and by feedback on the results of enforcement activities.

Improvements in traffic law enforcement have been shown to lead to rapid reductions in deaths and injuries when best practice is applied. Thus it should be part of an integrated road safety policy. One of the recommendations highlighted in the WHO

(2018) was about enforcement. The report states that “enforcement of strong road safety laws is essential for success,” and that enforcement was considered weak in most countries, including the developed. Strict enforcement has both long and short-term effect and influences road safety outcomes significantly by addressing serious problems such as driving under the influence of alcohol (Yannis et al., 2008), speeding (Elliot & Broughton, 2005; Walter et al., 2011) and not wearing seatbelts (Bendak, 2005).

Many road safety researchers have investigated the level of enforcement of traffic law control and its role in improving driver behaviour. Most of these reported that intensifying traffic enforcement with stiffer penalties proved to have an immediate positive impact on road safety (Ghuzlan et al., 2012; Hajeeh, 2012). Improved enforcement was reported to be a major contributor to speed reduction in Norway (Ryeng, 2012), improved seat belt use in Nigeria (FRSC, 2013) and reduced crash rates in Australia (Soole et al., 2009).

Erke et al. (2009) conducted a meta-analysis on the effects of Driving Under the Influence (DUI) check points on crashes in Australia, New Zealand, USA and other countries. The results indicated that crashes involving alcohol were reduced by 17% at a minimum. DUI check points were found to be more effective in Australia. They concluded that highly visible checkpoints where many drivers are pulled out and tested, following the Australian example, are likely to be most effective.
Goldenbeld & van Schagen, (2005) conducted an evaluation study covering 5 years of enforcement in other to assess the effects of targeted speed enforcement on speed and road crashes in the Dutch province of Friesland. Enforcement was carried out on rural non-motorways using mobile radar. The effects on mean speed, percentage speed limit exceedance, the number of injury crashes, and the number of serious casualties were assessed by comparing the development on the roads that were subject to targeted speed enforcement with the development on similar roads without targeted enforcement. ANOVA results showed that mean speed and percentage speed limit exceedance decreased and the number of crashes and crash casualties decreased (more at the enforced road). Li et al. (2017) used 8 years of monthly city-wide data to examine the relationship between road safety and mobile photo Enforcement Performance Indicators (EPI) in Edmonton, Canada. Three EPIs (number of enforced sites, average check length and number of issued tickets) were examined using generalised linear Poisson model. Results showed that as the number of enforced sites and issued tickets increase, the number of speed-related collisions decreases. Additionally, as the average check length decreased, a greater reduction of speed-related collisions was observed.

The effect of speed enforcement is mostly successful in improving road safety by reducing crash frequency and an increase in speed compliance. Hössinger & Berger

(2012) used telephone survey of admitted speeders and face-to face interview to collect data to investigate how traffic offences related to speeding and driving unbelted could be reduced in Austria. Data analyses were performed separately for the two offences using linear regression with ordinary least squares estimation (OLS). Results showed that drivers feel a tension between driving faster and the fear of punishment. Seatbelt wearing rate was high and the fear of being punished for it was low. They concluded that the frequency of speeding was reduced by increasing penalty. Council et al. (2005) carried out a before and after study of 132 Red Light Cameras (RLC) installations in the US. Result of an exploratory analysis found that red light cameras were most effective when sites were highly publicised with public information programmes, when the detected violations were enforced with higher fines, when the traffic light had one or more left turn protected phases, shorter signal lengths and inter-green periods, when the intersection had a reduced speed red light cameras limit, a high proportion of traffic in the major road, and a high ratio of right-angle to rear-end crashes. Walter et al. (2011) summarised a study carried out in London in 2008 to investigate the effects of increasing the level of traffic policing in a busy area under modern conditions. Two teams of six officers and one sergeant were deployed in two shifts per weekday on the six mile route, using both static and mobile policing methods in a mixture of vehicles. Results showed a reduction in the proportion of speeding drivers and ‘extreme’ speeding drivers (15mph or more above the speed limit), due to the increase in the level of enforcement. Vehicle speeds reduced systematically during the period along the route and in surrounding areas, and some effects remained at least two weeks after the operation had finished. The survey data do not, however, show any positive effect of enforcement on the use of mobile phones or seatbelts.

A common finding in the literature is that speed enforcement effects are limited in terms of time (Vaa, 1997) and distance (Hess, 2004). These are referred to as halo effects. Time halo is the length of time that the effects of enforcement on drivers' speed behaviour continue after the enforcement operations have ended while distance halo is the distance over which the effects of an enforcement operation last after a driver passed the enforcement site. Depending on the type of enforcement (physical policing or automatic), the effects vary from 1 hour to 8 weeks for time halo and 500m to 10km for distance halo after enforcement has stopped (Keall et al., 2002; Elliott and Broughton, 2005).

Studies associated with the effect of enforcement of seatbelt use recorded a general increase with improved and stricter enforcement (Carpenter et al., 2007; Nichols et al., 2014; Thomas et al., 2017). Increasing penalties was viewed as an effective speeding countermeasure in Victoria, Australia (Austroads, 2013). Stanojevic et al. (2013) used questionnaires and field observations to investigate the influence of traffic enforcement on attitudes and behaviour of drivers in Serbia (with enforcement) and

Northern Kosovo (without enforcement). Analysis with t test revealed that in the absence of enforcement, drivers were found to speed, use seatbelts less, drive with high levels of alcohol in their blood, commit more traffic violations and commit more risky behaviour on roads. Retting (2011) in his review of running traffic controls concluded that sanctions, as a measure of enforcement were useful tools for behaviour modification and attributed the reported frequency of red light violations to the absence of strict and consistent enforcement.

Absence of strict and consistent enforcement may lead to increased violation which will probably increase traffic crash risk. On the other hand, the threat of sanctions will help discourage people from committing traffic violations. According to Özkan et al. (2006), drivers in countries where there is strong enforcement commit fewer traffic violations because of their awareness of the consequences compared with countries where enforcement is relaxed. Most of these countries for example France has adopted the automatic enforcement system. Automatic enforcement does not suffer the same problems as manual enforcement and have been highly effective. They produce photographic evidence of vehicles detected speeding or running red lights and can be used to supplement manual enforcement. Following the implementation of this policy in France in 2003, the number of traffic fatalities reduced by more than 30% between 2003 and 2009 (Carnis, 2011). This is a stricter form of enforcement and the programmes improve fairness for all road users. Strict enforcement influences risky behaviour and thus affects the number of crashes (Zaidel, 2002). McNeely & Gifford (2007) and Constantinou et al. (2011) maintain that improving road safety through enforcement must be dynamic and tailored to address all violators of different socio-economic groups within the society.

4.5.5 Behavioural change theories

Glanz et al. (1997) described a theory as a set of interrelated propositions including concepts that describe, explain, or predict a phenomenon. He further explained that the phenomenon of interest could be human behaviour (e.g., risk behaviour, safety practices) and concepts or constructs as the component parts of a particular theory (e.g., self-efficacy, social support, perceived susceptibility).

In recent years, there has been increased interest in the application of theories in the areas of health, education, energy and transport research with the hope that understanding behavioural change will improve the services offered in these areas. Some scholars have made distinctions between models of behaviour and theories of change. Van der Linden (2013) reported that models of behaviour are more diagnostic and geared towards understanding the psychological factors that explain or predict a specific behaviour while theories of change are more process-oriented and generally aimed at changing a given behaviour. Thus, from this perspective, understanding and changing behaviour are two separate but complementary lines of scientific investigation. Furthermore, to study the theoretical basis for behaviour change, some behavioural models focus on existing behaviour to explain why people make certain decisions and exhibit certain behaviours. For example, how intentions, attitude, values etc. shape behaviour. On the other hand, some theories use behavioural models to explain how behaviour change can be achieved. Behavioural change theories are attempts to explain why behaviours change by using environmental, personal and behavioural characteristics as the major factors in determining behaviour.

Generally, models and theories can inform policymakers, researchers, implementers and others about the issues to consider and the likely success of initiatives and interventions. They can be used to formulate scientific evidence. They help to identify points of policy interventions or how to target initiatives aimed at influencing behaviour but cannot bring about behaviour change, nor predict with certainty what changes in behaviour will occur. According to Michie et al. (2008), they can provide a basis for designing interventions needed to change behaviour but offers little guidance on how to go about it. This limitation could partly be as a result of the inability to fully understand the determinants of the behaviours and failure to properly apply these theories to the development and implementation of effective countermeasures. Nevertheless, it is important that interventions are based on formal theory and models as it provides a previously validated framework for developing them.

Models tend to change over time as more research is carried out and new evidence is gathered about behaviour. Therefore, selection of the most appropriate theory depends on the situation, the specific audience, setting, and the behaviour to be changed. Some socio cognition models have been applied in road safety research to investigate driver behaviour and in some cases, applied in driver behaviour modification programmes. Some of the most well-known models are the Theory of Planned Behaviour (Ajzen & Fishbein, 1980), the Health Belief Model (Rosenstock, 1974), the Theory of Reasoned Action (Fishbein & Ajzen, 1975), the Reasoned Action Approach (Fishbein & Ajzen, 2010) and the Health Action Process Approach (Schwarzer, 2008). While the number of different models can seem confusing, a major advantage is that they are not specific to any particular behaviour.

4.5.6 The relationship between attitude and behaviour

Most research on the safety behaviour of road users has focused on their attitudes. Thus, road users' attitudes have been acknowledged as a key predictor of their behaviour. Shiraev & Levy (2010) maintained that attitudes are comprised of beliefs (e.g., political, ideological, religious, moral), values, knowledge, opinions and superstitions. It is generally assumed that attitude, as a function of belief about the perceived consequences of the behaviour under consideration, is a determinant of intended behaviour; the individual's intention to be engaged in a particular behaviour is believed to have a direct effect on behaviour. Sheeran et al. (1999) and Nordfjærn &

Rundmo (2009) pointed out that attitudes are strong predictors of behaviours, as they mediate the relationship between personality characteristics and risky driving behaviours. Similarly, Ulleberg & Rundmo (2003) and Iversen & Rundmo (2004) concluded that attitudes towards road safety have an impact on the involvement of risky behaviours in the road environment. Drivers' attitudes and behaviour have been widely recognised in the literature to be correlated to traffic violations, which, in turn, were found to increase crash risk (Parker et al., 1995; De Winter & Dodou, 2010).

Programmes focused on changing attitudes are developed based on the assumption that changes in attitude have the potential to bring about changes in behaviour. Attitudinal and behavioural change processes are more complicated than simply telling people how to think or what to do in traffic. However, understanding how people perceive risk and how they behave accordingly is critical in designing road safety countermeasures that are effective in reducing road crashes. Similarly, understanding and identifying the determinants or predictors of driving behaviour could lead to the development of effective and robust intervention which could serve as countermeasures in the hope of improving driver behaviour. Aberg (2003), concluded that attitude is only one of several factors that affect behaviour, and that this effect varies over behaviours and situations. Thus, it might be important to examine whether certain personality characteristics, beliefs, values, knowledge, opinions, and social influences are related to individuals' perceptions of safety.

Many researchers have used psychological models to explain the attitude-behaviour relationships, with the hope of motivating change. Though no single theory or model has gained universal acceptance in road safety research, they nonetheless have shaped a general understanding of the attitude-behaviour relationship. These theories and models have their strengths and limitations and none has complete scientific coverage of the scope of factors involved in the performance of these behaviours.

In conclusion, although from a psychological point of view, several behaviour change techniques may be used to influence unsafe driver behaviour (for example, informing, persuading rewarding, nudging, punishing), it is still difficult to predict which behaviour change strategy will be most effective. World Health Organisation (2004) reported that road safety campaigns were able to influence behaviour when used in conjunction with legislation and law enforcement. However, the report also states that "… when used in isolation education, information and publicity generally do not deliver tangible and sustained reductions in deaths and serious injuries" (Peden et al., 2004). Howard & Sweatman (2007) note that road safety measures were more likely to succeed if they gained social acceptance and approval from society over time. One effective means of influencing road safety outcomes is to change a society's attitudes towards risk-taking (i.e., its safety culture). Parker et al. (1996) and Assum (1997) proposed that changing the attitude of drivers is one of the most effective and long-term countermeasures in dealing with crash involvement. McNeely and Gifford (2007) proposed that this change is about using social resources to modify or force change at the individual level usually by changing relevant public policies.

Chapter 5 Methodological approach

5.1 Overview

- This thesis seeks to understand the road safety situation in Nigeria using observational non-crash data
- Investigates the influence of road safety culture and road environment on drivers' behaviour
- Examines the effect of some simple awareness-raising interventions on the behaviour of Nigerian drivers
- Examines the effectiveness and ease of implementation of selected road safety measures in Nigeria
- And sought to find ways to improve the road safety culture in Nigeria

In this chapter appropriate methodologies adopted in the various stages of this research are presented. It reports the various stages of the research and data collection methods adopted at each phase.

5.2 Stages of research and data collection methods

Different methods are generally used by researchers to collect data for road safety assessment. These could be quantitative or qualitative. Quantitative methods such as self-reports, on-road observations, driving simulator experiments and Naturalistic Driving Studies (NDS) and qualitative methods such as focus group discussions, interviews etc. are prevalent. These methods all have their advantages and limitations and the choice of any of them would depend on what the researcher is set to achieve.

Berg (2007) argues that no single measurement method (quantitative or qualitative) is perfect neither is any data collecting procedure useless. In some cases, several procedures may be better than one singular method. As their limitations may not be the same, one method probably complements the other. Sommer & Sommer (2002) agree that a multi-method approach provides flexibility in dealing with problems encountered in carrying out research projects in contrast to using single methods. Similarly, Lenné et al. (2011) have shown that the multi-method approach is important when carrying out studies to develop a comprehensive understanding of complex issues in transport.

To achieve the objectives and provide answers to the research question, a multi-method approach is adopted in different phases of this research. This approach helps to understand the complex road safety situation in Nigeria and helps to increase the validity and reliability of research findings. As there could be a difference in the reported and actual behaviour of drivers, several methods to observe driving behaviours have been devised to get a better idea of driving behaviour. Data were collected by conducting on-road observational studies, driving simulator experiments, use of DBQ and focus group discussion. Figure 8 shows a schematic representation of the research design. The different phases and data collection methods are discussed in the next section.

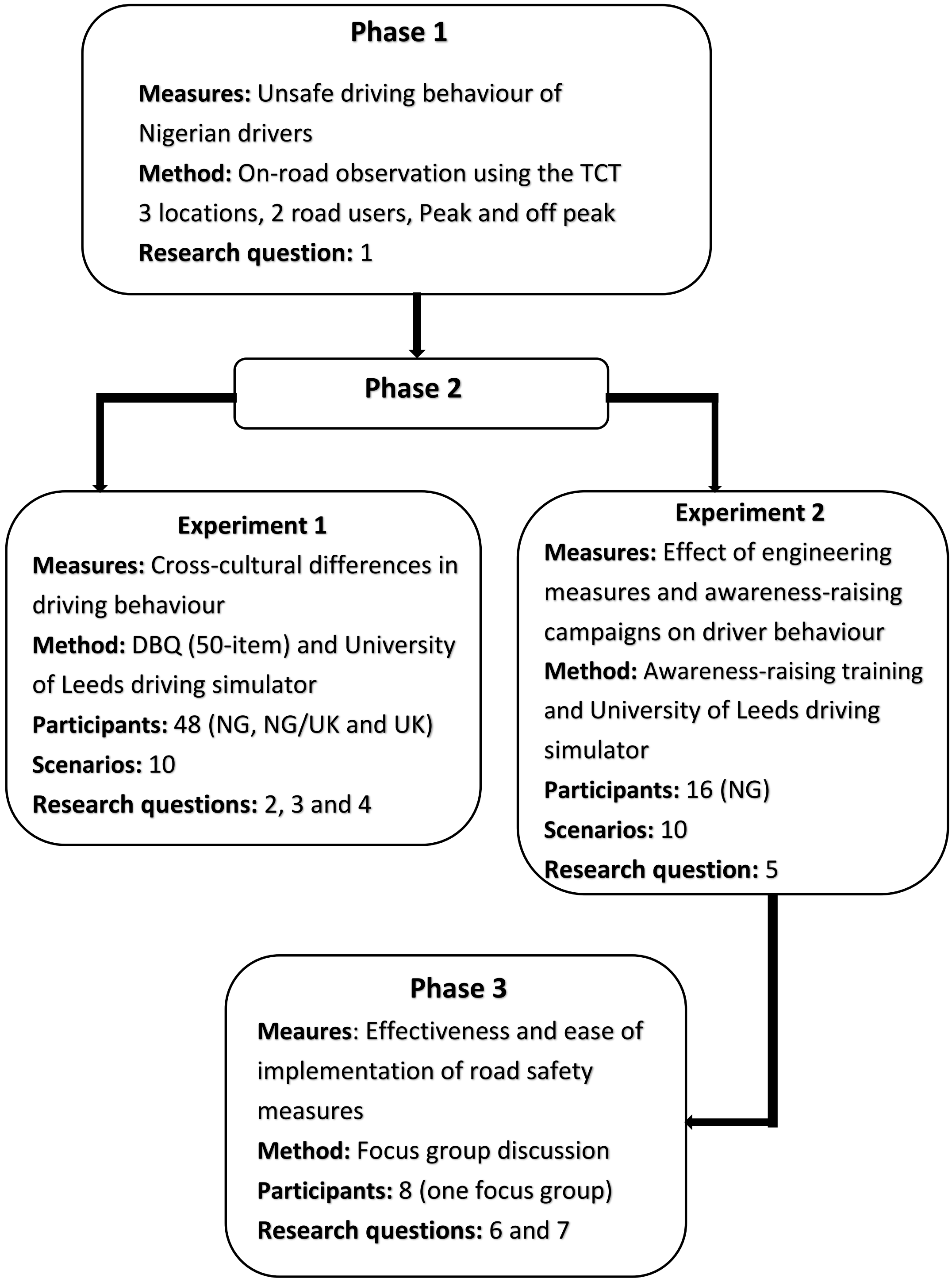


Figure 8: Thesis research design

5.3 Phase 1: On-road observation of traffic behaviour and conflicts in Nigeria (Chapter 5)

Phase 1 is an exploratory study using a quantitative approach. It involved an on-road observation of traffic behaviour and conflicts in Nigeria using the Traffic Conflicts Technique (TCT). The TCT was adopted to overcome the inherent problems associated with reliable, inadequate and accessible crash data in Nigeria. This was applied to have a better understanding of the road safety situation which according to (RSPA, 2017) is needed to identify road safety issues and what approaches are most likely to be effective in addressing them. This study provided an in-depth description of the road safety situation in Nigeria by identifying factors affecting conflict severity, unsafe behaviours at different road locations and time periods using non-crash data. It provided a proactive way of assessing the safety situation in the Nigerian road environment. The traffic conflict technique (TCT) was applied as an on-road method of data collection to observe the behaviour of road users in real traffic conditions. This technique has the advantage of providing information on pre-crash situations so as to understand the underlying factors leading to crashes. These are very important when planning effective crash reduction and prevention measures and requires obtaining accurate information about the problems involved. According to Muhlrad (1993), comprehensive safety diagnosis is needed not only to highlight the main crash problems but also complementary information for use in the design of appropriate safety measures. Therefore, TCT was used to collect non-crash data needed to examine and understand the underlying variables which contribute to the unsafe behaviour of drivers in Nigeria.

5.3.1 Rationale for the study

Transport systems and infrastructure have expanded rapidly in developing countries, while little has been achieved in preventing crashes or lessening their severity (Almqvist & Hydén, 1994). Over the years, road safety measures have been developed and while success has been recorded in developed countries, less has been achieved in developing countries; in fact, the crash rate keeps increasing (WHO, 2015). Partly to blame are the lack of empirical research and high-quality crash data. This scarcity of data has been emphasised by Downing (1991) where he estimates that there may be 20 person-years of research effort each year in developing countries compared to over 500 in developed countries.

Crash data are the most commonly used measure of assessment for road safety. They are important for monitoring and assessing progress on programmes where intervention has taken place and most of all for measuring trends and targeting intervention programmes on specific and identified causes of road traffic crashes. Road crash data help in defining the magnitude of the problem by comparing it with other causes of death in order to make informed decisions (WHO, 2015).

Road crash data collection has been an issue of concern for a long time; whilst in developed countries methodologies have evolved from the use of traditional methods such as questionnaires (Reason et al., 1990), interviews (Nielsen, 2011), travel diaries (Stopher & Greaves, 2007) to the use of mobile phones (Aguiléra et al., 2012), GPS recorders (Gong et al., 2012), instrumented vehicles (UDRIVE and SHRP2) and driving simulators (Comte & Jamson**,** 2000), this is not mirrored in developing countries. Most research in developing countries is based on interviews and questionnaires (Peltzer & Renner, 2003; Persson, 2008; Newnam et al., 2014). Lack of data in the developing countries has been a constraint to many developmental projects especially in the area of driver behaviour and road safety. This paucity of data has been attributed to the high cost of direct data collection, lack of established government information sources and low penetration of technology (Jug, 2014). One of the objectives of the Decade of Action (WHO, 2009) is to improve the quality of road safety data at the national, regional and global levels. Improving data quality makes interpretation, analysis and application of an outcome more relevant; it helps target interventions to specific and identified problems.

Properly collected, documented and analysed crash data helps to provide an understanding of why crashes occur, determination of crash severity, factors influencing the risks of getting involved in a crash and hence what measures to put in place to either reduce or prevent their occurrence. With a continued increase in crash rate in developing countries, reductions cannot be achieved without rich data including information about the time of day, traffic conditions, type of manoeuvre made by those involved in the crashes and so forth. However, directly applying research methods and results from countries perceived to have made significant improvements in achieving a reduction in crash rates to other countries who have achieved less may not be a viable approach. Research findings from experiments in other countries that attest to the effectiveness of measures used to improve safety may not have a similar effect in Nigeria considering that some behaviours could be localised due to the nature of the driving environment and vehicles using the transport system. It is very important that research and evaluation studies should incorporate country-specific conditions and suggest appropriate interventions accordingly. However, it is still important to explore how low and middle-income countries can improve their road safety records by learning from high-income countries (WHO, 2004). According to Wegman (2010), developing countries could analyse road safety problems and design road safety strategies, using the experiences of developed countries and thereby speed up progress.

Many crashes can be prevented by implementing effective road safety measures; this relies on decision makers having information on the effectiveness of different causes of action before investing in them. According to Muhlrad (1993), appropriate behavioural information can be obtained at relatively low cost and is a great advantage as support for safety policies. The observation of human behaviour in real traffic situations is a useful means of investigation as it provides greater knowledge of road user behaviour and interaction of various road users as well as means to identify and describe some of its determining features.

According to Hauer (2015), to continue achieving success in reducing road traffic crashes, it is not necessary to have to wait for crash data which might take several years to gather. Reducing crash rate is an urgent task which must be tackled as fast as possible. A look at the magnitude of the problem indicates that there is no time to wait to collect data while crashes continue to happen. This study, therefore, uses direct behavioural observation to examine traffic behaviour and conflicts of various road users in Nigeria using non-crash data and to investigate the role various factors play in determining conflict severity. In addition, it attempts to examine and understand various unsafe behaviours leading to traffic conflicts in Nigeria. Cost-effective methods of data collection using locally available resources were employed, and this has provided information on the operation of different traffic systems which is important in safety diagnosis.

5.3.2 Contribution and justification for approach

Crash data are not readily available in Nigeria and where they are, they are usually incomplete and lack the necessary information needed to tackle most road safety problems. For example, crash data is mostly aggregated and does not give specific information or details on how or why most crashes occurred. The Federal Road Safety Corps (FRSC) and the traffic police are responsible for collecting and registering information on crashes but they are poorly harmonised resulting in under-reporting. Road traffic crash data are generally only presented as a summary with little or no detail regarding road users involved and other contributory factors. As most road safety campaigns in Nigeria are based on road crash data, therein lies the problem; according to Osayomi (2013), while several road safety intervention efforts have been implemented, crashes keep increasing. Intervention efforts cannot yield much without proper research targeted at specific identified needs.

The magnitude of the road safety problems in Nigeria will require more information than can be elicited from crash data. Lord & Mannering (2010) and Savolainen et al. (2011) have shown that to urgently address the enormous social losses caused by road crashes, there is a need to gain a better understanding of factors, events and circumstances that could lead to a crash. This cannot easily be achieved with past crash data. Crash numbers are too small, take a very long time to collect and collate, the method of collection and reporting is biased and not informative. The need for a more comprehensive and informative understanding of the connections, various factors and events leading to a crash, the relationship between the behaviour of road users by considering both unsuccessful and successful interactions, informed the application of the Traffic Conflict Technique (TCT) in this study. Traffic conflicts are much more frequent compared to crashes. Thus, instead of waiting for years to get crash records, the data can be collected during much shorter time. Traffic conflicts are observed can provide more information compared to what can be elicited from crash data. Traffic conflict studies are pro-active as the safety problems can be detected and addressed before the actual crashes occur. They study processes and provide information on precursors to crashes. To our knowledge, the TCT has not been used for road safety assessment in Nigeria. Data from this type of study could provide baseline information of risk factors on the behaviour of road users, especially a combination of these that would most likely lead to conflicts and possibly crashes. It can help design intervention measures targeted at the identified behaviours

5.3.3 The Traffic Conflict Technique

This study uses the Traffic Conflict Technique (TCT) as an alternative to analysing crash statistics. The TCT was adopted because of the limitations associated with crash data in Nigeria. The TCT is a method of observation, where near-crashes (conflicts) are recorded and used for predictions of accident risk and studies of events leading to crash situations. A conflict situation is defined as when two or more road users approach each other in time and space to such an extent that a collision is imminent if their movements remain unchanged (Amundsen & Hydén, 1977). Conflict points are locations where the travel paths of road users cross. If the paths and speeds of two road users lead to them passing a specific conflict point at the same time, then at least one road user must change their speed or direction to avoid a collision. This means that at least one road user must be aware of the other prior to the conflict point and correctly assess their location, speed and path trajectory.

According to Hyden & Stahl (1979), a serious conflict is similar to a crash, a situation that nobody puts him/herself into deliberately. One of the advantages of the TCT is that it is possible to collect sufficient data within a short period of time because traffic conflicts occur more frequently than crashes (Hyden, 1987). Other activities such as speed measurement, behavioural observation etc. can be undertaken at the same time. With regards to the validity of the TCT (correlation between conflicts and crash frequency), Hauer & Garder (1986) showed that serious conflicts and crashes belong to the same process, just with a different degree of seriousness; crashes can be described more or less as a continuation of serious conflicts at a higher severity on the scale. The Malmo study in 1983 (Grayson, 1984) where eight teams from different countries simultaneously made conflict observations at different intersections demonstrated that differences in observer reliability were not statistically significant and that observers were able to detect 75% of serious conflicts. Video recording is helpful in conflict studies as it aids in checking observer reliability and confirming conflict severity (Svensson & Carsten, 2007).

The traffic conflicts observed in this study were analysed using the Swedish TCT (STCT). This method was originally developed by Hyden (1975), who hypothesised there to be a close relationship between conflicts and crashes. The technique uses objective units to measure the severity of conflicts and studies only serious conflicts, recorded manually by observers. The STCT has been widely adopted in many studies on conflict analysis both in developed and developing countries, e.g. Thailand, Denmark, Finland, Uganda, Srilanka, Turkey, Costa Rica, Jordan, Brazil, Tanzania and Bolivia (Almqvist & Ekman, 2001) and is based on the two measures (Hyden, 1987):

i. Time to Accident (TA) - defined as the remaining time from when the evasive action is taken until a collision would have occurred if the road users did not change their speed and direction.

ii. Conflicting Speed (CS), the speed of the road user who takes the evasive action, just before the action is taken. This road user is called the "relevant road user" (rel.) while the other one is the second (sec.) road user.

In the application of the STCT, the TA is evaluated based on the subjective estimation of distance and speed carried out by a trained observer. The calculation of TA and the classification of conflicts are carried out after the data collection takes place. The first definition of conflicts by Hyden (1975) used a TA value of 1.5 seconds to make a distinction between serious and slight conflicts. A serious conflict was said to have occurred when the TA value is equal to or less than 1.5 seconds. This definition appeared to work well in the urban areas where speed was rather low compared to rural areas where speed is usually higher (Shbeeb, 2000). The definition was later changed by considering the speed of the relevant road user. The threshold was redefined, and a safety margin of 0.5 seconds was added and took into consideration the braking distance of the road user which Shbeeb (2000) defined as being inversely proportional to the square of the speed. The definition of serious conflicts according to the STCT is shown in Figure 9. Even though the STCT was designed to focus only on serious conflicts, Svensson (1998) extended the scope to include normal interactive behaviour. The aim was to show that the relationship between numbers of successive severity levels is also very important to gain insight and make a comparison between different traffic sites. The relevant road user is important for defining the TA and CS values and determines the severity of a traffic conflict (the road user who prevented crash).

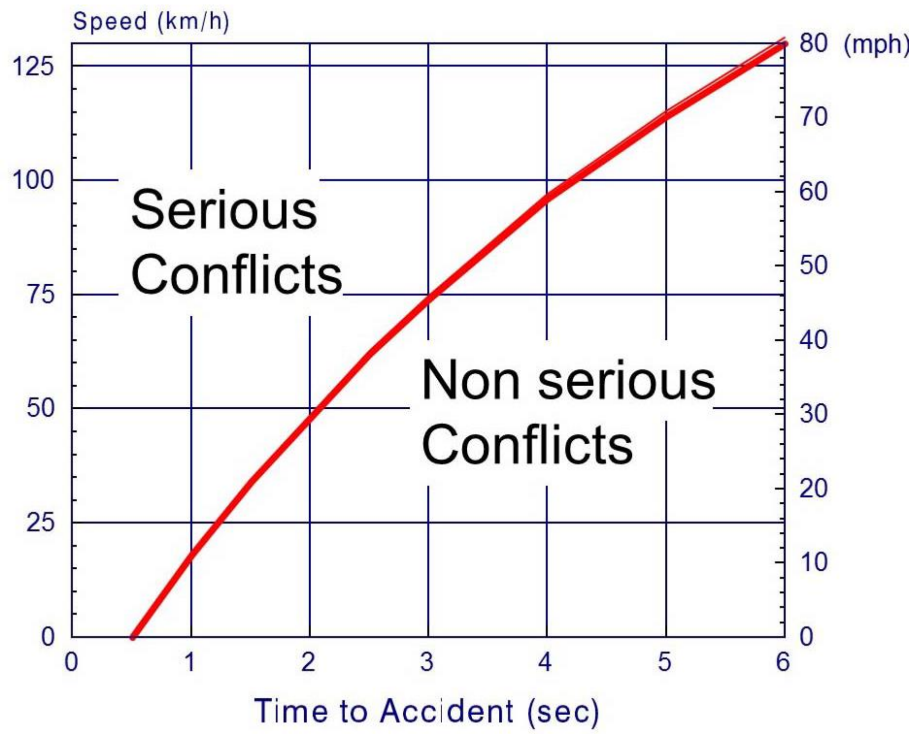


Figure 9: Graphical illustration of the link between TA and speed (Based on Hyden, 1987)

5.3.4 Materials

Materials used included recording sheets, pencil, measuring tape, radar gun, audio recorders, video Recorders and tripods.

The recording sheet used was adapted from the Swedish TCT recording sheet with very minimal modification. It covers information needed for evaluation such as time, location, weather conditions and road user category (Appendix A). Observers recorded conflict types and registered them according to their type, time, users involved etc. on the recording sheet. A video recorder was also used to supplement manual observation. Brief notes were taken on events preceding conflicts and a sketch was made to record paths of those that were involved in the conflicts, so as to make understanding easier. Conflicts that were recorded included vehicle-vehicle, vehicle-pedestrian, vehicle-tricycle, tricycle-tricycle and tricycle-pedestrian. The observers assessed and estimated speed and distances of relevant road users (the road user that made the evasive action).

5.3.5 Study area

This study was carried out in Owerri, Imo state in the Eastern part of Nigeria. Imo state has recorded variations in the number of road traffic crash over the years and although the crash rate has consistently decreased in the last three years, the injury rate remains very high. Figure 10 shows the trend in road traffic crashes and injury rate in Imo State (2007-2016) and according to Ukibe et al. (2011) road traffic crashes remain a significant cause of morbidity and mortality in Owerri. The city is made up of three

Local Government Areas namely Owerri municipality (where this study took place), Owerri North and Owerri West. The major activity centres are government public buildings such as the Federal and State secretariats, medical centres, hotels and centres for higher education. Population studies carried out in 2006 in Nigeria show that Owerri city has an estimated population of 3,927,563 (NBS, 2017).

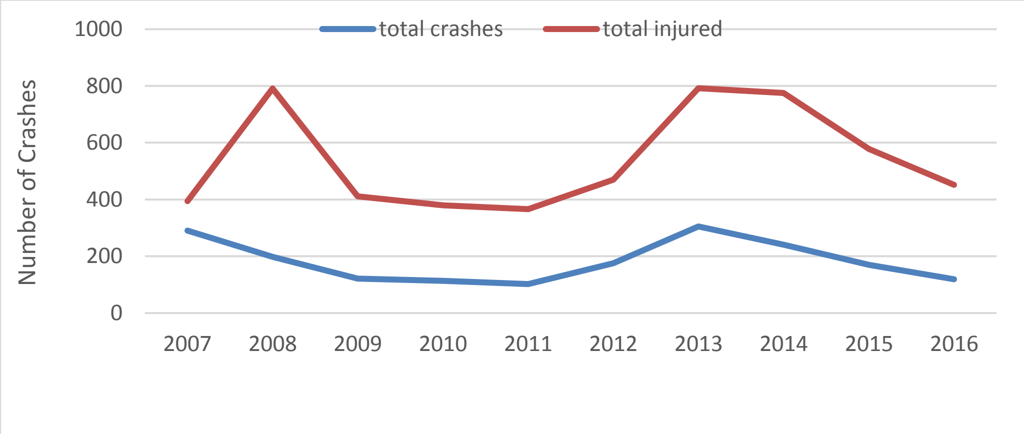


Figure 10: Trend of road traffic crashes and injury numbers in Imo state, 2007-2016 (FRSC, 2016)

In recent years, there has been an overwhelming increase in vehicle ownership in Imo state; the number of tricycles (popularly called *Keke* N.A.P.E.P., See Figure 12 for an example) as a means of public transportation has increased due to a ban placed on motorcyclists in the city a few years ago (Figure 11). It is expected that in a city where there are many vehicle types, different road user groups without much knowledge of road safety and roads lacking properly designed road furniture (or none at all), there will exist diverse (unusal) behaviours that might seem different from what is observed in the developed world.

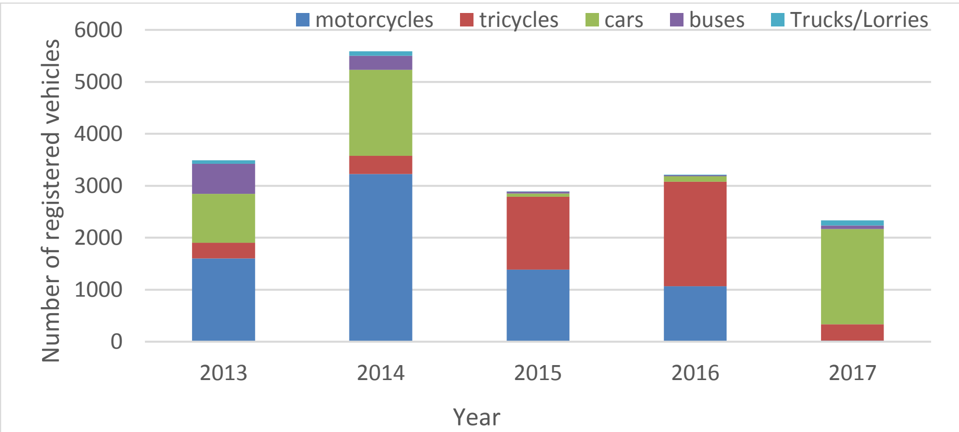


Figure 11: Number of registered vehicles in Imo state, 2013-2017 (Board of Internal Revenue Owerri, 2018)

5.3.5.1 Traffic observation locations

The locations chosen represented typical road environments in Nigeria and allowed observation without distractions and obstructions. Three locations were selected; Government College road (Govt. Coll.), Imo State University junction (IMSU) and Dick Tiger junction. These roads all have a speed limit of 50km/h for passenger cars and 45km/h for trucks and tankers (not posted**).** Figure 12 shows the study locations and the characteristics of each location are shown in Table 5. The data were derived from observation of traffic conflicts involving vehicle and tricycle drivers at different locations and time periods (peak 7:30-9:00; off-peak 11:00-12:30) every day of the week for seven days. This study was carried out in daylight and good weather conditions. Data collection was limited to daylight because most activities in Nigeria take place in the day. The sun goes down between 18:00–19:00, visibility decreases, the street lights are not always functional, and there are issues of personal safety. Data collection was performed during June/July 2016.

Figure 12: Study locations

Table 5: Characteristics of study location

	Govt. Coll.	IMSU	Dick Tiger
General description	Dual carriageway; mix traffic; good condition road	Dual carriageway; mix traffic; poor road condition laid in residential and commercial area	Single carriageway; mix traffic; poor road condition laid in residential and commercial area
Speed limit (km/h)	50	50	50
Posted	None	None	None
Lane marking	Yes	No	No
Parking on street	Restricted	Restricted	Restricted
Loading	Unrestricted	Restricted	Unrestricted
Pedestrian crossing	None	Yes, one side	None
Pedestrian path	Yes, all sides	None	None
Traffic light	None	Yes	None
Road layout	Straight	Roundabout, semi signalised (spatially)	Four-arm, unsignalised
Traffic control	No	Yes	No
Warden	Part of morning peak	Part of morning peak till dusk	Part of morning peak
Presence of road divider	Yes	Yes	None

5.3.6 Measures

The measures presented below where adopted in this phase of the research. It includes a description of the training received by the researcher, process of selecting and training field surveyors (observers) and inter- observer reliability was assessed.

5.3.6.1 Training

The researcher was self-trained on the use of the traffic conflict technique. This was because there was no funding available to register and receive the training from the developers in Lund University, Sweden. After going through the literatures and resources from the International Co-operation on Theories and Concepts in Traffic safety (ICTCT) website and the internet, a pilot study was conducted by the researcher in Leeds in April, 2016. The aim was to test the use of the technique, to validate skills and get familiar with various tasks such as estimating distances, measuring vehicle speed etc. that would be needed for further data collection in Nigeria. Following the completion of data collection in Nigeria (June 2016), the researcher attended the 29th ICTCT workshop in Lund Sweden (20 - 21 October 2016), to share experience gained during the data collection and to seek for expert advice about data analysis especially for developing countries. The researcher continued to receive support from ICTCT until this study was completed and written up.

5.3.6.2 Inter-observer reliability

Twelve persons were trained as conflict observers for five days. During the training period, a large number of conflict situations were scored and discussed comparing manually recorded and video recorded conflicts to assess the inter-observer reliability. At the end of the training, a practice observation was conducted, and the inter-reliability of the observers was calculated. Eight observers whose recordings were almost the same were chosen. The reliability rate, i.e. the percentage of conflicts that were scored correctly, compared with all conflicts that should be scored, plus all the non-conflicts that were scored (Almqvist & Hyden, 1994), was calculated at 84% by the researcher. These observers took part in the pilot study from which six were finally selected to take part in the main data collection while two were left in reserve in case a replacement was needed. The results from the pilot and main conflict studies were used to estimate the reliability of the observers. Even though there was a great similarity in the results of the teams at different locations, in some cases, there were differences in scoring but this could be as a result of traffic which was very busy at certain times and because the observers were newly trained. Observers were trained to measure speed by comparing their estimates with measurements by a radar gun as a control instrument.

5.3.7 Data collection

This study was carried out in real traffic, broad daylight and under good weather conditions using onsite video recording and manual data collection. Sixteen (16) field assistants helped with data collection as it was carried out at the same time across all locations. Two observers carried out the conflict studies, two measured speed while two others collected behavioural data at each location. Data collection was carried out every day of the week for seven days (Monday to Sunday). The initial plan was to start on a Monday and conclude on Sunday of the same week, but Saturday was declared an environmental sanitation day and movement was restricted until 10:00. Because of this, the Saturday data collection was rescheduled to the next Saturday, in order to ensure comparability of data. In addition, speed data were collected over the course of two weeks. At the end of data collection, the field assistants were given an honorarium financial reward. This method is labour intensive and can only be used in an environment where access to field assistants is neither difficult nor expensive.

5.3.7.1 Traffic volume

Vehicle, tricycle and pedestrian volumes were recorded. Cyclists' volume was also recorded (cyclists were banned in the city some years ago and as a result, the volume is very low). Traffic that crossed each location during the period of data collection were included in the traffic count, via the video-recording.

5.3.7.2 Speed and other safety-related behaviours

The speed of at least 100 free-flowing vehicles and tricycles were measured with a handheld radar during both peak and off-peak hours. To ensure free flow condition was enriched with observations of seatbelt use, mobile phone use, eating/drinking, headphone use, give way/red light violations and overloading was recorded. Data were collected at both peak and off-peak periods every day of the week.

5.3.7.3 Traffic Conflicts

This included interactions between different road users observed to be on a collision course. This implies the existence of an evasive action or manoeuvre (braking, swerving and accelerating) – action to avoid something. Also, events with an evasive action and almost a collision course were included. The speed and distance to collision point just prior to the evasive action were noted. Other road user related features such as gender, estimated age and type of conflict (same direction, crossing and opposite direction) and a brief description of events leading to conflicts were noted.

5.3.7.4 Unsafe behaviours in traffic conflict situations

In this study, unsafe driving behaviours are defined as deliberate and systematic practices that increase the risk of a conflict or crash. Following the completion of data collection in the field, more behavioural data were elicited from the video recording. This was needed to identify unsafe behaviours leading to conflicts at different locations, time periods and by different road users. This was carried out by the researcher in the office and validated by an assistant who volunteered to help. Because there were time stamps on the different conflict situations, it was easy to know when each conflict took place, analyse the situations in more detail and record unsafe behaviours leading to these conflicts. Unsafe behaviours derived from the observation of traffic conflicts are shown in Table 6.

Table 6: Unsafe behaviours derived from the observation of traffic conflicts

Unsafe behaviours	Description
Inappropriate Speed	According to Quimby (1986), inappropriate speed is defined as exceeding the speed limit or failing to slow down under different conditions, e.g. at intersections/junctions, approaching traffic lights, close to other vehicles or tricycles, parked cars or waiting cars, at road works etc.
Eating/Drinking	Consuming any kind of food/drink or seen holding anything related to these.
Cell phone use	Seen holding or using a cell phone, including earphones
Inappropriate overtaking	E.g. from the wrong side, too dangerous etc.

Tailgating	Following a vehicle too closely by leaving less than two-second gap between them and the vehicles in front
Right of way violation	E.g. give way, failure to yield, running the red light
Picking and dropping off passengers	Sudden and unexpected stops to pick up and drop off passengers without moving off the carriageway completely
Passenger scouting	This involves scouting for passengers while driving without stopping and parking appropriately
Incorrect indicator use	Either not using the indicator or using them incorrectly
Driving on One Way:	Driving on the wrong side of the road or on the same side with opposing traffic.
Others:	All other behaviours which were not very common e.g. smoking, personal grooming, calling the attention of other road users (drivers or passengers) etc. and could not be identified or categorised as above were classified as "others".

5.4 Phase 2: Driving simulator experiment investigating if driving culture can be modified by traditional engineering and awareness-raising interventions (Chapter 6)

Factor et al. (2007), in their "social accident" model, discussed the interaction between different social groups in traffic from a sociological perspective. They stated that drivers belonging to different social groups interpret a given situation differently and this varied interpretation could result in conflicting decisions, possibly leading to crashes. This could be linked to research examining systematic differences in traffic behaviour between drivers from different nationalities. Gregory (1985) and Edensor (2004) in different studies have shown that driving is dependent on culture and compared to the western countries, India and Egypt have a lower level of traffic regulation and enforcement which seems to have resulted in many culturally determined informal rules. In most middle/low-income countries, there is a paucity of formal rules which seems to be accepted, as drivers over the years have developed ways of communicating and interacting with each other informally. Most of these informal rules could be very dangerous (unsafe) but according to Batool (2012), even when drivers try to do the right things (by following the rules) the society they belong to forces them to do otherwise. Therefore, simply importing solutions designed and developed in developed countries may not work in developing countries given their different road safety cultures.

For example in Nigeria, drivers engage in behaviours which are presumably unsafe and have been developed as a result of constant interaction with other road users, lack of basic road furniture and poor driver education and training. For example in a situation where there are no pedestrian signals and crossings, drivers and pedestrians on their own develop ways of crossing and avoiding each other. It is very common on Nigerian roads to see pedestrians crossing while cars are approaching and very close. Subsequently, it is believed that drivers look out for pedestrians who they assume could enter into the road at any time. Even though this is very risky, especially when the driver is distracted or at high speed, that is the most common way people cross the road, especially in heavy traffic. Consequently, a driver's traffic environment could have a possible effect on driving behaviour, in that drivers from environments with stricter regulations, better roadways and very good driver training and tests could drive safer than those from environments characterised by frequency and high rate of crashes as a result of unsafe driving culture. Behavioural change is not easy to achieve but some unsafe behaviours could be overcome with a better transport system whilst some cannot.

This study aimed to understand the extent to which culture and road environment affect drivers' behaviour and performance. This was achieved by using both objective and subjective measures to examine the performance of three groups of drivers. Objective measures such as vehicle positioning/control, compliance with road rules and perception of hazards were elicited via the driving simulator. The subjective measures were be elicited with a questionnaire.

5.4.1 Rationale for the study

Previous research on cross-cultural driving behaviour mostly used only self-reported data (Matthews et al., 1999; Nordfjaern & Rundmo, 2009; Warner et al., 2009). The present study will combine self-report and behavioural data to determine the possible effect of a better road environment and training on driver behaviour and performance using an array of measures. These will include measuring drivers' level of compliance with road rules, perception of hazards and vehicle positioning and control. One aim of this study is to investigate differences in driving patterns among three groups of drivers from different cultures (NG, NG/UK and UK) and to identify how the road environment impacts any observed cultural differences.

This phase was built on the findings of the study in phase 1 (chapter 6), which found that NG drivers engaged frequently in a number of unsafe behaviours which have the propensity of increasing conflicts and subsequently crash risk. Most of these behaviours were observed at uncontrolled roadways. It is assumed that some of these behaviours could be improved, for example, by providing an improved road environment with information, guidance and traffic control and supports the idea that the environment greatly affects road user behaviour (WHO, 2009). It is also assumed that in addition to improving the road environment, proper driver education and training will go a long way in improving driver behaviour. Consequently, for this phase of the research aimed to establish whether the behaviour NG drivers can be changed when presented with an improved better road environment with appropriate training.

5.4.2 Contribution and justification for the approach

This study is unique because this is the first study to test, in controlled laboratory conditions, the effect of the strength of culture on driver behaviour using Nigerian participants. In addition, there is no other study known to the author that has specifically applied direct observation of driving behaviour and performance between these groups of drivers (NG, NG/UK and UK). The present research particularly assumes that NG drivers will drive more safely on roads with traffic control and signalisation. They may not do better than the NG/UK and UK drivers but there will be modifications in behaviour to adapt to the new environment. It is important to establish if simply applying UK road standards to Nigerian roads would lead to an improvement in the behaviour of Nigerian drivers or if the cultural factor is stronger. Researchers (Huang et al., 2006; Yannis et al., 2007; Ozkan et al., 2011; Simsekoglu et al., 2012; Atchley et al., 2014; Nordfjaern et al., 2014) have carried out cross-cultural driving and navigation studies using different methodologies such as questionnaire survey, focus group and data from crash statistics. The majority of them have focused on investigating whether there are differences in behaviour between drivers from different nationalities/cultures. **This study took a step further by combining both questionnaire and driving behaviour data to investigate these differences, how the road environment affects them and if changes in the environment and/or awareness-raising intervention could improve behaviour.**

Questionnaires have been used extensively in road safety research to understand and describe issues regarding the various aspects of driver behaviour and have proved to be very useful (Parker et al., 1996; Deffenbacher et al., 2003; Newnam et al., 2004; Özkan et al., 2006; Clapp et al., 2011). Previous studies have shown that questionnaire studies can be a reliable method of obtaining data related to driving behaviour (Åberg et al., 1997; Ulleberg, 2002) as they complement simulators and NDS. The Driver Behaviour Questionnaire (DBQ), used in this study, is one of the most cited questionnaires used in the field of road safety (Chliaoutakis et al., 2005; Özkan & Lajunen, 2005; Forward, 2006; Bener et al., 2008). It was developed by Reason et al. (1990) to observe the distinction between errors and violations. It required drivers to report the frequency with which they committed different types of errors and violations, and identified three fairly robust factors: deliberate violations, dangerous errors, and relatively harmless slips/lapses respectively.

One of the ways to carry out a more reliable assessment of drivers' behaviour is by observing their actual driving performance. Hence, a driving simulator experiment was also applied in this study. The DBQ together with the driving simulator experiment provided a more reliable measure of drivers' behaviour in this thesis.

Driving simulators are widely used and have become effective in traffic-related research (Carsten & Jamson, 2011). This research was carried out using the motion-based University of Leeds driving simulator which provided a very realistic setting. This was of an utmost advantage because it provided the highly controlled environment necessary to measure behaviour changes with a consistent set of scenarios (Boyle & Lee, 2010) for each participant. Every participant was subjected to two or three experimental conditions, each of these comprising an urban and a rural section. A session with a participant involved about ten scenarios, which had to be under the same conditions. For this reason, other research methods employed in road safety research such as NDS and FOT could not be applied in this study. This study needed a controlled environment due to the nature of the experimental conditions. The real-world setting would not have been able to provide the stability needed between different driving conditions, scenarios and participants. Moreover, simulator studies are less expensive than on-road tests and a reliable method for driving assessment (de Winter et al., 2009). Driving simulator has been used extensively in studies such as speeding (Jamson et al. 2010; Helman & Reed, 2015), risk perception (Erkuş, 2017) and traffic light compliance (Meuleners & Fraser, 2015). However, studies investigating cross-cultural differences in behaviour are limited and none has involved Nigerian drivers.

The driving simulator environment provided the level of control needed to be sure that the different group of drivers are investigated in the same environmental conditions without variations. This could help determine if and to what extent drivers understand basic traffic rules as defined in the Highway Code. One way to understand driver behaviour is to compare the road safety practice of one group to another. In this aspect of the research, the behaviour of three different groups of drivers were examined. These groups were chosen because of the road traffic crash rates in their countries, different cultural values that impact traffic safety, and different levels of safety on their roadways. Understanding the factors that produce these differences can provide an insight into the safety culture of each country as well as a better understanding of the factors that influence road safety culture more generally.

5.4.3 Research environment

This section presents the environment where the research was conducted.

5.4.3.1 The University of Leeds driving simulator

This research employed the motion-based high fidelity driving simulator of the University of Leeds Driving Simulator (UoLDS). The use of the simulator permitted the creation of a realistic setting where behaviours relevant to safe driving could be examined. UoLDS is based on a 2005 Jaguar S-type vehicle model housed in a 4m spherical projection dome with a 300 ° field of view projection system (Figure 13). It has fully operational controls, including a steering wheel with force feedback and pedals, as well as rear view and side mirrors. A spherical screen projection area provides the road environment at 60 Hz and a resolution of 3x1920x1200 to the front and 1024x768 in the peripheral and rear views. The rear view and side mirrors provide a field view of 42°, which is displayed on and therefore only visible through these mirrors. While driving, the participant can perceive forces caused by braking and cornering. An immersive sound system with a speaker mimics the sound of the vehicle's engine and other road noise. The dome is attached to a hexapod plus X-Y table motion platform with eight degrees-of-freedom. Within the Cartesian frame, the motion system is able to move the dome in six orthogonal degrees-of-freedom (3 linear, 3 rotational). In addition, rails allow further 5m of movement to the front and side to better simulate acceleration and deceleration movements in the longitudinal and lateral directions. The software assumes an engine model from a 2002 Jaguar X-type and braking data from a Ford Mondeo. The simulator records data at 60 Hz, which is inferred from the driver's inputs, the vehicle movement and position, as well as data related to other vehicles on the simulated roads. The vehicle has an automatic transmission so participants are not required to interact with the gear-shift lever.

Figure 13: The University of Leeds Driving Simulator

5.4.4 Materials

In this section, the questionnaire and training materials used in the study are described.

5.4.4.1 Questionnaire

To examine the differences in self-reported driving behaviour between groups, the DBQ was utilised. In the present study, the original 50-item Driver Behaviour Questionnaire (Reason et al., 1990) was modified and used (**see Appendix B).** The modified version was pre-tested on a sample of Nigerian drivers before it was used in the main study. The DBQ questionnaire includes 20 items of violations (ordinary and aggressive), 21 items of slips/lapses, and 9 items of errors. From those items, 45 were retained verbatim and 5 were modified as needed to ensure clarity and relevance for the Nigerian driving context. One example of modification was the item "**Park on a double-yellow line and risk a fine**" (Reason et al., 1990). Due to the scarcity of double yellow lines on Nigerian roads, this item was modified to, "**Park on a double-yellow line/diagonally striped area and risk a fine (DBQ29)**". The DBQ questionnaire has 50 behaviours on a six-point scale (0 = never, 1= hardly ever, 2 = occasionally, 3 = quite often, 4 = frequently, and 5 = nearly all the time) and respondents were asked to indicate how often they have committed each behaviour or violations and errors when driving in the last 2 years**.** Higher scores in a given factor represent higher frequency of the related behaviour. The aim was to identify key items which are rated differently by drivers from different cultures (NG, NG/UK and UK). Secondly to investigate the applicability of the three-factor structure (violations, errors and slips/lapses) of the DBQ, comparing the driving behaviours of three cultures (i.e. NG, NG/UK and UK). Thirdly, to compare drivers' self-reported driving to actual driving behaviour.

5.4.4.2 Intervention and instructions

Training in the form of a short awareness-raising intervention was organised for NG drivers. This took place a few minutes after the second drive. The intervention served as instructions for drivers to drive safely. It aimed to raise awareness of the benefit of safe driving and to address poor driving related attitudes and motivational orientations associated with risk-taking behaviour. The manual and instructions (adapted from the Highway Code, DfT, 2017) is shown in Appendix C**.** The aim of the intervention was to achieve the following objectives:

- To make participants aware of what behaviours are risky and the implication of engaging in them
- To increase understanding of the consequences of engaging in unsafe and risky behaviours
- To identify the benefits of safe driving

The content of the intervention had specific reference to behaviours related to the measures being examined such as lane changing, speeding, overtaking, compliance to traffic rules and perception of hazards.

5.4.5 Experimental design

The driving simulator experiment was divided into two: Experiment 1 and Experiment 2

A two-way (2x3) mixed design was employed in experiment 1, which aimed to investigate the effect of culture and variations in infrastructure on drivers' behaviour. The within-subjects factor is ***infrastructure*** with 2 levels (low and high). The between-subject factor is the ***culture*** of the participants with 3 levels (NG, NG/UK and UK drivers), as participants were selected specifically for this purpose. For these, participants were asked to drive on roads with low or high infrastructure. For assessment of the effect of awareness-raising intervention (experiment 2), a one-way within-subjects repeated measures design was employed. The within-subject factor is ***intervention*** with 3 levels (low infrastructure, high infrastructure and training) in which only the NG group participated. Data for NG participants from experiment 1 were compared with data obtained after the intervention. Hence after the second drive, NG participants were trained and given instructions on safe driving after which they repeated the high infrastructure drive. This was aimed to evaluate the effect of some simple awareness-raising intervention on their driving behaviour. For experiment 1 and 2, participants were asked to drive normally and without specific instructions to avoid the drivers increasing their attentional resources and improving performance, as drivers deliberately control their behaviour (Trick and Enns, 2009). All drives were counterbalanced to account for order effects. This means that the participant sample was divided in four, with each sample completing different conditions in one particular order (Table 7).

Table 7: Randomisation and counterbalancing

Road 1	With signs; overtaking no traffic (1st); overtaking with traffic (2nd)
Road 2	Without signs; overtaking with traffic (1st); overtaking no traffic (2nd)
Road 3	With signs; overtaking with traffic (1st); overtaking no traffic (2nd)
Road 4	Without signs; overtaking no traffic (1st); overtaking with traffic (2nd)

Experiment 1									**Experiment 2 (NG drivers only)**				
Group 1 (NG)			Group 2 (NG/UK)			Group 3 (UK)				1st drive	2nd drive	Training	3rd drive
P1	Road 1	Road 2	P17	Road 1	Road 2	P33	Road 1	Road 2	P1	Road 1	Road 2		Road 1
P2	Road 2	Road 1	P18	Road 2	Road 1	P34	Road 2	Road 1	P2	Road 2	Road 1		Road 1
P3	Road 3	Road 4	P19	Road 3	Road 4	P35	Road 3	Road 4	P3	Road 3	Road 4		Road 3
P4	Road 4	Road 3	P20	Road 4	Road 3	P36	Road 4	Road 3	P4	Road 4	Road 3		Road 3
P5	Road 1	Road 2	P21	Road 1	Road 2	P37	Road 1	Road 2	P5	Road 1	Road 2		Road 1
P6	Road 2	Road 1	P22	Road 2	Road 1	P38	Road 2	Road 1	P6	Road 2	Road 1		Road 1
P7	Road 3	Road 4	P23	Road 3	Road 4	P39	Road 3	Road 4	P7	Road 3	Road 4		Road 3
P8	Road 4	Road 3	P24	Road 4	Road 3	P40	Road 4	Road 3	P8	Road 4	Road 3		Road 3
P9	Road 1	Road 2	P25	Road 1	Road 2	P41	Road 1	Road 2	P9	Road 1	Road 2		Road 1
P10	Road 2	Road 1	P26	Road 2	Road 1	P42	Road 2	Road 1	P10	Road 2	Road 1		Road 1
P11	Road 3	Road 4	P27	Road 3	Road 4	P43	Road 3	Road 4	P11	Road 3	Road 4		Road 3
P12	Road 4	Road 3	P28	Road 4	Road 3	P44	Road 4	Road 3	P12	Road 4	Road 3		Road 3
P13	Road 1	Road 2	P29	Road 1	Road 2	P45	Road 1	Road 2	P13	Road 1	Road 2		Road 1
P14	Road 2	Road 1	P30	Road 2	Road 1	P46	Road 2	Road 1	P14	Road 2	Road 1		Road 1

P15	Road 3	Road 4	P31	Road 3	Road 4	P47	Road 3	Road 4	P15	Road 3	Road 4		Road 3
P16	Road 4	Road 3	P32	Road 4	Road 3	P48	Road 4	Road 3	P16	Road 4	Road 3		Road 3

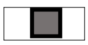
5.4.6 Driving scenarios

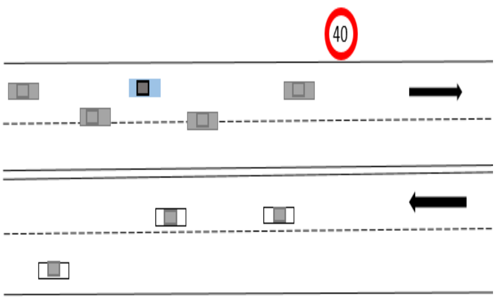
The road layout for this study represented those where observation took place in phase 1 of this research. It was 22km long and consisted of urban and rural road segments forming a single stretch for a 27-minute drive. The initial section of the road was comprised of two lanes in each direction and then merged into a one lane road in each direction. There was traffic in the participants' lane in some scenarios and several junctions with and without traffic lights. The speed limits at different points were 30 (48km/h), 40 (64 km/h) and 60 mph (97 km/h). The surrounding traffic was driving at or below the speed limits. Some of the intersections were uncontrolled (where no traffic lights or signs are used to indicate the right of way) and some were controlled.

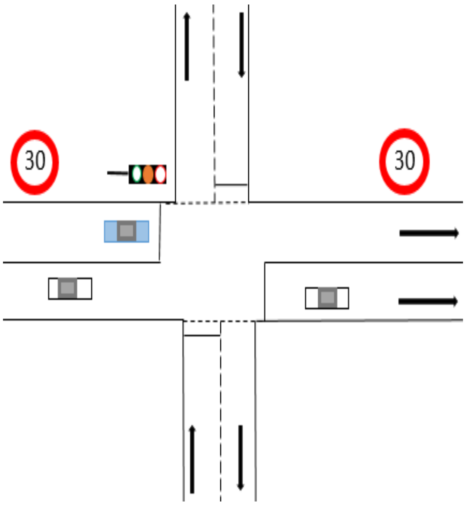
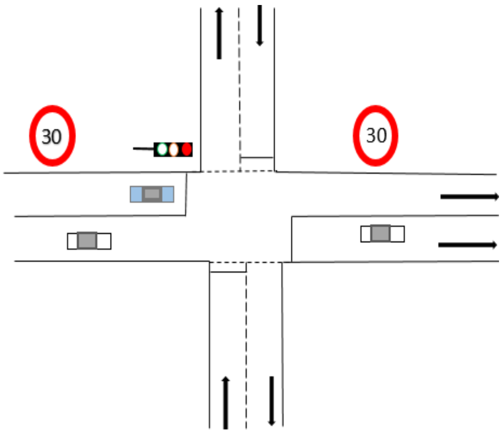
Ten scenarios were developed, as listed in Table 8. These scenarios provided an opportunity to observe driving style in different conditions. Scenarios were created to evaluate drivers' performance, for example, to see how fast they accelerate to the speed limit, to test how smoothly they accelerate, measure whether the participants approached the junctions with a lower speed, their speed choice, safety of overtaking, compliance with road rules, vehicle control and positioning, lane changing and keeping, reading and interpreting road signs and markings. There were safety critical scenarios which involved vehicles cutting and crossing in front of the participant at different values for TTC, most of which required immediate reactions.

Table 8: Description of Scenarios

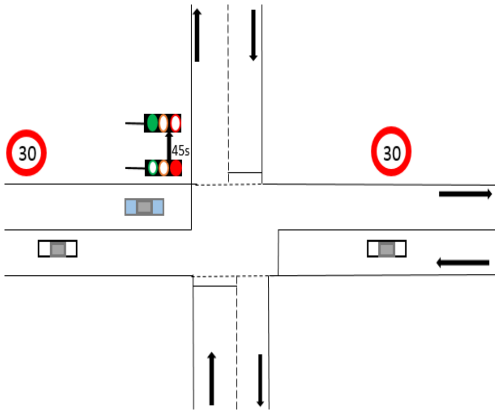
Please, note that the participant, leader and other road users in the sketch of driving scenarios are represented by:

 **Participant**  **Leader/crossing car**  **Other road users**

Road layout	Scenario description
Lane changing 	**Road environment**: Urban road, two lanes in each direction: with a slow-moving leader travelling at 30mph in the participant's lane and another one on the left lane behind the participant. **Length**: 1500m; approximately 1min 20secs; **Speed limit**: 40mph **Description:** the participant follows a slow-moving leader with oncoming traffic in the opposite direction. The participant is allowed to overtake and go back to the left lane. If the

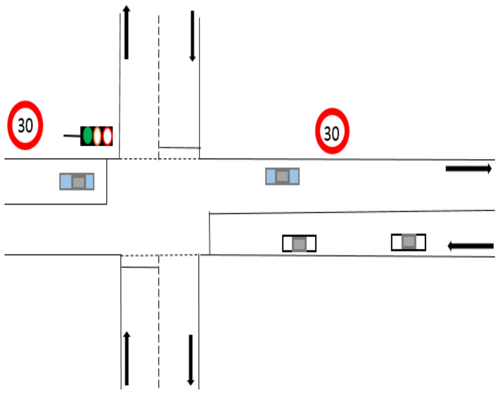
	participant does not overtake, the leader turns left at the next junction and the participant will keep moving straight **Purpose:** This scenario was important to assess participants' lane changing behaviour. **Dependent variables:** Mean speed, SD. of speed, mean acceleration, SD. of acceleration, minimum time headway, TTC_{min} and indicator use.
Amber dilemma 	**Road environment:** Urban road, one lane in each direction: four arm traffic light junction (single lane) **Length**: 38m approximately 3secs; **Speed limit**: 30mph **Description:** This scenario started when participant approaches a green light at a controlled junction and just before entering the junction, the green light turns to amber. The participant has to decide whether to cross the junction or brake. The traffic light at the junction turned amber when participant's TTJ was 2.5 secs to the stop line. The scenario ended when the traffic lights turned red or when the junction was crossed **Purpose:** This scenario was important for the decision of whether to cross the junction or stop **Dependent variables:** cross or stop, junction crossing violation (crossing at red) and spot speed (at TTJ = 2.5secs).
Acceleration: Deceleration to red light 	**Road environment:** Urban road, one lane in each direction: four arm traffic light junction (single lane) **Length**: 7secs approximately 100m; **Speed limit**: 30mph **Description:** In this scenario, participant started decelerating when the traffic light turned red. Data capture commenced 100 meters before the traffic light and ended when the traffic light turned red. **Purpose:** This was designed to measure deceleration behaviour. **Dependent variables:** Speed profile, mean deceleration, SD. deceleration and maximum break pressure.

Acceleration: Anticipatory behaviour



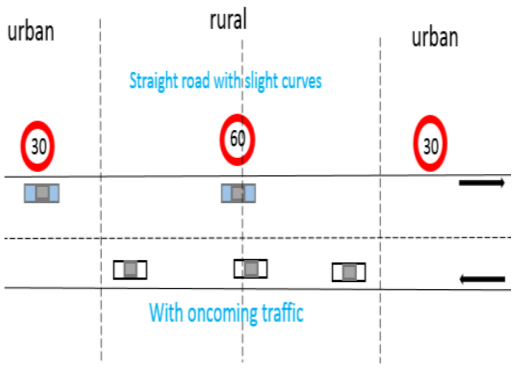
Road environment: This is the same road and junction as acceleration (deceleration to red light)
Length: 45secs **Speed limit**: 30mph
Description: Participant was stationary at this junction for 45 secs, this scenario ended when the traffic light turned green which is the start of the acceleration away from the red light. There were no vehicles or traffic on participants lane
Purpose: To measure anticipatory behaviour as (impatience and aggressiveness)
Dependent variables: Distance covered in 45 secs anticipatory period.

Acceleration away from red light



Road environment: This is the same road and junction as acceleration (deceleration to red light)
Length: 27secs approximately 400m; **Speed limit**: 30mph
Description: In this scenario, participant was stationary at a red traffic light that switched to green, the participant then accelerates to the speed limit. Data capture commenced when the traffic light turned green and ended approximately 350m later.
Purpose: This was designed to measure acceleration behaviour including how fast participants accelerate to the speed limit.
Dependent variables: speed profile, mean acceleration, SD. acceleration, time to accelerate to the speed limit and maximum accelerator pedal depression

Speed choice

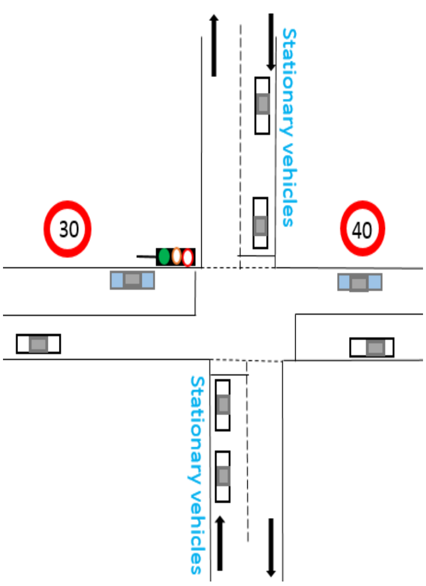


Road environment: Urban-rural, one lane in each direction: (single lane), free flow, no vehicles in participant's lane but there will be oncoming traffic. Straight road with a slight curve.
Length: 6 km approximately 6mins; **Speed limit**: varying speed limits (30, 60mph);
Description: This scenario started from a traffic light junction that remained green for a duration of 5km. The speed limit changed from 30 mph (48 km/h) to 60 mph (97 km/h) halfway through (at approximately 2800m).

Purpose: This was designed to measure speed choice including variation in speed and speed limit exceedance.

Dependent variables: speed profile, mean speed, SD of speed, speed limit exceedance and spot speed

Green lights



Road environment: Urban road, one lane in each direction: (single lane), free flow, no vehicles in participant's lane

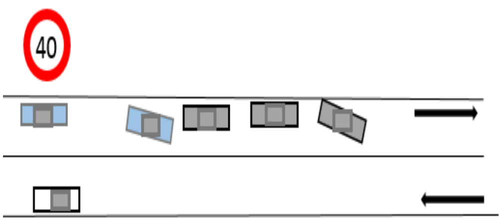
Length: 358m approximately 20secs; **Speed limit**: 30mph

Description: This scenario involved a junction with traffic light that remained green throughout. There were other stationary vehicles on the minor arms of the junction. It started from about 250m before and 80m after the junction.

Purpose: It was designed to measure anticipatory behaviour and to observe behaviour while approaching a junction.

Dependent variables: mean speed, mean deceleration, SD. of deceleration, maximum deceleration and minimum speed

Car cutting scenario 1



Road environment: urban area: single carriageway, free flow with parked vehicles

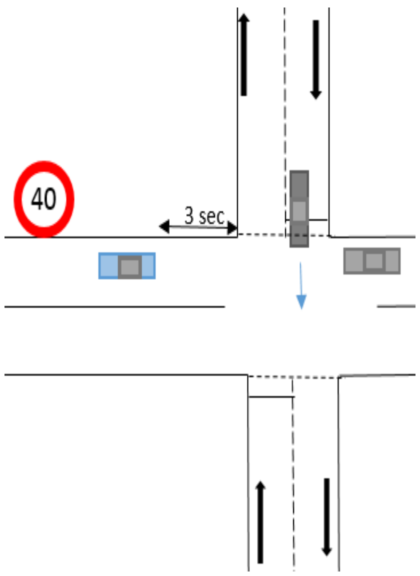
Length: 7secs approximately 130m; **Speed limit**: 40mph

Description: In a row of three parked cars, the third car started merging into the main road from the left side of the road without signalling, when the time to collision (TTC) of the participant's vehicle with the merging vehicle is 2.5 seconds. The speed of the merging vehicle is low and would not allow for overtaking. The end of the measurement is 100 metres after the place where the car was parked.

Purpose: This scenario was important to investigate participants' reaction to expected hazards and to investigate the choice to either brake or take the risk of maintaining a constant speed.

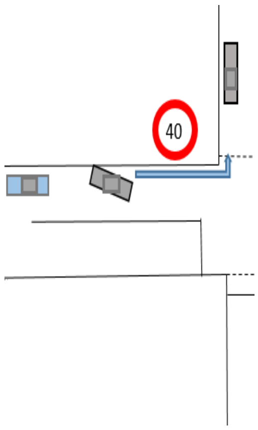
Dependent variables: mean speed, sd. of speed, mean deceleration, SD. of deceleration and maximum brake pressure.

Crossing car scenario



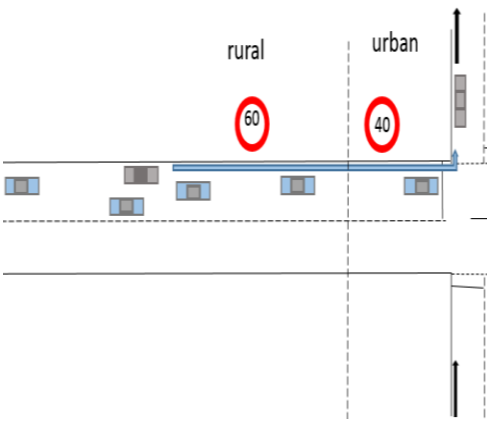
Road environment: urban area: single carriageway, no vehicles on participants lane
Length: 300 approximately 10secs **Speed limit**: 40mph
Description: This was a priority junction without traffic lights. The scenario involved a car merging from the left and crossing the road in front of the participant even though the participant had priority. It began when the TTJ of the participant's vehicle with the stop line of the junction was 3 seconds. Then the car which was stationary at its stop-line, crossed the road in front of the participant and accelerated to 40mph within 2.5 secs before clearing from the junction. Measurement started when the participant's vehicle is 150meters from the junction and ended 150 meters after the junction.
Purpose: This scenario was designed to investigate participants' reaction to unexpected hazards
Dependent variables: speed profile, speed at junction entry, TTJ with crossing car, brake reaction time

Cutting car scenario 2



The same as in '**cutting car scenario 1**', the only difference is that there was only one vehicle parked on the roadside.

Overtaking (easy)



Road environment: Urban-rural, single carriageway, with a slow-moving leader travelling at 30mph

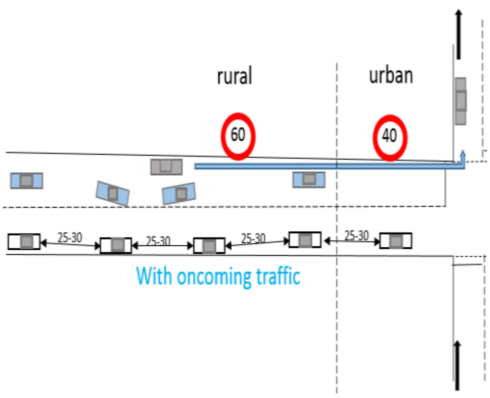
Length: 3000m approximately 2mins, **Speed limit**: 60mph and 40mph

Description: This represented an easy overtaking condition with no oncoming traffic flow and a slow-moving leader.

Purpose: to investigate participants' tendency to perform overtaking and the safety of the overtaking manoeuvre

Dependent variables: total number of overtaking attempts, percentage of successful overtaking, minimum time headway with slow leader, overtaking duration, maximum speed reached during overtaking, time headway with oncoming vehicle and distance tail way with slow leader

Overtaking (difficult)



Road environment: Urban-rural, single carriageway with a slow-moving leader travelling at 30mph and oncoming vehicles with a gap of 25-30 secs

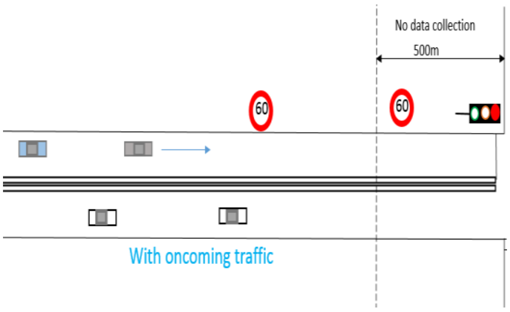
Length: 3000m approximately 2mins, **Speed limit**: 60mph and 40mph

Description: This scenario represented a difficult overtaking condition in which there was a low flow of oncoming traffic with a range of time headway approximately 25-30 seconds travelling at 45mph. Visibility was not a problem as this was on a straight road.

Purpose: Same as overtaking (easy)

Dependent variables: same as overtaking (easy)

Compliance with road markings



Road environment: rural road, one lane in each direction: (single lane), free flow, double white solid lines

Length: 2 min approximately 3500m; **Speed limit**: 60mph

Description: Double solid white lines show that overtaking is prohibited. The scenario started when a vehicle pulled in from the left into the major road in front of the participant and ended when the lane marking changed to single broken white lines. The leader varied its speed between 40 and 50 mph.

Purpose: to assess knowledge and adherence to road markings
Dependent variables: cross or not, mean speed, SD. of speed, mean acceleration and SD. of acceleration

5.4.7 Dependent variables

Data collected included subjective data with the DBQ as well as objective behavioural measures from the simulator experiments. The DBQ included closed questions about driving behaviour specifically related to error, violations and slips/lapses. Several dependent variables were measured during the simulator experiment for the entire road layout, as well as for the distinct scenarios taking place within each drive, which were relevant for each of the longitudinal measures of interest. Longitudinal control, control of lateral position and headway were considered. Longitudinal control involves speed control aimed to prevent collisions, keeping a steady flow of traffic and allowing the driver to be in control even when faced with sudden critical situations/events. These were assessed by the mean and standard deviation values for speed, spot speed, acceleration and deceleration data. Spot speed was measured in some scenarios. This was to measure participants free flow speed and to take care of factors such as junctions and other vehicles which may require drivers to reduce speed. Measures that relate the position of the participant's vehicle to junctions and other vehicles were included in the analyses. Control of lateral position consisted of maintaining the vehicle properly on the road and was measured through variations occurring in lateral position, lane excursions, mean lateral position, time headway and TTC. Others included assessing compliance with basic road rules and indicator use. Additionally, hazard detection tasks were employed whereby drivers' reaction to hazards in the roadway were assessed, minimum speed reached on approach to the hazards and brake reaction time (BRT) were also used as performance measures. For the accelerator pedal angle and brake pedal pressure, maximum values were identified.

Some measures adopted in this study include:
Braking
BRT was calculated for scenarios involving expected and unexpected hazards. It is the most commonly used brake related driving performance metric and requires a critical event to which the driver has to react quickly in order to avoid a collision. The event has to have a well-defined onset in order to achieve a reliable BRT (Östlund et al., 2004). Reaction times were calculated from the beginning of the hazard window (see Table 8: crossing car), based on the initial strict measure of response rate. Only drivers that had reacted to the pre-defined hazards during the hazard window were included; all other responses were removed, as were those who did not react (stop). According to Johansson & Rumar (1971), shorter BRT is recorded for expected events compared

to unexpected events. This is because when confronted with severe emergency, drivers probably slow response to increase the time required for assessing the situation and to check the feasibility of other escape actions (Green, 2000). On the other hand, drivers seeing a car cut them off at an intersection often expect the vehicle to be stopped (van Elslande & Faucher-Alberton, 1997), creating a slight hesitation and a longer RT.

Overtaking

There are different approaches to defining the boundaries (start to finish of overtaking task) within which the duration of overtaking is measured. This study set boundaries that included drivers who had both successful and unsuccessful attempts at overtaking for appropriate analysis. The boundary for the performance of each overtaking includes the period from the first indication of an attempt to overtake to the cessation of overtaking (termination of the attempt/s or completion of overtaking). This is when the centre of gravity (CG) crossed centreline and either lead vehicle was passed or not. Visibility was not an issue as all drives were conducted on straight roads without curves.

Driver behaviour was observed in two overtaking scenarios- easy and difficult. In the easy overtaking scenario, there was no oncoming traffic but the difficult overtaking scenario had oncoming traffic which made overtaking riskier. Results are presented for the two scenarios where relevant.

Overtaking stages and their appropriate measures are provided below:

(a) The propensity to overtake: Tendency to perform overtaking; the number of participants in each sample group that performed or attempted overtaking (difficult overtaking)

(i) The total number of overtaking manoeuvres attempted by different groups of drivers are presented (difficult overtaking):

In order to assess the tendency to overtake, a record of participants' propensity to perform overtaking was generated. This could only be achieved with the difficult overtaking scenario because participants were faced with the oncoming traffic flow that made performing an overtaking manoeuvre a risk. A record of the number of overtaking attempts by participants reveal the tendency towards performing overtaking even in the face of the potential risks.

(ii) The total number of successful overtaking manoeuvres: this was used to reveal the number of successful overtaking manoeuvres by different groups

(b) Overtaking safety

(i) Start of overtaking: this is considered as the last moment that both front corners of the participant's vehicle are in its original lane

- Minimum time headway with the slower-moving vehicle

For this measure, time headway (TH) is recorded in relation to the slow-moving vehicle. Time headway is an important factor in safe driving (Van Winsum, 1998; Dragutinovic et al., 2005; Piccinini et al., 2014). It represents the time gap between two following vehicles and includes the speed and distance headway which are the measures that vary between the participant and the slow leader in this phase. This measure reveals the closeness of the participant's vehicle to the slow leader at the start of overtaking since the speed of the slow-leader is the same for all drivers. Time headway is defined as the time needed that the front of participants' vehicle reaches to the rear of the slow leader. Small time headway shows an unsafe overtaking. Time headway is measured in seconds.

Smaller time headway at the start of overtaking can have negative implications in terms of safe driving. Firstly getting too close to the slow leader is dangerous because of the reduction in the available time for reacting to a possible change in the speed of the slow-leader. Additionally, a small gap from the slow leader is a sign of poor preparation because it results in a shorter run-up distance prior to the start of overtaking.

(ii) During Overtaking (while in the opposite lane and passing the slower-moving car)

This phase, *passing the slower-moving vehicle*, starts from the start phase until the completion phase. It is the period when the participant's vehicle is in the opposite lane. In this section, only participants that completed the overtaking task were included in this analysis.

- Overtaking duration: Time spent completing the overtaking manoeuvre

Overtaking duration refers to the time from the moment in which the front right of the participant's vehicle crossed the centre line of the single carriage way until the vehicle has completely returned back to its original lane positioned in front of the slower-moving vehicle. Overtaking duration is directly linked to the risk of head-on collision since it is the time the participant's vehicle is exposed to oncoming traffic. In this research, one of the overtaking scenarios was designed with the inclusion of oncoming traffic flow, making it more difficult and risky to successfully complete overtaking.

- Maximum speed reached during the overtaking manoeuvre

Maximum speed while performing overtaking, during the time the participant's vehicle is in the oncoming traffic lane, is another performance measure used for this study. Maximum speed during overtaking would be looked at from two aspects- the safety implication of high speed and the effect of higher speed needed to perform overtaking.

(iii) End of overtaking- Last moment that the centre of the vehicle is in the opposite lane.

This is the last moment in which the centre of the participant's vehicle is in the opposite lane and on its way back to the original lane.

- Time headway with the oncoming vehicle (for difficult overtaking scenario)

The measure used for studying this phase is the time headway in relation to the oncoming vehicle. Since the speed of the oncoming vehicle for all drivers is the same and the only measures that vary are the speed of participant's vehicle and their distance to the oncoming vehicle, time headway can be used for analysing this phase. Time headway at the end of the overtaking is the minimum time headway with the oncoming vehicle. Therefore the larger the time headway, the safer the task is performed.

- Distance tail way with the slow-moving vehicle (This provided a measure of how sharply a driver pulled back in front of the lead vehicle)

Tailway is used to describe the gap between the rear end of the participant's vehicle and the front of the slow-moving vehicle (Horrey & Simons 2007; Gates & Noyce 2010). It is important to study tail way since this measure is directly related to the safety performance of overtaking task especially in the situations where drivers have a small gap with the oncoming vehicle and end up cutting in front of the slow-moving vehicle despite having a small tailway distance. Since the speed of the slow-moving vehicle for all participants was the same, distance tailway was used in this measure.

5.4.8 Pilot study

Pilot studies were conducted at different stages during the experiment design. This was to ascertain that scenarios developed were important and ideal for the variables to be measured and that all participants can be accommodated in the study. In addition, it was important that potential practical problems that may arise in the main experiment were identified and corrected, thereby improving the study design.

5.5 Phase 3: Focus group study on the effectiveness and ease of implementation of road safety measures in Nigeria (Chapter 8)

Despite the poor traffic safety culture in Nigeria, there have been few studies investigating the road safety status, why drivers engage in unsafe behaviours, current road safety measures and what could possibly be done to integrate road safety into the culture. This study forms the third of a three-phase PhD research investigation, designed to explore the *influence of road safety culture on driver behaviour*. The other two studies were an observational study using the traffic conflict technique (phase 1 discussed in chapter 6) and a driving simulator experiment involving drivers from different nationalities (phase 2 discussed in chapter 7). Phase 1 highlighted the most prevalent unsafe behaviours observed in Nigeria and showed that most of these behaviours are localised and can only be found in specific cultural environments with the same traffic and transport system like Nigeria (some developing countries). Further study in phase 2 revealed that some interventions put in place to improve these unsafe driver behaviours were not effective in bringing about the desired behavioural change in Nigerian drivers. Measures such as improvement in road condition, adding information signs and traffic control to the road environment did not bring about any behavioural change. Small changes were observed when the drivers were trained and informed of the implications of engaging in unsafe behaviours. Considering this, a qualitative study was perceived as being a well-suited approach to critically examine which road safety measures have proved effective and easy to implement in Nigeria and what could be done to improve the road safety culture. This present study was intended to provide an understanding of the reasons for the poor road safety standards in the country by an identification of the factors aggravating the situation, to find out which road safety measures are effective and easy to implement and at the same time best suited for the country. It was decided that a focus group study with the FRSC which is the lead agency in charge of road safety in Nigeria would be most suitable and will provide answers to questions raised in the previous studies.

5.5.1 Rationale for the study

Focus group studies have been applied in transport research to investigate the attitudes of the public to red signal cameras (Wissinger et al., 2000), investigate commuter drivers' perceptions of the level of service of freeways (Hostovsky et al., 2004), study lane changing behaviour and ramp merging behaviour on freeways (Sun & Elefteriadou, 2011). In addition, they have been used to explore different stakeholders' perception of the effectiveness of road safety programmes in developing countries like India, Namibia, Malaysia and Pakistan (Batool, 2012; Tetali et al., 2013; Lipinge & Owusu-Afriyie, 2014; Eusofe & Evdorides, 2017). To explore all aspects of road safety in Nigeria so as to make evidence-based recommendations, a focus group study was conducted with the lead safety agency in Nigeria-the Federal Road Safety Corps (FRSC). The aim was to examine the effectiveness and ease of implementation of some road safety measures in Nigeria. This is to enable prioritization of the most effective measures considering all limited resources such as time and capital. These could not be achieved with the studies described earlier (phases 1 and 2). The study provided insight and a greater understanding of relevant road safety measures, by enabling personal, in-depth descriptions by the individual participants, as well as allowing for group interaction.

5.5.2 Contribution and justification for the approach

This study explored the opinions of participants broadly under three themes: road safety problems, road safety measures and strategies for improvement. During the focus group study, quantitative questions were included and used to rank the road safety measures in order of effectiveness and ease of implementation. This approach was anticipated to lead to more meaningful explanations of the safety standards in the country. In addition, strategies for improvement which can help strengthen the implementation of road safety measures and consequently improve the road safety culture in Nigeria were highlighted by participants. Strengthening and improving road safety in Nigeria with the overall goal of reducing crashes and their consequences requires strong and continuous participation from all stakeholders, including road-users. Most published studies from Nigeria have examined RTIs in the context of disease burden and risk factors, using mainly a quantitative approach (Ogwude, 2001). Qualitative studies move beyond risk factors and severity of injuries and shed light on stakeholder perceptions, which can provide impetus for behaviour change and greater coordination.

To the knowledge of the authors, no study was found to have applied the qualitative method and involved officials of the FRSC in Nigeria to studies on road safety management in Nigeria. According to Tetali et al. (2013), qualitative studies improve the understanding of contextual factors that play an important role in uptake and implementation of programmes and shed light on stakeholder perceptions, which can provide the drive for behaviour change and greater coordination (Puvanachandra et al., 2012).

5.5.3 Study template

5.5.3.1 Qualitative measures

The Focus group template was developed based on the result of phase 2 (see chapter 7, section 7.9). The discussion followed a semi-structured format of open-ended questions. It began with very basic questions about road safety problems in Nigeria. This was followed by questions about road safety measures operational in Nigeria and their effectiveness and ease of implementation. Questions concerning the share of responsibility between other government bodies involved in road safety and how they collaborate to improve the transport situation of the country were asked. The focus group was concluded by asking participants to recommend strategies or steps that could be taken to improve the status of road safety in Nigeria. The complete study template is included in Appendix D.

5.5.3.2 Quantitative measures

Some activities were introduced during the meeting which comprised the quantitative part of the study whereby participants were presented with a list of road safety measures and asked to rate the effectiveness and ease of implementation of each measure (see appendix E). These measures are carefully laid out plans put in place to prevent road users from getting into crashes, being killed or seriously injured in case a crash occurs and they include:

(i) **Road design:** This involves designing and defining the road environment from the onset to encourage safe behaviour, e.g. cycle lanes, tracks and pedestrian sidewalks, pedestrian underpass and overpass crossings, by-passes, roundabouts, good road alignment and sight distances, good quality roads with lighting, guardrails and crash cushions.

(ii) **Road maintenance:** These are usually carried out on existing roads, e.g. resurfacing of roads, improving road surface friction, traffic control at road work sites, black spot treatments etc.

(iii) **Traffic control:** These are put in place to influence or direct road users' behaviour in traffic. For example, traffic calming, priority control, yield and stop signs at junctions, traffic signal control at junctions, signalised pedestrian crossings, speed limit signs, speed reduction measures, bus stops and bus lanes.

(iv) **Vehicle inspection:** Safety measures set to make sure vehicles are roadworthy, e.g. roadside vehicle inspection, vehicle safety standards and motor vehicle inspection, vehicle fitness checks etc.

(v) **Driver education and training:** These are formal programmes put in place to prepare new drivers and old drivers to drive safely, e.g. Basic and strict driver training and tests, regulation of driving and rest hours, safety standards for school buses, periodic health check-up of drivers

(vi) **Public education and information campaigns:** This involves teaching good road behaviour through awareness campaigns, e.g. road Safety Education and awareness in schools and public places using educational materials, road user information and campaigns, road safety awareness through the media (adverts using billboards, posters, handbills, television, radio), road safety awareness through social media (Facebook, Twitter, Instagram etc.)

(vii) **Legislation and Enforcement of traffic regulations:** These are usually directed towards traffic violations and involves strict application of the laws, e.g. proper implementation of the ban on drink driving, use of mobile phones while driving, use of mobile phone while crossing the road, people buying and selling on Pedestrian sidewalks, speed limit enforcement, seatbelt enforcement, licence suspension and Penalties etc.

(viii) **Post-crash care:** These aim to reduce severity of injuries sustained in crashes, e.g. roadside medical care, emergency medical services, call centres for crash notification.

To assess the effectiveness of a measure, the scale presented to participants ranged from very ineffective (1) to very effective (3) and for the ease of implementation, it ranged from very difficult (1) to very easy (3) (see Appendix E). Measures about vehicle design were omitted from the list because it is beyond their (FRSC) scope but measures about vehicle inspection and roadworthiness were included. The scale was used to rate and know which measures have been proved to be very effective and easy to implement in the country considering all available resources.

Chapter 6 Phase 1: On-road observation of traffic behaviour and conflicts in Nigeria

6.1 Overview

This chapter presents the results of a study undertaken to develop a better understanding of the road safety situation in Nigeria. It consists of an in-depth description and analysis of the current traffic safety problems in Nigeria, examines the behaviour of various road users and environmental factors affecting road safety. The main results and conclusions drawn from this study are presented in this chapter. This study forms the first of a three-phase research study designed to **investigate the *influence of road safety culture on driver behaviour.*** The others are a simulator experiment and a focus group study. No specific hypotheses were tested as the study was exploratory, thus the study sought to address one research question:

RQ1: What unsafe (bad) driving behaviour(s) are most prevalent among drivers in Nigeria?

6.2 Objectives

- To investigate the applicability of the TCT to road safety assessment in Nigeria
- To provide greater knowledge of behaviour and interaction of various road users, in order to make up for the inconsistencies associated with crash data in Nigeria
- To determine what aspect of driving in Nigeria is most unsafe and to determine which unsafe behaviours are most prevalent and need to be investigated further.
- To develop a basis for further studies on the comparison of driving behaviour across cultures.

6.3 Procedure

Data were collected via roadside observation using a video recorder, clipboard, conflict recording form and pen by trained observers. According to Svensson & Carsten (2007), video recording is helpful in conflict studies as it aids in confirming conflicts and checking observer reliability. The definitions of conflicts were established according to Amundsen & Hydén, (1977) as they can be identified by the fact that the closeness to a collision is anticipated and very imminent. Conflicts recorded included interactions between different road users (vehicle and tricycle drivers). Only manoeuvres where the vehicle driver proceeds straight ahead or makes a turn and interacts with either another vehicle or tricycle were included. The situations of interest were those where the road users were on a collision course, implying the existence of an evasive action or manoeuvre (braking, swerving and accelerating).

Observation procedures included the detection, recording and estimation of speed and distances, sketching the situation and describing the causes of the conflict. Observers had audio recorders to enable them to talk about the traffic situation and causes of conflicts. Observers recorded basic data about each conflict, such as date, time of the day, light conditions, weather, involved road users etc. They recorded all circumstances that may contribute to the understanding of the possible reasons for occurrence of the conflicts. For ease of measurement, distances at the locations were mapped out using electric poles, billboards and other road furniture. Observers arrived 30mins before data collection started, to set up all necessary equipment, to become familiar with traffic movement and to practice speed and distance estimation. The observation started at the same time in all the locations and was the same length of time. The locations were filmed with video recorders set at some distance from the focus of observation. Their position was carefully chosen during the site survey to get the best view of the locations, and the video recorders and observers were positioned covertly to reduce any influences or interference with normal road user behaviour; in addition, observers were discouraged from wearing reflective vests. For each location, conflict observers worked in teams of two, each recording session lasted for 90mins and a total of 21 hours of observation was carried out. This study received approval from the Faculty ethics committee (review reference AREA15-130).

6.4 Data analysis

Data were collected and analysed with different methods using Statistical Package for Social Sciences (SPSS) v24 and Traffic Conflict Technique.

The STCT was used to define and categorise conflicts according to severity (serious or slight). Svensson, (1992) showed that the number of events classified as serious conflicts according to the definition of this technique has a strong correlation with the number of police-reported accidents and in some cases (when the number of accidents is small), serious conflicts can be better estimators of the expected number of accidents than the actual accident statistics.

Descriptive analysis was used to provide simple summaries of data from behavioural observation based on frequency counts. This was to identify the percentage of road users who violated traffic rules and exhibited unsafe behaviour while driving and to find out at what time of the day it was most prevalent. Following the standardized approach of analysing speed data for different time periods, univariate descriptive including mean (*M*) and standard deviation (*SD*) were generated to determine speed distribution of different road users and an independent-samples *t*-test was used to determine whether the differences in mean scores of different groups of road users for different time periods were statistically significant or not.

In addition, since the aim of this study was to use surrogate safety measures for road safety assessment, further statistical analysis was carried out on the conflict data using different methods of discrete data analysis. This allowed investigation of the influence of road user's behaviour on conflict severity. Data used in the analysis were extracted from the conflict observation form and recorded video**.** All the data are dichotomous or categorical variables. Normality tests (Shapiro-Wilk) were conducted to determine if the sample comes from a normal distribution. Small values indicate the sample is not normally distributed. Pearson's Chi-square test was used to test the relationship between different categorical variables, while Odds Ratios and Cramér's V are used to investigate the strength and direction of association of variables. Logistic regression established the most influential factors affecting conflict severity of different road users. Specifically, the aim is to determine the mean value of the dependent variable (in this case conflict severity) given the values of the independent variables (road user type, direction of traffic, etc.). Binary logistic regression is used because the dependent variable is dichotomous (0: serious, 1: slight). The resulting linear regression equation and the odds ratio associated with each predictor variable are reported.

Furthermore, Chi-square test (χ2) was used to examine whether there are any associations between eleven categories of unsafe driving behaviour observed in conflict situations and i) different road users, ii) locations and iii) time of day. Cramér's V was used to test the strength of association. With a large number of cells for some of the cross tabulations, it can be difficult to determine which groups have significant differences within the analyses. Therefore, post hoc tests using residual analysis were conducted on statistically significant variables to test the direction of association in each cell and to determine which cell differences contribute to the chi-square results. The size of the standardized residuals was compared to the critical values that correspond to an alpha of 0.05 (+/- 1.96). For example, where statistically significant differences were found in the chi-square results, the standardised residuals were further examined to identify which cells were responsible for the difference (those larger than 1.96 indicate that the observed frequency was statistically significantly different at 95% confidence from that which would have been expected if there were no association between the variables in question). According to Delucchi (1993), the larger the residual, the greater the contribution of the cell to the magnitude of the resulting chi-square obtained value. As stated by Agresti (2007), "a cell-by-cell comparison of observed and estimated expected frequencies helps to better understand the nature of the evidence" and cells with large residuals "show a greater discrepancy…than would be expected if the variables were truly independent".

6.5 Results

6.5.1 Traffic volume

Figure 14 shows the results of the hourly traffic counts for all road users across all locations for different time periods (peak, off-peak). Generally, traffic volume was higher during the peak period compared to the off-peak period for all categories of traffic across all the locations. At LOC_1, pedestrian volume was observed to be the highest during the peak period probably because of the City College very close to the study site. Vehicles and tricycle volumes were also high during the peak period. At LOC_2, the highest proportion of road users were vehicle drivers in the peak period. Pedestrian volume recorded during the peak and off-peak period were high. Results from LOC_3 shows that vehicle volume was the highest during the peak period. Pedestrian volume was observed to be lower at this location compared to the other locations.

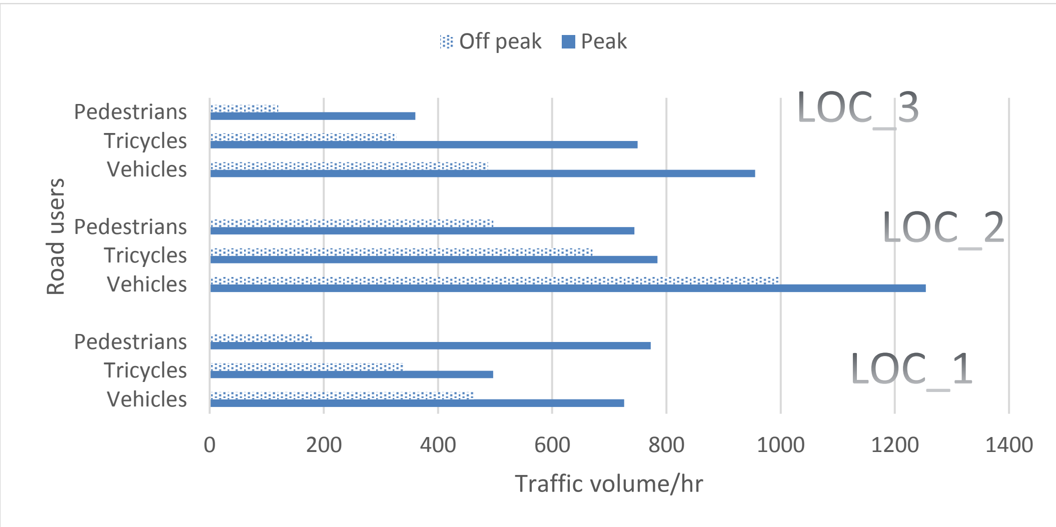


Figure 14: Traffic volume per hour

Additional analyses performed to explore differences in gender and estimated age of observed road users show that approximately 72% of the vehicle drivers were male (age range 18-75) and the remaining 28% were female (age range 22-65). Of all observed tricycle drivers during both peak and off-peak period, 99.8% were male between the ages of 20-56.

6.5.2 Safety related behaviour

Mean speeds measured in km/hr were statistically significantly lower during the peak compared to the off-peak period across all locations and for both vehicle types (see Table 9) likely due to high volume of traffic. As such, in off-peak periods, vulnerable road users are exposed to higher risk as a result of these higher speeds.

Table 9: Mean Speed by location and road user type

Locations	*Road user type*	*Peak mean (SD)*	*off-peak mean (SD)*	*df*	*t*	*p*
LOC_1	Vehicle	43 (19.1)	57.9 (25.8)	198	-4.358	.000
	tricycle	38.4(9.8)	44.7(13.1)	198	-3.864	.000
LOC_2	Vehicle	45.4(12.7)	54.8(24.0)	198	-3.435	.001
	tricycle	39.6(7.5)	43.7(15.5)	198	-2.337	.020
LOC_3	Vehicle	35.6(9.1)	43.9(10.9)	198	-5.873	.000
	tricycle	30.9(5.6)	34.2(7.2)	198	-3.628	.000

Figure 15 shows the percentage frequency of all behavioural observations made during the study period for all locations, as a percentage of the traffic volume[4]. For vehicle drivers across all locations, the most prevalent behaviours observed were not wearing seatbelts, red light/give way violation, speed violation and cell phone use. Speed violations by vehicles were observed at all three locations (78%, 52% and 32% respectively), as well as for tricycles (43%, 25% and 0% respectively). Red light/give way violation was more prominent during the peak period while the other behaviours were mostly observed during the off-peak periods.

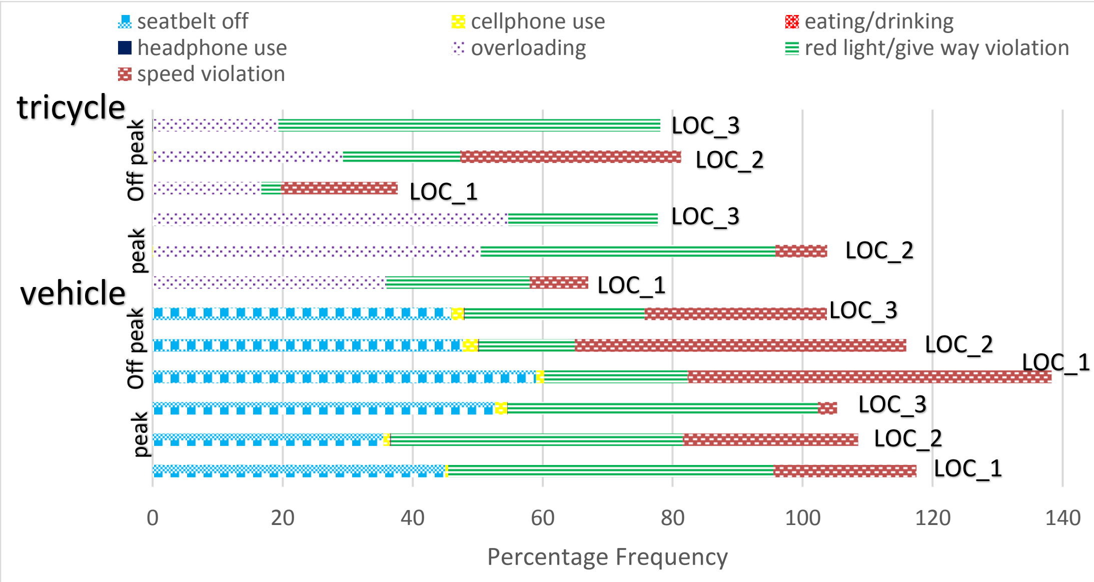


Figure 15: Results from behavioural observation

For tricycle drivers, the most prominent unsafe behaviours recorded were overloading, red light/give way violation and speed violation. There were few or no observations recorded for cell phone use, eating/drinking and headphone use during both peak and off-peak periods.

---

[4] These figures are the percentages at each location based on counts. For example at LOC_1: 45% wore seatbelt and the remaining 55% did not, 0.5% used cell phone, 99.5% did not etc.

6.5.3 Traffic conflicts

The total number of conflicts recorded was generally higher during the peak period compared to off-peak, but when normalised by percentage frequency and seriousness, the relationship reversed **(Appendix F).**

At LOC-1, 92 of the total 170 conflicts observed were serious as opposed to slight, evenly split between peak and off-peak hours. The majority (86%) were either vehicle-vehicle or vehicle-tricycle conflicts. At this location, 4.4 serious conflicts occurred every hour. The majority of conflicts recorded during the peak period were crossing conflicts compared to the off-peak period when there were more same direction conflicts. No opposing traffic conflicts were observed at this location.

A total of 445 conflicts were observed at LOC_2 with a marginally higher proportion occurring during the peak hours (56%) and 67% being serious. Just over half of these occurred during peak hours, and three actual collisions took place during the off-peak hours, involving vehicles and tricycles. As a result of the high traffic volume and improper enforcement at this location (even though it is partially signalised), the conflict rate was very high (13.9/hr). Similar to LOC_1, the majority of conflicts recorded during the peak period were crossing conflicts and a particular problem here involved vehicles and tricycles approaching the roundabout from all directions.

LOC_3 is quite different from the others both in layout, traffic enforcement and regulation. With 10.8 conflicts being observed at this location every hour, 62% were serious, split evenly across peak and off-peak times. Almost 90% of these were either vehicle-vehicle or vehicle-tricycle conflicts; five actual collisions took place. Considering lower traffic volume at this location, it could be considered as being riskier than the other locations, especially for vulnerable road users. Unlike the other previously discussed locations, more conflicts involving vehicle-pedestrian, vehicle-tricycle and tricycle-tricycle were observed during the off-peak period. The majority of conflicts recorded during both the peak and off-peak periods were crossing conflicts. A high number of opposing conflicts were observed here unlike the other locations. Figure 16 shows examples of some observed conflicts.

Figure 16: Examples of observed conflicts

6.5.4 Predicting conflict severity from behaviour

Appendix G shows the variables included in the regression analysis. It considered conflict severity as a dependent variable which is dichotomous (1: serious or 2: slight) and predicts the likelihood that Y=1 instead of Y=0, considering the influence of a set of X values. If P is the probability of a road user being in a slight conflict (Y=1), then the probability of not being in a slight conflict (being in a serious) is 1-P (Y=0).

The independent variables were elicited from the conflict observation form and video recording. Out of 989 interactions recorded at the three locations, there were 501 vehicle-vehicle, 71 vehicle-pedestrian, 338 vehicle-tricycle, 67 tricycle-tricycle and 12 tricycle-pedestrian interactions. Overall, a very high percentage of observed conflicts involved male road users compared to females. In addition, more conflicts were observed in the peak compared to the off-peak period.

Before developing the model, a Chi-square test was used to investigate the association between the variables, Appendix H. All interactions involving different road users across the three locations were analysed. Different variables were found to be strongly related to conflict severity at different locations.

At LOC_1, a very strong relationship was observed ($p<0.05$) between variables of age_rel., gender_rel., speed, evasive action, time of day and conflict severity while at LOC_2, variables such as direction of traffic, age_rel., gender_rel., age_sec. and speed were found to be strongly related to conflict severity. Additionally a strong relationship ($p<0.05$) was observed between direction of traffic, gender_rel., speed and conflict severity at LOC_3. An important point to note is that speed and gender_rel. appears to be common across all three locations showing that they are strongly related to conflict severity regardless of where the observation was made.

6.5.4.1 The conflict severity model

To further analyse the data, a conflict severity model was developed using binary logistic regression. Table 10 shows the model estimates of the logistic regression model for different locations, along with the reference categories of the variables, parameter (beta) estimates, significance level as well as the exponential of the beta estimates.

Table 10: Binary logistic model for conflict severity

	Reference category	*LOC_1*			*LOC_2*			*LOC_3*		
Variables		***B***	*p*	O.R	***B***	*p*	O.R	***B***	*p*	O.R
Direction of traffic			003*			.000*			.000*	
same direction	crossing	1.435	003*	4.2	0.154	.565º	1.2	1.509	.000*	2.2
opposite direction		n/a	n/a	n/a	2.507	.000*	12.3	-0.056	.857º	0.5
Age (rel.)			.005*			.016*			.029*	
26-45	15-25	1.768	003*	5.9	0.365	.214º	1.4	0.386	.177º	1.5
46-64		0.335	.592º	1.4	0.730	.017*	2.1	0.900	.005*	2.5
65+		2.340	.012*	10.4	1.580	.007*	4.9	0.985	.066º	2.7
Gender(rel.)			.002*			.000*			.011*	
female	male	1.539	.002*	4.7	1.029	.000*	2.8	0.738	.011*	2.1
speed			.026*			.018*			.002*	
yes	no	1.546	.026*	4.7	0.831	.018*	2.3	1.161	.002*	3.2
Time of day			.010*			-			.027*	
peak	Off peak	1.129	.010*	3.1	-	-	-	0.542	.027*	1.7
constant		-0.711	.749	0.5	-0.382	.712	0.7	-0.344	.756	0.7
Nagelkerke's R^2		.438			.254			.187		
Correctly classified		75%			73%			70%		
Hosmer and Lemeshow			.150			.961			.599	

*significant at a 95%confidence level; ºnot statistically significant

The predictive ability of the models (75%, 73% and 70%) for the three locations is considered satisfactory. Regarding model validation, the Nagelkerke R-Square (which is between 0 and 1) is used and suggests that the new model can explain approximately 44%, 25% and 18% of the variance at each location. Finally, the *p*-value of the Hosmer and Lemeshow test indicates that the models fit the data well. The outcomes indicate that the model developed is reliable for analysis and interpretation.

Of the variables selected for analysis, direction of traffic, age and gender of relevant road user, speed and time of day when conflict was observed were found to be statistically significant. The effects of the identified factors in conflict severity were revealed by the odds ratio compared with the reference level.

The binary logistic regression method was applied to identify these factors and their statistical relationship to conflict severity which was categorised as serious or slight. The serious group was used as a basis for comparison. The same explanatory variables were identified across all three locations except at LOC_2 where there was no statistically significant relationship between time of day and conflict severity. These variables were modelled as a function of conflict severity and are shown to be statistically significant at a 95% confidence level. Variables such as evasive action and age (sec.) were not statistically significant and were removed from the model.

According to the way the models were developed, the coefficient of an independent variable is directly related to the probability of not being in a serious conflict. Therefore, a positive coefficient indicates a variable that increases the probability of having a slight conflict while a negative coefficient indicates a decrease in probability. Invariably, positive coefficients indicate that being in a slight conflict becomes more likely as the independent variable (predictor) increases while negative coefficients show that being in a slight conflict becomes less likely as the independent variable (predictor) increases. The interpretation of results is accomplished through the analysis of odds and probabilities, related to these variables. It is used to represent the likelihood of a slight conflict occurring instead of the likelihood of not occurring and are expressed as ODDS= (P/ (1-P)).
The most influential factors among the independent variables are discussed below:

(i) Direction of traffic
Direction of traffic in the study was defined as the direction the road users involved in the interaction were travelling when the conflict occurred. It was categorised as the same direction, opposing direction and crossing (reference category). There were no opposing direction conflicts at LOC_1. Additionally, no interactions between pedestrians and other road users travelling in opposite direction were recorded.

Across all locations, this variable was found to contribute statistically significantly to the models. At LOC_1, road users who are crossing are 4.2 times more likely to be in a serious conflict than those travelling in the same direction. LOC_2 shows that those crossing are 1.2 and 12.3 times more inclined to be in a serious conflict compared to those travelling in the same direction and opposite directions respectively. The result is fairly similar in LOC_3, where the odds of being in a serious conflict while crossing is twice compared to those travelling in the same direction. Results (LOC_3) further showed that when travelling in opposite directions, a conflict is more likely to be serious. The negative beta coefficient indicates that being involved in a conflict while travelling in the opposite direction tends to increase the probability of being in a serious conflict.

(ii) Age (relevant road user)

Results from all three locations showed that age of the relevant road user is an important predictor of conflict severity. Table 10 shows that not all age groups are consistently statistically significant across all locations. Compared to road users in the age brackets 26-45, 46-64 and 65+ (5.9, 1.4, 10.4 [LOC_1]; 1.4, 2.1, 4.9 [LOC_2] and 1.5, 2.5, 2.7 [LOC_3] times) respectively, those aged 15-25 (reference category) are more likely to be involved in a serious conflict. At all the locations, there were no observations made involving pedestrians aged <15.

(iii) Gender (relevant road user)

There is a relationship between gender of the relevant road user and conflict severity at all locations. The odds of being in a serious conflict is greater for males compared to females. At LOC_1, females are 4.7 times more likely to be in a slight conflict than males. This is the same at LOC_2 and LOC_3, where the odds of females being in a slight conflict are 2.8 and 2.1 times respectively. Serious conflicts were found to be more common for males than for females.

(iv) Speed (relevant road user)

Speed of the relevant road user was found to be an important factor in the models at all three locations. Road users observed not to have reduced their speed as an evasive action are more likely to be involved in a serious conflict compared to those who did. Looking at LOC_1 which is a link road and characterised by slightly higher speed, those who do not reduce their speed are 4.7 times more likely to be in a serious conflict than those who do. The same is seen in LOC_2 and LOC_3, where the odds of being in a serious conflict is 2.3 and 3.2 times more for those who did not reduce their speed. This shows that no matter the design of the intersections or roads, inappropriate and high speeds increase the chances of being in a serious conflict.

(v) Time of day

The final explanatory variable included in the logistic regression model is the time of day when conflict was observed. Serious conflicts were more common during the off-peak period than peak period, while more slight conflicts were observed during the peak period. The odds ratio shows that conflicts observed during the off-peak period were (3.1[LOC_1] and 1.7 [LOC_3] times) more likely to result in a serious conflict than those observed during the peak period. Invariably, road users were more likely to be involved in a serious conflict during the off-peak period. However, this variable is not statistically significant in the model at LOC_2. LOC_1 (the higher speed location) performing more safely at the peak times could be due to the calming effect on speed due to increased volume of traffic.

6.5.5 Unsafe behaviours by road users, location and time of day

Conflict observations involving vehicle and tricycle drivers were analysed. Tables 9 and 10 show the result of statistical analysis for various unsafe behaviours by different road users, at different locations and time periods.

6.5.5.1 Road Users

About 70% of observed road users were vehicle drivers, while 30% were tricycle drivers. Of all unsafe behaviours observed, vehicle drivers were involved in 68% while tricycle drivers were involved in 32% of the conflicts. The chi-square test (Table 11) revealed a statistically significant association between road users and incorrect indicator use ($\chi 2=13.967$, $p<0.001$), passenger scouting ($\chi 2=12.928$, $p<0.001$), picking/dropping passengers ($\chi 2=4.229$, $p<0.05$). No differences were found with speed, eating/drinking, cell phone use, inappropriate overtaking, tailgating, right of way violations, one-way violations and others. When comparing the Cramér’s V, there is a weak association between road user and cell phone use, tailgating, others. A moderate association between road user and speed, one-way violations, a relatively strong association with eating/drinking, inappropriate overtaking, right of way violations, picking/dropping passengers and a strong association with indicator use and passenger scouting. An examination of the standard residuals (Table 12) shows that tricycle drivers engage in more unsafe behaviours than would be expected if road user type was unrelated to engage in unsafe behaviours. The most frequently observed unsafe behaviour for both vehicle and tricycle drivers was incorrect indicator use (30.8% and 16.5% respectively), followed by tailgating (28.8%) for vehicle drivers and picking/dropping off passengers (12.5%) for the tricycle drivers. Concentrating on statistically significant behaviours (Table 11, in bold), standard residuals which were calculated to determine which cell differences contribute to the chi-square result test, show that among road users who did not use their indicator (correctly), there were more tricycle drivers (2.3) than would be expected and less vehicle drivers (-1.5). Similarly, passenger scouting where tricycle drivers were observed scouting for passengers relatively more 1 (2.6) compared to the vehicle drivers (-1.7). Tricycle drivers were over-represented (1.4) in picking up/dropping off passengers compared to vehicle drivers (-0.9).

Table 11: Chi-square results of unsafe behaviours by road user, location and time of day

Unsafe behaviour	Road user type	Location	Time of day
Inappropriate speed			
χ^2	0.635	**36.843****	**9.445****
p-value	0.426	0.00	0.002

Cramér's *V*	0.026	0.197	0.100
Eating/drinking			
χ^2	2.504	**8.551***	**14.040****
p-value	0.114	0.014	0.000
Cramér's *V*	0.051	0.095	0.122
Cell phone use			
χ^2	0.206	0.693	0.214
p-value	0.650	0.707	0.643
Cramér's *V*	0.015	0.027	0.015
Inappropriate overtaking			
χ^2	2.329	**8.788***	3.106
p-value	0.127	0.012	0.078
Cramér's *V*	0.050	0.096	0.057
Tailgating			
χ^2	0.046	**56.129****	0.662
p-value	0.831	0	0.416
Cramér's *V*	0.007	0.244	0.026
Right of way violations			
χ^2	2.827	**17.992****	**5.772***
p-value	0.093	0	0.016
Cramér's *V*	0.055	0.138	0.078
Incorrect indicator use			
χ^2	**13.967****	1.767	0.346
p-value	0	0.413	0.556
Cramér's *V*	0.122	0.043	0.019
Passenger scouting			
χ^2	**12.928****	**13.343****	**6.301***
p-value	0	0.001	0.012
Cramér's *V*	0.117	0.121	0.082
Driving on one way			
χ^2	0.681	4.530	1.052
p-value	0.409	0.104	0.305
Cramér's V	0.027	0.069	0.033
Picking up/dropping off passengers			
χ^2	**4.229***	**11.018****	0.616
p-value	0.040	0.004	0.433
Cramér's *V*	0.067	0.108	0.026
Others			
χ^2	0.002	**7.185***	0.252
p-value	0.961	0.028	0.615
Cramér's *V*	0.002	0.087	0.016

Note: * statistically significant at a 0.05 confidence level, ** statistically significant at a 0.01 confidence level.

6.5.5.2 Location

Depending on the physical characteristics of the locations, a number of unsafe behaviours were found to be spread across different locations (Table 11). At Government Coll., 21% of unsafe behaviours were observed, 44% at IMSU and 35% at Dick Tiger. Chi-square test results show statistically significant association for inappropriate speed (χ2=36.843, p< 0.001), eating/drinking (χ2=8.551, p< 0.05), inappropriate overtaking (χ2=8.788, p< 0.05), tailgating (χ2=56.129, p< 0.001), right of way violations (χ2=17.992, p< 0.001), passenger scouting (χ2=13.343, p< 0.001), picking up/dropping passenger (χ2=11.018, p< 0.001), others (χ2=7.185, p< 0.05).

When comparing the Cramér's V, there is a moderate association with cell phone use, a relatively strong association with incorrect indicator use and a strong association with speed, eating/drinking, inappropriate overtaking, tailgating, right of way violations, passenger scouting, one-way violations, picking up/dropping off passengers and others.

Although a greater percentage of unsafe behaviours were observed at IMSU, a closer look at the result of the post hoc tests, using standardized residuals indicate otherwise (See Table 12). Observations at Govt. Coll. shows that speed (4.5), eating/drinking (2.4), inappropriate overtaking (2.1), right of way violations (1.7), passenger scouting (2.6), one way violations (1.7), picking/dropping of passengers(2.2) and others (1.1) were over-represented in the actual sample compared to the expected frequency. This means that there were more unsafe behaviours in this location than would be expected. At IMSU, tailgating (3.2) was relatively more common than would be expected and right of way violations (1.7) was over-represented at Dick Tiger.

6.5.5.3 Time of day

Of all unsafe behavioural observations, 55% was made during the peak and 45% during the off-peak hours. There were statistically significant associations between time of day and inappropriate speed ($\chi2=9.445$, $p< 0.001$), eating/drinking ($\chi2=14.040$, $p< 0.001$), right of way violations ($\chi2=5.772$, $p< 0.05$) and passenger scouting ($\chi2=6.301$, $p< 0.050$), with a strong effect size (Cramér's V =.100, .122, .078, .082 respectively). Post-hoc tests, using standardized residuals (Table 12), indicate that the pattern and type of behaviour observed were different between the peak and off-peak periods. Observation of inappropriate speed and right of way violations appeared to be more in the peak period, although the standardised residual was under 1.96 (+1.6 and +1.3). On the other hand, during the off-peak period, it was observed that eating/drinking (2.5) and passenger scouting (1.6) were relatively more common than expected.

Table 12: Standardised residual results of unsafe behaviours by road user type, location and time of day

Condition		Inappropriate speed	Eating/ drinking	Cell phone use	Inappropriate overtaking	Tailgating	Right of way violations	Incorrect indicator use	Passenger scouting	One way violations	Picking/ dropping of passengers	Others	All unsafe behaviours (%)
Road user type													
Vehicle	*n*	233	119	168	245	271	183	**291**	**162**	98	**240**	272	2282
	(%)	(24.6)	(12.6)	(17.8)	(25.9)	(28.8)	(19.30)	**(30.8)**	**(17.1)**	(10.4)	**(25.4)**	(28.6)	(68.1)
	Std. Res.	-0.3	-0.8	0.2	-0.6	0.1	-0.8	**-1.5**	**-1.7**	-0.4	**-0.9**	0	
Tricycle	*n*	103	61	65	115	109	90	**156**	**98**	46	**118**	111	1072
	(%)	(10.9)	(6.4)	(6.9)	(12.2)	(11.5)	(9.5)	**(16.5)**	**(10.4)**	(4.9)	**(12.5)**	(11.7)	(31.9)
	Std. Res.	0.5	1.2	-0.3	1	-0.1	1.2	**2.3**	**2.6**	0.6	**1.4**	0	
Location													
Govt. Coll.	*n*	**89**	**43**	39	**76**	**78**	**57**	77	**60**	32	**76**	**72**	699
	(%)	**(9.4)**	**(4.5)**	(4.1)	**(8.0)**	**(8.2)**	**(6.0)**	(8.1)	**(6.3)**	(3.4)	**(8.0)**	**(7.6)**	(20.8)
	Std. Res.	**4.5**	**2.4**	0.1	**2.1**	**1.9**	**1.7**	0.3	**2.6**	1.7	**2.2**	**1.1**	
IMSU	*n*	**133**	**74**	99	**149**	**210**	**93**	207	**118**	56	**161**	**182**	1482
	(%)	**(14.1)**	**(7.8)**	(10.5)	**(15.8)**	**(22.2)**	**(9.8)**	(21.9)	**(12.5)**	(5.9)	**(17.0)**	**(19.2)**	(44.2)
	Std. Res.	**-1.4**	**-0.7**	-0.5	**-0.9**	**3.1**	**-2.6**	0.5	**0.2**	-1.0	**0.1**	**0.8**	
Dick tiger	*n*	**114**	**63**	95	**135**	**92**	**123**	163	**82**	56	**121**	**129**	1173
	(%)	**(12.1)**	**(6.7)**	(10.0)	**(14.3)**	**(9.7)**	**(13.0)**	(17.2)	**(8.7)**	(5.9)	**(12.8)**	**(13.6)**	(34.9)
	Std. Res.	**-1.4**	**-0.8**	0.5	**-0.4**	**-4.5**	**1.7**	-0.8	**-1.9**	0.0	**-1.5**	**-1.6**	
Time of day													
Peak	*n*	**210**	**78**	127	214	206	**169**	245	**128**	86	194	210	1867
	(%)	**(22.2)**	**(8.2)**	(13.4)	(22.6)	(21.8)	**(17.9)**	(25.9)	**(13.5)**	(9.1)	(20.5)	(22.2)	(55.6)
	Std. Res.	**1.6**	**-2.2**	-0.3	0.9	-0.4	**1.3**	-0.3	**-1.4**	0.6	-0.4	-0.3	
Off peak	*n*	**126**	**102**	106	146	174	**104**	202	**132**	58	164	173	1487
	(%)	**(13.3)**	**(10.8)**	(11.2)	(15.4)	(18.4)	**(11)**	(21.4)	**(14)**	(6.1)	(17.3)	(18.3)	(44.4)
	Std. Res.	**-1.8**	**2.5**	0.3	-1.0	0.5	**-1.5**	0.3	**1.6**	-0.7	0.5	0.3	
Total	*n*	336	180	233	360	380	273	447	260	144	358	383	3354
	(%)	(10)	(5.4)	(6.9)	(10.7)	(11.3)	(8.1)	(13.3)	(7.7)	(4.3)	(10.7)	(11.4)	(100)

In bold: statistically significant behaviours. Example: Chi Square test shows that inappropriate speed as an unsafe behaviour has a statistical relationship with Location. Although a greater number and percentage of this unsafe behaviour was observed at IMSU (133; 14.1%), the result of the standardized residual shows that inappropriate speed observed at Govt. Coll. (4.5) was more than expected compared to the other locations (-1.4).

6.6 Summary of main results

- Traffic volume was higher during the peak period compared to the off-peak period for all categories of traffic across all the locations, highest in LOC_2 and for vehicle drivers.
- Mean speeds were statistically significantly lower during the peak compared to the off-peak period across all locations and for both vehicle types, highest in LOC_1.
- Conflicts recorded for all locations were generally higher during the peak period compared to off-peak, but when normalised by percentage frequency, the relationship reversed
- Major conflicts involved vehicle and tricycle drivers and were crossing, opposing traffic and same direction conflicts
- Even though LOC_3 had the lowest traffic volume, it recorded a conflict rate of 12.4/hr which is considered very high
- Factors affecting conflict severity include direction of traffic, age, gender and speed of relevant road user and time of day.
- Most prevalent unsafe behaviours identified include inappropriate speeding, traffic light violation, non-seatbelt use, passenger scouting, incorrect indicator use, random picking up and dropping off of passengers inappropriate overtaking, eating and drinking, tailgating.
- Most of these unsafe behaviours were identified at LOC_1.

6.7 Discussion

6.7.1 Traffic conflicts and traffic volume

The number of conflicts observed at LOC_2 seems to be higher than that recorded at the other two locations. However, the number of road users present at that location during the time of observation was also higher. This does not mean that this location is riskier than the others. This is because road users who are not interacting with each other can never be in a conflict and it may be more appropriate to take into consideration the number of interactions instead of the number of road users. Consequently, the conflict rate per interaction, especially involving vehicle-vehicle is higher at LOC_3. This is in line with literature stating that un-signalized intersections represent potential hazards not present at signalized intersections because of the priority of movement on the main road (TRB, 2003). Traffic signals are very important in road design because they help to control conflicting flows of traffic entering the intersection at the same time and can subsequently reduce crash risk.

6.7.2 Traffic conflicts and behaviour

Traffic safety diagnosis should include not only crash data but also data about behaviours that precede crashes. This study used onsite observation of traffic behaviour and conflicts at three locations with a view to assess the safety of various road users and to investigate factors predicting conflict severity at each location. Most of the influential variables (age, gender and speed) identified in this study as contributing to conflict severity are in line with results of past studies on crash rate and severity (Reason et al., 1990; Massie et al., 1995; Busch et al., 2002; Harré et al., 2005; Rhodes et al., 2005; Box, 2012; Chen et al., 2012; Vatanavongs & Sonnarong, 2014).

Direction of traffic was identified as an important variable in the model. It was observed that road users travelling in the same direction were more likely to be in slight conflicts compared to those crossing or travelling in opposite directions. This could be related to the high incidence of give-way violations reported from onsite behavioural observation (Figure 15). In a situation where there is no information or warning signs and right of way is neither posted nor defined, road users find it difficult to understand and communicate with each other.

The analysis of speed data showed that drivers were consistently exceeding the speed limit, especially during the off-peak period (Table 9). This is likely to increase the severity level of potential crashes which is consistent with Golob et al. (2004) and Quddus et al. (2009). In addition, interactions observed during the off-peak period were more likely to result in a serious conflict. Comparing this to data on behavioural observation (Figure 15), more violations (seatbelt off, cell phone use, eating/drinking, speed violation) apart from overloading and give way violations (which could be as a result of high traffic density) were observed during the off-peak period.

It is important to note that the road users involved in the conflicts are not the same as the ones included in the behavioural observation. However, it could provide a possible explanation for the violations, behaviours associated with conflicts and why they happen.

6.7.3 Differences in conflict severity across locations

This study supports previous research that the road environment greatly affects road user behaviour (WHO, 2009). There are differences in the number and severity of conflicts recorded across the different study locations. The results demonstrate that road users tend to exhibit more unsafe behaviour at poor road layouts and where there is little or no enforcement. For example, crossing conflicts were more prevalent at LOC_3 and less at the other locations. The locations are not exactly comparable but were selected to have a general idea of traffic behaviour of road users.

At LOC_1, road users are more likely to violate the speed limit especially during the off-peak period, and this eventually results in more serious conflicts (Table 10). The reason could be that unlike LOC_2 and LOC_3 which are intersections, LOC_1 is a clearly demarcated link road and road users find it difficult to slow down even while approaching the City College on this road (De Waard et al., 1995; Oron-Gilad & Ronen, 2007). Speed limits which are not posted or enforced, in addition to the absence of traffic control on a very long stretch of this road contribute to this violation.

The highest traffic volume was recorded at LOC_2, which is a roundabout, with traffic control and enforcement. Most of the interactions observed during the off-peak period were as a result of road users being in a hurry to beat the traffic lights. During the early part of the morning peak before the traffic police have arrived, the behaviour of road users is the same as in LOC_3 where there is no control and the rule is on a first come first pass basis. This could be part of the reason why a large number of crossing conflicts which resulted in many serious conflicts were mostly observed at this location, especially at the morning peak.

Percentage frequency of conflicts especially involving vehicles-vehicles was more at LOC_3. This could be due to the nature of the intersection which is narrow and on a single carriage road, without any traffic control or proper enforcement. Road users cross the intersection as they deem fit considering that there are no posted rules on who should cross first, even though those on the major road have priority. Apart from the latter part of the morning peak where traffic wardens were seen trying to control the traffic (which seemed quite difficult for them), at the other periods (early peak and all off-peak hours), there was no form of traffic enforcement. A high number of opposing conflicts were also observed here unlike the other locations. The reasons are probably because of the nature of the intersection (see Table 5).

The effect of restricting the flow of simultaneous traffic stream could be seen in LOC_1 and LOC_2. Road demarcation in LOC_1, signalisation and traffic control and enforcement at LOC_2 to an extent reduced simultaneous conflicting traffic stream. This greatly reduced the incidence of conflicts and crashes that result from vehicles moving into the main traffic stream at high speed. The frequency and number of conflicts especially during the morning peak at LOC_2 reflect the greater traffic volume. Despite the lower traffic volume at LOC_3, the number of serious conflicts involving vehicle-vehicle was higher compared to LOC_2. This is consistent with Salman and Al-maita (1995), Svensson (1998) and Archer (2005), where a higher number of traffic conflicts were recorded at unsignalised intersections compared to signalised intersections. Even though the traffic volume was lower compared to some signalised intersections. In a study by Ekman (1996) investigating bicycle conflicts, he found that the number of bicycle conflicts per bicyclist is twice as large at locations with low bicycle flow as compared to locations with higher flow. He further argued that it is possible that at larger flows there is an increased awareness of the fact that there are other road users around.

Svensson (1998) found that as opposed to traffic conflicts at non-signalised intersections, traffic conflicts at signalised intersections are more spread out and there is a tendency towards lower severity. This could be because a lot of possible interactions have been reduced due to signalisation. The results of this study demonstrate that drivers tend to exhibit more unsafe behaviours where there are poor traffic regulations and enforcement or poor road layout without traffic control and management devices.

Serious conflicts between vehicles and vulnerable road users (pedestrians and tricycles) were predominant, representing more than 55% of the total across all locations. At locations where vehicle-pedestrian conflicts were observed, they were observed to be mostly crossing conflicts as a result of pedestrians trying to cross the road in spite of vehicles and tricycles approaching (there were no pedestrian crossing facilities). Most conflicts involving tricycles were due to them making sudden and unexpected stops to pick up and drop off passengers. Some of them were observed to have stopped at the intersection and others on the major road. Some of them were observed entering and leaving the road without using their indicators.

Several conclusions can be drawn from this study. First of all, road users moving in the same direction were observed to be involved in more slight conflicts compared to those crossing. In addition, male road users were observed to be involved in more serious conflicts than females. Age of road users has a statistically significant impact on conflict severity as younger road users were involved in more serious conflicts. Road users who reduced their speed prior to the evasive action were observed to be involved in more slight conflicts and more serious conflicts were observed during the off-peak compared to the peak period. Finally, It is very important to note that relevant road users’ (road user who takes the evasive action) behaviour before and in the event of an interaction contributes significantly to conflict severity. And a road user being a young male travelling at high speed is more likely to be involved in a serious conflict compared to young females, older male etc. travelling at a lower speed.

6.7.4 Unsafe behaviours in traffic conflicts

This section explored the impact of road user type, location and time of day on unsafe behaviours observed in conflict situations. It was found that one or more unsafe behaviours preceded in observed conflicts. According to Lee et al. (2009), these types of behaviours have the potential to degrade driving performance resulting in serious consequences for road safety and in addition greatly increase the risk of crashes.

There were statistically significant associations between road user type and three variables (incorrect indicator use, passenger scouting and picking up/dropping off passengers). Regarding road user type and incorrect indicator use, a greater number of vehicle drivers were identified as not using it or using it in the wrong way, but the post hoc test (Table 12) showed that tricycle drivers were over-represented in this behaviour. The same was observed with the other variables (passenger scouting and picking/dropping off passengers). As stated earlier, tricycles became more prevalent following the ban on motorcycles. The desired reduction in crashes seems far from being achieved as reports from media an observation by this study showed that tricycle drivers disregard the rules and regulations. In a bid to attract passengers, they stop the vehicle wherever they want, creating chaos on the roads. Reckless driving and abrupt stopping in the middle of the roads often lead to crashes. In a qualitative study by Tetali et al. (2013), they stated that the driving practices of auto-rickshaw drivers (tricycle drivers), specifically speeding and making frequent and often unexpected stops to pick up and drop passengers, increases the risks of road traffic injuries for themselves, their passengers, and other road-users. It is therefore very important to regulate this group while organising some form of training for them and other road users and in addition, providing them with dedicated stops where they will have to pick and drop off passengers.

There was a statistically significant association between location and eight variables related to unsafe behaviours (speed, eating/drinking, incorrect overtaking, tailgating, right of way violations, passenger scouting, picking/dropping passenger, others). Whilst the lowest number of unsafe behaviours (700) were recorded at Govt. Coll., the result of the residual analysis (Table 12) showed that the behaviours were more than expected and contributed significantly (2.2) to the Chi-square value compared to the other locations (-1 1 and -1.5 respectively). As described in Table 5, this location is on a straight road which according to Haynes et al. (2007) could be riskier than curved roads as drivers tend to be less careful and drive at higher speeds.

Time of day was found to be statistically significantly associated with unsafe behaviours such as speed, eating/drinking, right of way violations and passenger scouting. Overall it appeared that this significant association was due to more unsafe behaviours observed in the morning peak. Of these, speed and right of way violations were mostly observed in the peak period and are closely associated with increased traffic volume and density. Eating/drinking and passenger scouting were more present in the off-peak period than would be expected.

The most frequently observed unsafe behaviours in this study were speeding, incorrect overtaking, tailgating, wrong indicator use, right of way violations, passenger scouting, one-way violations and picking up/dropping off passengers. All these are not exactly what has been identified in previous studies conducted in developed countries where most reported unsafe behaviours are mobile phone use, smoking, eating/drinking etc. (Stutts et al., 2005; Sullman 2012). The results of this study show that some unsafe behaviours can be localised and only be identified in specific environments. For example, behaviours such as passenger scouting and picking/dropping off passengers cannot be seen in environments with an organised transport system where passengers go to designated public stations to board taxis or buses instead of drivers shouting, stopping and moving at the same time while scouting for passengers. In a study by Olapoju (2016), investigating non-driving activities that commercial drivers were engaged in while driving in Nigeria, 93% of drivers were observed scouting for passengers. As is seen in this study, results of the Chi-square test show that passenger scouting was statistically significantly associated with all the variables tested (road user type, location and time of day). This indicates that this is a very big problem which should be further investigated.

6.8 Conclusion and implications for phase 2

The method applied in this study was successful in identifying different models to predict conflict severity at the different locations of interest, used to identify variables associated with different unsafe behaviours and provided a surrogate measure of safety that could be used for the low-cost safety assessment of these locations. The findings show that these behaviours represent driving activities that may be considered unsafe and are often linked to crashes. Even though conflicts are not actual crashes, crashes could be described as unresolved conflicts and this study has provided the rare opportunity of observing what happens before most crashes occur. This is important because it is a proactive approach to traffic safety analysis without necessarily waiting for crashes to happen. In addition, it is important to say that the behaviours observed are what is happening in real traffic situation in this particular environment and reflects the nature of behaviours that could precede crashes. This study provided additional information on safety challenges especially in a developing country. It goes to show that safety of various road users at different road locations and time periods can be assessed not just with crash data but also by conducting studies examining interactions between road users and the road environment.

The results of this exploratory study raise some questions for further research in which more detailed analysis of road users' behaviour is investigated and to understand the impact of certain factors such as culture and the road environment on crash risk. This would be desirable to further understand behaviour and provide important information for the design and operations of road layouts, in order to adopt measures to reduce the number and severity of crashes on Nigerian roads. Hence, the next step in this research, presented in chapter 7 (phase 2) was to investigate the behaviour of drivers from different cultures and is based on some of the unsafe behaviours identified in this study.

Chapter 7 Phase 2: Driving simulator experiment investigating if driving culture can be modified by traditional engineering and awareness-raising interventions

7.1 Overview

Based on the results of phase 1, a driving simulator study was designed to investigate distinct differences in the behaviour of drivers from different cultures and to investigate how changes in the road environment affect driver behaviour under different scenarios (overtaking, lane changing and speed choice). **The driving style of Nigerians (NG) with no experience of driving in the UK was compared to that of Nigerians with some experience of driving in the UK (NG/UK), to UK drivers.** The conditions varied depending on how much regulation was provided. The regulation provided included low or high infrastructure. With the low infrastructure, there was little or no information, no signs and markings or traffic signals while the high infrastructure condition had all the information including signs, markings and traffic signals. In addition, a short training in the form of awareness-raising intervention was organised for Nigerian drivers after which the effect of the intervention was evaluated.

This phase is divided into three: a Driver Behaviour Questionnaire (DBQ) survey investigating the differences in the self-reported behaviour of different groups of drivers, a driving simulator experiment (Experiment 1) investigating the differences in actual performance of the same group of drivers and a second driving simulator experiment (experiment 2) involving only the Nigerian drivers where the effect of the awareness-raising intervention on drivers' behaviour was evaluated. The questionnaire and experiment 1 were used to identify which group of drivers exhibited the highest risky behaviour and to compare self-reported to the actual driving performance of drivers. Experiment 2 which involved only the Nigerian drivers was used to examine the effect of a simple awareness-raising intervention on risky driving behaviour and to find out which behaviours were improved as a result of the intervention provided. The following research questions were examined in this chapter:

RQ2: Are there differences in reported and observed behaviour among different groups of drivers (NG, NG/UK and UK drivers)?

RQ3: Do drivers exhibit different behaviours across different scenarios?

(a) Are there statistically significant differences in behaviour between the driving activity patterns of drivers (NG, NG/UK and UK) in different scenarios?

(b) Is poor driving behaviour a function of the influence of culture and are drivers with a history of unsafe driving culture more likely to commit road traffic violations or exhibit the greatest risky behaviour?

RQ4: Do drivers adjust or change unsafe behaviours when they move to a better-disciplined driving environment with clear regulations and strict policies?

RQ5: Can a simple awareness-raising intervention improve driver behaviour?

7.2 Objectives

- To investigate differences in self-reported driving behaviour of different groups of drivers
- To investigate differences in vehicle positioning and control, perception of hazard and compliance with traffic rules between different groups of drivers
- To determine and measure changes in the driving pattern when drivers are asked to drive on roads with varying amounts of infrastructure and guidance
- To determine the effect of an awareness-raising training on drivers' behaviour
- To compare self-reported and actual driving behaviour of different groups of drivers

7.3 Hypotheses

H1: *Drivers' self-reported behaviour will not be different from observed behaviour*
The literature review in chapter 4 has noted the limitations of self-reported studies and how this could have an effect on data needed for road safety interventions especially as this is the most common method of data collection in developing countries. This hypothesis is therefore designed to investigate if there are differences between self-reported (using the DBQ) and actual observed driving behaviour (using the driving simulator) of different groups of drivers (NG, NG/UK and UK).

H2: *There will be differences in behaviour between different groups of drivers. It is therefore hypothesized that due to the traffic environment in Nigeria, NG drivers will engage in more erratic and risky driving behaviour in comparison with the NG/UK and UK drivers.*

H3: *It is expected that different groups of drivers would adjust behaviour in high (low) infrastructure and guidance conditions in order to drive safely (i.e. there will be differences in their behaviour in different conditions).*

There will be differences in behaviour (vehicle positioning and control, perception of hazard and compliance with road rules) of different groups of drivers in different road environments (low or high Infrastructure).

Drivers behave differently once they move into a new environment to which they are not familiar. This will be observed in different ways by introducing and removing infrastructure. Consequently, it is expected that NG drivers will modify behaviour in the high infrastructure environment by driving safely, UK drivers who are used to high infrastructure will modify behaviour by trying to adapt and drive more safely in the low infrastructure environment. NG/UK drivers are expected to drive safely in both environments. When driving in unfamiliar environments, drivers are expected to lower speed and maintain adequate control of the vehicle.

Vehicle positioning and control

Results of phase **1 (chapter 6)** indicated that most Nigeria drivers lacked proper control of their vehicles as was seen in the proportion of drivers speeding inappropriately, overtaking wrongly, tailgating, randomly changing lanes and those who either do or do not or use their indicators correctly.

The driving simulator was used to investigate whether the UK and NG/UK drivers drive more safely in the low (high) infrastructure conditions by properly positioning and controlling their vehicles more compared to NG drivers. Specifically, the measures used in the analysis were:

- Mean speed: To establish whether mean speed will be lower for NG drivers in the high Infrastructure environment compared to the other drivers and if it will be higher in the low Infrastructure environment.
- To establish whether the speed variability and speed limit exceedance would be higher for all drivers in the low Infrastructure environment compared (higher for NG drivers) to the high Infrastructure environment.
- Lateral position: To establish if the standard deviation of lateral position (e.g. weaving along the road) would be higher for NG drivers in both Infrastructure conditions.
- To establish if the mean and standard deviation of time headway will be higher for NG drivers in both Infrastructure conditions.

Perception of hazards

Experience of driving in a hazardous environment may increase the speed with which hazards are spotted. In the previous study **(phase 1: chapter 6)**, many hazards involving different road users were observed. And this was a major cause of most of the conflicts recorded. Pedestrians were observed suddenly stepping into and running across the road even when vehicles were very close, cars suddenly entered the roads while others were making turns in the middle of the road without warning. There were unexpected and sudden incursions and stops which were seen as very dangerous. Therefore based on the experience of driving in a hazardous road environment, this research will test whether NG drivers would perceive and react faster to hazards than the NG/UK and UK Drivers. Afukaar et al. (2003) in a cross-cultural study comparing Ghanaian and Norwegian drivers concluded that Ghanaians perceived risks as higher than Norwegians and a plausible explanation for the higher risk estimates in the Ghanaian sample is that the traffic environment in Ghana is considerably more hazardous than in Norway. According to Fuller (2002), the experience and diversity of situations with which drivers are daily confronted (e.g. exposure and experience of multiple situations), leading to the continuous acquisition of practice and new knowledge and behaviours, allow the improvement and consolidation of skills necessary to implement safe, effective and efficient driving.

Compliance with road rules

Phase 1 (chapter 6) demonstrated that Nigerian drivers fail to obey traffic lights or basic road rules. This was seen in the percentage of road users violating the right of way, running the red light and driving on one way. Non-compliance with traffic rules according to Björklund & Åberg (2005) could be attributed to social norms among the drivers even as Ajzen (2006) has shown that social norms are a strong predictor of behaviour. It is possible that drivers do not understand what some road rules (especially signs and markings) mean as most roads in Nigeria lack these. Based on these, this research sought to establish if in the high infrastructure condition, UK drivers will drive more safely followed by NG/UK and then NG drivers. And to test if NG drivers would know that there are strict rules and make efforts to comply. These behaviours were only measured for the high infrastructure conditions because traffic signs and lights were needed to take accurate measurements. The only exception was for measures relating to road marking compliance, measurements were taken in the low and high infrastructure conditions. This is because in the high infrastructure condition, there was a road sign showing that the road ahead was marked with double white lines while this sign was removed in the low infrastructure environment.

H4: It is expected that a simple training in the form of an awareness-raising intervention will improve the behaviour of NG drivers.

So far, the research hypotheses in this phase are set to investigate differences in the behaviour of drivers from different cultures and establish the effect of modifying the road environment on the behaviour of these drivers. These hypotheses measure the effect of culture and infrastructure on drivers' behaviour and lead to **H4**. It is believed that some simple training in the form of an awareness-raising intervention will have a positive effect on the behaviour of NG drivers. The purpose was to test whether NG drivers will drive more safely after the intervention as vehicle positioning and control, perception of hazard and compliance with road rules would have improved.

Summary of hypotheses

H1: Drivers' self-reported behaviour will be similar to observed actual behaviour

H2: There will be differences in behaviour between different groups. It is therefore hypothesized that due to the traffic environment in Nigeria, NG drivers will engage in more erratic and risky driving behaviour in comparison with the NG/UK and UK drivers

H3: It is expected that different groups of drivers would adjust behaviour in low or high infrastructure conditions in order to drive safely (i.e. there will be differences in their behaviour in different conditions).
H4: It is expected that a simple training in the form of awareness-raising intervention will affect the behaviour of NG drivers. They will be able to drive more safely after the intervention

7.4 Participants

Different approaches were used for recruiting participants such as sending emails, advertising on online social networks and approaching people directly. As stated earlier (section 3.5), participants were recruited specifically to fit into three groups – NG, NG/UK and UK drivers (NG Drivers: drivers from Nigeria who have no experience of driving in the UK or any other developed country; NG/UK drivers: drivers who have experience of driving in both Nigeria and the UK; UK drivers: drivers from the UK who have no experience of driving in any developing country).

There were forty-eight participants with 16 participants per group (NG: 12 males, 4 females; NG/UK: 12 males, 4 females; UK: 11 males, 5 females) aged 19 to 55 years old. No statistically significant age differences were found between the three cultures. Every participant held either a Nigerian and/or a full UK/EU license and had at least 2 years of driving experience (range 2-20 years). As a gesture of appreciation, all participants were given £20 or £25 depending on the number of drives they completed. This study received approval from the Faculty ethics committee (review reference AREA17-008) and accordingly, participants gave informed consent to take part in the research.

7.5 Procedure

During recruitment, the participants were told that the study was about 'how different people drive', without giving details to prevent the participants from preparing for the study. Following the initial contact with those who showed interest, emails were sent with questions such as where they obtained their licences, where they have driven and how long they have been driving. This was to double check and ascertain that the participants were eligible to participate. When appointments were confirmed, a calendar invite was sent to them with a brief explanation of the practicalities of the experiment, address, their availabilities, the information sheet (See Appendix I) and the DBQ (Appendix B). In addition to the mentioned criteria, the recruited UK drivers were required to have obtained their driving education and licence in the UK and have never driven in a developing country. The NG drivers were required to have obtained their driving education and licence in Nigeria and never driven in the UK. The NG/UK group were required to have experience of driving in both countries and be in possession of both country's driving licences.

On arrival at the driving simulator, participants were welcomed by the experimenter and taken to the briefing room. They were asked to read the information sheet again and were reminded that their participation was voluntary and their right to withdraw from the study at any point in time without giving any explanations. After reading the information sheet participants were allowed to ask any questions that they may have, then they were asked to sign the consent form (See Appendix J). A brief overview of the experiment and driving simulator was given. They were briefed on how to operate the car and that they are expected to drive as they would normally do.

Together with the experimenter, the participants performed a practice drive to become familiar with the driving simulator. The practice drive lasted a minimum of 10 minutes, but participants were free to continue driving until they felt very comfortable. The scenarios involving junctions and other vehicles in the participant trajectory were not included in the practice drives. This was to prevent participants from expecting them in the main drives. Following the practice drive, they were then given a short break during which they were monitored for any signs of motion sickness. This was done by asking them how they felt and by informing them to always let me know whenever they feel unwell during the experiment. After this, they were asked to start the main experiment. All participants completed the drives on two roads (low infrastructure and high infrastructure), each approximately 27-minute duration, separated by a short break. In addition to these, NG drivers completed a third road after the intervention.

For the two experimental drives (experiment 1 and 2), participants were asked to drive through a two-lane road into a one-lane road with slight curves, junctions and hazard conditions introduced at various points. All drives were on urban and rural roads. In experiment 1, they had to drive on roads with low or high infrastructure. In the low infrastructure experiment, participants were presented with a road environment with no traffic signs, signals and little or no marking. The high infrastructure conditions had traffic signs, traffic lights and signals added to the road environment. These were used to compare the effect of improved infrastructure and a better road environment on driving performance. For the awareness-raising intervention experiment (experiment 2), NG participants were given some basic safety awareness-raising intervention training (See section 5.4.4.2) before they completed a third drive which was the same road environment as the high infrastructure drive.

Additionally, participants submitted their DBQ which was previously sent to them before the day of the experiment. Subsequently, a debriefing took place and they had the opportunity to ask questions about the study.

The sample group for the DBQ and driving simulator experiment were the same. All participants took part in experiment 1 and completed the questionnaire while only the NG drivers took part in experiment 2.

Please note that the different conditions designed for the driving simulator experiment were:

(i) Low Infrastructure

(ii) High Infrastructure

(iii) And Training (High Infrastructure + Awareness-raising).

7.6 Analysis

This analysis is divided into two. The first deals with the DBQ and hypothesis H1. The second relates to the driving simulator experiment and is made up of two experiments- 1 and 2. Experiment 1 investigates the cross-cultural differences in driving behaviour between drivers from different cultures and investigates how changes in the road environment affect drivers' behaviour. It deals with Hypothesis H2 and H3. Experiment 2 investigates the effect of awareness-raising intervention on driving behaviour of NG drivers and deals with Hypothesis H4. These hypotheses are detailed in section 7.3.

7.6.1 DBQ

Data were analysed using the Statistical Package for the Social Science (SPSS Version 24) and Microsoft Excel (Version 2013). Before analysis, data were screened for accuracy of entry by identifying invalid or unusual cases and incorrectly entered data, For example, where the researcher entered 6 instead of 3 or 4. Overall, there were no missing data for items from the questionnaires returned.

One-way analysis of variance (ANOVA) with pairwise post hoc Bonferroni correction[5] was used to identify differences in the tendency to commit aberrant driving behaviours across the three groups. Principal component analysis (PCA) with Varimax rotation and Kaiser Normalization were performed to examine the factor structure of the DBQ among NG, NG/UK and UK drivers. Internal consistencies of each factor with percentage variance were calculated using Cronbach's alpha (α) coefficients which according to Nunally & Bernstein (1994) should be above 0.70 to reliably measure a construct. The level $p<0.05$ was considered as the cut-off value for statistical significance. The techniques used to determine the number of factors were the "eigenvalue greater than one" rule ("minigene criterion"), visual inspection of "Scree plots" and parallel analysis (Thompson and Daniel, 1996). Preliminary analyses showed that some measurements were not normally distributed but when applying PCA to summarize the relationships in a large set of observed variables (for example 40 or more), assumptions regarding the distribution of variables are not in force (Tabachnik & Fidell, 2001; Hatcher, 2003)

---

[5] To limit the analyses only the fifteen items where significant differences were found between cultures were further analysed using post hoc test with Bonferroni correction.

Principal components analysis is a data reduction procedure designed to transform and summarise a matrix of correlations into a set of orthogonal variables or a minimum number of factors for prediction purposes (Hair et al. 2006). The first component accounts for the largest proportion of variance in the original variables. Successive components account for the maximum remaining variance with the restriction that they are uncorrelated with previously extracted components. The component loadings provide guidance for the interpretation of the components. Furthermore, these components can be rotated so as to bring about “simple structure,” where items tend to load on one and only one component, facilitating easier interpretation. Rotation can either be orthogonal or oblique. Orthogonal rotations (e.g. varimax) assume that factors in the analysis are uncorrelated. In contrast, oblique rotation (e.g. Quartimax) methods assume that factors are correlated.

The suitability of the data for factor analysis was assessed prior to performing the PCA. Inspection of the correlation matrices (due to their size they are not included in the thesis) for the three groups showed that few variables (six) did not have correlations greater than 0.3, the KMO-values were all larger than 0.6 (Kaiser, 1974) and Barlett’s tests of sphericity (Norušis, 2008) were all statistically significant which showed that the data were suitable (Pallant, 2003). Responses to the 50 DBQ items were submitted to a PCA with varimax rotation, as conducted by Reason et al. (1990). The three methods (eigenvalues greater that one, Cattell’s Scree test, parallel test) for deciding on the number of factors produced slightly different results. Reason et al. (1990) reported that their DBQ yielded three components, accounting for about 33% of the total variance; violations, errors and slips/lapses. In contrast, our data initially produced an eleven, twelve and thirteen component solution with Eigenvalues greater than Kaiser (1974) criterion of >1 that explained 95%, 97% and 98% of the total variance for NG, NG/UK and UK respectively. However visual inspection of the scree plot produced a three-component solution accounting for 63% (NG), 74% (NG/UK) and 43% (UK) of the variance. The parallel test suggested four factors for the NG and three for the NG/UK and UK data. The three-factor solution seemed to be most feasible as the four-factor solution was not readily interpretable in the NG dataset. Similarly, varimax-rotation solution resulted in inconsistent loadings onto the four factors. To decide how many factors to retain, a combination of three principal criteria were used. According to Norusis (2008), the most applied rule is that each component should have at least three variables that load highly on it, the conditions of an eigenvalue (>1) and inspection of the scree plot. The cut-off value for loadings was determined as 0.60 (Comrey and Lee, 1992; Tabachnick & Fidell, 2007). Therefore Factor loadings of less than 0.60 are omitted. This was adopted because of the small sample size and following Field (2005) who advocates the suggestion of Guadagnoli & Velicer (1988) to regard a factor as reliable if it has four or more loadings of at least 0.6 regardless of sample size. Furthermore, as the purpose of each extracted factor was to exclusively quantify an underlying behaviour of each sample group, high internal consistency was imperative to confirm the reliability of results. Therefore, Cronbach's Alpha (α) was computed to determine the internal consistency of each of the three factors for different groups.

7.6.2 Driving simulator data[6]

Descriptive statistics were performed on the data for each scenario, separated by Culture, Infrastructure and intervention (training) where appropriate.

In experiment 1, a mixed methods ANOVA was performed with a between-subjects factor Culture (3 levels: NG; NG/UK; UK) and a within-subjects factor Infrastructure (2 levels: low and high). Where the assumption of sphericity was violated, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. Main and interaction effects are reported, along with post hoc tests where appropriate. Bonferroni correction was used in all post hoc tests. Statistical significance was accepted at $p < 0.05$.

For experiment 2, to evaluate the effect of the awareness-raising intervention on the behaviour of NG drivers, a separate within-subject repeated measures ANOVA was conducted with data from drive 1 and 2 (low and high infrastructure), and an additional data from drive 3 after the intervention/training. When assumptions of parametric testing were violated, non-parametric method used was the Friedmann test. Post hoc tests were with Wilcoxon signed-rank with a Bonferroni correction applied, resulting in a significance level set at $p < 0.017$ (0.05/3). The Friedmann test is appropriate because it is a non-parametric test that compares the median of the values and is more flexible in terms of data distribution (Field, 2009).

For scenarios where a traffic signal was present, analysis was conducted on data from the high infrastructure and intervention conditions only. This is because the traffic signals were required to measure behaviour at each scenario and this could not be achieved with the low infrastructure conditions because there were no traffic signals. For these scenarios, a one way ANOVA was performed, with data from the high infrastructure condition only for experiment 1 and for experiment 2, a paired sample t-tests with two conditions (high infrastructure and intervention) was used. Where the normality, homogeneity of variances, or outliers assumptions were not met, the non-parametric Kruskal-Wallis test was applied on experiment 1 and a Wilcoxon signed-rank test on experiment 2.

Where results were based on counts, Chi-square test was used to determine whether there are any associations between the variables. Post hoc tests using residual analysis

[6]Unless otherwise stated, data analysis was conducted on the low and high infrastructure conditions in experiment 1 and low, high infrastructure and training conditions in experiment 2.

were conducted on statistically significant variables to test the direction of association in each cell and to determine which cell differences contributed to the Chi-square result. The size of the standardized residuals was compared to the critical values that correspond to an alpha of 0.05 (+/- 1.96). For example, when statistically significant differences were found in the Chi-square results, the standardised residuals were further examined to identify which cells were responsible for the differences (those larger than 1.96 indicate that the observed frequency was statistically significantly different from that which would have been expected if there were no association between the variables in question).

7.7 Results

7.7.1 Principal Component Analysis of DBQ

Based on the inconsistencies in factor loading between different groups of drivers, results of the PCA were analysed and reported differently for different groups. (See Appendices Ki, Kii and Kiii for the three-factor solution of the DBQ items, Cronbach's alpha coefficients, and variance of the DBQ subscales for NG, NG/UK and UK drivers).

Results show that the three-factor solution including errors, slips/lapses, and violations was fairly stable over the three groups even though there were some inconsistencies. Alpha reliability coefficients (α) for the DBQ scales for NG, NG/UK and UK (Appendices Ki, Kii and Kiii) were overall satisfactory and in line with the conventional criteria for items to constitute a coherent scale (Nunnally, 1978; Hair et al., 1998). In all three samples, violations scale seemed to be the most internally consistent (α = 0.80–0.97) whereas the "errors" scale had the lowest alpha values (α = 0.69–0.87). DBQ Scale scores showed the highest reliability coefficients in NG and NG/UK groups.

In the NG group (Appendix Ki), the three-factor solution explained 63. % of the total variance. The first component appears to measure slips/lapses. As a single-component scale, it has considerable reliability, indicated by a Cronbach's alpha of 0.92. It included nine items of slips/lapses (S14, S10, S9, S12, S4, S15, S7, S13 and S2) and one of errors (E2). "Queuing, nearly hit car in front" (DBQ25) loaded highest on slips/lapses. The second component is a mix of Violations (V9, V14, V15, V3, and V13) and Slips/lapses (S21, S18, S19 and S20) which could be called violations. It has considerable reliability, indicated by a Cronbach's alpha of 0.91. "Fail to see pedestrians crossing" (S21) had the highest loading on this factor. The third component is a mix of slips/lapses and mistakes that could be called errors. It included four error items (E7, E8, E4 and E5) and one violation item (V16). It has considerable internal consistency, with a Cronbach's alpha of 0.87.

For the NG/UK group, the three-factor solution explained 74% of the total variance (Appendix Kii). The first component reflects violations plus five items designated as slips/lapses (S13, S19, S12, S15 and S20). Cronbach's alpha for these items is 0.97.

“Angry, give chase” V6 loaded highest on the violation component. The second and third components appear to measure slips/lapses and errors. The slips/lapses component has a Cronbach's alpha of 0.90 and included five items of slips/lapses and two items of violations (V14 and V11). “Manoeuvre without checking mirror” S18 loaded highest on this component. The errors component yielded a Cronbach's alpha of 0.82. It included three error items, one slip/lapses item (S17) and one violation item (V20). “No clear recollection of the road being travelled on” S13 loaded highest on this component.

For the UK group, the three-factor solution accounted for 43% of the total variance (Appendix Kiii). The first component reflects violations plus one item designated as an error (E6). Cronbach's alpha for these items is 0.80. “Ignore give way signs” DBQ40 had the highest loading on this component. The second and third components appear to measure error and slips/lapses. The error component has a Cronbach's alpha of 0.69 and included two items of slips/lapses (S6 and S8). “Plan route badly” E5 had the highest loading on the error component. The slips/lapses component yielded a Cronbach's alpha of 0.90 and included three items of violations (V17, V3 and UV8). “Drive wrong way down one-way street” V17 loaded highest on this component.

In summary, ANOVA was conducted to investigate the cross-cultural differences on the three factors of the DBQ. The difference between groups was statistically significant for violations (F (2, 45) = .6.96, p = .002, η^2p = .24) but not for errors (F (2, 45) = .05, p = .949, η^2p = .00) and slips/lapses (F (2, 45) = 2.13, p = .131, η^2p = .09) [Table 13]. Post hoc comparison using Bonferroni test showed that NG drivers reported more and higher frequency for violations compared to the UK drivers (1.09), p = 0.004, and NG/UK reported higher frequency of violations compared to UK drivers (.94), p = 0.01. There was no statistically significant difference between NG and NG/UK (.15), p=0.725.

Table 13: Comparison of NG, NG/UK and UK samples using ANOVA on the DBQ factors

Factors	NG	NG/UK	UK	F	*p*	*η²p*
	Mean	Mean	Mean	(2,47)		
Violations	.412	.26	.-68	6.96	**.002**	.24
Errors	-.03	.07	.-03	.05	.949	.00
Slips/lapses	-.39	.08	.31	2.13	.131	.09

7.7.2 Differences in DBQ scores

Table 14 shows the mean scores (SD) for each of the individual items relating to violations, errors and slips/lapses in the DBQ as classified by Reason et al. (1990) among drivers in the three different groups. To simplify the discussion, all violation items (aggressive and ordinary) have been grouped together and distinctions made where appropriate.

NG drivers scored highest on most violation items (nine out of twenty) with a statistically significant difference in comparison to the other two cultures on eight items (Table 14). The most common violation (V1 "*Check your speedometer and discover that you are unknowingly travelling faster than the speed limit*" was similar in NG, NG/UK and UK drivers. "*Overtake a single line of stationary or slow-moving vehicles, only to discover that they were queueing to get through a one-lane gap or roadwork lights*" (E6) was the most frequent error among NG, *"Plan your route badly, so that you meet traffic congestion you could have avoided" (E5)* was the most common error for NG/UK while *"Get into the wrong lane when approaching an intersection or roundabout" (E7)* was the most common error for UK. None of the error items was statistically significantly different between the different groups of drivers**.** ***"****Miss your exit on a motorway/highway and have to make a lengthy detour"* (S8) was the most frequent lapse among NG and NG/UK drivers while *"Fail to notice pedestrians crossing when turning into a side street from a main road" (S21)* was the most frequent lapse among UK drivers. There were statistically significant differences between groups in six items relating to slips/lapses (Table 14).

Table 14: Differences in different cultures' self-reported yearly crash involvement and tendency to commit different unsafe driving behaviours

Variables	**NG**	**NG/UK**	**UK**	**F(2,45)**	**Eta^2**
Yearly crash involvement	**1.50(1.37)** [c]	**.50(1.27)**	**.56 (.73)**	**.38***	**.14**
Violations					
V1 Unknowingly speeding (OV)	2.88(.95)	2.75(1.52)	2.31(1.14)	.92	.04
V2 Drive without papers (OV)	**1.38(1.31)** [d]	**1(1.15)**	**.13(.34)**	**6.24***	**.22**
V3 Fail to see pedestrian waiting (OV)	.88(1.03)	.94(.68)	.56(.73)	.95	.04
V4 Impatient, overtake on the inside (AV)	**2.31(1.44)** [c]	**1.31(.79)**	**1.44(1.26)**	**3.30***	**.13**
V5 Drive close to or 'flash' the car in front (AV)	**2.38 (1.41)**	**1.63(1.45)**	**.44(1.03)** [a]	**8.87***	**.28**
V6 Risky overtaking (AV)	**1.56(1.36)** [d]	**1.38(1.14)**	**.56(.63)**	**3.80***	**.14**
V7 Take a chance and run the red light (OV)	.63(.72)	.81(1.17)	.19(.40)	2.42	.09
V8 Angry, give chase (AV)	**.13(1.29)** [a]	**1.06(1.39)**	**1.06(1.38)**	**6.07***	**.21**
V9 Disregard speed at night (OV)	1.25(1.34)	1.38(1.14)	1.56(1.42)	.23	.01
V10 Drink and drive (OV)	.19(.544)	.13(.34)	.25(.57)	.25	.01
V11 Have an aversion (AV)	.50(.73)	.75(.77)	.25(.77)	1.73)	.07
V12 Illegal parking (OV)	.44(.62)	.88(.88)	.56(.89)	1.23	.05
V13 Overtake on right/left on motorway (OV)	.94(1.12)	.94(.85)	.94(1.12)	.00	.00
V14 Cut corner on a left/right-hand turn (OV)	**.94(1.12)**[d]	**.88(.72)**	**.25(.44)**	**3.51***	**.13**
V15 Fail to give way to bus (OV)	.81(1.17)	1.25(1.34)	1.19(.83)	.70	.03

V16 Ignore give-way signs (OV)	**1.00(1.32)** [d]	**.75(.78)**	**.06(.25)**	**4.72***	**.17**
V17 Drive wrong way down one-way street (OV)	**1.00(.82)** [a]	**.38(.62)**	**.19(.54)**	**6.46***	**.22**
V18 Disregard red lights when driving (OV)	.81(.98)	.81(1.38)	.25(.58)	1.59	.07
V19 Get involved in unofficial races (OV)	**.81(.98)** [d]	**.63(.81)**	**.06(.25)**	**4.37***	**.16**
V20 Race vehicles for a one-car gap (AV)	.63(.96)	.69(.79)	.13(.34)	2.74	.11
Errors					
E1 Drive as fast on low beam as on high beam	1.50(1.2)	.88(.72)	1.13(1.09)	1.50	.06
E2 Turn left/right on to vehicle's path	1.44(1.03)	.88(.89)	.88(.72)	2.14	.09
E3 Misjudge available space/gap in car park	.75(.86)	1.25(1.12)	1(.82)	1.13	.05
E4 Hit something when reversing	.94(.85)	.88(.72)	.38(.50)	3.05	.12
E5 Plan route badly	1.44(.96)	1.69(1.07)	1.25(1.24)	.64	.03
E6 Overtake queue	1.51(1.03)	1.44(1.03)	.75(.86)	2.90	.11
E7 Get into wrong lane at roundabout	1.25(1.18)	1.13(1.09)	1.69(.87)	1.25	.05
E8 Brake to quickly	.63(1.15)	.75(.78)	.38(.62)	.76	.03
E9 Misjudge crossing interval when turning right/left	.56(.73)	.88(.81)	.25(.58)	3.10	.12
Slips/lapses					
S1 Attempt to drive away in wrong gear	1.13 (1.03)	1.12 (1.24)	.88(.62)	.59	.03
S2 Locked out of car with keys inside	**.75 (1.18)** [d]	**.69(.95)**	**.12(.71)**	**3.62***	**.14**
S3 Attempt to drive off without switching on the ignition	.44(.81)	.31(.48)	.38(.70)	.12	.01
S4 Forget where car is	1.19(1.33)	.81(.91)	.75(.68)	.88	.04
S5 Distracted, have to brake hard	1.38(.81)	1.13(.89)	1.13(.50)	.59	.03
S6 Intend to switch on wipers, but switch on lights	1.56(1.15)	1.44(1.09)	.69(.95)	3.14	.12
S7 No recollection of recent road	1.19(1.17)	1.44(1.37)	1.31(.80)	.20	.01
S8 Miss exit on a motorway/highway	1.81(1.38)	2.06(.99)	1.69(.87)	.48	.02
S9 Forget which gear	1.00(1.10)	1.31(1.10)	1.50(.82)	1.01	.04
S10 On usual route by mistake	1.19(1.10)	1.75(1.07)	1.63(1.09)	1.18	.05
S11 overtake without checking mirror	**.94(1.06)**	**1(.89)**	**.13(.34)** [a]	**5.59***	**.20**
S12 Forget light on main beam	1.38(1.20)	1.44(1.31)	1.06(.68)	.53	.02
S13 Turning right/left, nearly hit cyclist/tricycle	**1.00(1.09)**	**1.13(1.03)**	**.19(.40)** [a]	**5.16***	.19
S14 Queuing, nearly hit car in front	1.19(1.17)	1.25(.86)	.69(.79)	1.67	.07

S15 Misjudge speed of oncoming vehicle	**1.31(1.01)** [d]	**1.19(.91)**	**.56(.51)**	**3.65***	.14
S16 Fail to see pedestrian stepping out	**.56(.81)**	**.94(.85)** [d]	**.25(.45)**	**3.57***	**.14**
S17 exit roundabout on the wrong lane	1.19(1.28)	1.44(1.09)	1.38(.96)	.22	.01
S18 Manoeuvre without checking mirror	1.06(1.06)	1(.73)	1(.73)	.03	.00
S19 Try to overtake vehicle turning left/right	**1(.967)**	**1.25(1.13)** [d]	**.44(.63)9**	**3.20***	**.13**
S20 Only half-an-eye on the road	1.44(1.41)	1.50(1.59)	1.94(1.39)	.55	.02
S21 Fail to see pedestrians crossing	.56(.73)	.88(.89)	.81(.66)	.75	.03

Results are based on one way ANOVA, with Bonferroni correction. All the numbers are presented as Mean (SD); **(In bold)** * statistically significantly different at 0.05%. [a] statistically significantly different from other two cultures ($p<0.05$); [b] statistically significantly different from NG ($p<0.05$); [C] statistically significantly different from NG/UK ($p<0.05$) [d] statistically significantly different from UK ($p<0.05$). V=Violations (OV-ordinary violation; AV-aggressive violation); E=Errors and S= Slips/lapses

There were significant differences between the three cultures for 15 of the 50 items. Self-reported yearly crash involvement and the statistically significant items were further analysed using post hoc test with Bonferroni correction. These fifteen items included nine violations (five ordinary and four aggressive) and six slips/lapses, but no errors. In general, NG drivers reported more crashes and a higher frequency of violations in all violation items found to be statistically significantly different than NG/UK and UK drivers while NG/UK drivers reported slips/lapses more frequently (four out of six) than did drivers from the other two cultures.

In eight out of nine statistically significant violation items, NG drivers reported the highest frequency of violation with NG/UK drivers in second place and UK drivers in a third place, except on the item “Become impatient with a slow driver in the outer lane and overtake on the inside” where UK drivers were in second place and NG/UK third place. NG drivers reported the highest frequency of ordinary violation (5 out of 5) and aggressive violations (3 out of 4). There were statistically significant differences between NG and NG/UK drivers on three items of violation (V1, V8, V17), NG and UK drivers on eight items of violation (V2, V5, V6, V8, V14, V16, V17, V19), NG/UK and UK on one item of violation (V5).

NG/UK drivers reported more slips/lapses (four out of six) compared to NG (two out of six) and UK drivers (none). There were statistically significant differences between NG and UK drivers on four items of slips/lapses (S2, S11, S13, S15), NG/UK and UK drivers on four items of slips/lapses (S11, S13, S16, S19). There were no statistically significant differences between NG and NG/UK drivers on any of the slips/lapses.

7.7.3 Experiment 1- Investigating the influence of road safety culture and road environment on driver behaviour

Results are presented for each scenario and address hypotheses H2 and H3 (see section 7.3). The means (SD) for each variable measured in each scenario and the statistically significant differences between cultures and Infrastructure conditions are shown in Appendix M (Table of Means).

7.7.3.1 Lane changing

Mean speed

There was a statistically significant main effect of Culture (F (2, 44) = 4.736, $p < .014$) on mean speed. Bonferroni pairwise comparison showed that both NG and UK drivers drove at a higher mean speed than NG/UK drivers by (5.516 mph), $p < 0.023$ and (5.038 mph), $p < 0.048$ respectively. There was no statistically significant difference between NG and UK drivers, $p = .478$ (Figure 17).

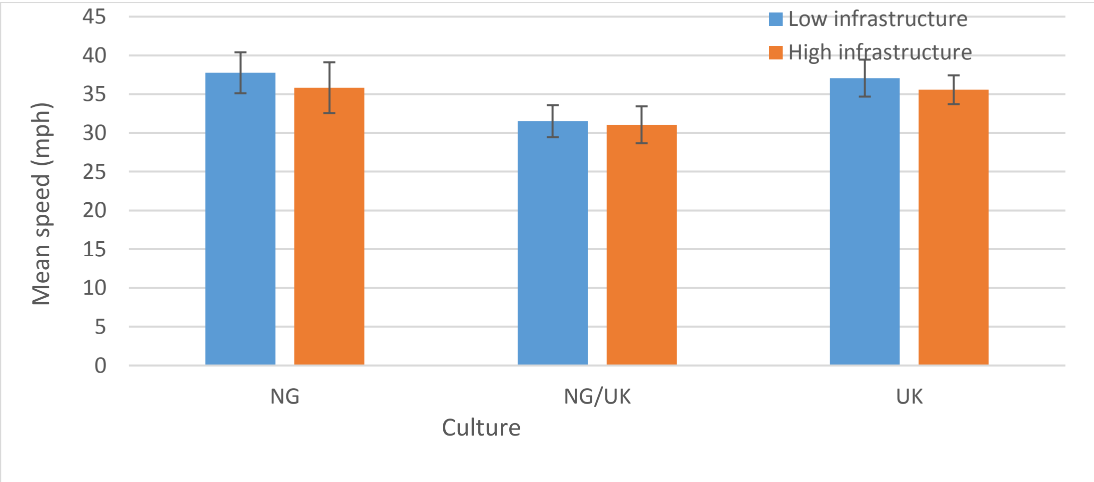


Figure 17: Effect of Culture on mean speed

There was no statistically significant main effect of Infrastructure on mean speed and no interaction between Infrastructure and Culture.

SD. of speed

There was a statistically significant main effect of Culture (F (2, 44) = 6.858, $p < .003$ on speed variation. Bonferroni pairwise comparison showed a statistically significant difference between the variation in speed of NG and NG/UK drivers (3.394), $p < 0.002$. There were no statistically significant differences between NG and UK; NG/UK and UK drivers. Figure 18 shows the speed variation of different groups of drivers for different Infrastructure conditions.

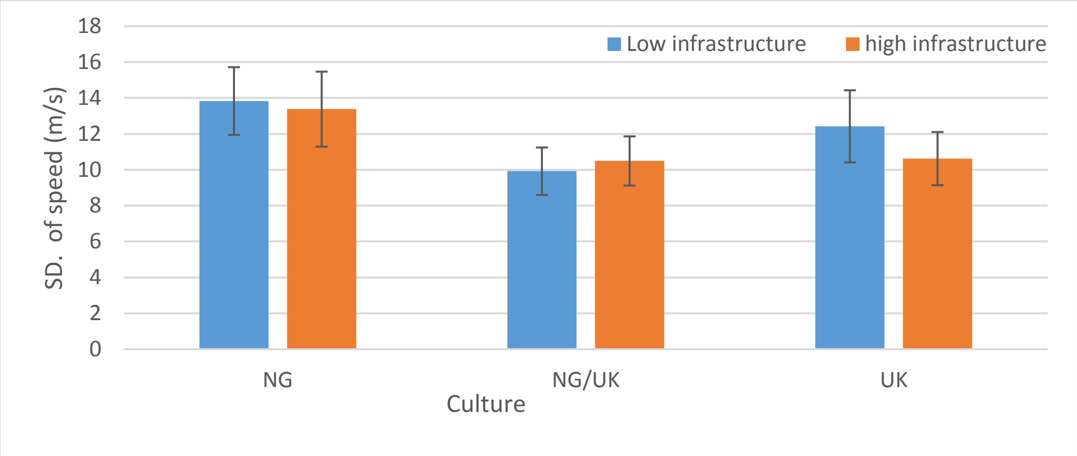


Figure 18: Effect of Culture on variation in speed

There was no statistically significant effect of Infrastructure in speed variation and no interaction between Infrastructure and Culture.

Mean acceleration

There was a statistically significant main effect of Culture (F (2, 44) = 3.458, *p* < .040 on mean acceleration with NG, NG/UK and UK drivers all performing differently overall. Bonferroni pairwise comparison showed a statistically significant difference between the variation in acceleration of NG and NG/UK drivers (.105), *p* < 0.036. There were no statistically significant differences between NG and UK; NG/UK and UK drivers (Figure 19).

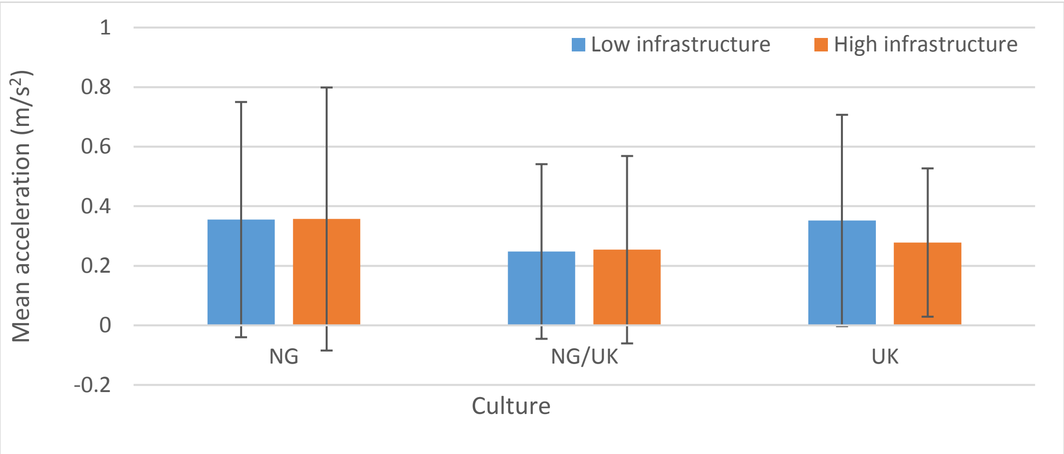


Figure 19: Effect of Culture on mean acceleration

There was no statistically significant effect of Infrastructure on mean acceleration and no interaction between Infrastructure and Culture.

There were no statistically significant main effects of Culture in SD. of acceleration and indicator use and no interaction between the conditions. In addition, results for time headway, TTC and distance tail way for those who completed overtaking did not reveal any statistically significant Cultural and Infrastructural differences. Similarly, there were no interactions between Infrastructure and Culture.

7.7.3.2 Amber dilemma (high infrastructure only)

There were no main effects of Culture on the variables measured in the amber dilemma scenario.

7.7.3.3 Acceleration (high infrastructure only)

(a) Deceleration to red light

In this scenario, drivers had extended preview of the red traffic light, the speed profiles in Figure 20 suggest that the participants began to decelerate as they approached the junction and in a steep manner. On approaching the junction, all participants reduced their mean speed and this was the same between groups as no statistically significant main effects of Culture were found. The stop-line speed is not zero at zero distance because of the coarse scale used to plot the X-axis.

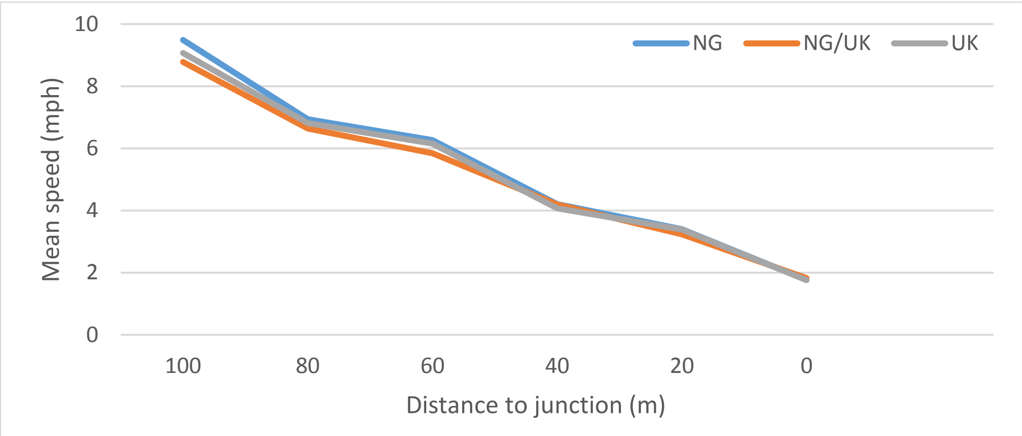


Figure 20: Speed profile for different Cultures

On the other hand, there was a main effect of Culture on variation in deceleration [F (2, 45) = 6.804, *p* = .003]. Post-hoc testing revealed that with -0.324 m/s2, it was statistically significantly lower in the UK group compared to the NG group (Figure 21). No statistically significant differences were found between NG and NG/UK or NG/UK and UK drivers.

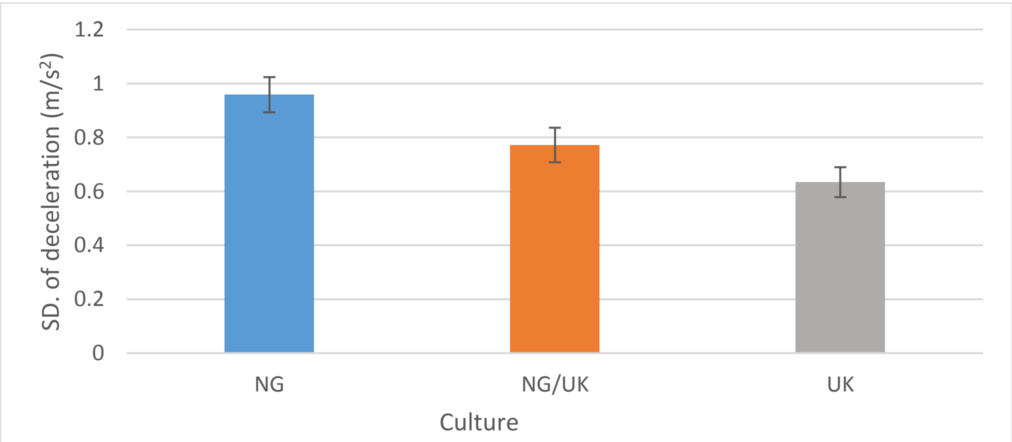


Figure 21: Effect of Culture on SD. of deceleration

No statistically significant main effects were found for mean deceleration and maximum brake pressure.

(b) **Anticipatory behaviour**

To measure anticipatory behaviour, counts of the number of drivers in each group who accelerated (moved) during the 45 seconds waiting period was noted (see Table 8). Results showed that 63% of NG, 38% of NG/UK and 31% of UK drivers moved during this period. A Kruskal-Wallis test provided strong evidence of a statistically significant difference (X^2 (2) = 6.693, p = 0.035, ϕ = .80) in the distance covered by the three groups (Figure 22). Dunn's pairwise tests were carried out on the three groups revealed that there were differences (p = 0.030, adjusted using the Bonferroni correction) between the NG and UK and the NG and NG/UK groups. The median distance covered during the 45 seconds waiting time for the NG group was 14.11 metres compared to 6.67 metres and 4.17 metres for the NG/UK and UK groups respectively. There was no evidence of a difference between the NG/UK and UK groups. The result showed NG drivers to be more impatient compared to the other groups.

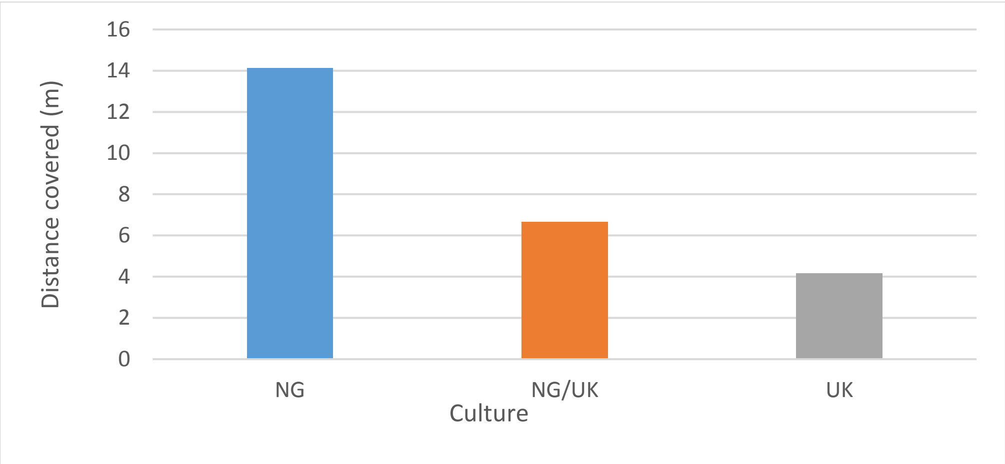


Figure 22: Effect of Culture on distance covered in 45 seconds

(c) Acceleration away from red light

Figure 23 shows the speed profiles of different groups of drivers in the acceleration away from red light. It shows that the UK group maintained the lowest speed in this scenario. NG group was the first to accelerate to the speed limit of 30 mph at a distance of about 130m from the junction while NG/UK drivers accelerated to the speed limit at a distance of about 220m from the junction respectively. UK drivers did not accelerate to the speed limit in this scenario.

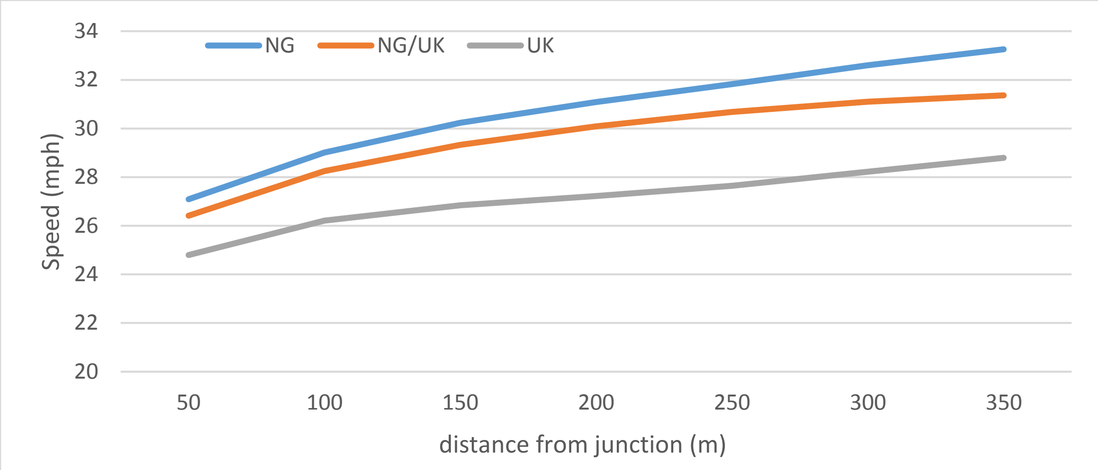


Figure 23: Speed profile of different Cultures

There was a main effect of Culture on mean acceleration [F (2, 45) =8.067, *p* = 0.001]. Post hoc comparisons revealed that there was a statistically significant difference between NG and NG/UK (*p* = 0.002) with NG accelerating more harshly on average 0.1904 m/s^2 than NG/UK drivers. There was a statistically significant difference between NG and UK (*p* = 0.006) with NG accelerating more harshly than UK drivers (Figure 24). There was no statistically significant difference between NG/UK and UK drivers (p=.896).

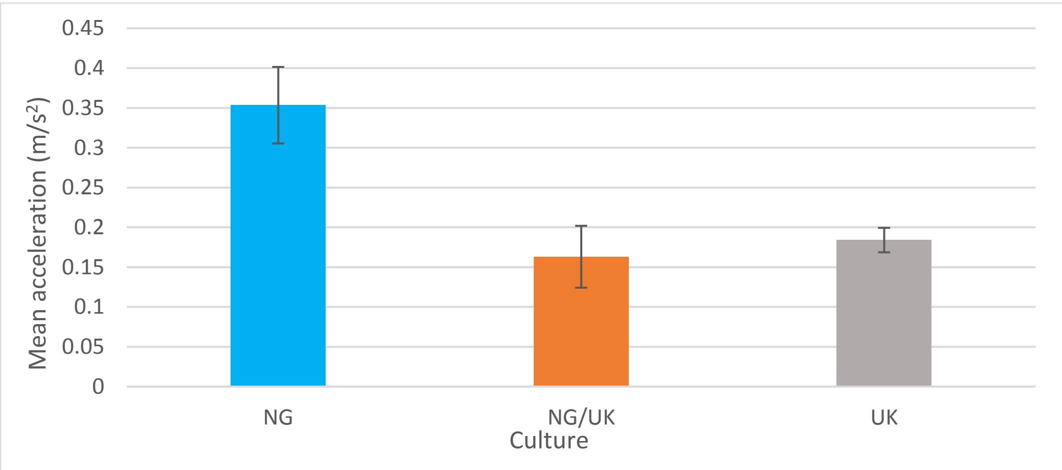


Figure 24: Effect of Culture on mean acceleration

There was a main effect of Culture on time to accelerate to speed limit [F (2, 45) = 12.335 *p* < .001]. Post hoc comparisons showed statistically significant differences between groups (Figure 25). NG drivers accelerated to the speed limit faster than the NG/UK (p= .002) and UK drivers (p < .000) by 10 and 13 secs respectively. There were no statistically significant differences between NG/UK and UK drivers (p = .843).

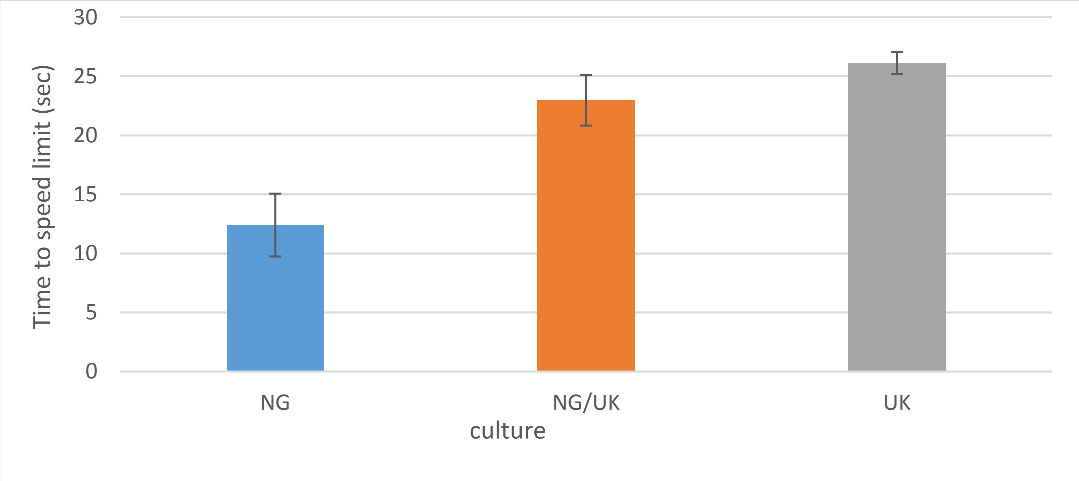


Figure 25: Effect of Culture on time to accelerate to the speed limit

7.7.3.4 Speed choice

In this scenario, participants were provided with two conditions- low infrastructure and high infrastructure. In the high infrastructure condition, there were traffic signs and signals with speed signs displayed in miles per hour while there were none in the low infrastructure condition. Participants were required to drive from a 30 mph (48.3 kilometres per hour) road to a 60 mph (96.6 kilometres per hour) road. Figure 26 shows the speed profiles for different groups in different conditions.

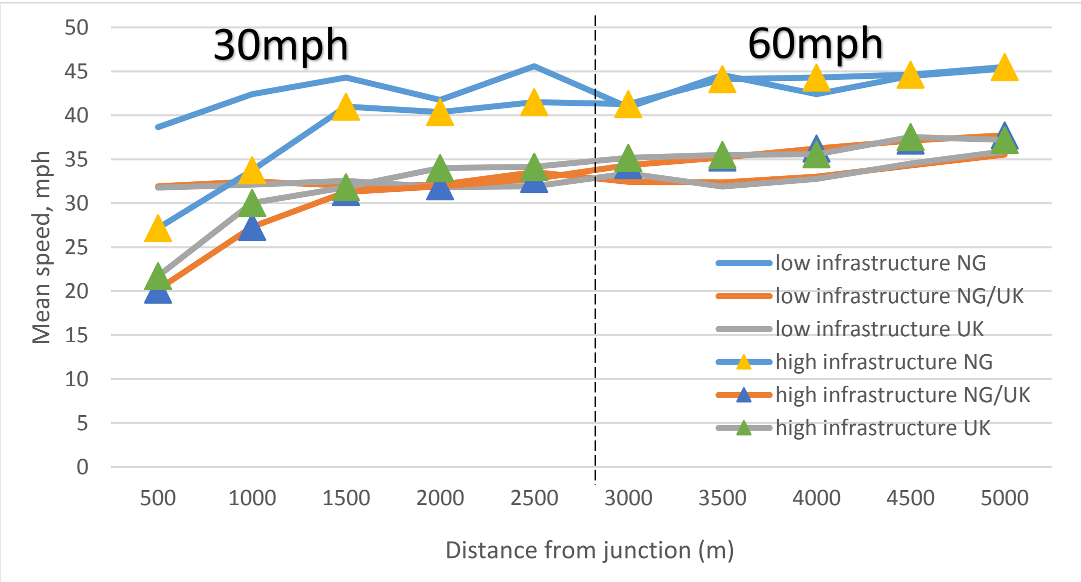


Figure 26: Speed profile for different Cultures in different infrastructure scenario

Mean speed

There was a statistically significant main effect of Culture [F (2, 90) = 9.420, $p < .001$, $\eta p^2 = .173$] on mean speed (Figure 27). Bonferroni pairwise comparison showed that NG drivers drove at a higher mean speed than NG/UK drivers (7.398 mph), $p < 0.001$ and UK drivers (4.28 mph), $p = 0.043$. There was no statistically significant difference between NG/UK and UK drivers (3.117), $p = .216$.

There was no statistically significant main effect of Infrastructure on mean speed (F (1, 90) = .464, p = .497, ηp^2 =.005). Participants in different groups recorded similar mean speeds in the different infrastructure conditions.

There was a statistically significant interaction between Culture and speed limit (F (2, 90) = 5.454, p =.006, ηp^2=.108). This showed that participants in different groups drove at different speeds under different speed limits and shows that the different speed limits affected driver speed.

There were no statistically significant interactions between Culture and Infrastructure or speed limit and infrastructure.

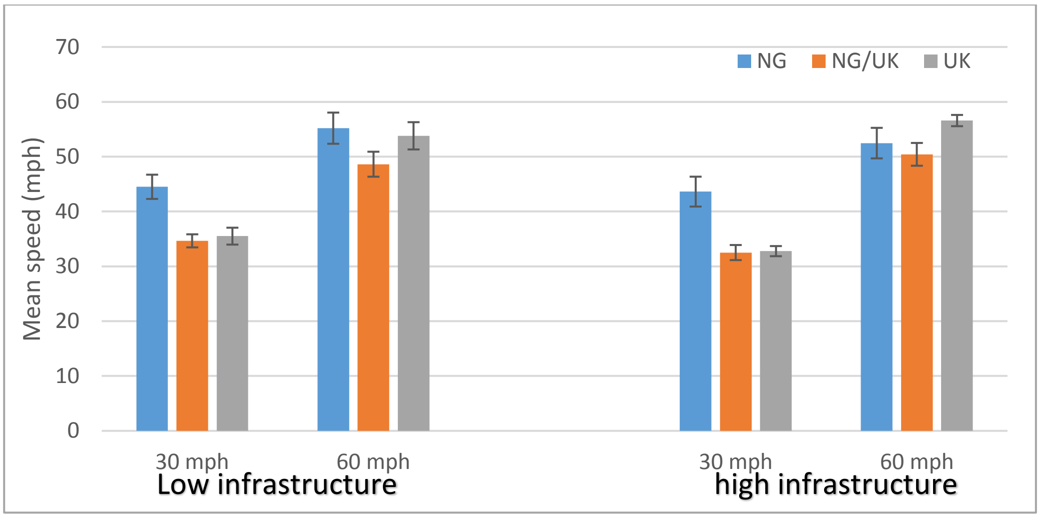


Figure 27: Effect of Culture on mean speed for different Infrastructure conditions

Standard deviation of speed

There were no statistically significant main effects of Culture and Infrastructure on SD of speed.

On the contrary, there was a statistically significant main effect of speed limits (30 mph & 60 mph) on SD of speed (F (1, 90) = 9.485, p = .003, ηp^2 =.095) with participants SD for 30mph (5.19) and 60mph (6.62) being different. Pairwise comparison showed that variation in speed increased in the 60 mph by 1.432 m/s^2.

There was a statistically significant interaction between speed limits and Infrastructure (F (1, 90) = 53.504, p < .001, ηp^2 =.373) with 30 mph (low infrastructure: 7.087 m/s^2; high infrastructure: 3.284 m/s2) and 60 mph (low infrastructure: 5.408 m/s^2; high infrastructure: 7.827m/s^2), Figure 28.

There were no statistically significant interactions between Infrastructure and Culture or Culture and speed limits.

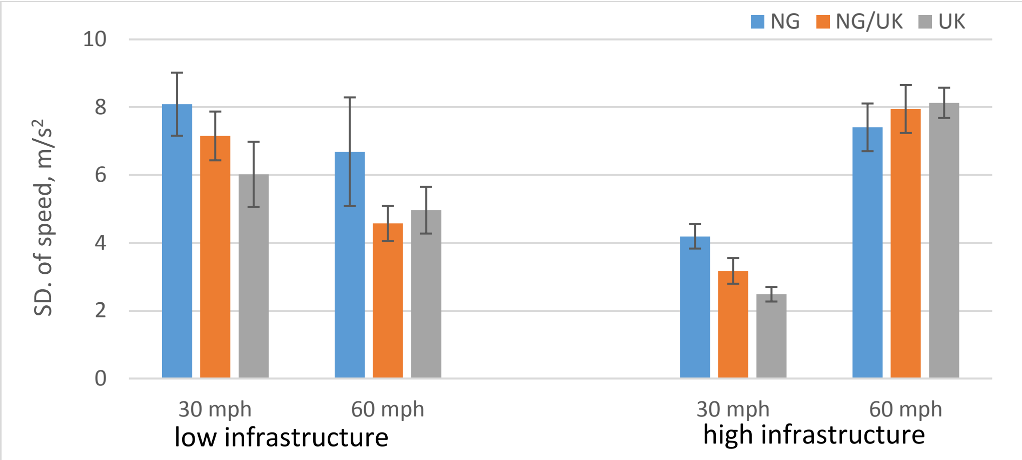


Figure 28: Interaction between speed limit and different Infrastructure conditions

Speed limit exceedance

There was a statistically significant main effect of Culture (F (2, 90) = 3.781, $p < .026$, $\eta p^2 = .078$) on speed limit exceedance, Figure 29. Post hoc comparison showed that NG drivers exceeded the speed limits by 15.43%, *p*= 0.032 more compared to the NG/UK drivers. There were no statistically significant differences between either NG and UK drivers or NG/UK and UK drivers.

There was a statistically significant main effect of speed limit (F (1, 90) = 108.442, $p < .001$, $\eta p^2 = .546$) on speed limit exceedance. Bonferroni pairwise comparison showed that speed limit exceedance was higher in the 30mph compared to the 60 mph by about 50%, $p < .001$.

In contrast, there was no statistically significant main effect of Infrastructure on speed limit exceedance.

There were no statistically significant interactions between Culture and speed limit, Culture and Infrastructure and Infrastructure and speed limit.

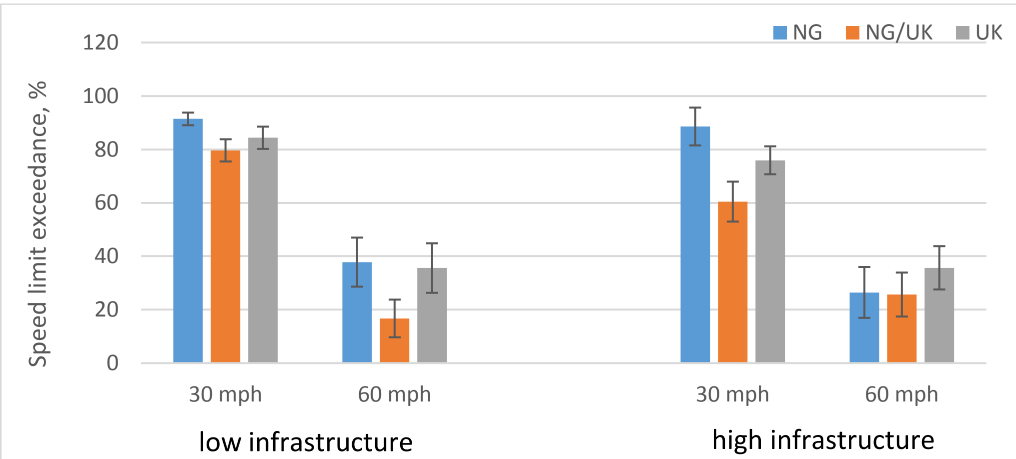


Figure 29: Effect of Culture on speed limit exceedance for different Infrastructure conditions

Spot speed
This speed was measured midway into the drives for the different speed limits (30mph & 60mph) and at about 100m after a junction.

There was a statistically significant main effect of Culture (F (2, 89) = 7.880, *p* = .001) on spot speed as depicted in Figure 30. Bonferroni pairwise comparison showed that the spot speed of NG drivers was higher than that of NG/UK drivers (7.728), *p* < 0.001. There were no statistically significant differences between NG and UK drivers and NG/UK and UK drivers.

There was a statistically significant main effect of speed limit (F (1, 89) = 147.461, *p* < .001) on spot speed. Bonferroni pairwise comparison showed that spot speed was higher at 60mph compared to 30mph (by 19mph), *p* < .001.

In contrast, there was no statistically significant main effect of Infrastructure on spot speed of different groups.

There was a statistically significant interaction between Culture and speed limit (F (2, 89) = 4.466, *p* =.014). This showed that participants in different groups tend to drive at different speeds under different speed limits and shows that the different speed limits affected driver speed.

There were no statistically significant interactions between Culture and Infrastructure or speed limit and Infrastructure.

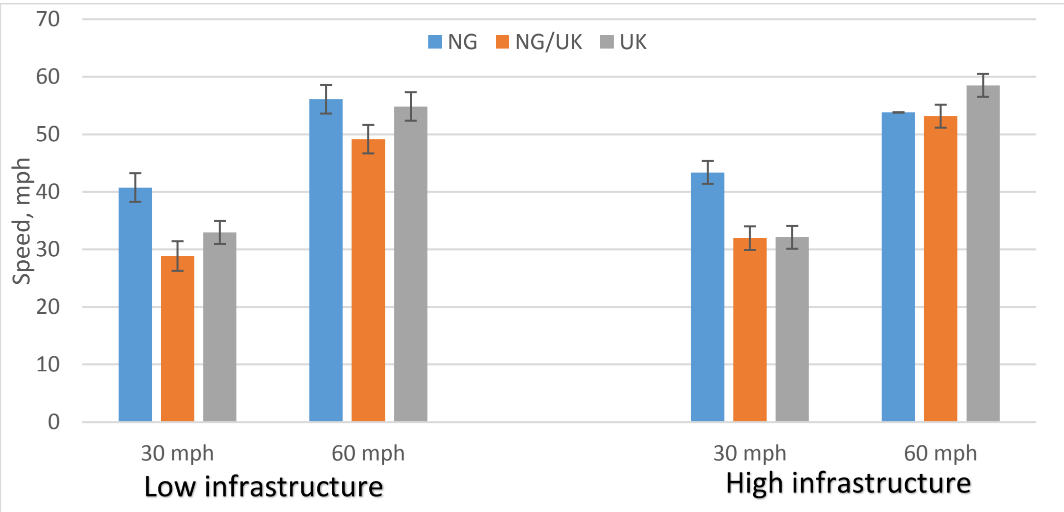


Figure 30: Effect of Culture on spot speed for different Infrastructure conditions

7.7.3.5 Green lights (high Infrastructure only)

There was a statistically significant main effect of Culture [F (2, 45) = 6.393, *p* = 0.004] on mean speed, Figure 31. Bonferroni test revealed that NG drivers drove at a higher mean speed than NG/UK drivers (8.31 mph), *p* = 0.004 and UK drivers (6.55 mph), *p* = 0.031. There was no statistically significant difference between NG/UK and UK drivers.

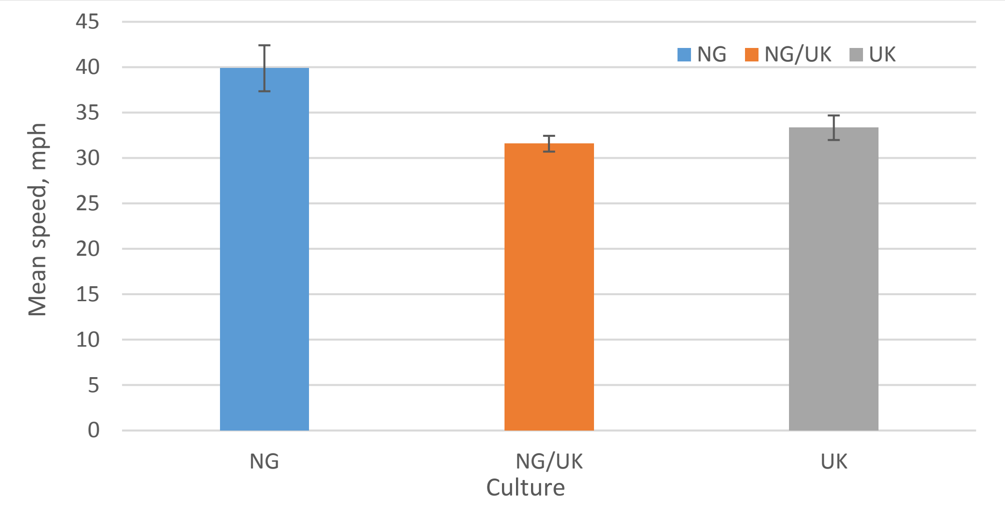


Figure 31: Effect of Culture on mean speed

There was a statistically significant main effect of Culture on the SD. of deceleration [F (2, 45) = 4.619, *p* = 0.015] as illustrated in Figure 32. Post hoc test showed that the variation in deceleration of NG drivers was higher than the UK group (0.2240 m/s^2), *p=.021.* There were no statistically significant differences in SD. of deceleration between NG and NG/UK or NG/UK and UK.

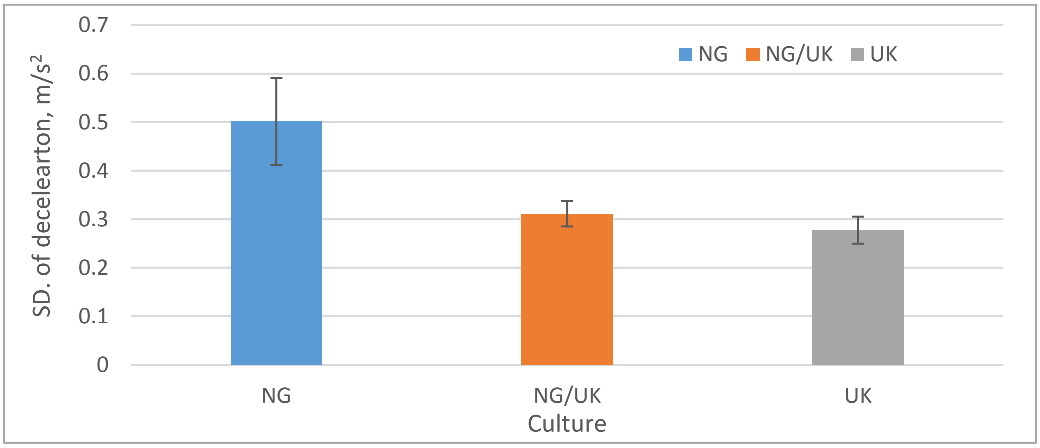


Figure 32: Effect of Culture on SD. of deceleration

There were no main effects of Culture on mean deceleration, maximum deceleration and minimum speed in this scenario.

7.7.3.6 Car cutting 1

There were no main effects of Culture or Infrastructure and no interactions between the conditions (Culture and Infrastructure) in the variables measured in car cutting 1.

7.7.3.7 Car crossing

(i) Speed profile

The speed profile for the different groups of drivers is shown in Figure 33. NG drivers started reducing their speed earlier (about 50m to the junction) on approaching the junction compared to the NG/UK (20m) and UK (20m) drivers because they were driving fast.

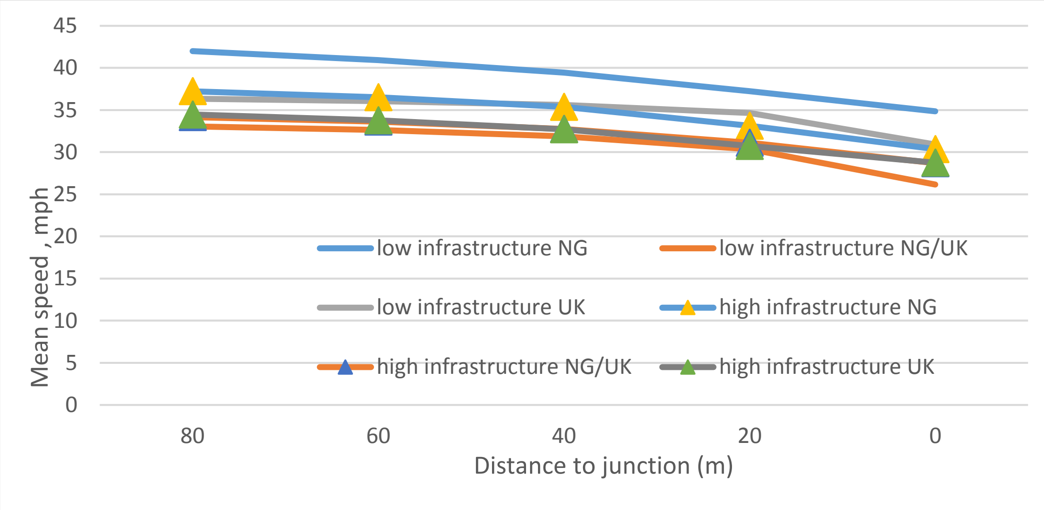


Figure 33: Speed profile of different cultures in different Infrastructure conditions

(ii) **Time to collision with crossing car**

There was a statistically significant main effect of Culture on TTC [(F (2, 45) = 4.723, *p* =.014], Figure 34. Bonferroni pairwise comparison showed that the TTC of NG drivers was lower than that of the NG/UK drivers by .77 seconds, *p* = .013. There were no statistically significant differences between the UK and NG/UK drivers or NG and UK drivers.

There were no main effects of Infrastructure on TTC and no interaction between Infrastructure and Culture.

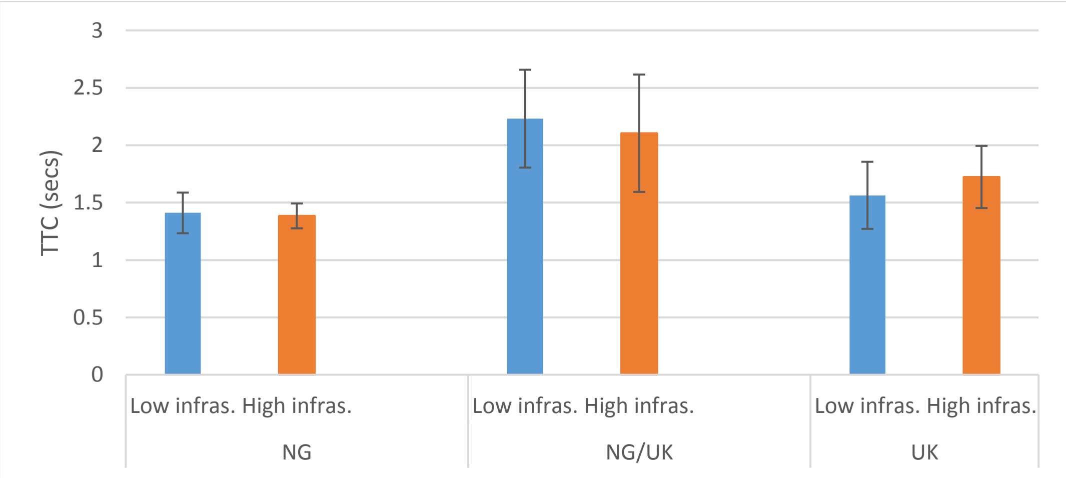


Figure 34: Effect of Culture on TTC with crossing car in different Infrastructure conditions

(iii) Spot speed and BRT at TTC = 3secs.

There was a statistically significant main effect of Culture on spot speed [(F (2, 18) = 6.598, p = .007, n_p^2 = .423] and BRT [(F (2, 18) = 6.317, p = .008, n_p^2 = .412] as shown in Figure 35. Bonferroni pairwise comparison showed that the speed of NG drivers was higher than that of the NG/UK drivers by 10.2mph, *p* = .020 and UK drivers by 10.7mph, *p* = .014. In addition, there was a statistically significant main effect of culture on BRT. It took NG drivers a longer time to react to the hazard (the crossing car, Table 8) compared with NG/UK (*p* = .026) and UK (*p* = .015) drivers (Figure 35). There were no statistically significant differences between UK and NG/UK drivers or NG and UK drivers

There was no statistically significant main effect of Infrastructure on spot speed and no interaction between Infrastructure and Culture of participants.

Note: in analysing the BRT, only participants' first drives were included, this was because participants may become more cautious and would expect the hazard in the second drive (i.e. the hazard will no longer be a surprise in the second drive).

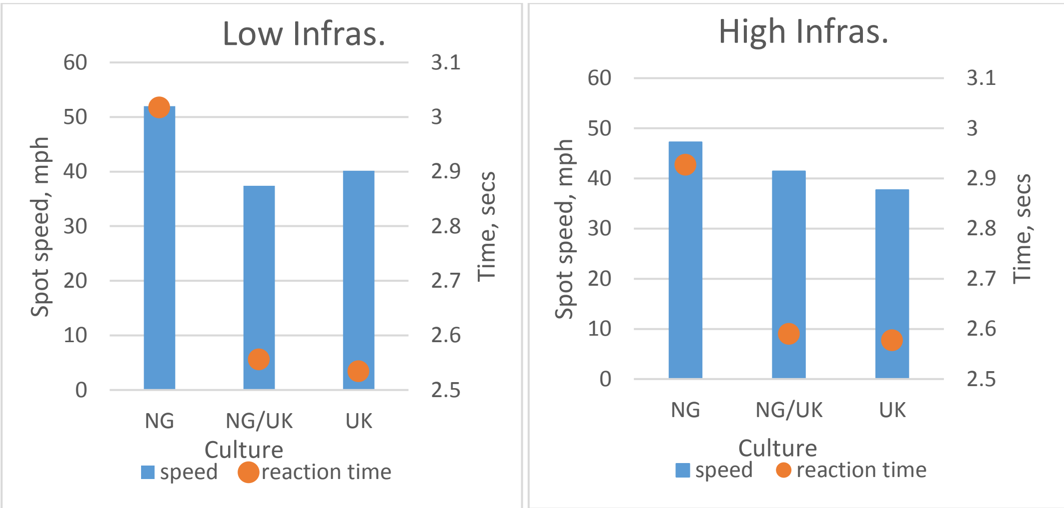


Figure 35: Effect of Culture on spot speed and BRT for different Infrastructure conditions

There were no main effects of Culture or Infrastructure on mean speed, mean deceleration, SD. of deceleration and max. brake depression in this scenario. In addition, there were no interactions between Culture and Infrastructure.

7.7.3.8 Car cutting 2

There were no main effects of Culture or Infrastructure and no interactions between the conditions (Culture and Infrastructure) in the variables measured in car cutting 2.

7.7.3.9 Overtaking

The total number of [7]attempts at overtaking (successful and aborted) for the different groups is shown in Figure 36. The result reveals a tendency among the NG drivers towards performing overtaking as they made more attempts at overtaking compared

[7] This could only be achieved with the difficult overtaking scenario

to NG/UK and UK drivers. In general, the NG/UK drivers displayed a considerable difference in tendency to perform overtaking compared with the other groups.

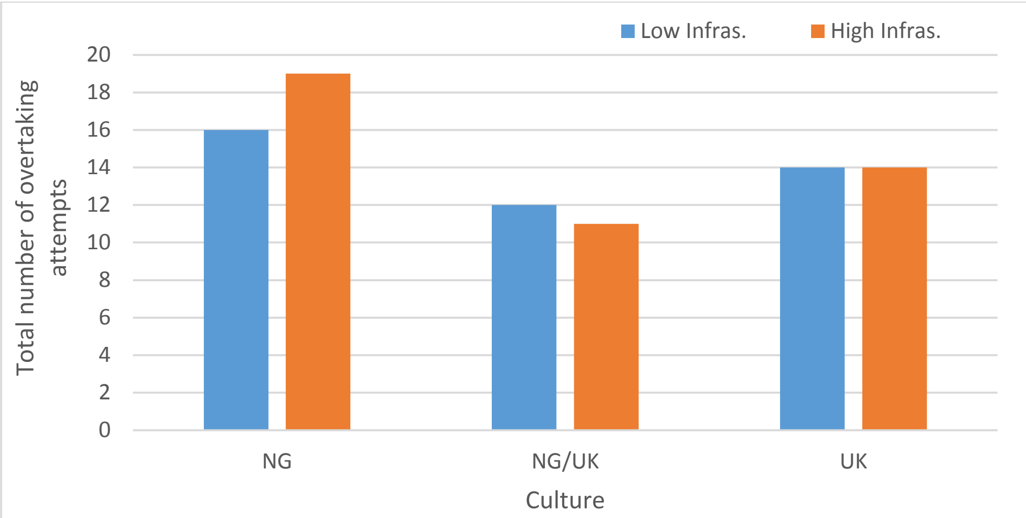


Figure 36: Effect of Culture on total number of overtaking attempts

(ii) The number of successful overtaking manoeuvres by different groups of drivers are presented

The data presented provides confirmation that drivers were able to discern differences in the difficulty of the overtaking scenarios. More successful overtaking manoeuvres among the NG/UK and UK drivers were performed during the easy overtaking scenario. Overtaking outcome was the same for NG drivers in the easy and difficult overtaking scenarios. NG drivers had the highest number of successful overtaking in the difficult overtaking scenario (Figure 37).

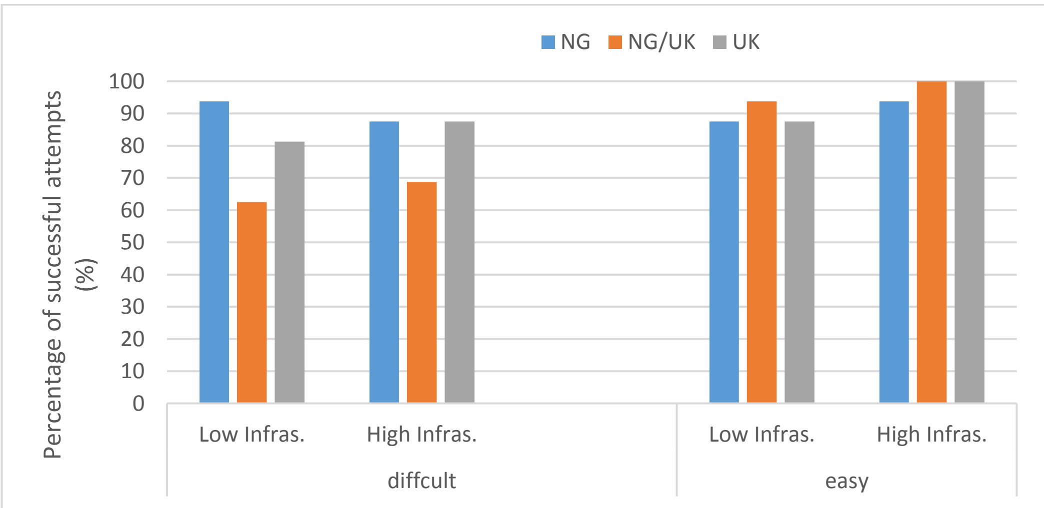


Figure 37: Effect of Culture on percentage of successful Overtaking for different Infrastructure conditions

(iv) Overtaking safety (start of overtaking)

Time headway (difficult overtaking)

For the difficult overtaking scenario, there was a statistically significant main effect of Culture on time headway at the start of overtaking [F (2, 30) =4.445, p= 0.020]. Bonferroni pairwise comparison showed that there was a statistically significant difference between the time headway of NG drivers and UK drivers (p= .018). There were no statistically significant differences between the time headway of NG and NG/UK or NG/UK and UK drivers, Figure 38.

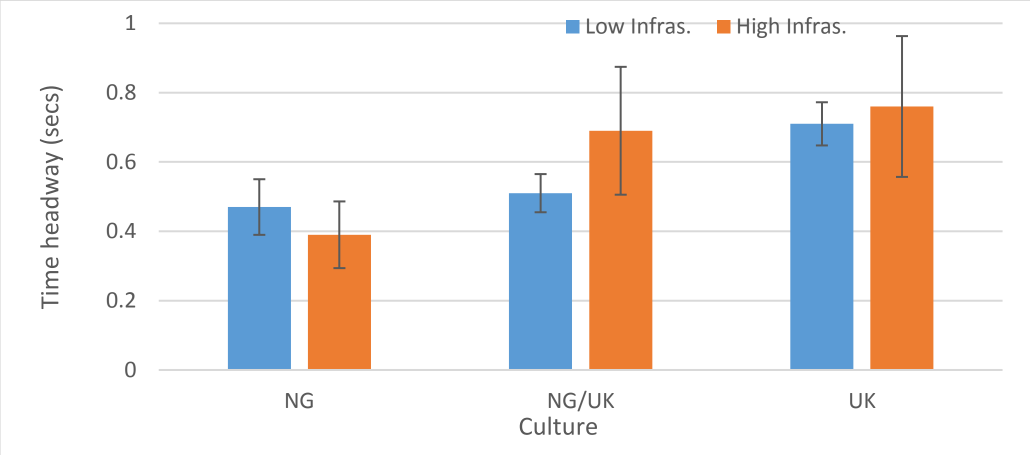


Figure 38: Effect of Culture on time headway for different Infrastructure conditions

On the other hand, there was no main effect of Infrastructure on time headway.

There was an interaction effect between Culture and Infrastructure [F (2, 30) =4.747, p= 0.016]. This shows that different infrastructure conditions affected the time headway of drivers from different cultures.

Analysis of the easy overtaking scenario did not show any statistically significant differences and interactions.

(v) During Overtaking (while in the opposite lane and passing the slow-moving car)[8]

- Overtaking duration: Time spent completing the overtaking manoeuvre

There were no statistically significant main effects of Culture and Infrastructure and no interactions between the conditions on overtaking duration for both the difficult and easy overtaking scenarios.

---

[8] In order to avoid possible errors in this section, only participants that completed the overtaking task were included in this analysis.

- Maximum speed reached during the overtaking manoeuvre

For the difficult overtaking scenario, there was a statistically significant main effect of Culture on maximum speed reached during overtaking [F (2, 31) =4.733, p= 0.016]. The maximum speed among UK drivers was greater than that of NG/UK and NG drivers. Bonferroni pairwise comparison showed that there was a statistically significant difference between the maximum speed of UK and NG drivers (5.958), p=.013, Figure 39.

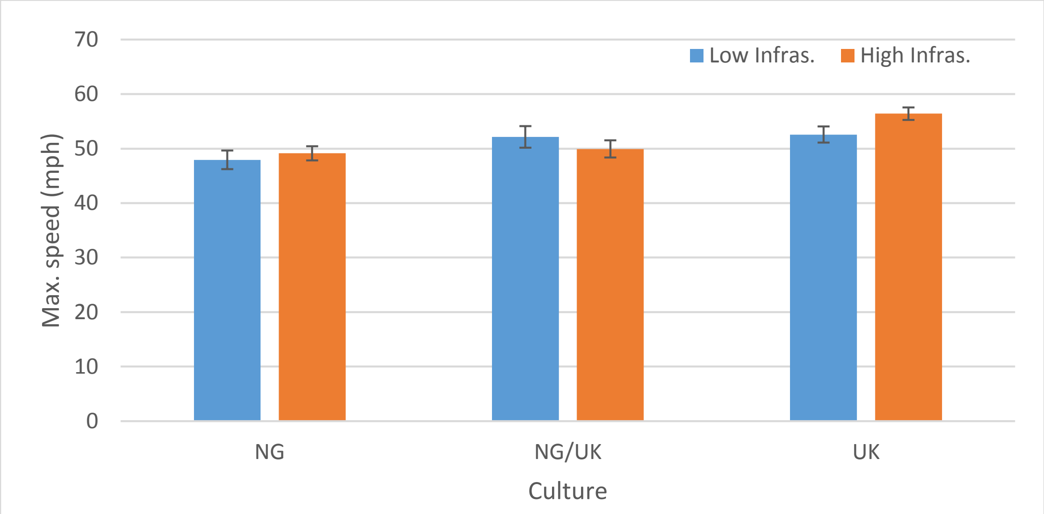


Figure 39: Effect of Culture on maximum speed for different Infrastructure condition for difficult overtaking

For the easy overtaking scenario, results showed that there was a statistically significant main effect of Culture on maximum speed reached during overtaking [F (2, 35) =3.329, p= 0.047], Figure 40. The maximum speed of UK drivers was greater than that of NG/UK and NG drivers. Bonferroni pairwise comparison showed that there was a statistically significant difference between the maximum speed of UK and NG drivers (4.861), p=.049.

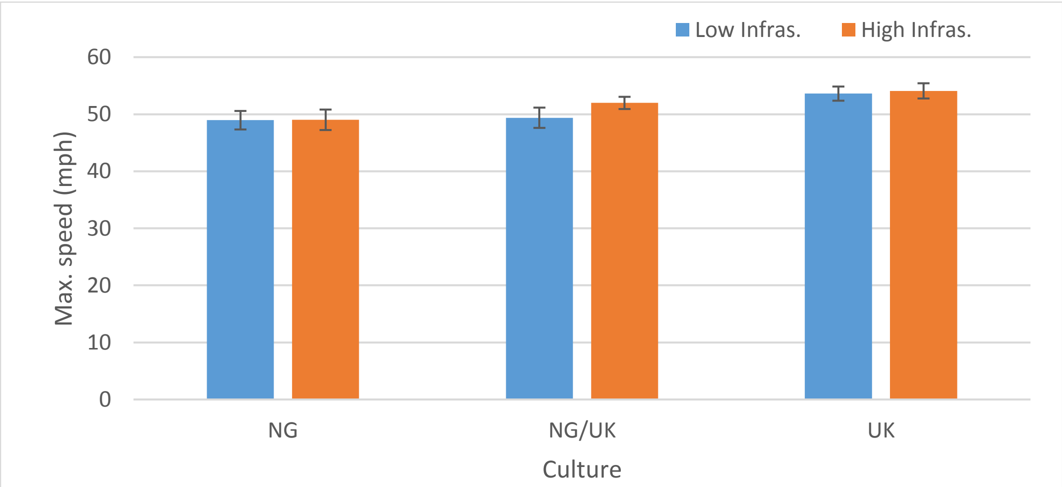


Figure 40: Effect of Culture on maximum speed for different Infrastructure conditions in the easy overtaking

Results for the difficult and easy overtaking scenarios showed no statistically significant main effect of Infrastructure on maximum speed reached during overtaking.

Similarly, there were no interaction effects between Culture and Infrastructure for both overtaking scenarios.

(vi) End of overtaking- Last moment that the centre of the vehicle is in the opposite lane.

- Time headway with the oncoming vehicle (difficult overtaking scenario only)

There was no statistically significant main effect of Culture or Infrastructure and no interactions between the conditions on time headway at the end of overtaking.

- Distance tail way with the slow-moving vehicle (This provided a measure of how sharply a driver pulled back in front of the lead vehicle)

For the difficult overtaking scenario, there was a statistically significant main effect of Culture on distance tailway [F (2, 30) = 7.380, p= 0.002] as NG drivers cut in more sharply, Figure 41. The tailway for UK drivers (mean=25.485) was greater than that of NG/UK and NG drivers. Bonferroni pairwise comparison showed that there was a statistically significant difference between the tailway of UK and NG drivers (10.947), p=.002.

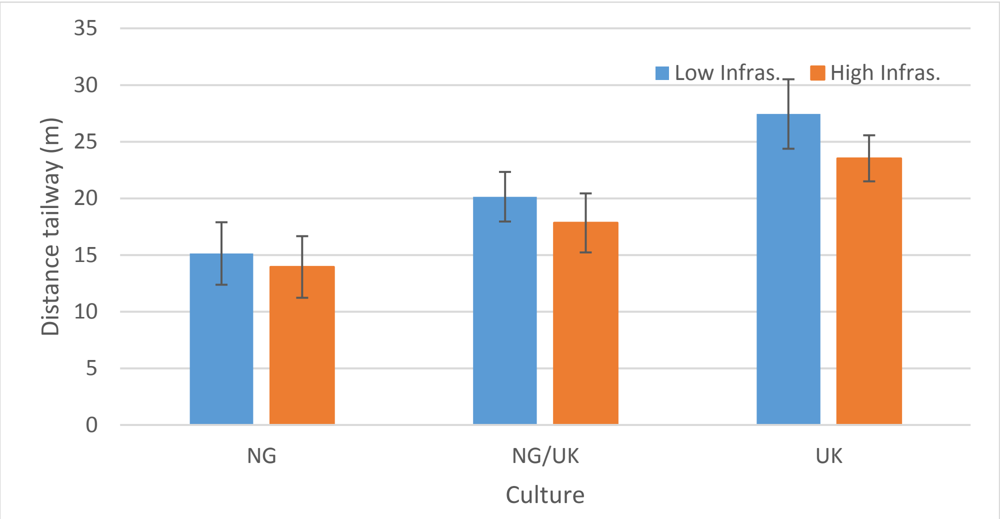


Figure 41:Effect of Culture on distance tailway for different Infrastructure conditions in the difficult Overtaking

There was no main effect of Infrastructure on tailway and no interaction between Infrastructure and Culture.

Analysis of the easy overtaking scenario showed that there was a statistically significant main effect of Culture on distance tailway (F (2, 35) = 5.397, p= 0.009). The tailway for UK drivers was greater than that of NG/UK and NG drivers. Bonferroni pairwise comparison showed that there was a statistically significant difference between the tailway of UK and NG drivers (12.747), p=.007 (Figure 42).

On the other hand, there was no main effect of Infrastructure on tailway and no interaction between Infrastructure and Culture.

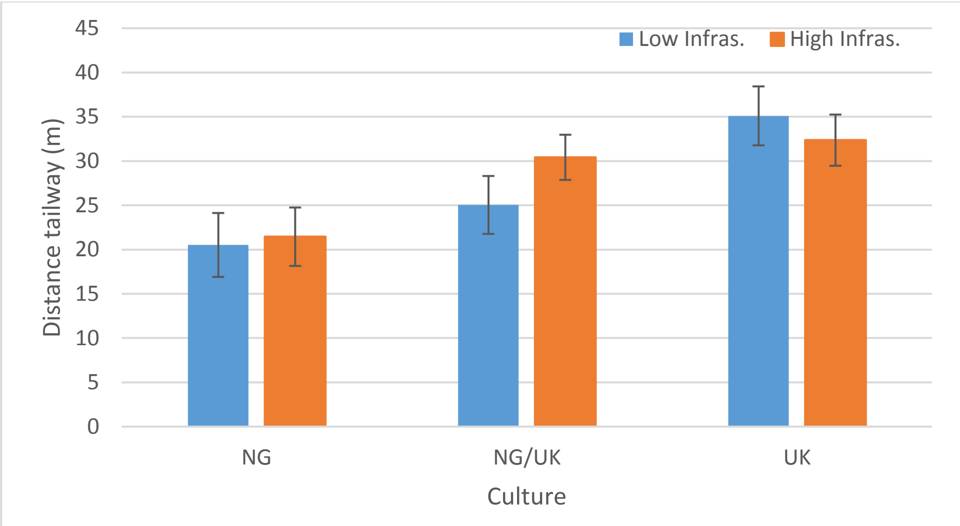


Figure 42: Effect of Culture on distance tailway for different Infrastructure conditions in the easy overtaking

7.7.3.10 Compliance with road markings

In the high infrastructure scenario, there was a prohibition sign showing that drivers are not permitted to cross which was placed about 110km before the road marking but there was none in the low infrastructure condition.

Decision to cross

Participants' decision to cross or not to cross the double white lines was examined based on counts (Figure 43). The results were binary because either participant crossed or did not cross. Consequently, Chi-square test was used to analyse the data. Results revealed a statistically significant association between Culture and crossing violations for the low infrastructure ($\chi2= 7.807$, $p= .020$) and high Infrastructure ($\chi2= 13.844$, $p= .001$) conditions. Post hoc test using standard residuals showed that among drivers who violated the traffic rule, there were more NG drivers than would be expected for the low Infrastructure (3.7) and high Infrastructure (5.3) conditions respectively.

In addition, results for mean time headway and minimum TTC for those who violated the no crossing rule for different Infrastructure conditions did not reveal any statistically significant effects or interactions.

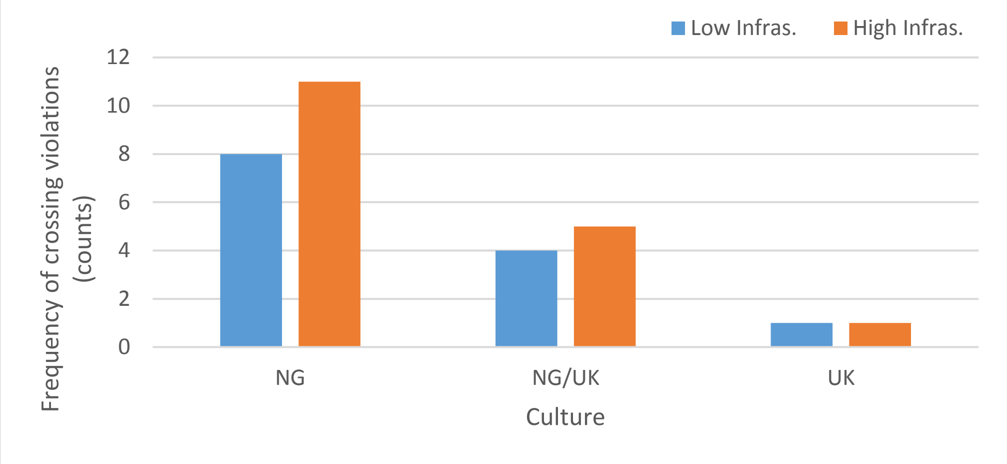


Figure 43: Effect of Culture on number of participants who crossed the double solid white line under different infrastructure conditions

SD. of speed

There was a statistically significant main effect of Culture [F (2, 45) = 4.947, $p < .011$, $\eta p^2 = .180$] on speed variation, Figure 44. Bonferroni pairwise comparison showed a statistically significant difference between the variation in speed of NG and UK drivers (2.863), $p < 0.009$. There were no statistically significant differences between NG and NG/UK and NG/UK and UK drivers.

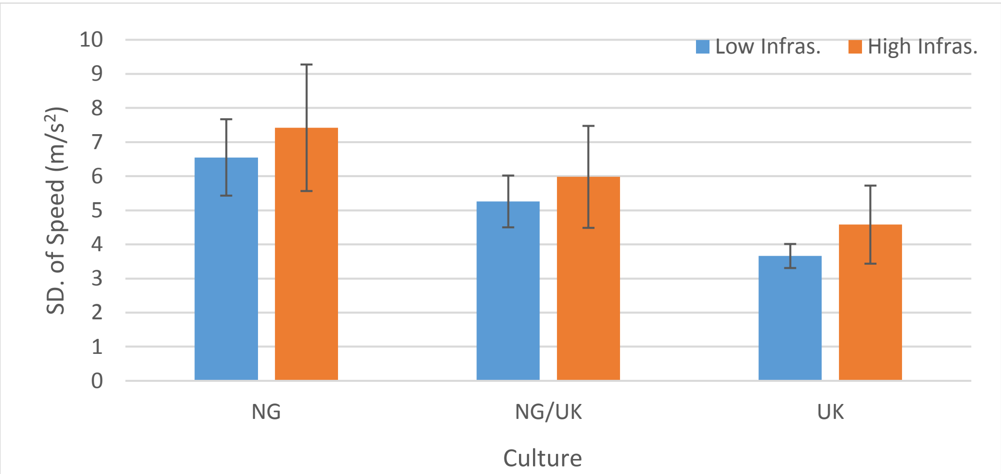


Figure 44: Effect of Culture on speed variation

There was no statistically significant main effect of Infrastructure on SD of speed and no interaction between Infrastructure and Culture.

There were no statistically significant effects of culture and infrastructure in the mean speed, mean acceleration and SD. of acceleration.

7.7.4 Experiment 2- Effect of awareness-raising intervention on drivers' behaviour (NG drivers only)

Results are presented according to scenarios and each scenario address hypothesis H4 (see section 7.3). The means (SD) for each variable measured in each scenario and the significant differences between different intervention conditions are shown in Appendix L (Table of Means).

7.7.4.1 Lane changing

There were no main effects of Intervention in the lane changing scenario.

There were no main statistically significant effects of intervention in mean speed, SD. of speed, mean acceleration and SD. of acceleration**.** In addition, results for time headway, TTC_{min} and minimum distance tailway for those who completed overtaking did not reveal any statistically significant differences.

7.7.4.2 Amber dilemma (high Infrastructure and training only)

Spot speed (at TTC = 2.5 - when the traffic light changed to amber)
This was used to measure the speed distribution of the participants when the traffic light turned amber. There was a statistically significant difference in spot speed for different conditions. There is evidence (t (15) = 2.430, p = 0.028) that participants reduced speed after the training, from 29.65 ± .4m/s to 22.08 ± 2.9 m/s ; a reduction of 7.6 ± 3.1m/s (Figure 45).

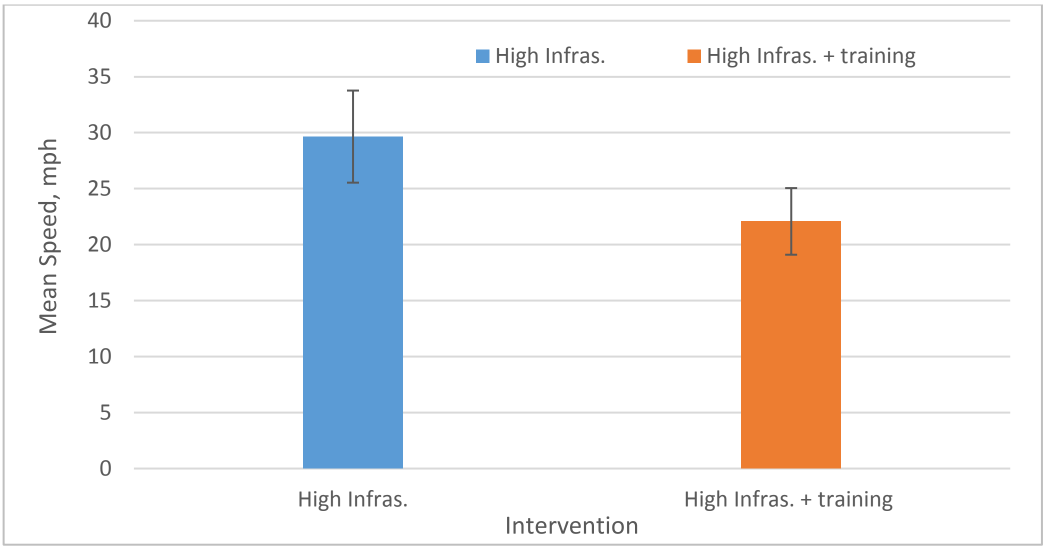


Figure 45: Effect of Intervention on spot speed

There were no main effects of Intervention in the number of participants who crossed at amber and those who violated the red light.

7.7.4.3 Acceleration (high Infrastructure and training only)

(a) Deceleration to red light

The speed profile (Figure 46) shows that the participants reduced their mean speed on approaching the junction in different conditions.

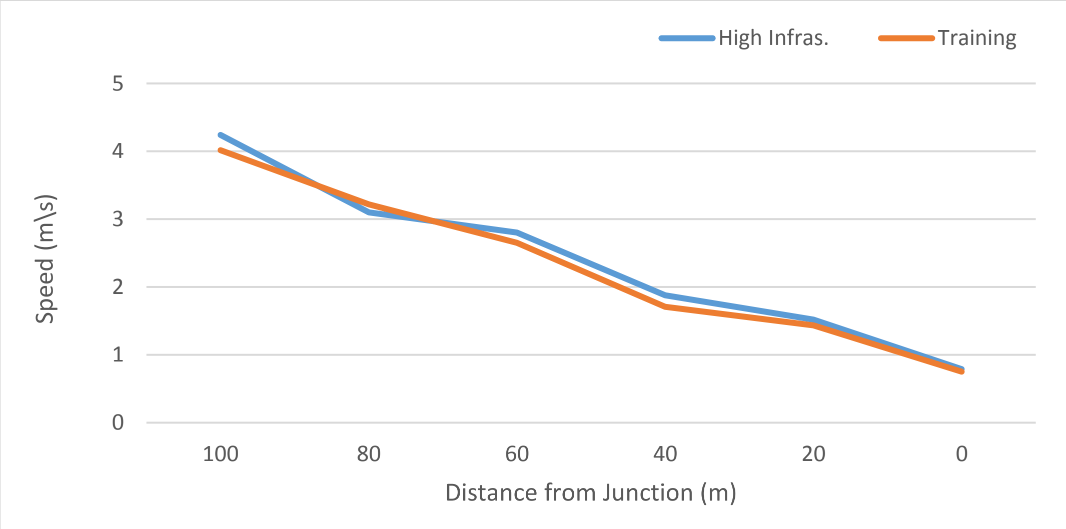


Figure 46: Differences in speed profile for different Intervention conditions

There was a statistically significant difference in variation in acceleration for different conditions (t (15) = 2.600, p = 0.020) while approaching the junction (Figure 47). Participants decelerated more smoothly after the training was provided, from .958 ± .3 m/s to .799 ± .2 m/s; a reduction of .159 ± .2m/s.

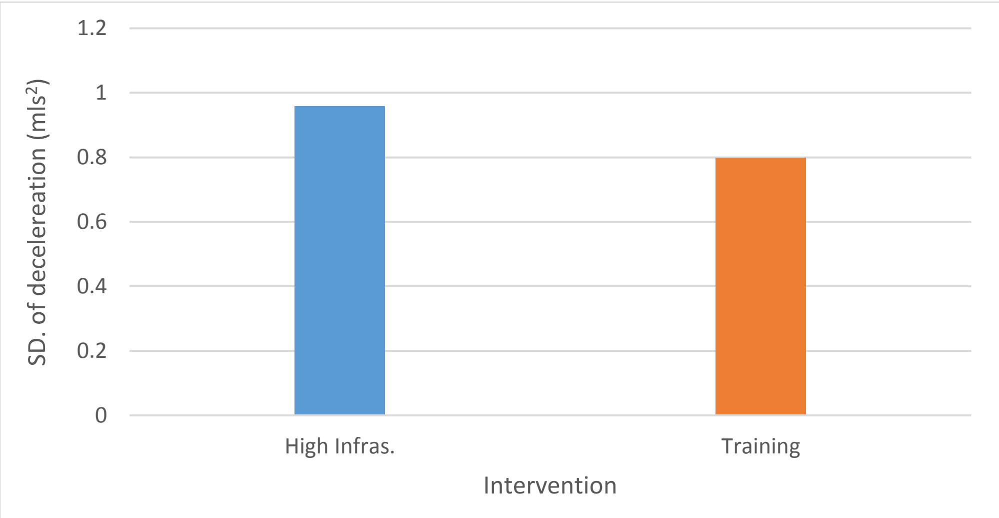


Figure 47: Effect of Intervention on SD of deceleration

No statistically significant effects were found for mean deceleration, mean speed and maximum brake pressure.

(b) Anticipatory behaviour

The percentage number of drivers who moved during the 45 seconds waiting period under different conditions were 63% for high Infrastructure and 44% for training.

There was a statistically significant difference in mean distance covered under different conditions (t (15) = 2.314, p = 0.035). Behaviour of drivers improved as there was a statistically significant reduction in mean distance after training was provided, from 14.12 ± 19.9m to 3.65 ± 10.1m (p=0.035); a reduction of 10.47 ± 18m (see Figure 48).

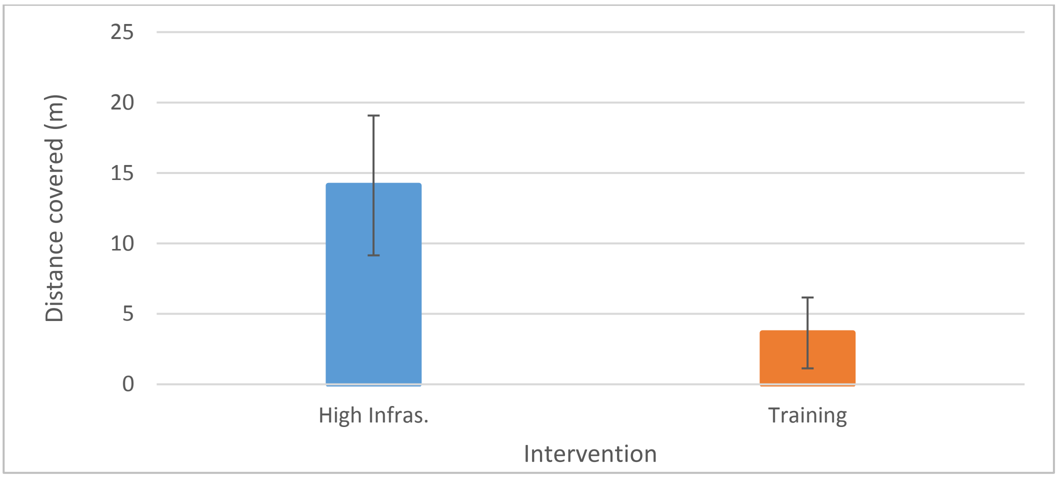


Figure 48: Effect of Intervention on distance covered in 45 seconds

(c) Acceleration away from red light

Figure 49 shows the speed profiles for the different Intervention conditions. Speed was very low and below the speed limit (30mph) after training. It could be seen that participants accelerated to the speed limit at about 260m from the junction after the training compared with 130m recorded in the high infrastructure condition.

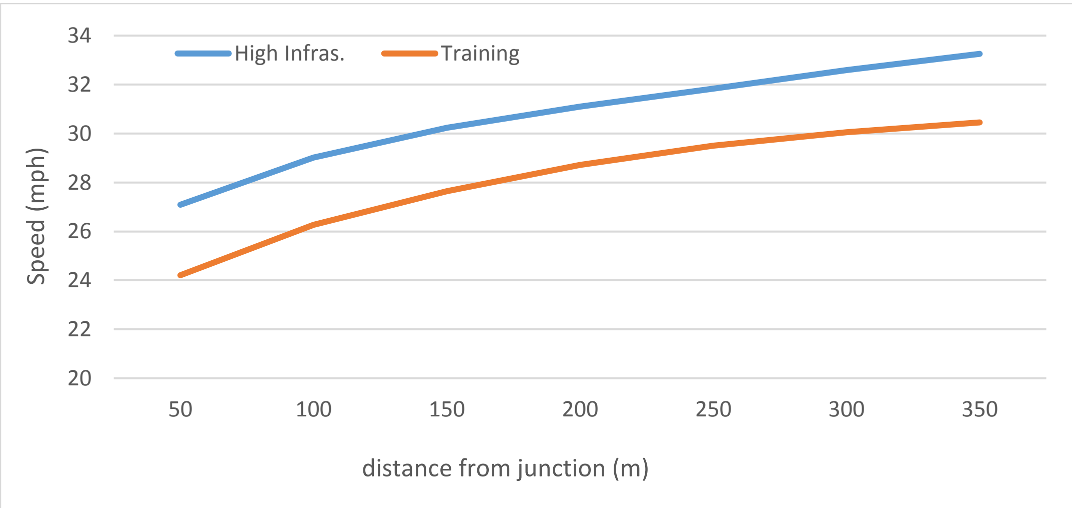


Figure 49: Different speed profiles in different Infrastructure conditions

There was a statistically significant difference between the different Intervention conditions and mean acceleration, [t (15) = 2.760, p = 0.015]. Post hoc test showed that participants accelerated more smoothly after the training from .353 ± .2 m/s^2 to .193 ± .2 m/s^2 (p=0.015), a difference of .161 ± .2 m/s^2, Figure 50.

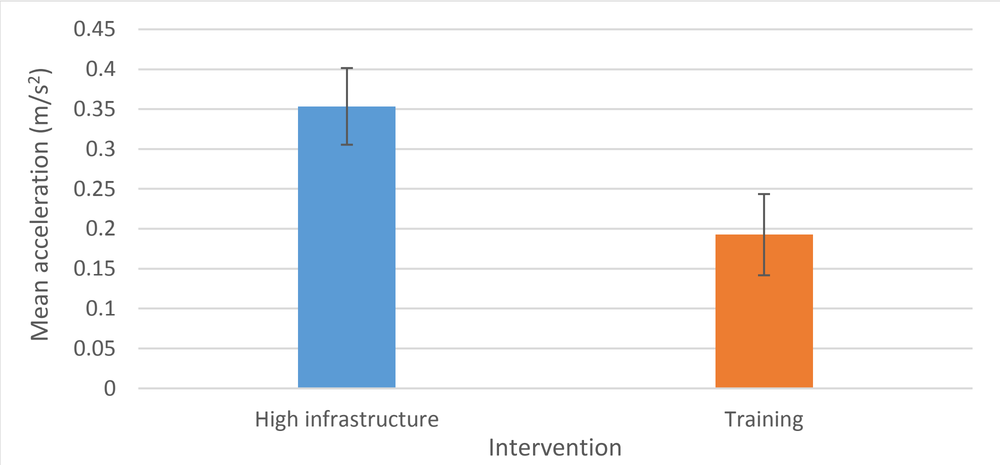


Figure 50: Effect of Intervention on mean speed

There was a statistically significant difference between the conditions and accelerator pedal angle, [t (15) = 2.143, p = 0.049]. Post hoc test showed that there was a statistically significant reduction in maximum accelerator pedal depression after the training from 22.13 ± 6.8 ° to 18.40 ± 6.1 ° (p=0.015); a reduction of 3.73 ± 6.9 °, Figure 51.

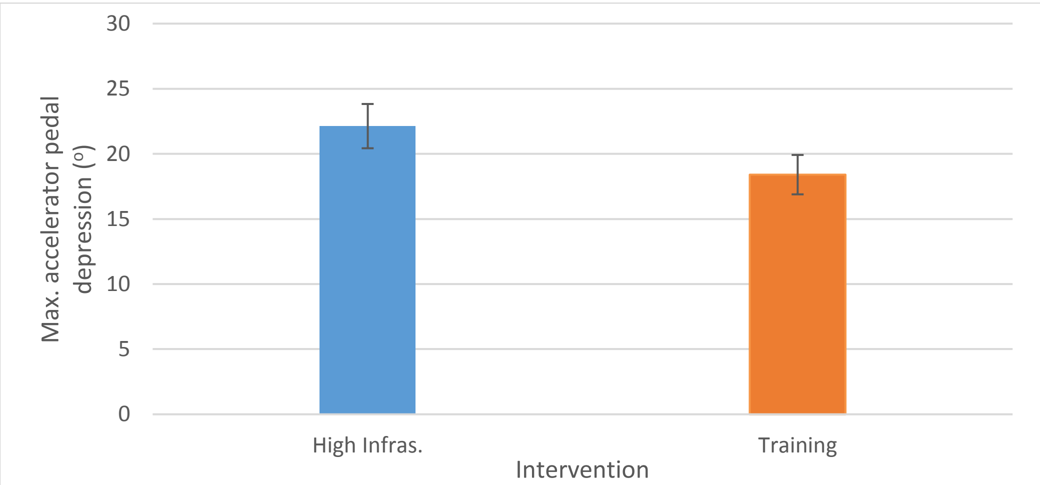


Figure 51: Effect of different Intervention conditions on maximum accelerator pedal depression

There were no statistically significant differences in SD of acceleration and time to accelerate to speed limit for different Intervention conditions.

7.7.4.4 Speed choice

Figure 52 shows the speed profile for different Intervention conditions.

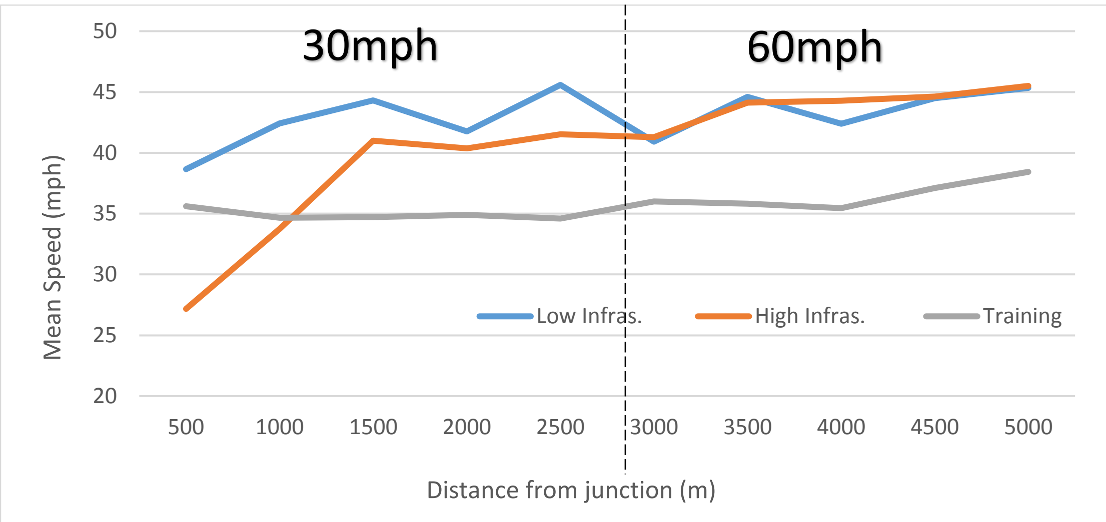


Figure 52: Speed profile in different Intervention conditions

Mean speed

There was a statistically significant main effect of Intervention [F (2, 60) = 5.078, p = 0.009] on mean speed. Post hoc tests revealed that there was a statistically significant difference between the low infrastructure and training conditions (p = .001). There were no statistically significant differences between either the low and high infrastructure conditions or the high infrastructure and training conditions (Figure 53).

Similarly, there was a main effect of speed limit on mean speed [F (1, 30) = 21.292, $p <$ 0.001]. Post hoc tests showed that mean speed increased by 12.34 mph in the 60 mph speed limit, $p < .001$.

There was no interaction between intervention and speed limits.

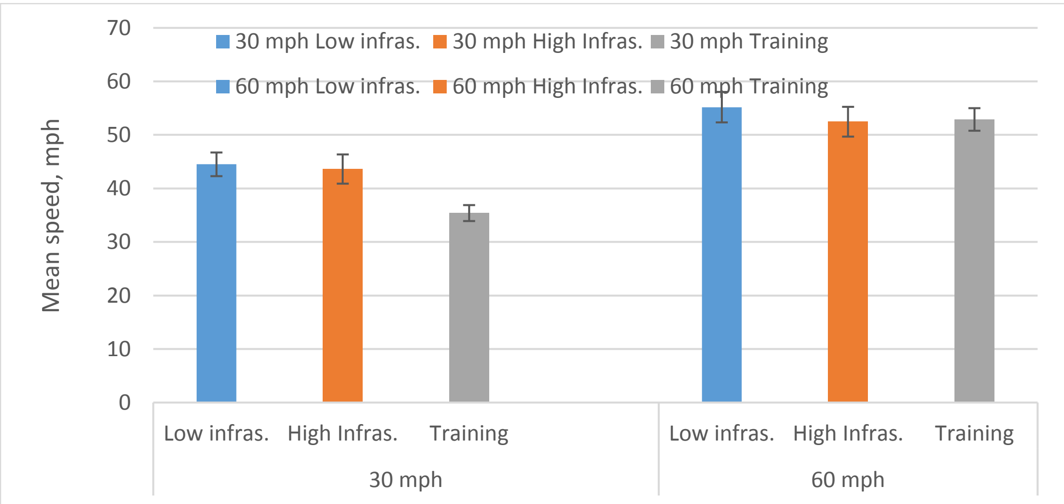


Figure 53: Effect of Intervention on mean speed for different speed limits

SD of speed
There was no statistically significant main effect of Intervention on speed variation.

On the contrary, there was a main effect of speed limit on speed variation [F (1, 30) = 7.614, *p* = 0.010]. Post hoc test showed that speed variation Increased by 2.443 m/s in the 60 mph limit, *p*=.010 (Figure 54).

There was a statistically significant interaction between speed limits and intervention [F (1.596, 47.874) = 5.445, *p* < 0.012].

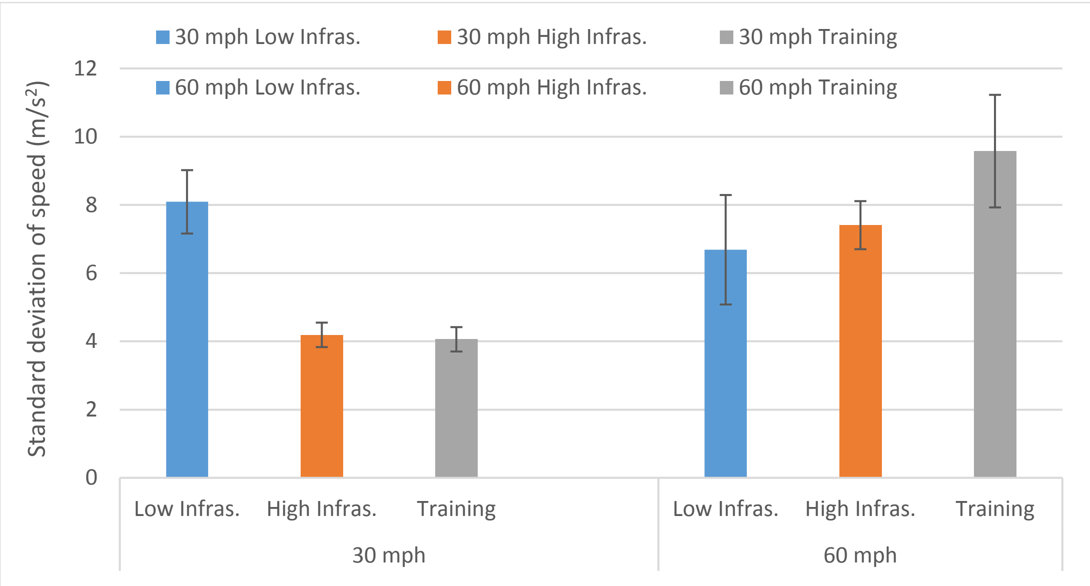


Figure 54: Effect of Intervention on mean SD of speed for different speed limits

Speed limit exceedance
There was no statistically significant main effect of Intervention on speed limit exceedance.

On the contrary, there was a statistically significant main effect of speed limits on speed limit exceedance [F (1, 30) = 42.460, p < 0.001]. Post hoc test showed that participants exceeded the speed limit by about 53% in the 30 mph compared to the 60 mph speed limits, p < .001

There were no statistically significant interactions between speed limits and Intervention (Figure 55).

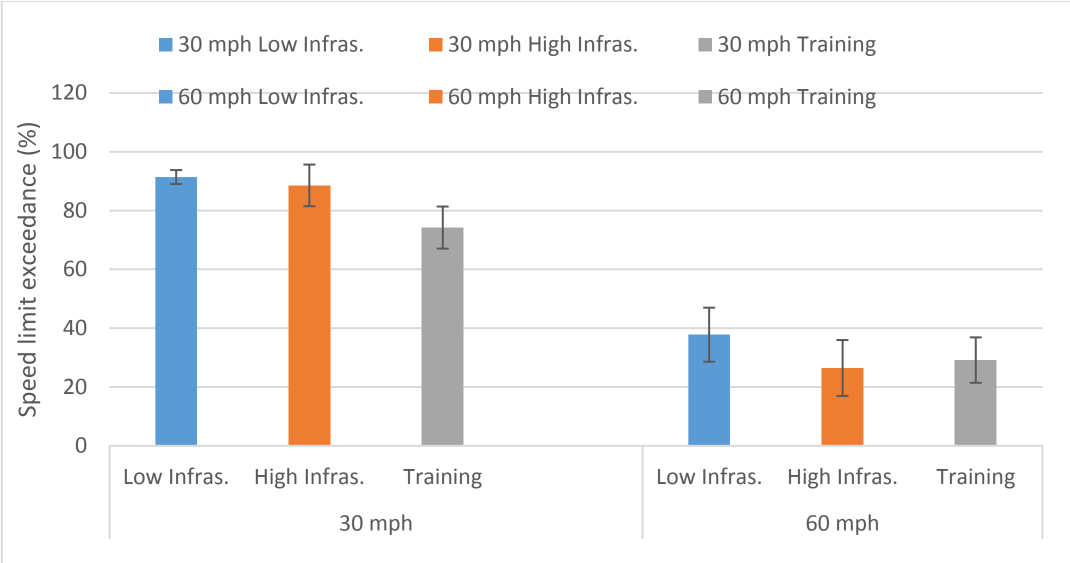


Figure 55: Effect of Intervention on speed limit exceedance

Spot speed

Spot speed was measured midway into the drives for the different speed limits (30mph & 60mph) and at about 100km after a junction.

There was no statistically significant main effect of Intervention on spot speed.

On the contrary, there was a statistically significant main effect of speed limit on spot speed [$F(1, 30) = 26.583$, $p < 0.001$, $\eta p^2 = .470$] as post hoc tests showed that mean speed increased by 16.147 mph in the 60 mph speed limit, $p < .001$ (Figure 56).

There was no interaction between Intervention and speed limits.

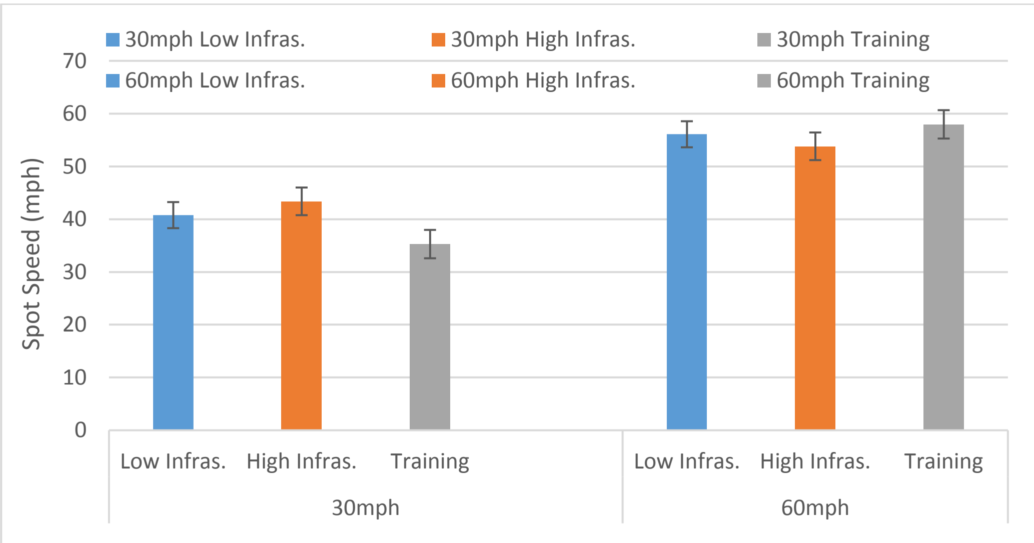


Figure 56: Effect of Intervention on spot speed for different speed limits

7.7.4.5 Green lights (high Infrastructure and training only)

There was a statistically significant effect of Intervention on speed (Z = - 2.120, p = .034). Speed reduced significantly after training as shown in Figure 57.

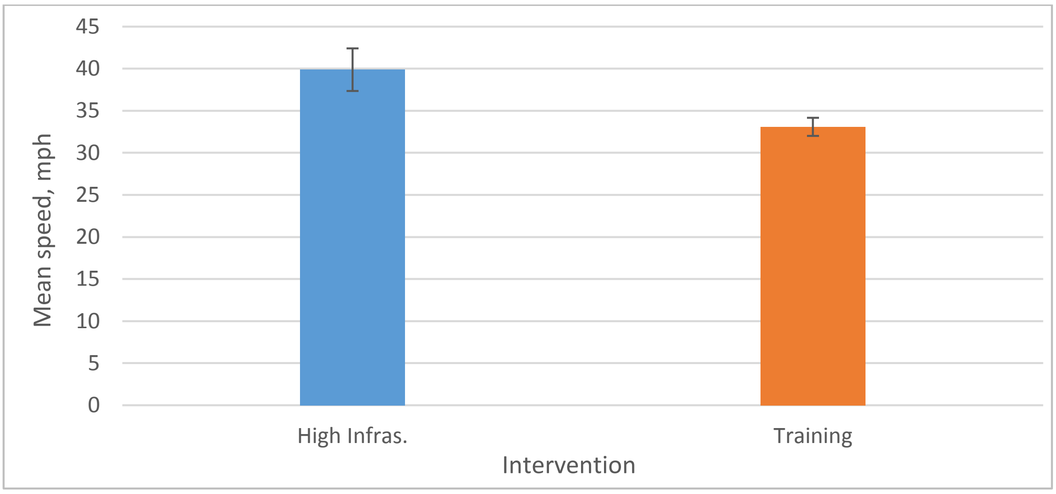


Figure 57: Effect of Intervention on mean speed

There were no statistically significant main effects of Intervention on mean deceleration, SD. of deceleration, maximum deceleration and minimum speed in this scenario.

7.7.4.6 Car cutting 1

There were no statistically significant main effects of Intervention on the variables measured in the car cutting 1 scenario.

7.7.4.7 Car crossing

(i) Speed profile

The speed profile (Figure 58) shows that mean speed was greatly reduced after the training intervention.

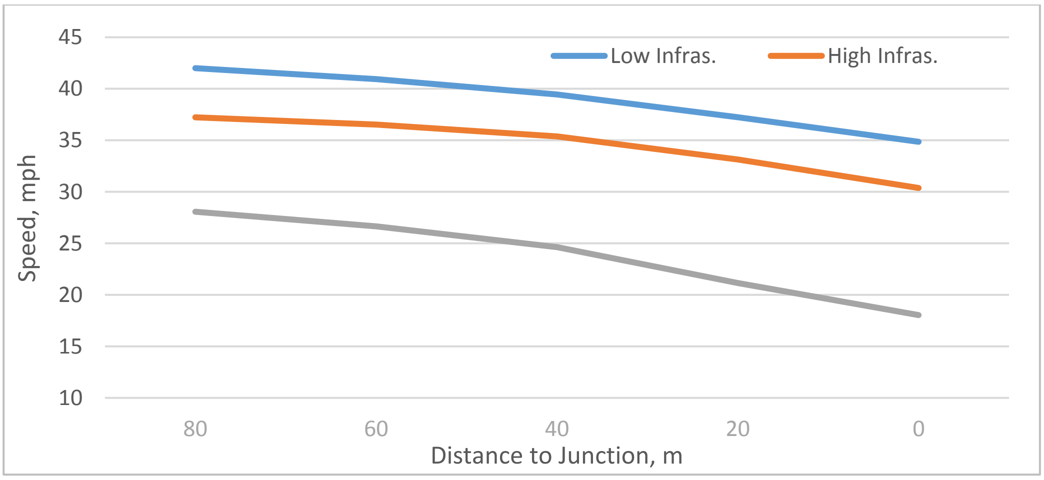


Figure 58: Speed profile for different Intervention conditions

There was a statistically significant main effect of Intervention on mean speed [F (2, 30) = 4.921, p = .014]. Speed was reduced by 16.15 mph/s after the training (Figure 59).

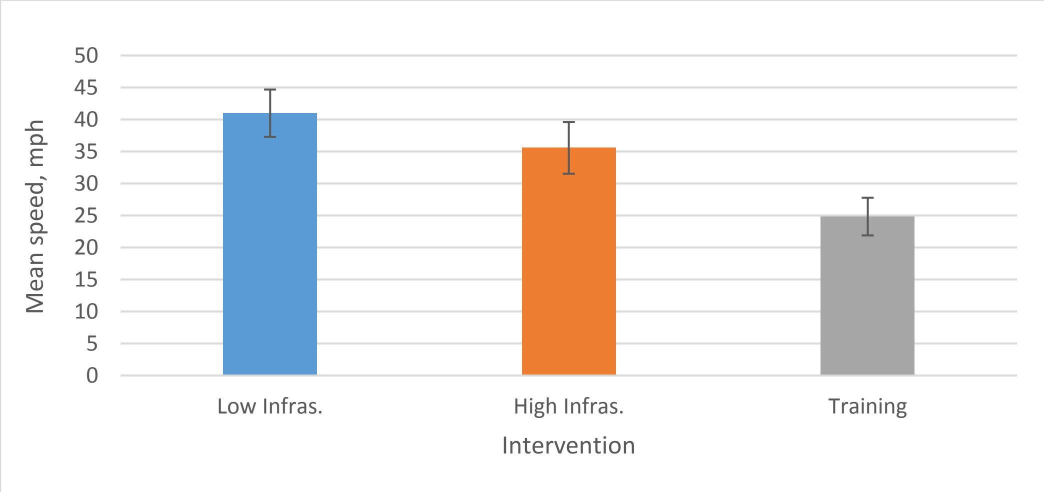


Figure 59: Effect of different Intervention conditions on mean speed

(ii) Time to collision with crossing car

There was a statistically significant main effect of intervention on TTC [F (1, 15) = 4.697, p = .038]. TTC increased to 2.34secs, p = .011 after intervention. There were no significant differences between the low and high infrastructure, Figure 60.

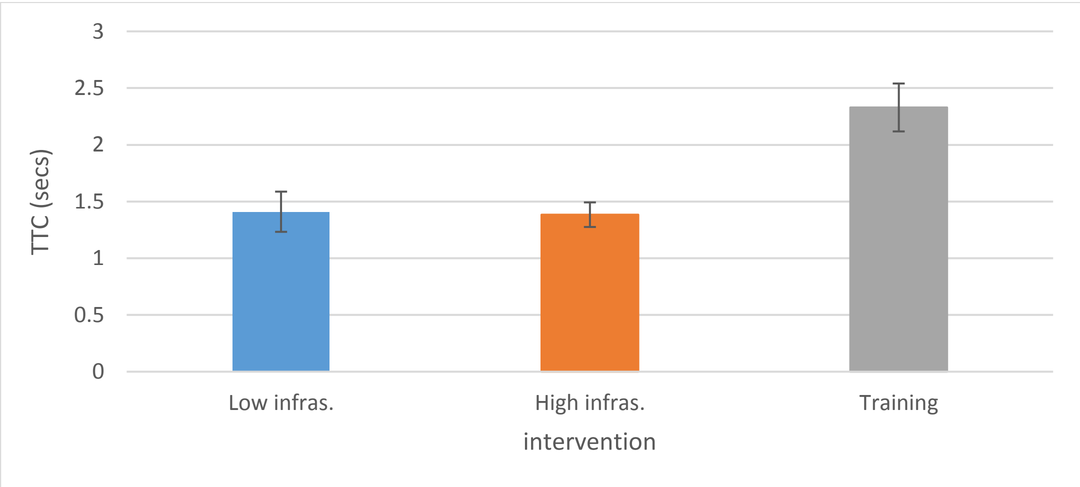


Figure 60: Effect of different Intervention conditions on TTC with crossing car

There were no main effects of Intervention on mean deceleration, sd. of deceleration and max. brake depression.

7.7.4.8 Car cutting 2

There were no statistically significant main effects of Intervention on the variables measured in the car cutting 2 scenario.

7.7.4.9 Overtaking

(a) The propensity to overtake or tendency to perform overtaking (see section 5.4.7 for description)

(i) The total number of overtaking manoeuvres attempted in different intervention conditions of drivers are presented (difficult overtaking scenario)

Total number of overtaking attempts was slightly reduced by 1 in the Low Infrastructure and 3 in the High Infrastructure conditions after the training (Figure 61) but the reduction was not statistically significant.

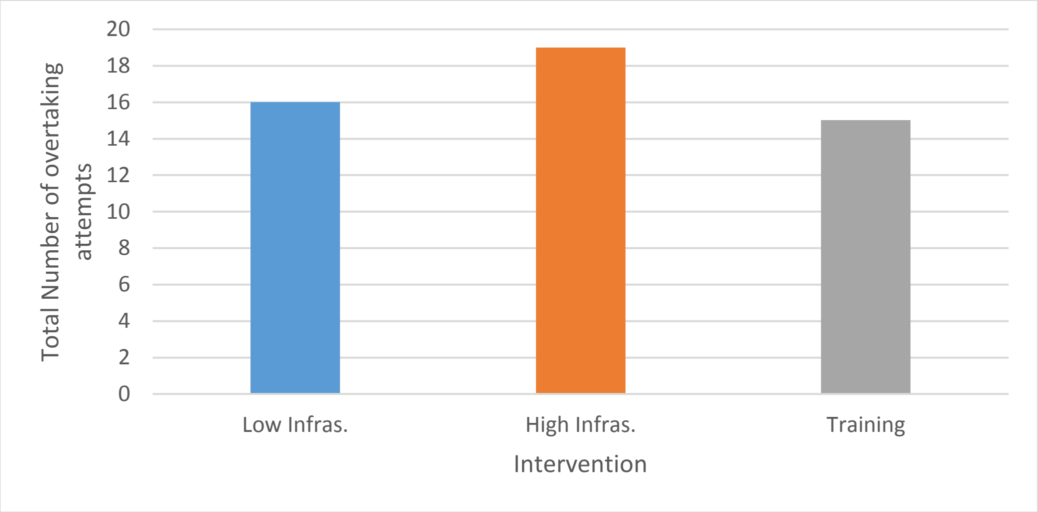


Figure 61: Effect of Intervention on total number of overtaking attempts

(ii) The number of successful overtaking manoeuvres in different intervention conditions are presented

Percentage number of successful overtaking remained almost the same irrespective of the different Intervention conditions (Figure 62).

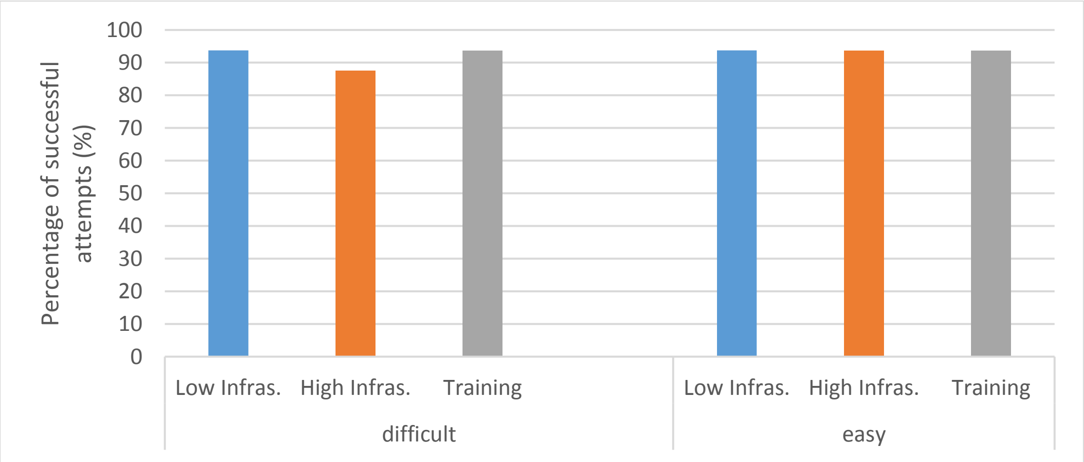


Figure 62: Effect of Intervention on percentage number of successful overtaking

(b) Overtaking safety

(vii) Start of overtaking (see section 5.4.7 for description).

- Minimum time headway with the slow-moving vehicle

Time headway

For the difficult overtaking scenario, there was a statistically significant association between time headway and Intervention conditions, $X^2(2) = 7.569$, p= .023 (Figure 63). Dunn-Bonferroni tests showed a statistically significant difference between high infrastructure and training (p=.043) as time headway increased by 0.23 seconds after the training. There was no statistically significant difference between low infrastructure and training or low and high Infrastructure conditions.

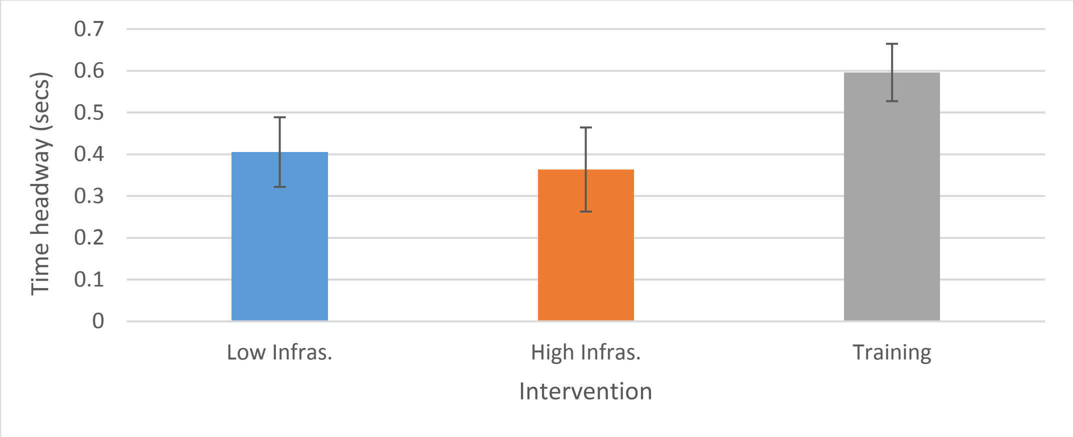


Figure 63: Effect of Intervention on time headway

Analysis of the easy overtaking scenario did not reveal any statistically significant effects.

(viii) During Overtaking (see section 5.4.7 for description)

- Overtaking duration: Time spent completing the overtaking manoeuvre

There were no statistically significant main effects of Intervention on overtaking duration for both difficult and easy overtaking scenario.

- Maximum speed reached during the overtaking manoeuvre

There were no statistically significant main effects of Intervention on maximum speed reached during overtaking for both difficult and easy overtaking scenarios.

(ix) End of overtaking (see section 5.4.7 for description)

- Time headway with the oncoming vehicle (difficult overtaking scenario only)

For the difficult overtaking scenario, results showed that there was a statistically significant main effect of Intervention on time headway at the end of overtaking (F (2, 20) =5.837, p= 0.010). Drivers as a whole accepted a higher time headway in the low infrastructure compared to the high infrastructure and training conditions. Bonferroni pairwise comparison showed that there was a statistically significant difference in time headway in the low infrastructure and training conditions as the headway decreased by 3.3secs, p= .049 (Figure 64) after the training.

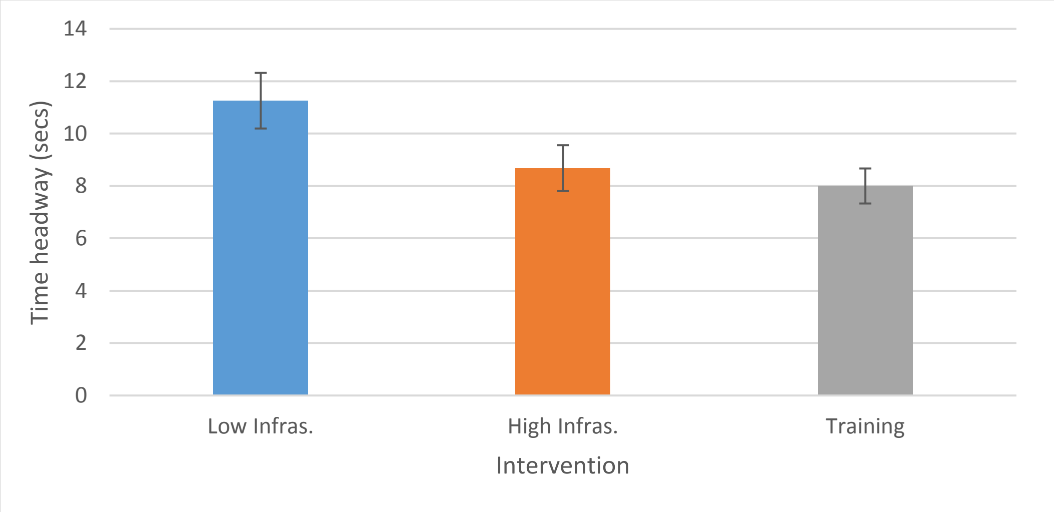


Figure 64: Effect of Intervention on time headway (difficult overtaking)

Results show that time headway was higher in the low infrastructure compared to training condition. It shows that drivers returned to their original lane sooner in the low infrastructure compared to the training conditions. By this, they left a larger gap in the difficult overtaking scenario.

There were no statistically significant differences between the low and high Infrastructure condition or the high Infrastructure and training conditions.

- Distance tail way with the slow-moving vehicle (This provided a measure of how sharply a driver pulled back in front of the lead vehicle)

There were no statistically significant main effects of Intervention on tailway distance for both difficult and easy overtaking scenarios.

7.7.4.10 Compliance with road markings

Decision to cross

There was no statistically significant association between Intervention and crossing violations.

There was no statistically significant main effect of Intervention on mean speed, SD. of speed, mean acceleration and SD. of acceleration.

7.7.5 Summary of main results

- There were statistically significant differences between different groups for self-reported violations and slips/lapses, NG drivers reported higher violations compared to other groups;

- There were statistically significant differences in observed behaviour between different groups of drivers across different scenarios.
- Within each group, there were no statistically significant differences in behaviour when varying amounts (high and low) of Infrastructure and guidance was added to the traffic environment. Hence drivers' behaviour was similar in the different infrastructure conditions (low and high);
- UK and NG/UK drivers generally drove safely in the high and low infrastructure conditions while NG drivers generally exhibited unsafe behaviours across a range of scenarios. This did not change when improvement in the road environment was made;
- Behavioural changes were observed in the NG group after they were trained and informed of the implications of engaging in unsafe behaviours and
- Behaviour changes involved mainly acceleration/deceleration, speed choice and smoothness of actions.

7.8 Discussion

7.8.1 Findings from the Driver Behaviour Questionnaire

The first aim of the present study was to confirm the factorial structure of the DBQ used by Reason et al. (1990), with these groups of drivers. The results of the factor comparisons (Appendix K) showed that the DBQ three-factor structures (violations, errors, slips/lapses) found in this study were fairly congruent with Reasons et al. (1990). Slips/lapses contributed more to the variance and had the highest eigenvalue for the NG group compared to the NG/UK and UK groups where violation contributed more. NG and NG/UK had the highest score for violations compared to UK drivers. “Fail to see pedestrians crossing” was loaded highest on violations in NG, “Angry, give chase” was loaded highest for NG/UK and “Ignore give way signs” for UK drivers. NG drivers loaded highest for errors compared to NG/UK and UK. “Get into wrong lane at roundabout” was loaded highest for the NG drivers, “Manoeuvre without checking mirror” for NG/UK drivers and “Plan route badly” for UK drivers. For the slips/lapses, UK drivers loaded highest, followed by NG/UK and then NG. “Queuing, nearly hit car in front” loaded highest for NG drivers, “no clear recollection of the road being travelled on” for NG/UK and “Drive wrong way down one-way street” for UK drivers. The result of ANOVA analysis conducted to investigate the differences between NG, NG/UK and UK participants on the DBQ factors (i.e. violations, errors, and slips/lapses) showed that there was a statistically significant difference between violations and culture. NG participants reported higher scores and were more likely to violate traffic rules compared to NG/UK and UK drivers. There were no significant differences in the errors and slips/lapses (Table 13).

Another objective of this study was to identify key items of violations, errors and slips/lapses which are rated differently and to understand the differences in self-reported driving behaviour of drivers from different groups (NG, NG/UK, and UK). The data showed that NG drivers reported a higher number of violations, errors and slips/lapses (statistically significant different) compared to NG/UK and UK drivers. Even though the NG/UK and UK drivers were expected to show similarities in driving behaviour, there were some statistically significant differences observed in both groups. Results show that 15 of the 50 DBQ items were rated significantly different by drivers from the three groups. These included nine items of violations and six items of slips/lapses. Consistent with past studies (Ozkan et al., 2006; Warner et al., 2011; Bener et al., 2013), there were no statistically significant differences in the ratings for errors.

NG drivers had a higher mean score for violations especially for “Drive close to or 'flash' the car in front” which is similar for NG/UK drivers. UK drivers reported this violation less frequently. “Impatient, overtake on the inside” was the most frequent violation item recorded for the UK group and the second most frequent violation item recorded for the NG drivers. “Risky overtaking” was the second most frequent violation item observed in the NG/UK group and the UK group but NG drivers reported this violation more frequently and as the third most frequent violation. “Impatient, overtake on the inside” was the third key item of violations in NG/UK and “Drive close to or 'flash' the car in front” was the third item of violation for the UK. It is very interesting to note that the first three key items of violation (Drive close to or 'flash' the car in front; Impatient, overtake on the inside; Risky overtaking) were the same for all three groups but with different frequency of reporting. NG drivers had the highest mean score for all violation items while UK drivers had the lowest mean score in almost all violation items. The results showed that they were more likely to report rule violations than drivers in the NG/UK and UK sample. Table 14 showed that the third most frequently reported violation item in the NG group (Risky overtaking) was higher than the first most frequently reported violation item (Impatient, overtake on the inside) by the UK drivers. Although aggressive and ordinary violations were grouped together, the results presented in Table 14 showed that they were more common in the NG group. NG drivers had the highest mean score in three out of the four aggressive violation items which were found to be statistically significantly different between the groups. Aggressive behaviours involves being hostile especially towards other road users and aggressive drivers act on their anger by showing this hostility.

Contrary to violations, NG/UK drivers reported slips/lapses more frequently than NG and UK drivers. “Misjudge speed of oncoming vehicle” was the most reported item for the NG and UK drivers. “Try to overtake vehicle turning left/right” was the most frequently reported item for the NG/UK drivers but the second most reported item for the NG and UK drivers. “Misjudge speed of oncoming vehicle” was the second most reported item for the NG/UK drivers. “Turning right/left, nearly hit cyclist/tricycle” was the third most reported item for NG and NG/UK drivers while “Fail to see pedestrian stepping out” was the third highest for the UK drivers.

NG drivers, in general, appeared as the “riskiest group”. They were more undisciplined and aggressive compared to the NG/UK and the UK drivers. This finding may be an important explanation for why Nigeria has poorer traffic safety records than the UK (WHO, 2018). Rule violation is one of the important predictors of road traffic crashes and conflicts in Nigeria (FRSC, 2018; Uzondu et al., 2018).

Although results show that the structure of the DBQ is about the same in the three groups involved which makes international comparisons possible, it does not rule out the presence of cultural bias. Between different groups, there were similarities and differences in factor loading as different errors, violations and slips/lapses were loaded highest. Socio-economic and cultural differences between these samples could have caused the differences in factor structures found in this study which is in accordance with Özkan et al. (2006) and Warner et al. (2011). This emphasises the importance of taking cultural factors into account when applying an instrument developed for a specific country in another country. This is of importance especially when it is between countries with different traffic environments and cultures. As shown by Blockey & Hartley’s (1995), an instrument may function differently even in two countries using the same language. A study by Shinar (1998) reported that developing countries were more prone to interpersonal conflicts because of less developed infrastructure, lack of adherence to rules and problems with enforcement compared to the developed countries. These results indicate that different countries have different problems with regard to drivers’ unsafe behaviours and findings from one group may not necessarily be applicable to other groups. These different problems need to be taken into account when developing traffic safety interventions which are needed to provide better information for road safety practitioners in these countries.

In summary, this study identified the key items of violations, errors and slips/lapses which drivers from NG, NG/UK and UK rated differently. The results indicate that behaviour choices are different with high scores among NG drivers, but different from NG/UK and UK drivers, whose responses were fairly similar. NG drivers reported more violations than the other groups. The factor structures of the DBQ were similar, but with different loadings between different groups. These results indicate that DBQ can be used and the scale scores compared with confidence for both developed and developing countries but could be modified to take into account country-specific conditions as was done for the NG group in this study before it can be used outside the cultural group for which it was originally developed.

7.8.2 Findings from the driving simulator study: experiment 1

In this study, a range of driving tasks were designed to investigate whether there are any differences in behaviour between drivers from different cultures and to see if changes in the road environment would have an effect on drivers' behaviour. To directly compare the behaviour of drivers from the UK, a country with a very low frequency of road crashes with drivers from Nigeria, with a high frequency of road crashes. Drivers were asked to drive normally in environments where varying amounts (low or high) of infrastructure and guidance was provided. Drivers' behaviour was assessed by unsafe driving or behaviours made during the drives, which were analysed and compared. The emphasis was on behaviours such as lane changing, accelerating, speeding, overtaking, reaction to hazards, obeying traffic lights and road markings. Several culture effects were found in almost all the scenarios, but none of them could be attributed to the infrastructure and guidance provided. The primary differences were for NG drivers compared to NG/UK and UK drivers because, in almost all the scenarios, the performance of NG drivers differed statistically significantly from those of NG/UK and UK drivers. Irrespective of the infrastructure conditions, UK and NG/UK drivers exhibited safer behaviours compared to the NG drivers. This means that when the road environment was changed (low or high infrastructure), drivers' behaviour did not change. For instance, NG drivers drove faster, accelerated stronger and spent more time speeding. When setting off at junctions, NG increased their speed and reached the limit quicker than the other groups. Generally, NG/UK and UK drivers tended to keep these measures constant or lower, even though in some cases, UK drivers drove faster than the NG/UK drivers. Across all scenarios, the NG/UK and UK drivers tended to show safer patterns of performing the driving tasks compared to the NG drivers. It is very interesting to note that NG/UK and UK drivers were grouped together in the discussion because even though there were slight differences in their behaviours in some of the scenarios, no statistically significant differences were found. Out of ten scenarios observed, NG/UK and UK drivers showed safer performance in six scenarios, NG drivers showed a better performance in the green light scenario where they reduced their speed while approaching the junction probably because they were already travelling at high speed. No statistically significant differences were found for the remaining measures in terms of safe performance between the different groups of drivers. Results are discussed below under measures for vehicle positioning and control, reaction to hazards and compliance to traffic rules and are discussed with respect to hypothesis H2 and H3.

7.8.2.1 Vehicle positioning and control

(i) Lane changing

In this scenario, there was a slow leader on a double lane road. The road design encouraged participants to overtake and also expected them to return to their original lane after overtaking. On average, NG drivers drove at a higher speed with high fluctuations compared to the NG/UK and UK drivers. Their mean acceleration was higher than that of the other groups.

Infrastructure provided did not have any effect on measures of driver behaviour in this scenario. There were no statistically significant effects with SD. of acceleration, minimum time headway, minimum TTC, indicator use and no interactions between Infrastructure and Culture.

(ii) Acceleration (high infrastructure only)

This scenario provided acceleration behaviour for different groups of drivers. Several behavioural variables were measured: deceleration to the red light (behaviour while approaching the red light), anticipatory behaviour (45secs while waiting for the traffic light to change from red to green) and acceleration away from red light (behaviour after the traffic light changed to green.

While approaching the red light junction, all the participants reduced their speed and stopped at the red light. They had an extended preview of the red light. The result showed that there was no statistically significant main effect of culture on deceleration. The speed profile (Figure 20) suggests that drivers began to decelerate earlier at different rates. On the other hand, statistically significant effects were found on variation in deceleration with UK drivers braking more smoothly compared to the NG/UK and NG drivers. Post hoc test showed a statistically significant difference between the UK and NG drivers only, no statistically significant differences were between the other groups. This means that the UK and NG/UK drivers decelerated more slowly and more smoothly at a more constant rate while NG drivers (probably because they were at a higher speed decelerated more harshly with much higher fluctuations.

No statistically significant effects were found for mean speed, mean deceleration and measures relating to activation of the brake pedal (maximum brake pressure).

The 45secs waiting period at the red light was used to investigate impatience and aggressiveness. According to Tasca (2000), *'A driving behaviour is aggressive if it is deliberate, likely to increase the risk of collision and is motivated by impatience, annoyance, hostility and/or an attempt to save time*.' During this period, more NG drivers moved and the distance covered by them was more compared to the other groups. Though no traffic rule was broken, this could suggest impatience and aggressiveness which is consistent with the description by Laagland (2005). He described another level of aggressiveness in traffic light thus – "when a vehicle driver has a lower level of aggression it will stop at the traffic light first but the longer it has to wait, the more aggressive it will become, and as a result start moving but may actually drive through the red light if the level of aggression rises to the threshold".

When the traffic light finally changed to green, participants' speed profile was measured. Results showed that NG drivers accelerated faster than the NG/UK and UK drivers. This is not surprising considering how fast they accelerated to the speed limit. There were main statistically significant effects of culture on mean acceleration and time to accelerate to the speed limit. NG drivers accelerated faster as it took them 12.5 secs to accelerate to the speed limit of 30mph at a distance of 130m from the traffic light (Figure 23)

There were no statistically significant differences between Culture and maximum accelerator pedal depression and SD of acceleration

(iii) Speed choice

Speed is a risk factor influencing both the risk of a crash and the severity of injuries resulting from road crashes (Golob et al., 2004). Drivers' speed choice has been a particular focus of road safety research, as high speeds have been found to increase the risk of crashes (Aarts & van Schagen, 2006). On the other hand, low speed is considered safe and known to reduce crash risk (Taylor et al., 2002; Elvik et al., 2004; Nilsson, 2004). In all the scenarios where speed was measured (lane changing, speed choice), there were statistically significant main effects of culture on mean speed, speed variation and in some instances, speed limit exceedance.

For example, in the speed choice scenario (section 7.7.4.4), there were statistically significant main effects of culture on mean speed, speed limit exceedance and spot speed for the 30mph and 60mph zones. For the culture effect, NG drove at a higher mean speed, had the highest speed when spot speed was measured and spent more time exceeding the speed limit compared to the other groups. There were no statistically significant differences in mean speed, spot speed and speed limit exceedance between the other two groups.

NG/UK and UK drivers showed a higher intention to comply with the speed limit as well as time spent complying compared with the NG drivers. It is well known that high and inappropriate speed is one of many factors contributing to the number and severity of road traffic crashes. According to FRSC (2018), 44% of road traffic crashes in Nigeria in 2017 were caused by speeding. It could be reasonable to believe that international differences in the number of road traffic crashes would partly be affected by drivers speed choice. WHO (2018) shows that the number of road traffic crashes is higher in Nigeria (21.4 fatalities per 100,000 population) compared to the United Kingdom (3.1 fatalities per 100,000 population). This is consistent with a study by Warner et al. (2009) where it was concluded that drivers who live in a country with fewer road traffic fatalities (i.e. Sweden), compared with drivers who live in a country with more road traffic fatalities (i.e. Turkey), report a more positive attitude towards complying with the speed limit, a higher intention and a larger proportion of the time spent complying. Another reason for this could be because in Nigeria, speed limits are not generally posted, most drivers do not know the different speed limits on different roads and may not know when they are exceeding it.

There was a main effect of speed limit on speed limit exceedance as results showed that drivers exceeded speed in the 30mph zone more than the 60mph zone. In other words, mean speed was exceeded more in the 30mph limit compared to the 60mph limit. This corroborates past research which shows that more drivers report to drive above the speed limit when the speed limit is lower rather than higher and drivers exceed the speed limit to a relatively greater degree under a lower speed limit and to a relatively smaller degree under a higher speed limit (OECD/ECMT Transport Research Centre, 2006; Anastasopoulos & Mannering, 2016)

Next to speed, lateral position is another commonly used driving behaviour metrics. Analysis of the lateral position of the drivers in the speed choice scenario did not reveal any statistically significant differences as drivers maintained their lanes and safely. There were no statistically significant differences in variations of lateral position which is usually caused by the difficulty to drive completely straight and in the right lane.

For the low infrastructure condition, there were no speed limit signs but the environment consisted of built-up areas and country-side. This is so that drivers would naturally select their driving speed but they were expected to adjust speed based on their environments. It is very interesting to note that NG/UK and UK drivers adjusted their speed appropriately in the two environments, whereas NG drivers continued at high speeds in both environments (see Figure 26). Consequently, low (high) Infrastructure and guidance provided did not affect drivers' speed choice in any way. For all participants, mean speed remained almost the same in all drives both for the NG drivers who were speeding and for the UK and NG/UK drivers who drove slower and within the speed limit.

(iv) Overtaking scenario

Overtaking involves the consolidation of a set of behaviours that require planning, anticipation and prediction. According to Jamson et al. (2012), it is a complex task requiring the driver to monitor interaction with a lead vehicle, estimate the time to collision of any oncoming vehicles and take into account the time required to complete the overtaking based on their own speed and skill level. This is because failure to put these into consideration may lead to severe crashes (Schubert et al., 2010; Farah, 2011; Papakostopoulos et al., 2015). In this scenario, there were two different overtaking manoeuvres – (1) easy and (2) difficult. Results were interpreted as appropriate.

The first noticeable difference between the different groups was the higher tendency among the NG drivers to perform overtaking compared to the NG/UK and UK drivers.

This difference is most noticeable in the difficult overtaking, where there was a higher risk because there was oncoming traffic. This is an indication of unsafe driving as research (Hauer, 1971) has shown that increases in the number of overtaking manoeuvres correlate with increases in crash probability. Vehicles seeking to overtake can be more at risk of a rear-end crash due to the tendency of drivers to maintain shorter headways prior to overtaking (Ghods et al., 2012). This could be a possible explanation for the short time headway of NG drivers prior to overtaking.

Results of the time headway at the start of overtaking and the tailway distance at the completion stage of overtaking, both in relation to the slow-moving vehicle (leader), provides information about drivers' risk-taking propensity. In both situations, NG drivers accepted a smaller time headway and distance tailway compared to the NG/UK and UK drivers (Figures 37 & 40), even though the time headway was generally smaller than the generally recommended safe time distance of 2secs. This is in line with research by Hegeman (2008), who found that the headway between the overtaking and overtaken vehicles prior to overtaking can be as low as 7.7 m (0.35 secs). NG drivers pulled out of their original lane, at the beginning of overtaking, leaving a small gap with the slower-moving vehicle prior to the beginning of overtaking. The findings of the tailway distance at the end of overtaking also revealed a similar pattern. It is evident in Figures 41 & 42 that NG drivers had a shorter tailway distance compared to their NG/UK and UK counterparts. It would appear that the NG drivers traded off longer headway distance with the oncoming vehicle for shorter tailway with the slower-moving vehicle.

Duration of overtaking or time spent completing overtaking did not reveal any statistically significant differences in both the easy and difficult overtaking scenarios. This corroborates research by Hegman et al. (2005), in their study, by observing vehicles overtaking through an instrumented vehicle, they found that there was no statistically significant difference between the duration of performing different overtaking manoeuvres.

On the contrary, the maximum speed reached during the overtaking manoeuvre was higher for UK drivers in the two overtaking scenarios compared to the NG/UK and NG drivers. NG drivers did not increase their speed during overtaking probably because they were already at high speed and increasing speed could lead to loss of control. This is efficient on the one hand because time spent completing overtaking will be reduced. A similar trend was reported in earlier studies (Day et al., 2008; Chandra & Shukla, 2012). Results of the speeding could be looked at from the perspectives of safety and efficiency. Generally higher speed has an inverse relationship with safe driving. But in this instance, a higher speed will result in lesser time exposed to the oncoming traffic and the higher the speed the lower the overtaking duration. Therefore the higher speed among the UK drivers compared to the NG drivers can be defined as a cause of more efficient behaviour in terms of overtaking efficiency and consequently safer performance of overtaking. On the other hand, NG drivers had a lower maximum speed during overtaking. This finding seems logical since the NG group were found to have smaller headway prior to the start of overtaking performance consequently they had a shorter run-up distance within which to gain speed.

Generally, results showed that NG drivers showed less safe behaviour in performing the overtaking task compared to the other groups. Their time headway with the slow-moving vehicle at the start of overtaking, speed during overtaking and the distance tailway with the slow leader at the end of overtaking were found to be generally smaller than that of the NG/UK and UK drivers. Their accepted smaller safety margins is a concern. The other groups were more prepared before, during and after the overtaking task compared to the NG group. There was no effect of infrastructure on all the variables measured.

7.8.2.2 Reaction to hazards (expected and unexpected)

(i) Crossing car scenario

A critical part of traffic safety is a driver’s ability to detect and respond to emergency roadway hazards. In the car crossing scenario, the NG/UK and UK drivers reacted faster to the crossing car by stopping compared to NG drivers. Almost all the NG drivers crashed into the crossing car.

According to McKenna et al. (2006) and Wetton et al. (2010), Hazard Perception (HP) skill of a driver refers to the ability to identify potentially dangerous situations on the road, with shorter response times reflecting greater skill levels. In this experiment, the BRT was used to measure the HP skill of drivers.

There was a statistically significant main effect of culture on BRT as results showed that NG drivers were considerably slower to react to the hazard than NG/UK and UK drivers. This could be due to their high speed (see Figure 35)**.** Even though the speed profile (see Figure 33) showed that NG drivers started reducing speed earlier as they approached the junction, they could not lower it to that of the NG/UK and UK drivers. Another possible explanation for the better performance of the NG/UK and UK drivers could be explained from greater participation in hazard perception training, as all NG/UK and UK participants would have practised for and passed the traditional hazard perception test in order to obtain their license (Lim et al., 2014). A finding consistent with Bates et al. (2013) and McDonald et al. (2015) which shows that drivers who participated in hazard perception training could identify more hazards, scan their driving environment more effectively, anticipate hazards more quickly and slow down more when approaching hazards than those who did not participate in such training.

On the other hand, there was a main effect of culture on TTC. TTC is closely related to headway and is defined as the time to collision with a lead vehicle in the travel path if the speeds of the vehicles remain unchanged. It measures the longitudinal margin to lead vehicles or objects. But TTC has the advantage of taking the speed difference between the vehicles into account, which is a safety-related factor. Results showed that the TTC of NG drivers was smaller than that of the other groups which according to Minderhoud & Bovy (2001) is a safety-critical approach and not a good indication of safety.

The differences in deceleration did not reveal any statistically significant effects. In addition, there was no main effect of infrastructure on hazard reaction, TTC and deceleration. And there were no interactions between infrastructure and culture on all the measures.

(ii) Car cutting 1 & 2

There were no main effects of Culture and Infrastructure and no interactions between the conditions in mean speed, speed variation, mean acceleration, SD. of acceleration and maximum brake pressure.

7.8.2.3 Compliance with traffic lights and road markings

(i) Amber dilemma (high Infrastructure only)

There was no statistically significant main effect of culture on the decision to proceed or stop at amber, junction crossing violations (crossing at red light), mean speed and spot speed.

(ii) Green lights (high Infrastructure only)

This scenario allowed testing for anticipatory behaviours such as slow approaches. There was a main effect of culture on the mean speed of drivers while approaching the green lights. NG drivers drove at a higher mean speed. Drivers also reduced speed on reaching the traffic light, even though they did not stop completely. Analysis of the variation in deceleration showed a main effect on culture as different groups of drivers made attempts to decelerate on approaching the traffic light, the deceleration rate of NG drivers was higher than the others. Hence, merely knowing that there is a traffic light led to more anticipatory driving. According to Wickens & Hollands (2000), this behaviour could be interpreted in terms of uncertainty that drivers experience when they are not sure whether a traffic light change will occur. Generally, there was only a slight adaptation to speed and deceleration.

There were no main effects of Culture on speed variation, mean deceleration, maximum deceleration and minimum speed in this scenario.

(iii) Compliance with road markings (double white line)

This scenario was used to examine knowledge and compliance with lane marking. The double solid white lines signify no crossing but the result of the analysis showed that some groups of drivers violated this rule. Statistical testing showed a significant association between the violation rates of different cultures for the low and high infrastructure conditions. More NG drivers violated this rule. This could probably be because of lack of knowledge of what the lines represent. Even though in the high infrastructure condition, there was a sign indicating that the road ahead was marked, there was no statistically significant main effect of infrastructure on the decision to cross or not. Subsequently, behaviour within cultures was the same irrespective of the infrastructure conditions. There was a statistically significant main effect of culture on speed variation. In line with the result from previous scenarios, NG drivers drove with high fluctuations in speed compared to other drivers.

There were no statistically significant effects with mean speed, mean acceleration, SD. of acceleration and interaction between infrastructure and culture.

7.8.3 Findings from the driving simulator study: experiment 2 (NG drivers only)

This study investigated whether drivers show different behaviours when they are asked to drive on a road with low infrastructure compared to being asked to drive on a road with high infrastructure and then after an awareness-raising training. This was to assess the effects of intervention on drivers' on-road driving performance, hazard perception skills and general compliance to road rules. Results showed that there were significant differences in behaviour in six (amber, acceleration, speed choice, green lights, car crossing and overtaking scenarios) out of ten scenarios observed. There was a significant decrease in the prevalence of nearly all the risky driving behaviours among the NG drivers identified in experiment 1. This implies that participants recognised their shortcomings and tried to modify their behaviour even if the effect was for a short time.

7.8.3.1 Vehicle positioning and control

In accessing measures relating to vehicle positioning and control, statistically significant differences were recorded for some measures. The findings with respect to speed suggest that there were statistically significant differences in speed choice between the conditions, statistically significantly more after intervention as participants reduced speed generally. The training led to lower mean speed and adherence to the speed limits especially in the speed choice, green lights and car crossing scenarios. In the acceleration scenario, the accelerator pedal angle decreased significantly, mean acceleration decreased, variation in acceleration decreased, in other words drivers decelerated more smoothly. In addition, distance covered in the 45 secs waiting time reduced significantly. It would appear that the intervention affected driving performance with drivers demonstrating a potentially safer driving behaviour than in the low and high infrastructure conditions. In the overtaking scenario, results showed that participants exhibited greater caution during overtaking as there was increased time headway with the slower leader in the scenario with oncoming traffic even though this may have led to reduced time headway with the oncoming traffic. No statistically significant differences were found in the lane changing.

7.8.3.2 Reaction to hazards (expected and unexpected)

For measures relating to reaction to hazards, similar to results in experiment 1, there were no statistically significant differences in behaviour for scenarios relating to car cutting 1 and 2. The only difference recorded in the car crossing scenario after the training was the general reduction in mean speed and speed at junction entry. The participants exhibited more appropriate speed while approaching the hazard, a finding consistent with Crundall et al. (2010). This could be because they anticipated the hazard having done the drives previously. BRT was not measured after the intervention because participants were already aware of the hazard and would be expecting it. There were no statistically significant differences in TTC.

7.8.3.3 Compliance with traffic lights and road markings

For measures relating to compliance with traffic signs and road markings, there was a reduction in mean speed while approaching the green lights and a reduction in spot speed in the amber dilemma scenario after the training. There were no significant differences in behaviour for junction crossing violation (crossing at red light) and compliance with road markings.

The results of this study are consistent with findings from Isler et al. (2011) which focused on vehicle manoeuvring and peer feedback. They found improvements in on-road such as like appropriate speed choices but no improvement in hazard perception or risky driving attitudes after training. In another study by Dorn & Barker (2005), comparing trained and untrained drivers, trained drivers exhibited safer driving behaviours: they were statistically significantly less likely to attempt unsafe overtaking manoeuvres or enter dangerous situations and showed statistically significant greater speed reductions when approaching potential hazards. One possible explanation for the effectiveness of the intervention could be that drivers are more familiar with safe driving. For example, in experiment 1 there were no statistically significant differences between the low and high Infrastructure conditions. This suggests that the intervention may be able to improve driving safety among drivers who participate in training with the intent of learning safe driving. This finding needs to be replicated using a more representative population and a larger time duration after training as studies investigating the effects of training have shown that the timing can have an influence on the magnitude of behaviour change (Chapman et al., 2002; af Wåhlberg, 2007; de Groot et al., 2011). However, Bener et al. (2007) argued that educating drivers about the benefits of complying with traffic laws might help improve the compliance rates but if used alone, they would not be sufficient to reduce crash rates. In summary, the results demonstrated that drivers' behaviour generally improved after training.

7.9 Conclusion and implications for phase 3

There is limited research and literature related to cross-cultural studies of driver behaviour using driving simulators. Therefore, most of the results obtained in this study could not be compared with much existing research except self-reports. However, the data collected in this study serves to help fill this gap.

Results of the self-reported and actual observation studies showed that behaviour patterns were similar for different groups of drivers. The NG group showed the highest tendency to engage in unsafe behaviour in the actual observation and reported the same in the DBQ.

Another interesting finding from the study is indication that drivers from different cultures drive differently and that changes in the road environment on its own would not improve driver behaviour. This study showed that NG drivers who generally exhibited unsafe behaviour in the low infrastructure condition did not change behaviour when they were asked to drive on a road with improved conditions (high infrastructure). Hence, improving the road environment does not address the underlying problem that NG drivers do not generally drive safely. This necessitated a second experiment with the NG drivers to investigate if awareness-raising intervention would bring about significant changes in driver behaviour. In order to investigate this, the methodology used in experiment 1 was replicated and an additional experiment (experiment 2) with only the NG group was carried out whereby the effect of the awareness-raising intervention on the driving behaviour of NG drivers was evaluated. This was compared to the results obtained in experiment 1. It was hypothesised that the intervention will have an effect on NG drivers' behaviour. Hence the influence of the intervention on driving behaviour and observational patterns were examined in this second experiment.

Simple awareness-raising training and instructions by the experimenter were sufficient to encourage participants to improve behaviour in the short term. These instructions involved explaining what behaviours are safe and what the participants are expected to do at each scenario, with no explanations about enforcement. It was found that the intervention led to some behavioural changes. Even though changes were recorded after the training, this is believed to be for a short time as it is very easy to revert to old behaviours (Rasmussen, 1979). The present study showed that changes in the road environment alone would not be sufficient to bring about behaviour changes. In contrast, the intervention provided in person and immediately before driving was much more successful.

This study sought to establish itself as a contribution to the understanding of cross-cultural differences in driving behaviour and the following conclusions reached emerged from the results:

(i) There were similarities in self-reported and observed behaviour among different groups **(H1; RQ2)**.
(ii) Driver behaviour differs for drivers from different cultures **(H2; RQ 3a)**. This is due to the fact that these drivers may have different behaviours that define their different points of view and norms of behaviour. These could be different strategies of action, different interpretations of the situation, decision-making, and other types of behaviour on the road.
(iii) The likelihood of engaging in unsafe driving behaviour is higher for drivers from countries with poor road safety culture **(H2; RQ 3b)**.
(iv) High or low infrastructure did not affect driver behaviour in any way **(H3; RQ 4)**
(v) Rather the introduction of some safety awareness-raising intervention brought about significant improvements in the behaviour of Nigerian drivers **(H4; RQ 5)**.

The question arises whether it is possible to change driver behaviour in the long-term and what could be done to achieve this in Nigeria. Based on the fact that a wide range of road safety measures could not be evaluated in the present study, further study was deemed necessary to investigate the potentials of acting on the findings from this study and thus improve road safety in developing countries. For example, effect and ease of implementation of different road safety measures in Nigeria can be investigated in order to find out what road safety measures will bring about changes in behaviour and what could be done to integrate road safety into the Nigerian culture. These measures may or may not be different from what is obtainable in the developed countries but could be a means to make safe driving more prevalent in the Nigerian culture and thus cause drivers to improve their behaviour.

The following study, presented in chapter 8 is based on the effectiveness and ease of implementation of some road safety measures in Nigeria. It highlights stakeholders' views of the steps that could be taken to integrate road safety into the driving culture in Nigeria.

Chapter 8 Phase 3: Focus group study on the perceived effectiveness and ease of implementation of road safety measures in Nigeria

8.1 Overview

This chapter presents the results of a qualitative study, carried out in the third phase of this research with the intent of developing a better understanding of effective road safety measures which are easy to implement in Nigeria based on available resources and considering cultural and environmental factors. A focus group study was conducted with participants from the Federal Road Safety Corps (FRSC). In addition to highlighting road safety issues, the study assessed opinions about why drivers engage in unsafe behaviours, the effectiveness and ease of implementation of different road safety intervention measures and what could be done to improve the road safety culture in Nigeria.

No specific hypotheses were tested as the study was aimed to identify measures taken by the lead road safety agency to improve the road safety culture in Nigeria. It, therefore, addressed the research question:
RQ6: What road safety measures are perceived to be effective and easy to implement in Nigeria?

8.2 Objective

- To examine the perceived effectiveness and ease of implementation of road safety measures in Nigeria.

8.3 Participants

Participants for the focus group meeting were officials of the Federal Road Safety Corps (FRSC). The FRSC is the lead safety agency in Nigeria, with a vision to provide efficient and reliable transportation, thereby creating a safe motoring environment in Nigeria. Their mission is to regulate, enforce and coordinate all road traffic and safety management activities through sustained public enlightenment, promotion of stakeholders' cooperation, robust data management, improved vehicle administration, prompt rescue services and effective patrol operation. The FRSC was established under an Act of Parliament which enabled it to carry out its mandate as a traffic law enforcement agency. Road safety has an annual budget allocated to the lead agency. Financial supports are also obtained from donors, development banks and the private sector. The Corps is under the Presidency and the Vice President is the Chairman of the National Road Safety Advisory Council (NaRSAC). It is managed by the Corps Marshall who is also the Chief executive officer of the Corps.

The FRSC was initially contacted and a letter of invitation (see Appendix M) was sent to brief them about the intent and outline of the study. The Corps Marshall responded positively to the invitation letter and eight officials were selected from the agency to take part in the study. The officials were selected based on their experience, knowledge and involvement in road safety related projects and policy in the country. Eight officials were deemed an appropriate number for the study because research (Morgan, 1997) has shown that typical focus group study should include about six-ten participants as this gives scope for a range of different viewpoints and opinions while enabling all participants to make contributions without having to compete for time. The sample consisted of six male and two female participants within the age range of 45-60. Participants' years of experience was in the range of 22-27 (mean=23 years). The focus group meeting took place at the FRSC national headquarters, Abuja Nigeria and lasted approximately ninety minutes.

8.4 Procedure

The focus group meeting was undertaken on 21 November 2018. The researcher (who is also the author) commenced by expressing her gratitude to the Corps (participants) for accepting the invitation and making time to participate in the study. The research team which included two facilitators was introduced and their roles explained to the participants. Participants were given an introduction that emphasised the aim of the study with respect to driver behaviour in Nigeria. The participants were assured confidentiality would be kept and that all information provided will be anonymised. They were advised about their right to withdraw from the study at any time. The information sheet was read and explained, participants had the opportunity to ask questions and were asked to sign a consent form to indicate their willingness to participate in the study and to allow the recording and transcription of the meeting. The consent form is included in Appendix N. Participants completed a brief questionnaire about their age, gender, and years of work experience. A digital voice recorder was used for recording and hand-written notes were taken. During the meeting, discussions were guided by a number of open-ended questions which were developed after phase 2. Participants were probed and encouraged to share their views. At the end of the meeting, participants were thanked for their cooperation and time. No Incentives were given to them. The discussions were audio-recorded and transcribed verbatim removing any identifying details. Prior ethical approval had been granted by the Research ethics committee of the University of Leeds.

8.5 Analysis

In this section, the method of data analysis is described.

8.5.1 Qualitative data analysis

Data was transcribed by converting it verbatim into written text. Observations during the interview (e.g. sounds, pauses, and other audible behaviours) were also transcribed. The transcribed data were coded by grouping participants' responses into different themes (i.e. Problems, measures, strategies for improvement). Each of these themes is discussed together with supporting quotes from participants. To protect participants' confidentiality, each quote was presented only in relation to the order in which the participant had first spoken in the discussions and the question number. For example, the third participant to answer question 2 would be identified as (P3, Q2).

Data were analysed using the Deductive content analysis (DCA). The DCA has been used extensively in a wide variety of research applications and was adopted in this study because it is a systematic and objective means of describing phenomena (Krippendorff, 1980). The initial list of coding categories was generated from findings from phases 1 and 2 but was further modified during the analysis as new categories emerged from the responses. When using themes as coding units, expressions of ideas are primarily sought (Minichiello et al., 1990). According to Hsieh & Shannon (2005), the DCA is mostly used when the structure of the analysis is addressing questions from theories, previous empirical research and knowledge of the study area. It involves a structured matrix development whereby all data are reviewed for content and coded for correspondence to the identified categories (Polit & Beck, 2012). Results are then described by the content of the structures describing the phenomena (Elo et al., 2014).

8.5.2 Quantitative data analysis

The quantitative ratings generated from the scale of effectiveness and ease of implementation of the road safety measures were collated and analysed during the focus group discussion. The mean of each measure was found and effectiveness was plotted against ease of implementation on an effectiveness/ease of implementation grid. Based on the result of the analysis, more discussion about these measures and the findings from phase 1 and 2 followed. It is important to note that the quantitative rating and analysis of data were carried out during the focus group study. The focus group participants had an even dynamic which was perhaps made possible by their broadly similar levels of experience. No individuals dominated the conversation and efforts were made to ensure all participants contributed. All quotes attributed capture the main message from a particular topic area rather than a one off remark.

8.6 Results

Results of all the data (qualitative and quantitative) analysed in this study are presented in this section.

8.6.1 Qualitative findings

Analysis of the focus group study data led to several explanations or combinations of explanations for road safety in Nigeria under different themes (see Figure 65). The themes were elicited from setting up the questions for the study. The themes that emerged at the first level included: road safety issues, measures and strategies for improvement. These were further sub-divided into level two and level three. The first level-one code was mainly concerned with road safety problems in the country and the discussion was centred on five key sub-themes: road engineering and infrastructural, organisational and implementation, behavioural problems, operational problems and problems with road safety research and data management. The second level-one code showed different road safety measures currently in existence in the country. It is subdivided into eight level-two codes which include public education and information campaigns, driver education and training, legislation and enforcement of traffic regulations, post-crash care, vehicle inspection, traffic control and use of advanced technology, road design and road maintenance. The third level-one code of strategies for improvement emerged as one of the important themes in the meeting. It indexed some second-level codes such as awareness raising and campaigns, improved collaboration with stakeholders, Nigerian road safety strategy (NRSS) 2012- 2018, etc.

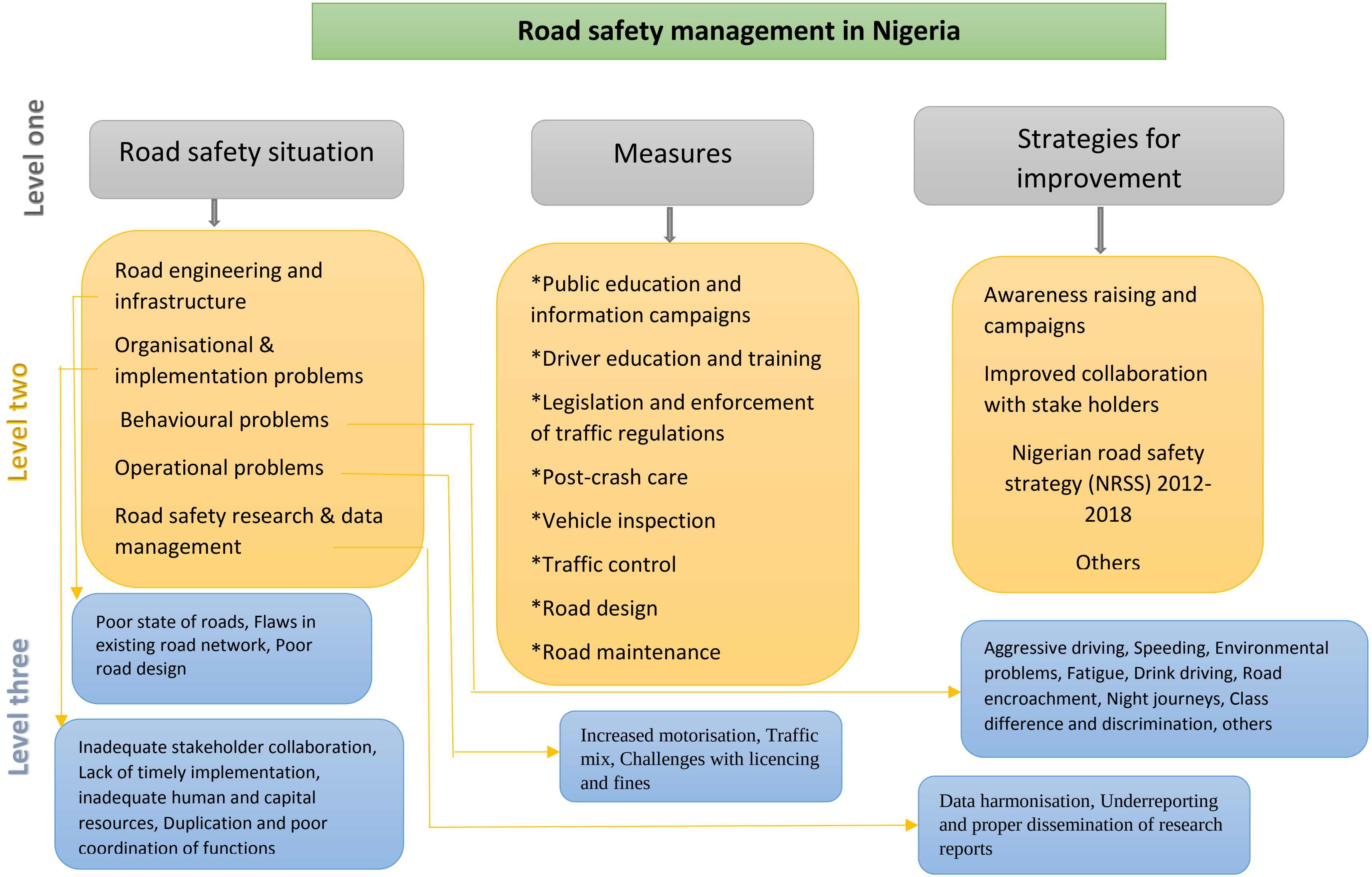


Figure 65: Result of data analysis on road safety management in Nigeria

8.6.2 Quantitative findings

Participants rated the eight road safety measures (see section 5.5.3.2) based on their effectiveness and ease of implementation in Nigeria. Figure 66 summarises the overall results by combining the responses of all the participants. It is relatively clear that public education and information campaigns (Appendix E, option 6) were rated by participants as the most effective and fairly easy to implement measure (2.6, 2). Driver education and training was rated the second most effective measure even though participants stated that it is not easy to implement. Legislation and enforcement of traffic regulations and post-crash care were rated third and fourth very effective measures respectively and not very easy to implement. On the other hand, traffic control and use of advanced technology were rated effective and not easy to implement. Vehicle inspection was rated effective and difficult to implement. Road design was rated effective but very difficult to implement while road maintenance was rated not effective and difficult to implement.

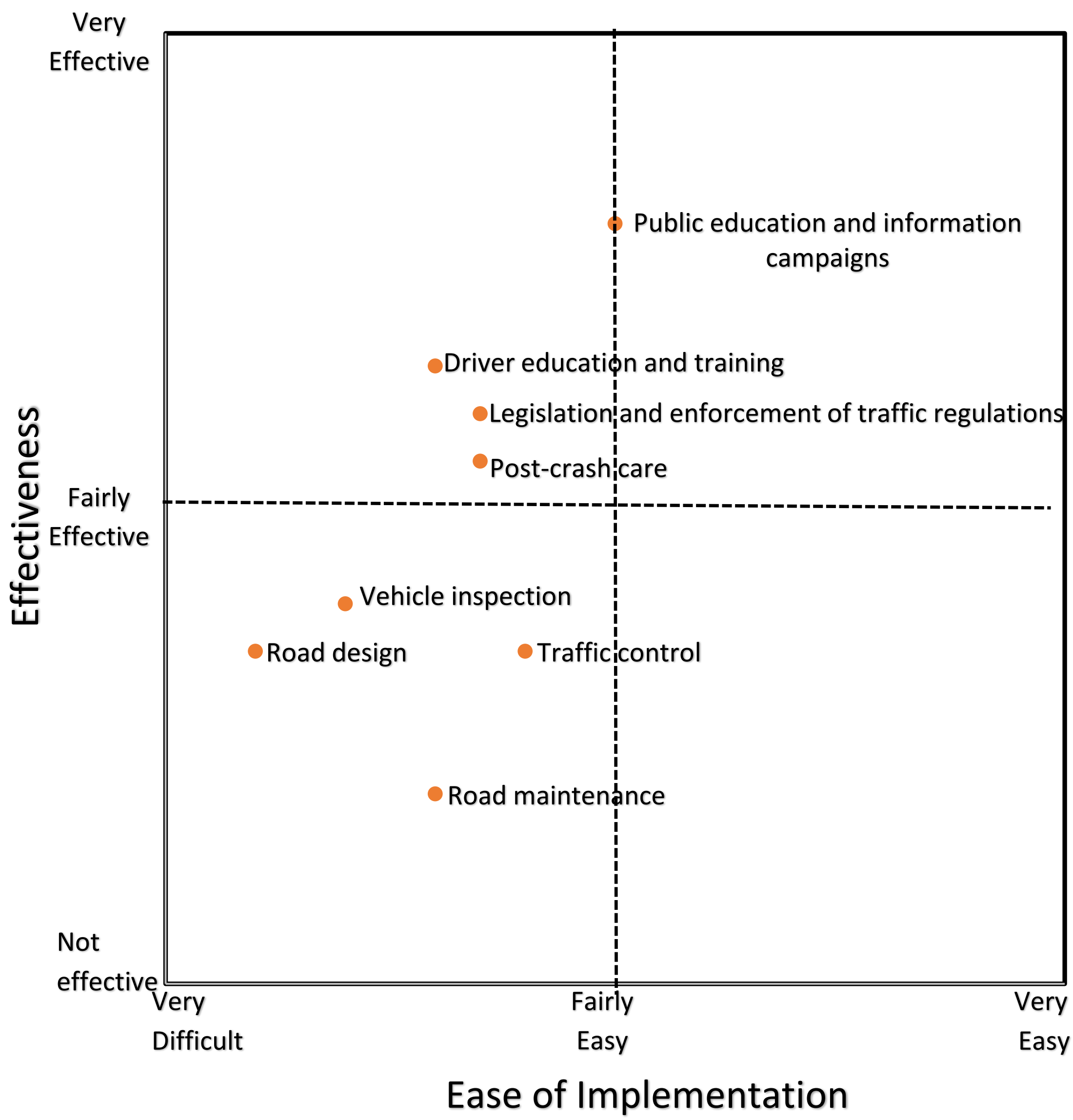


Figure 66: Effectiveness and ease of implementation ratings of road safety measures

It is interesting to note that the very effective measures with ratings between fairly effective and very effective combined with measures with ratings between very difficult and fairly easy were used to identify measures which the Corps deal with directly (top left in Figure 66). On the other hand, measures with ratings between fairly effective and not effective combined with measures with ratings between very difficult and fairly easy were used to identify measures which involve mainly infrastructure and vehicle maintenance and not directly under the purview of the Corps (bottom left in Figure 66).

8.7 Discussion

In this section, a detailed discussion of the results of the study has been provided with direct quotes from the participants. Quotes from study participants are in *italics*.

8.7.1 Road safety situation

8.7.1.1 Road engineering and infrastructure

Participants stated that poor and inadequate road engineering increases the risk of road traffic injuries in Nigeria. Okigbo (2012) and Farouq et al. (2017) raised the same concerns about poor road design and engineering, poor maintenance of existing roads and inadequate road infrastructure in Nigeria. Poor standards of the roads, poor visibility, inadequate and improper sign installation and disappearing road markings, failure in adding safety features to road design, encroachment of footpaths (sidewalks) etc. were cited as safety hazards by the participants. In Nigeria, the federal ministry of works is in charge of constructing new roads while the Federal Road Maintenance Agency (FERMA) is responsible for scheduling regular maintenance of roads with poor surface quality and numerous potholes.

> *FRSC carries out road audits and sends reports to FERMA, but because these projects would normally go through various stages before being approved, it sometimes takes time. Sometimes, when you send reports to the ministry, they tell you that they have completed their work and that the report should go to FERMA…. even when these are newly completed road projects (p1, q1).*
>
> *It is usually not very easy to get these projects approved and carried out, sometimes there are challenges with the capital needed to carry them out. The Senate has even removed road signs from the budgets for road construction, stating that there is no money… (p1, q2)*

In addition, road design fails to consider the infrastructural needs of other road users such as pedestrians, two wheelers etc. Different categories of road users such as vehicle drivers, tricycle drivers, pedestrians, motorcycle drivers, bicyclists have to share the roads. Little or no effort has been made to segregate the motorised from the non-motorised. Pedestrians and persons with disabilities are often overlooked in road design. Even though some pedestrian facilities such as bridges can now be seen in most parts of the country, most of them are under-utilised because they are poorly designed and not sited in the appropriate places.

> *There are bridges in the Federal Capital Territory (FCT), Abuja which we know pedestrians have never used because they were not properly sited. People do not live in those areas. We warned against it before it was constructed but…. (p1, q1).*

However, participants were of the opinion that, when provided, pedestrians do not make appropriate use of these facilities.

> *People avoid using pedestrian bridges and have even turned them to market sites. There are also security concerns on the use of the bridges at Night as there have been reports of and complaints about rape and robbery (p6, q1).*

Akinyemi (1986) attributed the poor state of Nigerian roads to bureaucracy and inattention to preventive maintenance projects and according to Odeleye (2000) inadequacies on road infrastructure in the country are rarely attended to, until they become death traps. In addition, night travel in Nigeria is highly discouraged because components that aid night travel such as road lighting are not adequately available.

8.7.1.2 Organisational and implementation problems

Road safety requires the collaborative or joint effort of all concerned government agencies, non-governmental organisation and private sectors. FRSC is the centralised government body responsible for road safety in Nigeria and is actively involved in implementing various road safety measures in the country. These measures relate to conducting studies and evaluating current procedures on road safety to generate information that will form the core of its programs to enhance road safety. According to participants, In the course of carrying out their functions, there are problems encountered which are challenges to improving the safety situation of the country. Lack of timely implementation reduces the effectiveness of road safety projects, this could be as a result of administrative formalities or improper coordination. Consistent with the findings from other studies, there are overlapping objectives and responsibilities among these agencies which need to be addressed because it has made it difficult to attain a better road safety status in Nigeria (Odeleye, 2000).

> *Sometimes, some projects would need to be considered and approved by different government agencies and this also takes time. The Minister is a listening minister and responds promptly to issues, but we still need to wait to get all necessary approval before implementation (p1, q2)*

> *There are inter-agency conflicts especially between the police, vehicle inspection officers…etc. Some activities performed by different agencies and ministries appear to overlap resulting in conflicts. Examples include activities such as traffic law enforcement delivered by the FRSC, Police, Vehicle Inspection*

> *Officers (VIOs) and State Traffic Management Agencies in some States of the Federation (p7, q2)*

Inadequate human resource (professionals or personnel) was identified by participants as one of the issues impeding road safety in Nigeria especially in the area of enforcement. For example, vehicle inspection is rarely carried out even when drivers renew vehicle licences. Drivers prefer using a third party because it is possible to get a vehicle fitness certificate without proper inspection.

> *Vehicle inspection is not directly under our purview, the VIO is in charge of vehicle inspection. The VIO lack the necessary resources (especially personnel and equipment) needed to carry out these duties and so people resort to using third parties (p1, q1).*

Lack of evaluation and monitoring of various road safety programmes and projects was mentioned as a very big challenge to the Corps. This is because most of these programmes phase out when they are not monitored and it is very difficult to measure their impact on road safety.

> *We do not follow up on some of our programmes and so they phase out, for example, the road safety games, reflective armbands for school children (p2, q1).*

8.7.1.3 Behavioural problems

This study found that road users are usually involved in behaviours which are termed unsafe for them and other road users. It was further revealed that most of these unsafe behaviours involve different categories of road users. It is very important to note that the most frequent unsafe behaviours, as well as factors which mediate these behaviours have been identified in phase 1 (see chapter 6) and are consistent with the result of past studies carried out in Nigeria (Ogwude, 2004; Olapoju, 2016) and other low and middle income countries (WHO, 2013).

- Speeding

Most of the participants cited speed and speed related problems as one of the most unsafe behaviours exhibited, especially by commercial drivers. The extent of this problem can be seen in the FRSC report (2017) showing its percentage contribution (44%) to traffic crashes in the country. In addition, a study by Uzondu, Jamson and Lai (2018) showed that speed is a major contributory factor to traffic conflicts in Nigeria.

> *Most problems are from speed-related causes. This is being tackled by the introduction of the speed limiting device which has been made mandatory in the first phase for all commercial drivers. We hope to extend it to private drivers after evaluating its impact in the first phase (p2, q1).*

- Aggressive driving

Participants felt that most of these road safety problems are in one way or the other related to behaviour. Aggressive driving is very rampant in the country. Lane discipline on the roads is rare, drivers honk their way into any little gap they see between vehicles. This is consistent with the results of a study by Ogwude (2004) on driver behaviour in Nigeria. The study showed that drivers (commercial drivers) are generally impatient and aggressive.

> *Most drivers do not want to wait in line or observe other traffic rules, they drive aggressively by tailgating, honking, weaving in traffic, excessive speeding, headlight flashing, and red light running. There is generally impatience on the part of drivers and non-drivers (p4, q2).*

- Vehicle maintenance

Another road safety problem that emerged was the type and condition of vehicles operating on the roads. Drivers do not consider or understand that vehicle maintenance and repair is a part of road safety. Vehicle repair is usually deferred by some drivers until the vehicles break down completely. They make use of very old, rickety vehicles with expired tyres. Vehicles and tricycles are routinely overloaded with people and goods, this could prevent effective use of the rear view and side mirrors.

> *Hmm…very bad and rickety vehicles are seen all over the roads because drivers refuse to put their cars in order, most people even use expired tyres (p1 q8)*

- Environmental problems

Environmental problems as a result of using vehicles which are not road-worthy were mentioned, most of the cars on the road are very old and defective, causing air, noise pollution and most times seen breaking down in the middle of the road causing unnecessary traffic or hold up. This is applicable to the tricycles which can be seen as rickety.

> *Defective and smoky vehicles cause reduced visibility which leads to crashes (q1, p2).*

- Fatigue

Fatigue was stated as a problem especially related to commercial bus and tanker drivers. Most of these drivers drive for long hours without taking adequate breaks. They sometimes strive to meet stringent deadlines while travelling on bad roads with black spots.

> *Tankers, trailers and commercial drivers in the country are the worst as their involvement in crashes are usually as a result of fatigue (paused) crashes among trailers and tankers in the country are generally attributed to fatigue (p3, q1).*

- Drink and drugs

Driving under the influence of alcohol and drugs was noted as a gradually emerging cause of road traffic crash and a road safety problem in Nigeria. This calls for urgent concern because of the number of offenders who have been apprehended recently and who have tested positive to drugs and alcohol.

> *The FRSC introduced an emotional evaluation test for traffic offenders in the FCT. In the last year, about 6,000 offenders were arrested. The result of their evaluation test showed that most of them were under the influence of drugs (marijuana, cocaine). The most pathetic thing is that most drugs they use are no longer expensive and can be obtained easily (within their reach and easily accessible) as they can go to any length to get "high" (intoxicated) e.g. tramadol, codeine, etc. (p1, q1).*

> *Easy access to drugs, there are very cheap accessible ones such as tramadol, codeine, inhaling the gas from [1]pit latrine/ toilet or soak away pits (these ones are free) etc. These are very easy to get (p2, q1).*

- Road encroachment

Another issue raised by participants' concerned encroachments and heavy haulage on roads that give no adequate consideration to safety. Participants stated that this has created undue inconvenience for many road traffic operations. Pedestrian footpaths and roads have been encroached by traders and other people and these have added to the discomfort of pedestrians.

> *Trading in the middle of the road where the road which should be free for traffic is turned to a market… uncontrolled parking (usually trucks carrying petroleum products, containers and other heavy goods), shopkeepers and street vendors (p3, q2).*

- Night Journeys

Night journeys were raised by participants as people are encouraged not to travel at night. As stated in section 5:3:5:1, most of the activities in Nigeria are carried out between 6 am and 7 pm as a result of reduced visibility and security issues.

> *Visibility at night is of very great concern to the Corps because security is low and a number of crashes happen at night (p4, q1).*

> *It is very difficult to get help at night (p1, q1).*

---

[1] A **pit latrine**, also known as **pit toilet** or long drop, is a type of **toilet** that collects human faeces in a hole in the ground. Urine and faeces enter the **pit** through a drop hole in the floor, which might be connected to a **toilet** seat or squatting pan for user comfort (Wikipedia, 2019).

Dangers associated with night journeys are enormous and thus are being discouraged. Some of these problems are security related, poor visibility at night, lack of street lights, bad road conditions and lack of emergency response at that time of the day in the event of a crash (p5, q1).

- Class difference and discrimination

Inadequate enforcement was identified as a major road safety problem in Nigeria. There is a general concern that law enforcement is not as strict as it should be, probably as a result of discrimination and unequal resource distribution in some parts of the country. Whilst this issue was not probed further, it was seen as a major challenge to road safety in Nigeria. Higher status, influential drivers or drivers with relatives in top government positions are more likely to have their fines waived and easily avoid punishment. The participants stated that some offenders in some parts of the country are not fined the same amount for an offence as their counterparts in certain parts of the country.

You would not expect us to fine an offender in Abuja #10,000 and also charge another driver who has committed the same offence in the north the same amount…, there is no way they can pay it… (p1, q1).

- Others

Participants identified low compliance with safety standards, disrespect for law and law enforcement, use of mobile phones, non-use of helmets, non-use of seatbelts and appropriate child restraints, neither slowing down at yellow lights nor stopping at red light etc. as risk factors for road traffic crashes. They identified tricycle and commercial drivers as high-risk road-users. Commercial drivers are always in a hurry to get more passengers and therefore making sudden stops to pick-up and drop-off passengers, which increases risk for all road users. Young drivers were identified as another high-risk group. These are in line and corroborate previous research (Uzondu et al., 2019) carried out in Nigeria.

When we do our campaigns, we encourage parents to talk to their children especially the young males and also show them examples by driving safely. 8

There is still this belief that road crash is an act of God, more like that is how God wants it. FRSC has been working on the minds of people to debunk this, letting them know that crashes are preventable and not an act of God (p2, q2).

There is a problem with passengers not using their seatbelt. They assume it is for the drive and the passenger sitting in front (p6, q1)

Even though we are still not where we want to be, we are gradually making an impact. Seatbelt-wearing rate has increased and we have improved in our emergency response and post-crash care (p8, q6).

8.7.1.4 Operational problems

- Increasing motorisation and poor public transport system

The analysis highlights the fact that rapid urbanisation and associated increased motorisation has worsened the road safety situation in the country. As discussed in chapter 2, Nigeria has witnessed increased motorization and urbanization in the recent past, and as a result of this, the major urban areas such as the FCT, Lagos and Port-Harcourt are suffering from heavy traffic congestion and lack of regulation. According to the study participants, one of the reasons for unprecedented motorisation is lack of adequate and accessible public transport which has made almost everybody to acquire personal vehicles. Some respondents reported that proper bus stops are either not provided or are poorly designed and managed. As shown in chapter 6, phase 1 of this study, it is common for the drivers of passenger vehicles to stop in the middle of the road or even at intersections to drop off or pick passengers.

> *Public transport is not well developed, as a result, people feel more comfortable travelling in their private vehicles (p1 q1)*
>
> *The public transport system in the country is not developed even though more recently, the public transport operators are beginning to form unions to make sure they have uniform rules. This is also being supervised by the FRSC (p1 q2).*

Participants reiterated that enforcement of traffic laws is not adequate in the country. There are laid down laws on seatbelt use, helmet use, drink-driving etc., but enforcement is not stringent for the latter two while strict for seatbelt use. Speed limit is regulated at national and local levels, but enforcement is not stringent as well.

> *Enforcement has not gotten to an appreciable level, we still need to do more in this direction (p8, q1).*

- Challenges with the national driver's licence

Participants identified challenges with the new improved driver licensing system as another major issue and contributing to unsafe driving practices. Participants said whilst progress has been made in the country and comprehensive driver training programs and computerised licensing systems have been introduced, people still try to get around it through registered driving schools. The improved driver licencing system in Nigeria is reported to be constantly abused by driving schools. In addition, majority of motorists still do not drive with a licence. This was reported in chapter 2, where it was stated that majority of drivers in Nigeria do not go through the appropriate training and tests and some do not have a drivers licence.

> *Most people like to obtain their licences through a proxy and in the process are issued a fake. This is also the issue with vehicle registration and plate number (p7, q1).*
>
> *Driver licencing system has improved… but we are still be sabotaged by driving schools who register people and give them certificates after 26 days without*

giving them any form of training. We have cases where they have hacked into the system to generate certificates, but some of them have now been arrested. We are making efforts to improve the security of the websites (p2, q2).

26 driving schools have been suspended presently for trying to hack into the system to generate certificates for people who did not actually go through the training, they collect bribes from them to do these (p1, q2).

Some drivers still do not drive with licence especially the commercial drivers (p8, q1).

- Penalties and fines

The issue of penalties and fines are still being abused through the use of power, influence and petty bribes. Participants cited it as a very big challenge which they are working very hard to improve.

Sometimes, people do not like to take responsibility for their actions. For example, when people are caught making phone calls and driving, they'd prefer to pay the fine of #4000. Which they feel is not a lot. This is now why we have now introduced emotional evaluation (p1 q1).

Offenders believe the worst FRSC can do is to give fines which they are willing to pay (q2, p3)

With the introduction of the emotional evaluation, offenders will now make out time to go to the hospitals, wait to take the test etc. and all these will take a little bit of their time. We believe that this and increasing the fines which we are currently looking at will make people deter or more conscious of using mobile phones (p1, q1).

When people are caught, they make phone calls to friends and relatives in Government (top government officials, senate president, national assembly etc.), who in turn call top FRSC officials to waive these fines. This is a very big challenge to us because…we will also need these people at one point or the other (finance, legislature, judiciary etc.) especially when we need approval for projects, so we sometimes bend the rules. (p1, q2).

…There are cases where we have lost cases in court just because a magistrate's wife was once arrested for a traffic offence. This is why we are reviewing the legislation so that even if we're to waive the fines, offenders will still get punished in one way or the other (p1, q2).

8.7.1.5 Research safety research and data

Crash data is collected at the scene by road safety personnel who had been on patrol or were called to the scene via the toll-free emergency call centre or by any other means. Police personnel also collect crash data during investigations. Previously, this was done by data information officers of the Federal Road Safety Corps (FRSC), who collected, collated and forwarded data to sector commands at the state level. Sector commands collected and forwarded collated data from local level to zonal headquarters. Zonal commands forwarded validated crash data to road safety headquarters for analysis. Now, the FRSC has digitalised the data collection process with computers and hand-held tablets at the scene of a crash, and data arrive directly into the FRSC data portal (www.frscrtcis.com.ng/). The Portal is designed to accommodate inputs from other data collection agencies such as the VIO, State Traffic agencies, Police, and hospitals. The portal can sieve the data to avoid multiple entries. This arrangement of data harmonisation comes under the National Committee on Crash Information System (NACRIS) which was launched in April 2014. Despite this, participants maintained that there are still gaps as not all crash data are recorded, especially places not regularly covered by FRSC and police. To address this issue, data information officers regularly visit these areas and collect missing data, but this is expensive

> *We have selected some young officers called data information officers who have been specifically trained to collate data from the police and hospitals in the rural areas where there is not yet FRSC presence (p2, q5).*
>
> *Unreported cases are also prevalent here, where victims settle on their own without involving the Police. There is no working insurance plan in the country presently so we do not get data from insurance companies (p5, q5).*
>
> *In 2016, the World Bank came up with a uniform template to record crash data for police, hospitals, FRSC (NACRIS) (paused) FRSC data is more comprehensive than what you can get from other government agencies. Research data is usually provided on demand when people request it and it is approved, the research department makes it available (p1, q5).*

8.7.2 Effectiveness and ease of implementation of road safety measures

There is a cost associated with every road safety intervention and because there is a limited budget with which to make improvements, it is very important to ensure that reductions in deaths and serious injuries are maximised within the budget available. Doing this requires a good knowledge about the effectiveness of road safety measures and a process to help prioritise these measures. It seemed very important to identify what measures the FRSC has adopted in the country and to know which ones are effective and easy to implement based on their effect on crash reduction, resources, compatibility with other measures etc.

Participants were provided with a list of road safety measures which were collated from the result of previous studied and from literature. Analysis showed that the very effective measures with ratings between fairly effective and very effective combined with measures with ratings between very difficult and fairly easy were used to identify measures which the Corps deal with directly (top left in Figure 66) and these are:

- Public education and information campaigns
- Driver education and training
- Legislation and enforcement of traffic regulations
- Post-crash care

8.7.2.1 Public education and information campaigns

Research (Phillips et al., 2011; Adamos et al., 2013) has shown that Public education and information campaigns have proved very effective in improving road safety. Participants rated this measure as very effective and fairly easy to implement. This is one of the core responsibilities of the Corps and over the years they have deployed various means to make sure road safety education gets to everyone in Nigeria, even road users with no access to electronic media such as television, radios etc. Participants stated that it was cost-effective because it is part of their job description and there are already some members of staff delegated to do this.

> *All the commands and special marshals engage in public enlightenment campaigns. It is cost effective, we do not need to pay the officials to do them and we want to increase the frequency (p2, q3).*
>
> *Recently, the 253 commands across the country have been instructed to carry out one motor park [2]rally every day. We have an average number of 80 motor parks in each command, this will give a rough idea of the number of people we reach in a week. When we do this, we're able to talk to both drives and their passengers (p1, q3).*

8.7.2.2 Driver education and training

Participants rated this as one of the effective measures, even though it is not very easy to implement because of the challenges which were mentioned in section 8.7.1.3 of this report. This is in line with the result of phase 2 of our study (chapter 7: section 7.8.3) which showed that driver education and training is effective in improving road safety especially for Nigeria drivers and research by Kosola et al. (2016) which highlighted the importance of driver education in improving driver behaviour.

> *We are trying to enlighten drivers and make them understand the importance of these training notwithstanding the monetary benefits (p2, q5).*

8.7.2.3 Legislation and enforcement of traffic regulations

This was rated as effective and not so easy to implement. This is because it is difficult to get drivers to adhere to traffic rules. They always find a way of breaking the rules. Studies have shown that enforcement of traffic regulations could produce positive

---

[2] Motor parks are designated areas fixed by state or local governments where passengers go to board buses to their different destinations either within or outside their cities.

effects on road safety. For example on seatbelt use (Vasudevan et al., 2009) and child restraint (Ausserer et al., 2009), speed enforcement (Van Schagen et al., 2016) etc.

> *We have these legislations in place and try to enforce them but it still comes with its challenges, apart from these, it is a very effective road safety measure. You still find parents carrying children in the front seat and even in the rear without child restraints, motorcyclists have refused to wear helmets (p2, q3).*

> *We currently reviewing our legislation and trying to amend it to tackle these issues, we think that the current penalties and fines on offenders are not deterrent enough (p1, q5).*

8.7.2.4 Post-crash care

Post-crash care and its effect on road safety cannot be overemphasized (Soro & Didier, 2017). Post-crash care was rated as fairly effective and not so easy to implement especially when there are not enough vehicles and people do not call the emergency numbers. When people call to report a crash, the FRSC tries as much as possible to redeploy an emergency vehicle to the crash site, this is usually monitored and tracked at the emergency call centre which has nationwide coverage. FRSC has designated a toll-free emergency line (122) for crash/incident reporting. The call is directed to its call centre, manned by FRSC staff on a 24x7 basis. On receipt of a distress call, the centre proceeds to locate an FRSC patrol vehicle nearest to the crash scene via the use of a vehicle tracking suite. In addition, Lagos State is the only state in Nigeria that has through the state government set up measures to improve road safety in the state. For example, the state government has an emergency call number (767) which is routed to an emergency call centre in Lagos state for people to call whenever there is a crash. Despite all these, there are still problems with people not calling the emergency numbers and more experts needed to attend to victims.

> *When crash victims or passer-by call the emergency numbers, we try to respond as quickly as we can. Giving first aid and subsequently taking the injured to the hospital. We have officials who have been trained to do this but instead of calling the emergency number, people would rather start recording videos and taking pictures (p2, q5).*

> *A total of 58 ambulances and operates about 48 roadside clinics. Each clinic is furnished with equipment and manned by trained FRSC personnel. However, capacity issues abound in this area in relation to required equipment and expertise especially in the area of Advanced Trauma Life Support (p1, q1).*

On the other hand, measures with ratings between fairly effective and not effective combined with measures with ratings between very difficult and fairly easy were used to identify measures which involve mainly infrastructure and vehicle maintenance and not directly under the purview of the Corps (bottom left in Figure 66). These are:

- Vehicle inspection
- Traffic control
- Road design
- Road maintenance

8.7.2.5 Vehicle inspection

Computerised vehicle inspection centres have been introduced in some states of Nigeria to check the roadworthiness of vehicles. More periodic technical inspection centres are also being established. Even though vehicle inspection is not directly the responsibility of the FRSC, participants rated it as fairly effective but difficult to implement

> *Vehicle inspection is not directly under our purview, it is under the VIO. For now, only Lagos and Abuja have electronic vehicle inspection centres, other states are beginning to sign on…Most vehicle inspection offices in the country do not have the capacity and resources to carry out their work (p1, q3)*

8.7.2.6 Traffic control and use of advanced technology

Traffic control in Nigeria is the responsibility of the traffic wardens who work an average of 10hrs in a day. As a result of the issues cited in section 8.7.1.3 about security and visibility at night, traffic wardens do not work late nights in Nigeria. The installation of traffic signals on some roads have taken care of this anomaly but drivers still find it difficult to obey traffic signals the same way they flaunt traffic wardens' directives. Installation of a traffic signal is also infrastructure based and the difficulty is in providing the finance needed to put these in place.

> *We would normally make recommendations and then let the ministry of works do their job, we also follow up on these (p5, q6)*

8.7.2.7 Road design

Participants reiterated that a lot of work is needed to include safety features to road design and maintenance in Nigeria. Even though this is an effective means of improving the safety situation of the country. Lack of finance has been an impediment to this for a very long time.

> *It's difficult to get roads under construction to comply with safety measures. Including safety features in road design would usually cost more money but they are important, we save a lot by preventing crashes (p2, q3)*
>
> Finance for project implementation is a very big challenge (p5, q6)

According to the participants, properly designed roads and road networks on its own will not improve the behaviour of drivers. This is in line with the result of phase 2 of this study **(**see chapter 7: section 7.8.2), more needs to be done in the area of road user behaviour.

Some roads are bad but even when they are improved, speeding increases (q1, p1).

8.7.2.8 Road maintenance

Most activities to improve road infrastructure are limited to minor black spot treatments which depend solely on the availability of funds. Federal Roads Maintenance Agency (FERMA) is in charge of road maintenance in Nigeria. Participants stated that the challenges with road maintenance were the same with road design.

> *Road audit- we carry out road audits and make recommendations to the federal ministry of transport and FERMA. There is presently a department in the ministry of works- road safety and security, we work hand in hand with them (p2, q1)*

> *When we asked that safety features be added to roads, the ministry of works tells us to go to FERMA because they have concluded their work (constructing the road), when we go to FERMA, they refer us back to the ministry. Sometimes there are diverging views between FERMA and the ministry of works (p1, q3).*

8.7.3 Strategies for improvement

8.7.3.1 Awareness raising and campaigns

Road safety awareness campaigns are an important tool to communicate road safety tips to road users. Past research (Aigner-Breuss & Eichhorn (2017) have shown that awareness-raising is beneficial for road safety on various levels. Kaiser et al. (2017), in their meta-analysis research on the effectiveness of road safety campaigns, showed that there is a positive association with crash reduction, increased safe behaviours and risk awareness. FRSC has conceptualised, designed and implemented various public education programmes which cut across language, cultures and religious barriers in order to reach people from the grass root.

FRSC has started inculcating safe behaviour from an early age by starting various programs for school children. It is believed that Children can play a vital role in positively influencing their parents.

> *We have developed a series of program to improve road safety in Nigeria. We believe that teaching road safety in schools could help people develop a better safety culture. Catch them young- is an enlightenment programme carried out in Primary schools teaching basic road safety tips so that children can grow with it, It has been on in most schools in Nigeria (q5, p4).*

A recent change in the national curriculum has enabled road safety education modules to be added and become mandatory for primary schools. School-based road safety education can instil safe attitudes to young people early in life. Teachers, road safety experts, educational psychologists, enforcement teams contributed to the development of these with massive support from FRSC.

> *Introduced road safety in school curriculum starting with primary schools. It was approved by the presidency and ministry of education and asked to be implemented by all state governments through the state ministries of Education. There is a safety quiz competition in secondary schools which rewards the first three schools. This is some sort of motivation for the schools and creates awareness for road safety (p4, q6).*

> *School bus programme- introduced standard school buses and ensuring that the drivers conform to FRSC guidelines. School clubs (FRSC school clubs) within the school premises, we talk about signage, zebra crossing etc. which FRSC supervise (p2, q6).*

> *We used to have reflective armbands for school children which fizzled out with time due to lack of evaluation, follow up and monitoring. (q5, p3)*

> *National Youth Service Corps (NYSC) road safety club, essay competition sponsored by some NGOs, for primary schools, secondary schools (p1 q6),*

Other channels are being explored and used to make sure that citizens are well aware of what behaviours are safe. This includes visiting churches, mosques, community outreaches, organising town hall meetings with the assistance of traditional rulers, through electronic and print media, social media etc.

> *Nigerians are very religious, so we try to find a way of doing these with religious tips. We have a meeting with the Christian Association of Nigeria (CAN) and their Muslim counterparts to develop tips for Sunday schools and teaching in churches and mosques. In Plateau state, the archbishop has given approval that the FRSC enlighten the congregation on road safety tips, emergency response and what could be done if one gets involved or witnesses a crash. We reach a lot of people through the churches and mosques (q6, p1).*

> *We also try to involve traditional rulers and encouraging town hall meetings, we try new things and these new developments help us improve (q6, p5)*

> *We have the community road safety initiative to train people on crash and rescue so that they know what to do if a crash happens. This is mostly for rescue and it’s done in collaboration with the Red Cross. This was started with 27 communities and trying to reach out to more communities. (q6, p1)*

> *We are trying to introduce the audiovisual road safety measures especially for those that lack reading culture. We share safety tips on social media. We work*

with some radio stations and have recently gotten approval to run FRSC radio (p7, q6)

8.7.3.2 Improved collaboration with stakeholders

While road safety has been recognised as a collective task, there is little collaboration among key stakeholders in Nigeria. As a combined economic, financial, education, public health and infrastructural challenge, road safety affect and is affected by stakeholders from government, business, civil society and the general public. These sectors need to work together to accomplish the goal of creating a safe motoring environment. They all have roles to play both individually and collectively. According to the participants, efforts have been intensified to improve collaboration between all stakeholders involved in improving road safety in Nigeria.

As regards data, we work mostly with the police, hospitals and ministry of health, National Bureau of Statistics (NBS), to harmonise data to avoid duplication. We are developing a strong relationship with NDDC (q4, p1)

There is an MOU with NPA to implement minimum safety standards for trucks, there is also a safe to load programme for all tank farms in the country, we are presently covering a quarter of these tank farms…We have a very cordial relationship with most of the government agencies except when we arrest their drivers (q4, p1).

8.7.3.3 Nigerian Road Safety Strategy (NRSS), 2014- 2018

The NRSS was used to set up a working plan to improve the state of road safety in Nigeria. It shows the targets and what the government is committed to achieve in road safety within a given time. Targets according to Marsden et al. (2009), set out the level of accomplishment that an organisation aims to achieve for a particular project within a given time frame. The policies and strategies laid down in the plan were based on the safe system approach and have been introduced to integrate various elements of road safety efforts into actualizing a safe motoring environment in Nigeria. The NRSS summarises the growing national consciousness on issues of road safety, collective responsibility for road safety and determination to reduce the level of RTCs so as to ensure that neither deaths nor serious injuries result from these crashes. It highlights the current road safety situation in the country; intervention strategies; road safety management; monitoring and evaluation framework; implementation cost; and key success factors/enablers for the effective implementation of the strategy. As a follow up to this, the Federal Government has recently announced plans to unveil the NRSS 2019-2023, to reiterate its commitment to improve road safety in Nigeria (FAAPA, 2019).

There is presently an inter-ministerial committee approved by the government which is made up of the ministry of finance, transport, NNPD, FRSC etc. to work on the Nigerian National road safety strategy (p1, q6).

8.7.3.4 Others

Review of the establishment act of the corps is currently being done as it is believed that it will remove some anomalies (areas of conflict) with other agencies and provide clear and explicit guidelines regarding all expects of road safety in the country. More effective and stricter enforcement, non-economic and stricter penalties (talking to offenders, sending them for evaluation etc.), introduction and implementation of the penalty points system to deter drivers from committing traffic offences, more effective monitoring and evaluation of road safety programmes, attending conferences and learning from countries who have been successful in reducing their crash numbers, improved and sustained integrity with driver licencing system, improving research, data collection and presentation and working hard to make data available especially for research purposes etc. were listed as activities currently being worked on by the Corps to improve road safety. Participants reiterated monitoring of all road corridors for crashes, presenting and reporting the data every week so as to redeploy more officials to the corridors found to have more offenders or crashes.

We believe that a review of the act will take out some anomalies (areas of conflict) with other agencies. We also want to review penalties attached to some unsafe behaviours.
We are trying to see if we can implement the points system which will be uniform for the whole country and affect everybody irrespective of their … income level (p1, q6)

We keep improving on our data, making it more comprehensive and broken down into different categories and sharing especially through the FRSC annual reports and when organisations request for them (q5, p2)

8.8 Conclusion

Stakeholders' perception plays an important role in shaping the road safety practices and in setting up road safety regulations of a country (Tetali et al., 2013). Their opinion is highly valuable when discussing the road safety situation of any country, especially where the country has a lead agency. Nigeria is one of such countries with a lead agency and this focus group study provided an opportunity to actively engage these experts, explore their experiences in road safety management in Nigeria over the years and to identify areas for improvement.

The findings revealed that road safety based projects are often impeded due to lack of collaboration between stakeholders, administrative formalities, the behaviour of road users and inadequate road safety research and data. Measures needed to improve some of these problems were rated by participants in order of effectiveness and ease of implementation. There were similarities in the scoring as participants did not disagree widely. Results showed that measures such as road safety education and awareness-raising which participants perceived as very effective and easy to implement were the ones they are responsible for. On the other hand, consistent with Batool (2012), engineering measures which they are not directly responsible for were scored very low. This could be because their contribution to including road safety standards in road designs are not usually accepted. Improving the Nigerian road safety system requires a total overhaul of the system following the safe system approach. It would involve all stakeholders, road users, researchers and non-government organisations involved in road safety.

Chapter 9 Summary, implications and conclusion

9.1 Introduction

The literature and phase 2 of this research has shown that drivers from countries with poor transport conditions and high crash rates exhibit more risky behaviours compared with drivers from countries with better transport systems and low crash rates. The road safety situation in Nigeria is poor, and driver behaviour has been identified as a major contributory factor. A good understanding of drivers' behaviour, including its determinants, could be a stepping stone in developing effective road safety countermeasures. This thesis explored the road safety situation in Nigeria, investigated the differences in behaviour between drivers from different cultures, evaluated the effect of awareness-raising campaigns on the behaviour of Nigerian drivers and sought to understand which road safety measures are effective and easy to implement in Nigeria. To achieve these, different studies were carried out in various phases of this research.

The approach adopted in Phase 1 to assess the road safety situation in Nigeria was the TCT. This phase helped to identify the most prevalent unsafe behaviours and enhance the understanding of the behaviour of various road users in Nigeria. Through on-road observation, phase 1 explored the road safety situation in Nigeria, factors influencing traffic conflicts and unsafe behaviours in traffic conflict situations were identified. The results of phase 1 informed the design of phase 2. Phase 2 was a self-reported and driving simulator study of the behaviour of drivers from different cultures (Nigeria and the UK), in addition to the evaluation of the short term effectiveness of an awareness-raising intervention on the behaviour of Nigerian drivers. Data was collected using the DBQ and the University of Leeds driving simulator. Since a full range of road safety measures could not be evaluated for Nigerian drivers in phase 2, a Focus group study was designed in Phase 3. This study assessed the effectiveness and ease of implementation of some road safety measures (including road infrastructure and awareness-raising evaluated in phase 2) in Nigeria and how improvement in road safety culture could be achieved.

This chapter summarises and integrates the main findings obtained from all three phases of this research. It begins with a general discussion of the key findings from each phase, which are then discussed in relation to the research questions. The implications emerging from the research follows this. Finally, the strengths and limitations of the research, directions for future research and final conclusions are presented.

9.2 Summary of findings

This section provides a summary of the findings from the studies carried out in different phases of this research.

9.2.1 Phase 1: On-road observation of traffic behaviour and conflicts in Nigeria

Research (Abdulhafedh, 2017; WHO, 2010) has shown that the collection of crash data is an essential tool to support the development and assessment of programmes that aspire to reduce road traffic crashes. According to WHO (2010), this data can be used to raise awareness about particular road safety issues, act as evidence and draw support for policies, programmes or allocation of resources. Crash data also provides a better understanding of road traffic problems, identifying risk factors, and it is a vital source of information for assessing and treating risks. However, considering that the crash data in most developing countries may not be reliable or available, additional sources of data may be needed for road safety management.

This phase, explored the behaviour of different groups of drivers at different locations and time periods and provided a surrogate measure of safety that could be used for the low-cost safety assessment of these locations. The main focus was on establishing the possibility of applying the TCT to examine the behaviour of various road users and to identify the most prevalent unsafe behaviours in different road environments. Most unsafe behaviours recorded in developed countries in the literature have always been linked to the use of mobile phones, speeding, eating and drinking etc., however, Nigerian drivers tend to be rather engaged in other unsafe behaviours which are not seen in the developed countries. Behaviours such as passenger scouting, picking/dropping off passengers were found to be prevalent across locations, during different times of the day and among various road users. Because of the nature of the environment, including the lack of road infrastructure, road users find it difficult to obey simple road rules. Even though drivers are aware that engaging in these activities could increase crash risk, they do so anyway. In general, incorrect use of indicators and tailgating were observed to be the highest among all unsafe behaviours observed. This shows that there are unsafe behaviours which are localised and can only be found in a particular cultural environment but also have an enormous effect on safe driving as other generalised behaviours. Several studies (Ozkan et al., 2006; Cale, 2011; Nordfjaern et al., 2011; Warner et al., 2011) which have compared driving behaviour in different countries, indicate that aside from variations in traffic composition and road infrastructure, driver behaviour and traffic characteristics can be distinctive. This research is one of the very few that have identified unsafe behaviour in traffic using data from the observation of traffic conflicts. These unsafe behaviours were established and categorised after careful examination of the events leading to observed conflicts. It is a proactive approach to traffic safety assessment without necessarily waiting for crashes to happen and reflects the nature of behaviours that could precede crashes. Various unsafe behaviours were identified at different locations and time periods.

The findings show that TCT could be practically applied to road safety assessment in developing countries, providing more information, especially from pre-crash situations, to complement crash data. It demonstrates the usefulness of conflict observation in road safety research where there is no (or limited) crash data (chapter 6). This type of research can be used to aid decision-making processes involving safety assessment of various road users as well as infrastructure improvements which could potentially reduce the number of future crash events. It is believed that the results of this study could provide a baseline to support future research related to the study of road user behaviour and traffic conflicts and will be a major ingredient to complement the inadequate crash data in Nigeria and other developing countries. For example, in Nigeria, data on pedestrian crashes are not provided in the official publication of the FRSC. This study was able to highlight the interaction between pedestrians and other road users. Even though the results may not be generalised, it provided an idea of the figures and the type of interactions involving pedestrians.

9.2.2 Phase 2: Driving simulator experiment investigating if driving culture can be modified by traditional engineering and awareness-raising interventions

Most past research on cross-cultural studies has used self-reported data. The observation of driving behaviour in specific scenarios and situations is an important tool in transport research (Liu, 2006). Results from self-reports and driving simulator experiment showed that road safety culture has a significant influence on drivers' behaviour. According to Delicado (2012), if drivers do not drive safely, it is not a simple lack of knowledge and skills or their unwillingness (Delhomme et al., 2013). The problem appears to be connected to routine behaviour (safety cultures), which is inherently very difficult to change. Musselwhite et al. (2010) also argue that regardless of whether a person intends to drive safely or not, habitual processes (developed out of frequent experience with the environment which occur without fore thought) tend to supersede cognitive processing. Results from the driving simulator experiment provide preliminary evidence that traffic safety culture compared to the road environment has a stronger influence on driver behaviour. It supports past research (Summala, 1996; Novaco, 2001; WHO, 2009) that improvements in the road environment alone may not bring about significant changes in drivers' behaviour especially for the NG drivers who have a history of unsafe driving behaviour which has been confirmed from the result of this study. It was assumed that infrastructure would significantly influence drivers' behaviour. The results, however, showed that infrastructure exerted minimal influence on drivers' behaviour (section 7.8.2). This became evident as drivers' behaviour did not change even when changes were made in the road infrastructure. Throughout the drives and in both infrastructure conditions (low or high), NG drivers drove at higher speeds, had a lower TTC and needed a longer time to react to hazards. The NG/UK and UK drivers on the contrary accepted a larger gap with the vehicles in front of them prior to performing the overtaking, kept a larger gap with the slow-moving vehicle that they overtook, reacted faster to the unexpected hazard because they were not at a high speed and in all the scenarios where speed was measured exhibited safer chosen speed, generally driving within the limit and spent less time above the speed limits. Even though the NG drivers performed more safely in few instances such as reducing speed while approaching a junction or traffic light (amber, green lights scenarios), overall the NG/UK and UK drivers showed a safer driving behaviour. Results from self-reports showed that NG drivers reported the highest violations, aggression and risky driving as was observed in their driving during the simulator experiment.

A plausible explanation for the higher unsafe behaviour in the NG sample may be because the road environment in Nigeria is considerably more hazardous than in the UK. This assumption is supported by traffic crash statistics, which shows that traffic crashes are the leading cause of injury-related fatalities in Nigeria (FRSC, 2017). Another possible explanation for the more dangerous road environment in Nigeria could be the absence of clearly defined traffic regulations. In the UK, regulations concerning speeding and general driving behaviour are relatively strict. For instance, explicit road signs state the speed limits in various areas, and sanctions for violating these limits are relatively severe and enforced. In Nigeria these road signs are rare and several areas lack explicitly defined speed limits. Furthermore, law enforcement of traffic regulations is relatively scant in Nigeria. These factors probably contribute to more risk-taking behaviour and higher crash risk in Nigeria. For example, the speed of traffic on many roads is much higher than the speed limit (see chapter 6, section 6.5.2); consequently, drivers may not see their speeding as a serious offence as is seen in the UK. These differences can explain the dynamic driving behaviour of NG drivers in this study.

Results are in line with Ozkan et al. (2006) who revealed that drivers from safe countries exhibited safer behaviours especially in the scenarios where speed, acceleration, hazard reaction, overtaking, traffic light compliance were measured compared to drivers from ‘’dangerous’’ countries. In addition, research has shown that drivers from countries with high crash rates are less motivated than those with low crash rate to comply with traffic laws and are more likely to drive aggressively (Shinar & Compton, 2004).

Driving tasks such as braking and accelerating tend to be automated and can be carried out without conscious attention (Boer & Hoedemaeker, 1998), however bringing safety into the consciousness of NG drivers would require more than just improvements in the road environment. Hence, it is not sufficient to focus on infrastructural developments alone but also on traffic regulations and driver education and training when developing measures to improve traffic safety in developing countries. One effective means of influencing road safety outcomes is to change a society’s attitude and behaviour towards risk taking (i.e. its safety culture). This concurs with some of the priorities which the stakeholders think need addressing (chapter 8), and could be achieved by taking into consideration any unique characteristics of the society such as socio-economic status, demography, culture, traffic environment, and the law of the land (Bener et al., 2003; Özkan et al., 2006). This study presents some evidence that suggests that drivers’ road safety culture has a considerable influence on driver attitudes and behaviour towards traffic violations and risky driving behaviours. Thus a driver's road safety culture has a stronger influence on driving behaviour compared to the road environment. Simple awareness raising interventions conducted periodically could improve the behaviour of Nigerian drivers.

9.2.3 Phase 3: Focus group study on the perceived effectiveness and ease of implementation of road safety measures in Nigeria

This phase evaluated stakeholder's perception of issues in road safety in Nigeria, road safety measures that are effective and easy to implement and strategies being put in place to improve the road safety profile of the country. The results of the study, presented in chapter 8, revealed some issues regarding road safety in Nigeria and supported some of the results of the studies conducted in phases 1 and 2 of this research. For example, some unsafe behaviours identified in phase 1, which were identified in phase 2 were highlighted by the stakeholders.

The key findings indicate that road safety measures such as public education, information campaigns, driver education and training are perceived to have the potential to be very effective and easy to implement in Nigeria compared with improvement in infrastructure which was rated very low by participants. This is in line with the result of experiment 2 in phase 2, where the effect of an awareness-raising campaign on the behaviour of Nigerian drivers was evaluated after it was observed that improvement in infrastructure (experiment 1, phase 2) on its own did not provide any statistically significant changes in drivers' behaviour (section 7.9). Even though engineering measures are effective in improving road safety, the case may be different in Nigeria if it is not implemented in conjunction with other measures such as training and awareness-raising. This is because drivers need to understand what behaviours are safe and their road safety implications. It is also important to acknowledge that the infrastructural improvements are outside of the control of the road safety agency and their delivery less certain.

This is, to the knowledge of the researcher, the first qualitative study to systematically present important aspects of road safety according to key stakeholders in Nigeria.

9.3 Review of research questions

This section reviews the research findings across the three phases and will be structured according to the seven questions underpinning the program of research. Combining quantitative and qualitative methods, the questions asked at the beginning of the present thesis were answered and the following conclusions are made:

9.3.1 Research question one (RQ1)

What unsafe (bad) driving behaviour(s) are most prevalent among drivers in Nigeria?

The rationale behind this research question came from the lack of road safety research and data and the need to improve and modify data collection methods in Nigeria (see sections 1.3.1 and 1.3.2). If research and data collection are appropriately coordinated and carried out, it will enable researchers, policymakers and the government to have a better understanding of the road safety situation in the country which is one of the main aims of this study (section 1.4). In this study, understanding the road safety situation of the country, including risky road users, risky road locations and most prevalent unsafe behaviours could not be achieved with the available crash data. Therefore the TCT was used in phase 1 (chapter 6) of this study to explore the road safety situation in Nigeria by on-road observation of traffic behaviour and conflicts. Results revealed a number of issues at different road locations, high-risk road users (tricycle drivers, young, males), time of day when the probability of being in a conflict is expected to be very high and especially various unsafe behaviours leading to conflicts at different locations. Although traffic conflicts are not actual crashes, they provide a proactive means of assessing safety and provide data from pre-crash conditions which cannot be elicited from crash data especially if it is fatal (see section 5.5.3 for a review). In conclusion, various unsafe behaviours were identified to have led to conflicts at different locations. The most frequently observed unsafe behaviours across the different locations were:

- Inappropriate speeding
- Overtaking
- Tailgating
- Wrong indicator use
- And traffic rules violations (section 6.6).

In addition, the findings also showed that there are some unsafe behaviours such as:

- Passenger scouting
- And picking/dropping off of passengers (see Table 6 for definition),

which are specific to Nigerian cultural environment and can only be found in societies with similar culture or traffic environment. Some of these unsafe behaviours were further investigated in phase 2 of this thesis.

Apart from providing a wide range of information about the road safety situation in Nigeria, this is the first application of the TCT in Nigeria. The results have demonstrated the possibility of adopting the technique (which is a low-cost method of data collection) in the safety assessment of different road locations in Nigeria.

9.3.2 Research question two (RQ2)

Are there differences in reported and observed behaviour among different groups of drivers (NG, NG/UK and UK drivers)?

The rationale for this research question came from the constant use of self-reports to assess driving behaviour, especially in developing countries (see sections 1.3.3). In addition, one of the objectives of this study was to examine the relationships and differences between the self-reported and actual behaviour of drivers. This is to find out if self-reported data are sufficient to measure driver behaviour. To assess the research question; self-reported and actual driving behaviours of the three cultures (NG, NG/UK and UK) were evaluated with the DBQ and driving simulator data in phase 2 (chapter 7) of this thesis. Generally, results of the two data sets were found to be similar such that the NG drivers emerged as the riskiest group and the NG/UK or UK drivers as the safest (see section 7.8).

Even though the self-reported data enabled the measurement of a wide range of behaviours, the objective data was more helpful in explaining different aspects of driving in much more detail. Explicit measures of behaviour such as TTC, distance headways, percentage speed limit exceedance and tailways were obtained from the objective data. These results confirmed research question 3. The conclusions drawn from the findings are: *First,* there were similarities in the results of self-reported and actual observation of driver behaviour except where explicit measures could not be obtained from self-reports as explained above. *Second*, the utilisation of Objective measures can provide rich and more reliable information about driving behaviours. Hence, this research suggests that objective methods should receive preference over subjective methods when possible and available.

9.3.3 Research question three (RQ3)

Do drivers exhibit different behaviours across different scenarios?

(a) Are there statistically significant differences in behaviour between the driving activity patterns of drivers (NG, NG/UK and UK drivers) in different scenarios?

The rationale for this research question came from the need to understand how drivers from different cultures drive as several factors could influence driver behaviour. Grouping the drivers based on their cultures (phase 2) provided an understanding and answer to this research question. Results indicated that there are statistically significant differences in behaviour between the driving patterns of different groups of drivers in different scenarios. The driving pattern of NG drivers was statistically significant different from that of NG/UK and UK drivers while the driving pattern of NG/UK and UK drivers were similar as no statistically significant differences were found in almost all the scenarios (see Appendix L: Table of Means).

(b) Is poor driving behaviour a function of the influence of culture and are drivers with a history of unsafe driving culture more likely to commit road traffic violations or exhibit the greatest risky behaviour?

The rationale for this research question came from the poor road safety performance of Nigeria (refer to chapter 2 and chapter 3: section 3.5). To answer the research question, the quantitative results from the DBQ and driving simulator experiment presented in chapter 7 are used. The findings highlighted that NG drivers exhibited more unsafe behaviour compared with drivers from the UK. In relative comparison to the drivers in the UK, the results identified that NG drivers were more undisciplined and aggressive. They tended to speed, show aggressiveness by flashing lights, impatient by overtaking on the inside, engage in improper overtaking as well as disregard lane markings.

To quantify the frequency of unsafe behaviours, a modified Driver Behaviour Questionnaire was deployed in this research (section 5.4.4.1). The results of the questionnaire highlighted “Check your speedometer and discover that you are unknowingly travelling faster than the speed limit” as the strongest unsafe behaviour among drivers with NG drivers scoring more than the other cultures (Section 7.7.2).

The results of the driving simulator experiment based on actual observation presented in section 7.7.3 reaffirmed the prevalence of inappropriate speeding, aggressiveness and non-compliance with road rules among NG drivers. It showed that NG drivers were involved in more risky driving across different scenarios compared with NG/UK and UK drivers. The results indicated that drivers from countries with poor road safety culture showed the least favourable behaviour towards road safety and also reported the most unsafe driving behaviours. As a result, the NG/UK and UK drivers emerged as the safest and the NG drivers as the riskiest groups of drivers. More specifically, road safety culture appeared to be a very strong determinant of the behaviour of drivers.

Together, these results confirmed research question 3b and three policy recommendations are suggested. *First*, this research acknowledges that a society’s road safety culture influences driving behaviours, and therefore, implies that behaviour-changing interventions developed on a good understanding of drivers’ cultural environment can prove highly successful. *Second,* the finding encourages conducting more country-specific research. The differences between the driving populations of developed and developing countries coupled with Nigerian’s extremely poor road safety statistics in comparison to the UK – a country that is about three times more motorised with lower current and projected fatality rates (see Table 1) – leads to the conclusion that drivers in Nigeria behave unsafely as compared with drivers from countries which have good road safety practices. And in this case, road safety solutions which are usually adopted from the developed world into Nigeria are not likely to succeed unless they are adapted to take into account local behaviours. *Third*, it empirically provides the basis to develop countermeasures specific to the most frequently committed unsafe behaviours on Nigerian roads (see section 7.7.4).

9.3.4 Research question four (RQ4)

Do drivers adjust or change aberrant behaviour when they move to a better-disciplined driving environment with clear regulations and strict policies?

The rationale for this research question came from the need to improve the road environment, as shown in the literature review (refer to section 4.5.1). One of the aims of this thesis is to investigate the influence of traffic safety culture and road environment (simple engineering measures) on driver’s behaviour. To inform the research question, phase 2 observed changes in the behaviour of drivers with changes in the road environment (refer to sections 7.7.3 and 7.8.2). The study noted that low or high infrastructure conditions (e.g. physical characteristics, traffic conditions) did not affect driver behaviour. It neither improved behaviour for those who were unsafe (NG) nor encouraged the group (NG/UK and UK) who drove safely to engage in unsafe driving behaviours. Generally, detailed analysis showed that behaviours of the different cultural groups (NG, NG/UK and UK) remained almost unaffected or unaltered with changing traffic conditions. In conclusion, drivers from different cultures showed different behaviours across different scenarios, but there were no differences in behaviour within each group in different road environments or conditions (low or high infrastructure). On the other hand, the safer behaviour exhibited by NG/UK drivers compared with the NG drivers shows that moving to a more disciplined driving environment could improve behaviour over time. This could be because the NG/UK drivers must have done the necessary driver training and tests, have experienced stricter enforcement in the new environment and are more aware of road safety implications of unsafe driving compared to the NG drivers. Therefore, NG drivers who have recently moved into a better disciplined driving environment may not be encouraged to develop a safe driving style unless they spend time to experience the new culture like the NG/UK drivers.

The two key conclusions which can be drawn from the findings are as follow. *First,* the influence of road environment on drivers' behaviour as observed in this thesis is very minimal. *Second,* there are significant differences in the behaviour of drivers from different cultures. This study provided a measurement of actual behaviour of drivers from different cultures and provided an empirical base for developing road safety policies with a focus on the diverse characteristics of different drivers. The discussion in the subsequent two sections recommends interventions to improve road safety in Nigeria.

9.3.5 Research question five (RQ5)

Can a simple awareness-raising intervention affect driver behaviour?

This is answered from another driving simulator experiment (experiment 2, see section 7.8.3) carried out in phase 2 to evaluate and examine the effectiveness of simple awareness-raising intervention training on Nigerian drivers. This training was carried out after the drivers have completed the two drives, where the effect of culture and infrastructure were investigated. The aim was to find out if there would be an improvement in behaviour after the training. Data from drives 1 and 2 were replicated and compared with data collected from only the NG drivers after the training. Results showed a general improvement in behaviour, especially in measures relating to speed choice, acceleration and overtaking. From this, it could be concluded that *First*, the awareness-raising intervention resulted in a significant improvement in driver behaviour even if this can only be concluded over a short time period. *Second,* interventions such as improvement in road conditions combined with proper training and awareness-raising are likely to have an advantage over infrastructural improvements alone in Nigeria.

9.3.6 Research question six (RQ6)

What road safety measures are perceived to be effective and easy to implement in Nigeria?

To assess the perceived effectiveness of a wide range of road safety measures which could not be achieved in phase 2, a qualitative study was carried out in phase 3. In this study, the perceived effectiveness and ease of implementation of a range of road safety measures (see section 5.5.3.2) were examined. This study was carried out with stakeholders who are officials of the lead road safety agency (FRSC) in Nigeria. Since this is the main agency in charge of road safety in Nigeria, it was essential to discuss their experiences and gather more information on road safety interventions in Nigeria. Results showed that participants rated measures relating to public education and information campaigns (Appendix E, option 6) as very effective and fairly easy to implement while driver education and training (Appendix E, option 5) was rated as very effective and not easy to implement. On the other hand, engineering measures such as road design were rated effective and very difficult to implement while road maintenance was rated not effective and difficult to implement. The reason for these could be seen in section 8.7.2. In conclusion, the result of this study considering the effect of awareness-raising campaigns, training and infrastructure were found to be similar to the result of the study in phase 2 of this research.

9.3.7 Research question seven (RQ7)

How could the evaluated road safety measures be effectively implemented in Nigeria to improve the road safety culture?

In Nigeria, drivers' behaviour towards safe driving might more likely be attributed to the functionality of the traffic system. The result of this thesis shows that improving road safety in Nigeria would require an overall system-based policy reform involving both government and road users. According to Almqvist & Hydén (1994), a successful safety programme involves actions in all the areas of education, health, information, enforcement, engineering and planning, which must complement and support each other. The goal is to have a functional system which, according to Gehlert et al. (2014), concerns the mobility and safety of the traffic environment. Therefore, it would be crucial that system-oriented reforms at different organisational levels complement plans to improve driver behaviour. These reforms would need to inform policy decisions which are primarily concerned with behaviour change in the population (Thornton et al., 2011). This is summarised in the safe system approach (OECD, 2008; GRSP, 2008) which acknowledges human errors and vulnerability and requires a holistic view of the road transport system, including the road environment, travel speeds, vehicles and road users (see section 3.4 for an overview of the safe system approach). In addition, the options of star rating vehicles as proposed in the New Car Assessment Program (GNCAP, 2017) are not currently being implemented in Nigeria. However, the use of the International Road Assessment Program (IRAP, 2016) to star rate roads and then accordingly use enforcement and control of speeds (Grzebieta et al., 2013) appropriate for the different roads could help improve road safety in Nigeria.

Taking account of the contextual discussions, such a systems based approach in Nigeria should include the following:

(i) Change in behaviour of road users is considered crucial in order to improve the road safety culture in Nigeria. There are significant variations in people's behaviour, and their perception of risk and the challenge is to shape especially the behaviour of the riskiest group by increased awareness and encouraging safe driving. This should be with respect to road sense, discipline, personal responsibility for safe road use, and understanding the implications of engaging in unsafe behaviours. Getting safe, competent and well-trained drivers on the road is very important and as such, driver education programs should be thoroughly supervised.

(ii) Proper road safety education (campaigns) for the general population and targeted groups through both formal and informal education systems to make people understand road safety and the implications of risky driving. Awareness raising using cost-effective means such as religious and cultural institutions, mass and social media to reach a wider audience. It is expected that these measures will increase the knowledge of traffic rules for all road users.

(iii) Improvement of the road environment by providing adequate infrastructure according to the safe system approach. So that system designers and operators need to take into account the limits of the human in designing forgiving roads so that human errors do not result in death or serious injury.

(iv) Strict and fair law enforcement, along with a well-integrated traffic management system can improve road safety in Nigeria. Improvements in the road environment alone cannot change driver behaviour in Nigeria. This should be in line with proper education, training and strict enforcement of traffic rules. Road maintenance and vehicle standards need to be improved. For a country like Nigeria, minimum vehicle safety standards for seatbelts, car seat anchorages, front and side crash protection etc. should be adhered to. Segregation of lanes for different categories of road users will also improve road safety.

(v) Comprehensive driver pre-licencing training program and driver improvement program during licence renewal: pre-licencing training programs must be supervised by qualified personnel and adequate testing conducted before the issuing of drivers' licences. The driving test should not be considered as the final stage of learning as drivers should take further training, especially during licence renewal.

(vi) Monitoring and evaluation are essential for effective road safety management. It helps to identify and measure changes that have occurred in crash frequency and severity and to determine whether the objectives of projects and programmes have been met. Therefore, there could be greater joint monitoring and feedback on interventions across agencies to try and make safety a more day to day norm.

(vii) Inadequate data and research work is a problem in most developing countries. The road safety academy at Udi Enugu state Nigeria should serve as a central repository of knowledge and information on road safety. Research findings from the academy which would cut across a wide range of road safety fields like engineering, psychology, traffic law enforcement etc. in addition to what the Corp is currently doing could provide more evidence-based recommendations and the basis for the formulation of new strategies, legislation and policies governing road safety at all levels. Organising and attending academic conferences and workshops will be another way of mapping and disseminating research work carried out by the corps.

9.4 Implications of research findings

It is apparent from this thesis that road safety culture has a significant impact on risky driving and on driving behaviour generally. The study results presented in this thesis have some important applied implications for the improvement of road safety, especially driver behaviour and general traffic management in Nigeria. They may have significant implications for the FRSC with existing road safety policies and procedures and may encourage other agencies without procedures to develop more appropriate systems.

9.4.1 Road safety culture

The research has shown that it is possible that a hazardous driving environment leads to driving behaviours that encourage greater danger or risk-taking. This was observed in Nigerian participants in both phases 1 and 2. Again, for the NG/UK group in phase 2 who obtained their driver's licenses in Nigeria and the UK, their driving habits have improved significantly. This was confirmed by their driving behaviour, which was similar to that of the UK group but completely different from that of the NG group.

The findings of this thesis show that drivers from different cultures responded differently to driving situations. The differences cannot be explained in terms of levels of competence and driving skills, but instead, they appear to be derived from cultural, behavioural and psychological factors. The differences between groups of drivers require the development of cultural-differentiated policies relevant to each culture. Strict laws and severe sanctions, along with the teachings of cultural values, particularly concerning safety, should be implemented to address risky behaviour. The exploratory study in phase 1 also identified some unsafe driver behaviours in Nigerian, which is slightly different from findings in high-income countries (see section 6.7.4). Therefore, this study can be used to inform future research directions to promote cultural change.

The promotion of safety culture in the country is especially pertinent considering the findings of this research and the need to develop tailored approaches to culture change. Having an appropriate strategy and action plan is one thing; achieving implementation is another. As there are several excellent road safety management systems in the literature and around the world, these cannot be implemented effectively without a political and communal willingness to develop a safe system path. Change in road safety culture would require political will and a strong commitment from the highest levels of government. A paradigm shift based on a change in road user's thinking is needed; behaviour modification and the establishment of the principle of socially and religiously unacceptable violations of traffic laws could be a good starting point. Appropriate traffic law legislation and enforcement could be an integral part of the cultural shift in road safety in Nigeria.

Another issue to address is the unawareness of basic rules and regulations. To rectify this, state governments, in collaboration with FRSC state commands can design intensive road safety courses for the drivers with a compulsion to attend. It is important to recall that not only private and mass transit services are extensively operational in the urban cities of Nigeria, tricycle services are also operational and were found to be over-represented in observed traffic conflicts (chapter 6). Besides, the NG group was observed to behave consistently in an unsafe manner on almost all the scenarios in phase 2 (section 7.7.3). Thus intervention was focused on aspects which are the main motivators for the drivers in promoting unsafe driving and how they can be persuaded to change. Therefore, this research strongly recommends training and awareness-raising for all groups of drivers. This can incorporate strategies that target behaviours and highlight the consequences of unsafe behaviour as was done in Phase 2, experiment 2 (section 7.7.4). Interventions could include speed awareness courses for intending and offending drivers, the use of persuasive media campaign messages which would be followed up with strict enforcement.

9.4.2 Infrastructure

Nigeria has undergone rapid and increased motorisation, particularly in and around major cities, but little has been done to improve the infrastructural requirements. Roads lack basic road signs and makings and are filled with potholes. The literature on road safety in Nigeria (chapter 2) and phase 3 (chapter 7) highlighted the poor road design and infrastructural conditions in Nigeria. Most of the unsafe behaviours (such as speeding, traffic light violations and inappropriate overtaking) observed in phase 1 were also observed in phase 2. But in phase 2, improvements were made on the road were observation took place in phase 1 by i) improving the road condition ii) adding traffic signs, road markings, traffic lights and signals and iii) providing training to raise awareness. Although one key finding from this study is that changes in infrastructure alone do not influence behaviour as drivers reported significantly less improvement in behaviour when infrastructure was improved (phase 2, section 7.8.2). However, improvement in infrastructure combined with other intervention strategies such as awareness-raising brought about significant improvement in driver behaviour as shown in phase 2 (section 7.8.3). Nevertheless, knowing about the improvement in infrastructure and not adapting behaviour to it means that behaviour cannot be changed with improvement in infrastructure alone. Therefore manuals and design standards developed in western countries have to be adapted to Nigerian conditions. Since most drivers do not understand some rules and markings, they need to be made aware of what these mean.

Furthermore, roads, especially in the rural areas, are in worse conditions. They are inadequately sign-posted with no lane markings and therefore provoke more disorderly behaviours. This thesis recommends that an instant action to improve the situation can be the introduction of simple and cost-effective road engineering measures (see chapter 4, section 4.5.1). The effectiveness of various low-cost measures has been tested and validated by traffic engineers (for details, see TrafficInfraTech, 2011).

9.4.3 Awareness-raising campaigns

This study demonstrates a framework for modifying behaviour. In phase 2, simple awareness-raising training by the experimenter resulted in significant improvement in the behaviour of Nigerian drivers. The training only involved reminding the participants of road rules and traffic regulations, importance of safe driving and the implications of risky driving. Awareness and education campaigns were found in this study (Phases 2 and 3) to be efficient means of delivering the road safety message in Nigeria thus should be used in highlighting the risks of unsafe behaviours and as well as stressing the benefits of compliance with road rules. However, such campaigns should be coupled with strict enforcement centred on the particular behaviour being targeted so that the safety campaign message can be reinforced and have an effect on reducing casualties. For instance, campaigns strengthening positive beliefs and confirming the consequences of unsafe behaviours can provide useful and stable bases for interventions. Persuasive strategies such as highlighting the losses in terms of grief and properties they can cause other road users and children can help translate their held beliefs into favourable behaviour. According to Delhomme et al. (2009), education can be used to communicate information and raise awareness of a specific issue.

It is very likely that most drivers in low-income countries like Nigeria lack knowledge of basic road rules. Although theoretical and practical road tests are a legal requirement for obtaining a driver's license, it is common knowledge that most Nigerians acquire their licences without undergoing these tests. In addition, most Nigerian roads either do not have road signs and pavement markings or available ones are either defaced or worn out. Therefore, it is important that the procedure for obtaining a drivers' license in Nigeria is strictly adhered to so that drivers can learn about basic road rules and for those who already have licenses, to go through additional training during the renewal of licenses. The driving test should not be considered as the final stage of driving learning and drivers should take further training or education, especially before licence renewal.

The second major finding of the first study is that simple instructions were sufficient to change the behaviour of drivers, and result in improvement of behaviour. The impact of these simple instructions was further investigated in phase 3. Results highlighted the importance of campaigns and, therefore, useful information regarding perceived gains from using it could be adapted into future implementations plans. This can involve information-based campaigns to promote favourable attitudes towards the system (Chorlton, 2007).

The awareness-raising campaign training used in this research, showed a significant effect on improving behaviour, even though evaluation of the effect was done over a short time. Therefore, further evaluation research would be useful to establish the medium and long-term effects of such training. An evaluation of the effect of a combination of interventions such as improvement in infrastructure, education and has shown that the effects persist over time, with impacts still visible up to three years following initial participation (see section 4.5). Following more comprehensive consultations with stakeholders and road safety experts, the above recommendations could be incorporated into existing national driver training curricula, road safety strategy and appropriate policies put in place for suitable implementations.

Cost-effective campaigns can be achieved through:

(i) Mass and electronic media: To reach a wider audience, this thesis recommends that policymakers in the country can also benefit from using the media such a radio, Television, Newspaper and social media networks like Facebook, Twitter and Instagram The emerging Information technology (IT) and telecommunication (Telecom) boom in Nigeria should not be overlooked as it provides a cost-effective medium of social marketing. The industry has shown tremendous growth in terms of its users. Utilising the potential of e-marketing, experts can build nation-wide media-literacy programs, road safety knowledge disseminating pages on social networking sites, road safety educational apps for smartphones and interactive road safety games.

(ii) Religious and cultural institutions: As seen in phase 3 (7.6.3.1), religious and community leaders can be a great tool in spreading the road safety message as they are highly respected in Nigerian society. This thesis recommends that road safety awareness can benefit from involving local mosques and churches. In addition to being religious centres, these places serve as centres for information, education and dispute settlement. Community leaders can play a vital role in spreading the road safety message through their public meetings and social gatherings. It can be expected that these kinds of initiatives will help to raise massive public awareness, and may succeed to gain support for stronger legislation. This is another cost-effective approach, as there are many religious centres in Nigeria.

The design of traffic laws and awareness campaigns should be tailored to take into account cultural and social factors in order to achieve higher success (Nordfjærn et al., 2012). This will assist in utilising and directing resources to target high crash risk drivers. These campaigns should be coupled with vigorous enforcement and broadly accepted laws to deter such drivers (Goodwin et al., 2013) and to improve road safety (Stanojevic et al., 2013). This combination of enforcement and road safety campaigns has consistently proved successful in the literature. For example, meta-analyses of road safety communication campaigns, conducted by Elliot (1993) found that campaigns that include publicity and/or enforcement are more effective than campaigns without these combined measures. Enforcement can be used to support the campaign messages (see section 4.5.4).

9.4.4 Enforcement

Even though this was not investigated in phase 2, phases 1 (section 6.7.3) and 3 (section 8.7.2.3) highlight it as a problem in Nigeria. Inconsistent enforcement, or rather lack of, is a recurring issue in the country and as a result, traffic violations occur regularly. While some systems have been implemented to enforce traffic rules and regulations especially using traffic wardens or FRSC field marshals, their effectiveness is limited to certain areas like the urban areas and enforcement of some rules is not done at all. For example, speed is not enforced because there are no measures to check the speed of drivers, no speed cameras or automated enforcement. Studies have shown that enforcement can substantially improve driver behaviour. Examples have been shown in speed reduction (Retting et al., 2008a; Retting et al., 2008b) and reducing red light violations (McCartt & Hu, 2014). Roadside electronic signs that display vehicle speeds to warn drivers they are speeding can reduce speeds in the immediate area of the signs (Casey & Lund, 1993). However, in Nigeria, without an associated human enforcement presence, motorists would ignore the signs, as shown in phase 1. Therefore, the first step would be to provide the infrastructure and equipment, periodic awareness-raising to make people understand these and then imposing fines with constant patrolling. There is a consensus in the results of phase 3 that strict and fair law enforcement can substantially improve road safety. According to Mäkinen et al. (2003), there is considerable evidence that substantial changes in the extent of police enforcement are correlated to changes in the number or severity of traffic accidents; more enforcement is associated with fewer accidents.

Even though police enforcement can prove useful in this regard, in most developing countries, the traffic police are grossly under-resourced and under-trained to deal effectively with road safety violations (World Bank, 2012). The situation is no different in Nigeria, as highlighted in phase 3. Therefore, it is recommended that traffic police enforcement can be improved effectively by increasing the human capacity and professional development as Baguley & Jacob (2000) have shown that improvements in traffic policing have considerable potential for both improving driver behaviour and reducing crashes.

It is important to note that people do not like paying fines in Nigeria (phase 3, section 8.7.1.3). To address this issue, innovative penalties and rewards system is needed to disqualify and suspend unlicensed drivers or habitual law offenders. Other measures in addition to fines and penalties could involve driving licence suspension, mandatory medical and psychological tests, re-licensing requirements, rehabilitation programmes, remedial courses, community work are some of the other possible consequences of traffic-related non-compliance (Mäkinen et al. 2003). Implementing such kinds of penalties in the country can not only raise awareness among drivers but make them follow the rules and regulations without creating a perception in the public that enforcement agencies impose fines to make money out of drivers.

9.4.5 Road safety management

Road safety should be promoted as a partnership between the government, families, NGOs, religious and community leaders and all road users to increase awareness. All road safety and road transport stakeholders should be consulted about any road safety matters (e.g., changing speed limits or improving road design). More channels of communication between road users and authorities (e.g., councils, regulators and Police) should be established to exchange feedback and suggestions.

It has been learned that different government departments are involved at various levels to control the transport system and road safety related programs (refer to section 8.7.1.2). It is highly recommended to identify factors that serve as communication and coordination barriers between the departments and to introduce intervention programs to induce harmony and coordination among institutions. Road safety is institutionally very complex with the actions of numerous agencies impacting its progress. Thus, meaningful cooperation among stake holders is very necessary.

It needs to be noted that the FRSC is responsible for coordinating road safety efforts and activities in Nigeria. A periodical review of traffic laws (e.g., speeding, seatbelts, etc.) could improve safety by taking into account any changes as well as the opinions of road safety stakeholders. Improving the licensing system and adopting the proven efficient graduated driver licensing (GDL) system (Senserrick, 2009) could be considered by the corps to improve road safety in Nigeria.

9.4.6 Road safety research and data management

A review of the road transportation system in Nigeria and road safety management, in particular, indicate a serious lack of focus on research and future transportation technology. Through research, relevant data and information for road safety planning, new strategies for solving road safety problems are evolved. Therefore, road safety in Nigeria should be assessed independently, i.e., by international groups such as the Global Road Safety Program (GRSP), World Bank, or consultants with expertise and experience. Moreover, the crash and fatality data published in Nigeria raises the question about the reliability of the official statistics, or the way data is collected and coded. The existence of an independent entity that carries out systematic data collections would improve the quality of data needed to inform the planning and development of road safety strategies. There is a dire need of mapping and disseminating the research work carried out by especially the FRSC in the country. In parallel, capacity development and programs for the concerned officials should be organised to enhance their technical knowledge and skills. According to Abiodun (1998), educational programmes and research must be relevant to our specific needs.

Most governments in Low and Middle-income countries have limited funding for road safety. Thus, a partnership with multinationals (those with active safety cultures) can assist through capacity building, knowledge sharing, advocacy and campaign delivery, serving as a way of applying the safety culture perspective to the general population of drivers'. These can affect road traffic safety by changing the behaviour and safety culture of drivers and road users in general, while also collaborating with government to set up effective road safety policies, sharing knowledge in the development of driver training and licensing procedures, training "trainers" and traffic management agencies, supporting road safety research, and support in the development of traffic safety campaigns that are sensitive to the socio-cultural context of these countries.

9.4.7 Summary

The gaps in Nigeria's road traffic safety system are significant and are responsible for the high rate of risky behaviours, which lead to most road traffic crashes. Problems such as driving culture, poor attitude and incompetence of many professional drivers, indiscipline, corruption, inadequate enforcement, disobedience for law, institutional gridlocks characterize the traffic environment. Indeed, most of the factors described above likely contribute to a generally poor road safety culture in Nigeria. Hence, well-founded and integrated road safety and behavioural education will serve as succour for this. Since improvements in infrastructure alone could not resolve these problems, an integrated traffic education, attitudinal change, persuasion, reorientation and modification of drivers and road users' minds and character could be more effective. This would require a total overhaul of the Nigerian road safety system. The transportation education development should be backed-up by an efficient traffic information system, effective citizens' participation, institutional radicalization, local knowledge development, prioritization and rationalizations as well as strong political will. The will influence the long-term attitude and behaviour changes, while the enforcement process will ensure laws are enforced fairly and justly by the agencies.

This research has provided a timely contribution to the body of work related to improving the status of road safety in Nigeria and has recognised that observing driver behaviour towards road safety is unarguably successful in distinguishing safe drivers from unsafe drivers and therefore, can legitimately form the basis of road safety interventions. It is hoped that a consistent and collective effort from individuals, communities and the government can help to achieve sustainable road safety practices in Nigeria. Considering the "limited" resources available for road safety interventions in Nigeria, and most developing nations, it will be sensible to focus more on evidence-based solutions, which are effective and easy to implement as seen in this thesis.

In summary, this thesis covered new ground in regards to traffic safety in Nigeria. It contributed a body of new evidence-based research on topics of concern: unsafe driver behaviours, the determinants of differences in driving behaviour between different cultures, effectiveness and ease of implementation of different road safety measures and measures to improve Nigerian road safety profile. Therefore, the ultimate contributions of this research could be the identification of useful targets for developing road safety interventions for the country using the evidence collected.

To the best of candidate's knowledge, there has not been any study to have investigated the Nigerian road safety culture and sought to find ways to improve it, given that most studies focus on traffic crashes using crash data. Thus, this research provides a valuable contribution to the available literature on road safety culture.

9.5 Limitations and suggestions for future research

9.5.1 Phase 1

Although no research has been conducted using the TCT in Nigeria, the method adopted in this study provided the opportunity to observe road users in real traffic environment and record all interactions including the serious and slight. Data for the analysis was limited to what could be obtained from the completed conflict recording form and video, there could have been variables or factors affecting conflict severity which were not captured in the study and not included in the analysis such as driver skills, road surface friction etc.

This study was conducted at three different locations representing typical road environment in an urban area in Nigeria. Even though most of the factors identified were spread across all the locations, it is possible for results to diverge from what would be obtained from the rural areas. To make a better comparison, the number of locations should be higher and of comparable nature. That is to say, locations selected should be as similar as possible, especially regarding locations. This could not be done in this study because the purpose was to have an idea of general traffic behaviour at different locations.

This study is based on behaviours observed in conflict situations at three different locations. The fact that the frequency of unsafe behaviours was closely associated with location and specifically on a straight road indicates how dangerous that location could be for road users, even though the absolute number was lower than other locations. These results may only be limited to studies in urban areas and unsafe behaviours may be different in rural areas. Further research with a larger sample and locations with similar characteristics could help make a better comparison and to find out if these are prevalent across different locations.

Unsafe behaviours observed and recorded in this study were those that led to conflicts, there could have been a number of unsafe behaviours which were not observed probably because they did not result in a conflict. As a result, the number of unsafe behaviours observed here is likely an underestimation of the true frequency. In addition, with this method of data collection, it was not very possible to observe all in-vehicle behaviours leading to conflicts. Different results may be obtained if every road user crossing the different locations of interest were observed. Future research could mitigate this issue by observing all road users including those not involved in conflicts and comparing unsafe behaviours across each group.

9.5.2 Phase 2

One limitation of this study is the sample size, especially regarding the use of the DBQ. This is believed to have been responsible for the difficulty in developing suitable and similar factor loadings for the different groups. In addition, the measure was adopted for the first time for NG drivers. Therefore a direction for future research would be the replication of these same items including some items from the Nigerian Highway Code in a larger sample of NG drivers. This would help to establish the reliability and generalizability of the Nigerian version of the DBQ. However, even if the present sample is not a perfect fit with the Nigerian population, the reported DBQ serves as a strong foundation for establishing a Nigerian version of the instrument.

An important aspect for furthering the current study would be the recruitment of more homogeneous sample groups for all cultures. It is important to note that the sample group used in this study does not necessarily represent the drivers in each society. While efforts were made to have a diverse sample group, it was not very feasible especially in recruiting the NG drivers. Based on this, an essential addition to this current research would be to investigate behaviour on more homogenous groups and examine the possible approaches for improving drivers' behaviour. Another suggestion for future research could be to investigate if the number of years the individual drivers in the NG/UK group has spent driving in the UK has an effect on adapting to the UK road environment. This could not be done in this research because the comparisons carried out were between groups of drivers and not individual drivers.

One could argue that in the current study, and as a limitation, only short-term intervention effects have been found and that this could question the practicality and value of the training. It would have been the intention of this study to measure long-term effects of the awareness-raising intervention; however, considering how difficult it was to recruit the NG and NG/UK drivers and their limited availability, it was finally decided that the awareness-raising intervention training will take place on the same day. This timing could affect behaviour, unlike if they were scheduled to come in at a later date to repeat the experiment. Hence, in future studies, driving could be repeated some days, weeks or months after training. Additionally, the reduction in speed in some scenarios after the training could be from learning effects.

9.5.3 Phase 3

There are very few limitations associated with this study. No studies were conducted with the other government agencies, NGOs and private establishment involved in one way or the other in road safety because the study was mostly about the road safety measures which are the general responsibility of the FRSC and what they are doing to improve the road safety culture in Nigeria. It is suggested that future studies should involve these agencies so as to gain more understanding of their responsibilities and their views on road safety and general transport management in Nigeria.

9.6 Contributions to existing knowledge

The significant contributions of this research are:

(i) The identification of the most prevalent unsafe driving behaviours in Nigeria using observational non-crash data, which is cost-effective and easy to implement. The thesis supports the applicability of the TCT as a diagnostic tool, and a guide for road safety assessment of different road locations.

(ii) Identification of the potential instruments, practical and statistical ways to comprehensively understand the Nigerian road safety culture and what aspects of driving behaviour in Nigeria is different from that of drivers from other cultures.

(iii) It is the first study to use the TCT, DBQ and driving simulator to investigate driver behaviour in Nigeria

(iv) It is the first to assess driving safety of drivers from different cultures using many components of safety indicators.

(v) It adds to the existing knowledge of the cultural differences in driving behaviour using empirical data

(vi) Identification of the influence or “strength” of culture on driver behaviour.

(vii) Highlighting the fact that study methods and interventions designed and developed in a specific culture may not be directly applied in another culture without modifying it by taking into account the unique conditions of the new culture.

(viii) Identification of evidence-based road safety measures needed to improve driving behaviour while addressing the unique characteristics of Nigerian drivers.

Apart from these, this research work led to the use of a multi-method approach which combined both subjective and objective methods to both identify and further investigate risk factors for crashes. The identification of the influence of culture and road environment was important but the subsequent driving simulator investigation provided experimental evidence regarding how behaviour can be modified. This was further improved with a qualitative study which provided valuable insight and more information by explaining contextual details behind those quantified responses, especially concerning road safety measures. Together, these approaches offer potentials for improvement of driver behaviour and application in general road traffic safety and performance in Nigeria. Most significantly, the research has demonstrated that culture has an influencing role in the behaviour of drivers and to improve the road safety situation of a people requires more than just improvements in the road infrastructure.

9.7 Final conclusion

Behavioural change processes are more complicated than simply telling people how to think or what to do when they are using the road. There are no universal guidelines to change behaviour, but different groups of people need to be approached in different ways to optimise the likelihood of affecting behaviour change (NICE, 2007). As mentioned in section 4.5.5, models and theories are important as they help to identify how to target initiatives aimed at influencing behaviour. In addition, understanding how people perceive risk and how they behave accordingly is critical in designing road safety countermeasures that are effective in reducing road crashes. Even though research (Parker et al., 1996; Assum, 1997) has shown that changing the attitude of drivers is one of the most effective long-term measures in dealing with crash involvement. Howard & Sweatman (2007) concluded that the change in road safety culture has proved to deliver better results when compared with other technology and enforcement approaches.

The overall aim of this thesis was to develop and apply a multidisciplinary approach to identify and understand the Nigerian road safety culture and develop suitable measures to improve it. This is because the first step to improving the road safety situation would be to identify problems in the environment as well as their determinants and then to develop possible interventions which would be effective and easy to implement. This thesis investigated the Nigerian road safety culture, focussing on unsafe drivers' behaviour and how behavioural change or modification can be achieved. This is because some methodologies developed and used to evaluate road safety culture in a certain society may not be suitable, transferrable or applicable to other societies. It is hoped that the research work presented in this thesis aids in the understanding of the reasons behind drivers' decisions to either drive safely or unsafely on the roads in Nigeria. And that it serves as a guide to policymakers and the government to develop measures needed to improve the road safety profile of the country and other LMICs with similar traffic conditions.

References

Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of road crashes: A review. *Accident Analysis & Prevention, 38* (2), 215–224.

Åberg, L., Larsen, L., Glad, A., & Beilinsson, L. (1997). Observed vehicle speed and drivers' perceived speed of others. *Applied Psychology, 46***,** 287-302.

Åberg, L. (2003). The role of attitudes in transportation studies. T&S, Dalarna University, Borlänge and Department of psychology, Uppsala University, Uppsala, Sweden. Retrieved from: https://pdfs.semanticscholar.org/46fd/33329d5b59b2bebec89fa8fd6ab45a4ec5f9.pdf.

Abdulhafedh, A. (2017). Road traffic crash data: An overview on sources, problems, and collection methods. *Journal of Transportation Technologies, 7*, 206-219.

Abele, L., & Moller, M. (2011). The relationship between road design and driving behaviour. In: 3rd International Conference on Road Safety and Simulation, Indianapolis, USA.

Abiodun, A. (1998). Human and institutional capacity building and utilization in science and technology in Africa (An appraisal of Africa's performance to-date and the way forward), Paper presented at the United Nations Development Programme - Africa's future, Abidjan, Cote D'ivoire.

Adamos, G., Nathanail, E.G., & Kapetanopoulou, P. (2013). Do road safety communication campaigns work? How to assess the impact of a national fatigue campaign on driving behaviour. *Transport Research Record: Journal of the Transportation Research Board, 2364* (1), 62-70.

Adekunle, J. A. (2012). Assessing the trends in road traffic accident casualties on Nigerian roads. *Journal of Science, 31*(3), 19-25.

af Wåhlberg, A. E. (2007). Long-term effects of training in economical driving: Fuel consumption, accidents, driver acceleration behaviour and technical feedback. *International Journal of Industrial Ergonomics, 37***,** 333-343.

af Wåhlberg, A.E. (2018). The effect of driver improvement interventions on crash involvement; has it been under-estimated? *Transportation Research Part F: Traffic Psychology and Behaviour, 54*, 349-356.

Afukaar, F. K., Antwi, P., & Amaah, S. O. (2003). Pattern of road traffic injuries in Ghana: Implications for control. *Injury Control and Safety Promotion, 10*, 69-76.

Aghabayk, K., Moridpour, S., Young, W., Sarvi, M., & Wang, Y. B. (2011). Comparing heavy vehicle and passenger car lane-changing manoeuvres on arterial roads and freeways. *Transportation Research Record: Journal of the Transportation Research Board, 2260*, 94-101.

Agresti, A. (2007). An introduction to categorical data analysis, second ed. John Wiley & Sons, Inc., Hoboken.

Aguiléra, V., Allio, S., Benezech, V., Combes, F., & Milion, C. (2012). Estimating the quality of service of underground transit systems with cellular network data. *Procedia - Social and Behavioural Sciences, 48*, 2262-2271.

Aigner-Breuss, E., & Eichhorn, A. (2017). Awareness raising and campaigns – Seatbelts. European Road Safety Decision Support System, developed by the H2020 project Safety Cube. Retrieved from www.roadsafety-DSS.eu on 12 January 2019.

Ajzen, I. (1991). The theory of planned behaviour. *Organizational behaviour and human decision processes, 50***,** 179-211.

Ajzen, I. (2006). Constructing a theory of planned behaviour questionnaire: Conceptual and methodological considerations. Working paper. Available from http://www. people.umass.edu/aizen/pdf/tpb.measurement.pdf (accessed 24 March 2018).

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behaviour. Englewood Cliffs, NJ: Prentice-Hall.

Akinyemi, K.E. (1986). Problems with planning, implementation and evaluation of road traffic safety engineering programmes in Nigeria In: J.O. Asalor, et al. (Eds.), Road Traffic Accidents in Developing Countries, Joja Publisher, Benin, Nigeria.

Akpoghomeh, O. S. (1998). Temporal variations in road traffic accident parameters in the Port Harcourt metropolis. *Journal of Transport Studies, 2*(1), 15-36.

Aljassar, A. H., Ali, M. A., & Al-Anzi, M. S. (2004). An investigation on the effect of traffic cameras on road safety in Kuwait. 2nd Gulf Conference on Roads, Abu Dhabi, UAE.

Almqvist, S., & Ekman, L. (2001). The Swedish traffic conflict technique: Observer's Manual. Department of Technology and Society Traffic Engineering, Lund University.

Almqvist, S., & Hydén, C. (1994). Methods for assessing traffic safety in developing countries. Building issues. Lund, Traffic and Roads, Lund University. 6.

Al-Balbissi, A. (2003). Role of gender in road accidents. *Traffic Injury Prevention, 4*, 64-73.

Ameratunga S., Hijar M, & Norton R. (2006). Road-traffic injuries: confronting disparities to address a global-health problem. *Lancet, 367*, 1533-1540.

Amundsen, F., & Hydén, C. (1977). Proceedings of first workshop on traffic conflicts. Institute of Transport Economics, Oslo.

Anastasopoulos, P.C., & Mannering, F.L. (2016). The effect of speed limits on drivers' choice of speed: A random parameters seemingly unrelated equations approach. *Analytic Methods in Accident Research, 10,* 1–11.

Arajaevi, E. (1998). Retrospective analysis of chest injuries in 280 seat belt wearers. *Accident Analysis & Prevention, 20*, 251-9.

Archer, J. (2005). Indicators for traffic safety assessment and prediction and their application in micro-simulation modelling: A study of urban and suburban intersections. PhD Thesis, Royal Institute of Technology, Stockholm, Sweden.

Assum, T. (1997). Attitudes and road accident risk. *Accident Analysis & Prevention, 2*9**,** 153-159.

Atchley, P., Shi, J., & Yamamoto, T. (2014). Cultural foundations of safety culture: A comparison of traffic safety culture in China, Japan and the United States. *Transportation Research Part - Traffic Psychology and Behaviour, 26*, 317–325.

Atubi, A.O. (2010). Road traffic accident variations in Lagos state Nigeria: a synopsis of variance. *Journal of Africa Research Review, 4*(2), 197-218.

Atubi, A. O., & Onokala, P. C. (2009). Contemporary analysis of variability in road traffic accidents in Lagos State. *African Geographical Review, 28*, 11–41.

Ausserer, K., Haupt, J., & Risser, R. (2009). Evaluation of a child restraint campaign in Austria. In book: Forward, S., Kazemi, A. (Eds), A theoretical approach to assess road safety campaigns, Evidence from seven European countries (pp 137-192). Belgian Road Safety Institute.

Austroads (2013). Driver attitudes to speed enforcement. Austroads research department, NSW Centre for Road Safety, Sydney Australia.

Baguley, C. J., & Jacobs, G. D. (2000). Traffic safety issues for the next millennium. Crowthorne, UK: Transport Research Laboratory.

Barkenbus, J. N. (2010). Eco-driving: An overlooked climate change initiative. *Energy Policy, 38***,** 762-769.

Barnard, Y., Utesch, F., van Nes, N., Eenink, R., & Baumann, M. (2016). The design of UDRIVE: the naturalistic driving study across Europe for cars, trucks and scooters. *European Transport Research Review, 8*, 14.

Bates, L., Filtness, A., Fleiter, J., Watson, B., Tones, M., & Williamson, A. (2013). How would changing driver training in the Queensland licensing system affect road safety? Deliverable 1: Trends in Driver Education and Training. Available from http://www.tmr.qld.gov.au/-/media/Safety/roadsafety/Road-safety-research-reports/report-1-trends.pdf?la=en [Verified 29 January, 2019]

Bates, L. J., Allen, S., Armstrong, K., Watson, B., King, M., & Davey, J. (2014). Graduated driver licensing: An international review. *Sultan Qaboos University Medical Journal, 14*(4), e423- e441.

Batool, Z. (2012) Attitudes towards Road Safety and Aberrant Behaviour of Drivers in Pakistan. PhD Thesis, University of Leeds, Leeds- UK.

Bealer, R. C., Willits, F. K., & Kuvlesky, W. P. (1965). The meaning of “rurality” in American society: some implications of alternative definitions. *Rural Sociology, 30*, 255–66.

Beanland, V., Goode, N., Salmon, P. M., & Lenné, M. G. (2013). Is there a case for driver training? A review of the efficacy of pre-and post-licence driver training. *Safety Science, 51*, 127-137.

Begg, D., & Langley, J. (2001). Changes in risky driving behaviour from age 21 to 26 years. *Journal of Safety Research, 32 (4),* 491-499.

Bell, M., Galaltioto, F., Giuffre, T., & Tesoviere, G. (2012). Novel application of red-light runner proneness theory within traffic micro simulation to an actual signal junction. *Accident analysis & Prevention, 46,* 26-36.

Bendak, S. (2005). Seat belt utilization in Saudi Arabia and its impact on road accident injuries. *Accident Analysis & Prevention, 37,* 367-371.

Bener, A., Achan, N. V., Sankaran-Kutty, M., Ware, J., Cheema, M. Y., & Al-Shamsi, M. A. (1994). Casualty risk reduction from safety seat belts in a desert country. *Journal of the Royal Society of Health, 114*, 297-299.

Bener, A., Abu-Zidan, F.M., Bensiali, A.K., AL-Mulla, A.A.K., & Jadaan, K.S. (2003). Strategy to improve road safety in developing countries. *Saudi Medical Journal, 24,* 603-608.

Bener, A., & Crundall, D. (2005). Road traffic accidents in the United Arab Emirates compared to Western countries. *Advances in Transportation Studies, 6,* 5-12.

Bener, A., Al Humoud, S. M. Q., Price, P., Azhar, A., Khalid, M. K., Rysavy, M., & Crundall, D. (2007). The effect of seatbelt legislation on hospital admissions with road traffic injuries in an oil-rich, fast developing country. *International Journal of Injury Control and Safety Promotion, 14***,** 103-107.

Bener, A., & Crundall, D. (2008). Role of gender and driver behaviour in road traffic crashes. *International Journal of Crashworthiness, 13***,** 331-336.

Bener, A., Ozkan, T., & Lajunen, T. (2008). The driver behaviour questionnaire in Arab Gulf Countries: Qatar and United Arab Emirates. *Accident Analysis and Prevention, 40*, 1411–1417.

Bener, A., Verjee, M. A., Dafeeah, E., Yousafzai, M. T., Mari, S., Hassib, A., Al-khatib, H., Cole, M., Nema, N., Ozkan, T., & Lajunene, T. (2013). A Cross "ethnical" comparison of the Driver Behavior Questionnaire (DBQ) in an economically fast developing country. *Global journal of health science 5(4*), 165-75.

Berg, B. L. (2007). Qualitative research methods for the social sciences, Pearson.

Berry, J. W., Poortinga, Y. H., Breugelmans, S. M., Chasiotis, A., & Sam, D. L. (2011). Cross-cultural psychology: research and applications. Cambridge, UK, Cambridge University Press.

Bishai, D., Asiimwe, B., Abbas, S., Hyder, A. A., & Bazeyo, W. (2008). Cost-effectiveness of traffic enforcement: case study from Uganda*. Injury Prevention, 14*, 223-227.

Björklund, G. (2005). Driver interaction: Informal rules, irritation and aggressive behaviour. Doctoral thesis, Acta Universitatis Upsaliensis.

Björklund, G., & Åberg, L. (2005). Driver behaviour in intersections: formal and informal traffic rules. *Transportation research Part F. Traffic Psychology and Behaviour, 8(3*), 239-53.

Bjurlin, M.A., Fantus, R.J., Fantus, R.J., Mellett, M.M., & Villines, D. (2014). The impact of seat belts and airbags on high grade renal injuries and nephrectomy rate in motor vehicle collisions. *Journal of Urology, 192,* 1131-1136.

Blaauw, G.J. (1982). Driving experience and task demands in simulator and instrumented car: a validation study. *Human Factors, 24(4),* 473-486.

Blockey, P. N., & Hartley, L. R. (1995). Aberrant driving behaviour: errors and violations. *Ergonomics, 38(9)*, 1759-1771.

Boer, E. R., & Hoedemaeker, M. (1998). Modeling driver behavior with different degrees of automation: A hierarchical decision framework of interacting mental models. Conference on human decision making and manual control. Valenciennes, France.

Boyce, T. E., & Geller, E. S. (2002). Using the Barnum effect to teach psychological research methods. *Teaching of Psychology, 29*, 316-318.

Box, E. (2012). Speed Limit: A review of Evidence, RAC Foundation London.

Boyle, L. N., & Lee, J. D. (2010). Using driving simulators to assess driving safety. *Accident Analysis & Prevention, 42***,** 785-787.

Broughton, J., Allsop, R.E., Lynam, D., & McMahon, C. (2000). The numerical context for setting national casualty reduction targets. *Transport Research Laboratory Report*, 382.

Busch, S., Zobel, R., & Kreiss, J.P. (2002). Determination of risk factors of accident causation. In: Proceedings of the International Conference on Vehicle Safety, Imeche Headquarters, London, 11-22.

Cale, M.H. (2011). Cultural Differences and Traffic Safety. Retrieved from https://www.unece.org/.../roadsafe/.../2011_Belgrade_Pres_ Cale_Cultural_Differences_and_Traffic_Safety (Accessed 2 April 2018).

Carnis, L. (2011) Automated Speed Enforcement: What the French Experience Can Teach Us. *Journal of Transportation Safety & Security*, *3* (1), 15-26.

Carpenter, C., & Stehr, M. (2007). The effects of mandatory seatbelt laws on seatbelt use, motor vehicle fatalities and crash related injuries among youths. National Bureau of Economic Research - NBER Working Paper No. 13408.

Carsten, O.M.J., Groeger, J.A., Blana, E., & Jamson, A.H. (1997). Driver performance in the EPSRC driving simulator: a validation study. Final report to EPSRC, Contract No. GR/K56162.

Carsten, O., & Jamson, A. H. (2011). Driving simulators as research tools in traffic psychology. In Handbook of Traffic Psychology (pp. 87-96). Academic Press.

Carsten, O., Kircher, K., & Jamson, S. (2013) Vehicle-based studies of driving in the real world: The hard truth? *Accident Analysis & Prevention, 58*, 162-174.

Casey, S. M., & Lund, A. K. (1993). The effects of mobile roadside speedometers on traffic speeds. *Accident Analysis & Prevention, 25*, 627-34.

Chaloupka, C., & R. Risser (1995). Don't wait for accidents - possibilities to assess risk in traffic by applying the Wiener Fahrprobe'. *Safety Science, 19(2-3)*, 137-147.

Chandra, S., & Shukla, S. (2012). Overtaking behaviour on divided highways under mixed traffic conditions. *Procedia-Social and Behavioural Sciences, 43*, 313-322.

Chapman, P., Underwood, G., & Roberts, K. (2002). Visual search patterns in trained and untrained novice drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 5,* 157-167.

Chen, H., Cao, L., & Logan D.B. (2012). Analysis of risk factors affecting the severity of intersection crashes by logistic regression. *Traffic Injury Prevention, 13 (3)*, 300-307.

Chliaoutakis, J. E., Koukouli, S., Lajunen, T., & Tzamalouka, G. (2005). Lifestyle traits as predictors of driving behaviour in urban areas of Greece. *Transportation Research Part F: Traffic Psychology and Behaviour, 8,* 413-428.

Chorlton, K. (2007). Understanding the Influences on Speed Choice. PhD, The Institute of Psychological Sciences, University of Leeds.

Christ, R., Delhomme, P., Kaba, A., Mäkinen, T., Sagberg, F., Schulze, H., & Siegrist, S. (1999). GADGET-Guarding Automobile Drivers through Guidance Education and Technology. Final Report. Vienna. Kuratorium für Verkehrssicherheit.

Christie, R. (2001). The effectiveness of driver training as a road safety measure: a review of the literature. Report 01/03. Melbourne: RACV.

Clapp, J. D., Olsen, S. A., Beck, J. G., Palyo, S. A., Grant, D. M., Gudmundsdottir, B., & Marques, L. (2011). The driving behaviour survey: Scale construction and validation. *Journal of Anxiety Disorders, 25***,** 96-105.

Claret, P. L., Del Castillo, J. D. L., Moleon, J. J. J., Cavanillas, A. B., Martin, M. G., & Vargas, R. G. (2002). Influence of driver nationality on the risk of causing vehicle collisions in Spain. *Journal of Epidemiology and Community Health, 56(5)*, 394-398.

Comrey, L.A., & Lee, H.B. (1992). A first course in factor analysis (2nd Ed.). Hillside, NJ: Lawrence Erlbaum Associates.

Comte S. L., & Jamson A. H. (2000). Traditional and innovative speed-reducing measures for curves: An investigation of driver behaviour using a driving simulator. *Safety Science, 36,* 137-150.

Constantinou, E., Panayiotou, G., Konstantinou, N., Loutsiou-Ladd, A., & Kapardis, A. (2011). Risky and aggressive driving in young adults: Personality matters. *Accident Analysis & Prevention, 43*, 1323-1331.

Council, F.M., Persaud, B.N., Eccles, K.A., Lyon, C., Griffith, M.S., Zaloshnja, E., & Miller, T. (2005). Implementing red light camera programs: guidance from economic analysis of safety benefits. *Transport Research Record: Journal of the Transportation Research Board, 1922*, 38-43.

Cristea, M., Paran, F., & Delhomme, P. (2012). The role of motivations for eco-driving and social norms on behavioural intentions regarding speed limits and time headway. *World Academy of Science, Engineering and Technology, 6,* 918-923.

Crundall, D., Andrews, B., van Loon, E., & Chapman, P. (2010). Commentary training improves responsiveness to hazards in a driving simulator. *Accident Analysis & Prevention 42,* 2117–2124.

Cummings P, Wells J.D., & Rivara F.P. (2003). Estimating seat belt effectiveness using matched-pair cohort methods. *Accident Analysis & Prevention, 35*, 143-149.

da Silva, F. P. (2014). Mental workload, task demand and driving performance: What relation? *Procedia-Social and Behavioural Sciences, 162*, 310-319.

Daniel, J., Tsai, C., & Chien, S. (2002). Factors influencing truck crashes on roadways with intersections. In: Proceeding of the 81st Annual Meeting of the Transportation Research Board, Washington, DC.

Darnton, A. (2008). Practical Guide: An overview of behaviour change models and their uses. In: Government Social Research Unit, GSR behaviour change practice guide 2, London. Available at www.gsr.gov.uk.

Day, P.P., Chandra, S., & Gangopadhya, S. (2008). Overtaking process on two-lane rural highways The 23rd Australian Road Research Board (APRB) Conference, Adelaide.

de Craen, S. (2010). The X-factor: A longitudinal study of calibration in young novice drivers, PhD thesis, Delft University of Technology, SWOV Leidschendam, the Netherlands.

de Groot, S., de Winter, J. C. F., García, J. M. L., Mulder, M., & Wieringa, P. A. (2011). The effect of concurrent bandwidth feedback on learning the lane-keeping task in a driving simulator. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 53***,** 50-62.

De Waard, D., Jessurun, M., Steyvers, F.J.J.M., Raggatt, P.T.F., & Brookhuis, K.A. (1995). The effect of road layout and road environment on driving performance, drivers' physiology and road appreciation. *Ergonomics, 38*, 1395-1407.

De Winter, J. C. F., & Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: a meta-analysis. *Journal of Safety Research, 41***,** 463-470.

de Winter, J. C. F., de Groot, S., Mulder, M., Wieringa, P. A., Dankelman, J., & Mulder, J. A. (2009). Relationships between driving simulator performance and driving test results. *Ergonomics, 52(2*), 137-153.

Deffenbacher, J. L., Richards, T. L., Lynch, R. S., & Deffenbacher, D. M. (2003). Anger, aggression, and risky behaviour: a comparison of high and low anger drivers. *Behaviour research and therapy, 41***,** 701-718.

Delhomme, P., De Dobbeleer, W., Forward, S., & Simoes, A. (2009). Manual for designing, implementing and evaluating road safety communication campaigns. Brussels: Belgian Road Safety Institute.

Delhomme, P., Cristea, M., & Paran, F. (2013). Self-reported frequency and perceived difficulty of adopting eco-friendly driving behaviour according to gender, age, and environmental concern. *Transportation Research Part D: Transport and Environment, 20***,** 55-58.

Delicado, A. (2012). Environmental education technologies in a social void: the case of 'Greendrive'. *Environmental Education Research, 18***,** 831-843.

Delucchi, K.L. (1993). On the use and misuse of Chi Square. In: Keren, G., Lewis, C. (Eds.), A Handbook for Data Analysis in the Behavioural Sciences. Lawrence Erlbaum, Hillsdale, pp. 294-319.

D'Elia, A., Newstead, S., & Scully, J. (2013). Evaluation of vehicle side airbag effectiveness in Victoria, Australia. *Accident Analysis & Prevention, 54,* 67–72.

Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., Sudweeks, J., Perez, M. A., Hankey, J., Ramsey, D., Gupta, S., Bucher, C., Doerzaph, Z. R., Jermeland, J., & Knipling, R. R. (2006). The 100-Car Naturalistic Driving Study: Phase II—Results of the 100-Car Field Experiment. DOT HS 810 593. Springfield, Virginia: NHTSA.

Dixit, V., Gayah, V., & Radwan, E. (2012). Comparison of driver behaviour by time of day and wet pavement conditions. *Journal of Transportation Engineering 138 (8*), 1023-1029.

Dixon, K.K., & Wolf, K.L. (2007). Benefits and risks of urban roadside landscape: Finding a liveable, balanced response. Transportation Research Board Business Office, Washington DC.

Dorn, L., & Barker, D. (2005). The effects of driver training on simulated driving performance. *Accident analysis & prevention, 37*, 63-69.

Downing, A. J. (1991). Pedestrian safety in developing countries. International Conference on Traffic Safety, New Delhi, Mcmillan India Limited.

Dragutinovic, N., Brookhuis, K. A., Hagenzieker, M. P., & Marchau, V. A. (2005). Behavioural effects of advanced cruise control use: A meta-analytic approach. *European Journal of Transport and Infrastructure Research, 5 (4), 267-280.*

Drottenborg, H. (2002). Are beautiful traffic environments safer than ugly traffic environments? Lund University bulletin no. 211 Lund, Sweden: Faculty of Engineering, LTH, Department for Technology and Society, Lund University.

DRSC (2000). Every accident is one too many. Road safety starts with you. Towards new objectives 2001-2012. Technical Report, The Danish Ministry of Transport.

Dumbaugh, E. (2005). Safe streets, liveable streets. *Journal of the American Planning Association, 71(3*), 283-298.

Edensor T. (2004). Auto mobility and national identity: Representation, geography and driving practice. *Theory, Culture & Society, 21(4/5*), 101-120.

Elander, J., West, R., & French, D. (1993). Behavioural correlates of individual differences in road-traffic crash risk: An examination of methods and findings. *Psychological Bulletin, 113 (2*), 279-294.

Elliot, B. (1993). Road safety mass media campaigns: A meta-analysis. Report CR118. Department of Transport and Communications, Australia.

Elliott, M.A., & Broughton, J. (2005). How methods and levels of policing affect road casualty rates (TRL Report 637) Wokingham: Transport Research Laboratory.

Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K., & Kyngäs, H. (2014). Qualitative content analysis: A focus on trustworthiness. *SAGE Open, 4(1*), 1-10.

Elvik, R., Christensen, P., & Amundsen, A. (2004). Speed and road accidents. An evaluation of the Power Model. TØI report. Oslo, Norway: The Institute of Transport Economics (TOI).

Elvik, R., & Vaa, T. (2004). The handbook of road safety measures. Elsevier.

Elvik, R., Vaa, A., Hoye, A., Erke, A. & Sorensen, M. (Eds) (2009). The handbook of road safety measures, 2nd revised edition, Elsevier, Amsterdam.

El-Sadig, M., Nelson Norman, J., Lloyd, O. L., Romilly, P., & Bener, A. (2002). Road traffic accidents in the United Arab Emirates: trends of morbidity and mortality during 1977-1998. *Accident Analysis & Prevention, 34***,** 465-476.

Erke, A. (2008). Effects of electronic stability control (ESC) on accidents: A review of empirical evidence. *Accident Analysis & Prevention*, 40 (1):167–73.

Erke, A., Goldenbeld, C., & Vaa, T. (2009). The effects of drink-driving checkpoints on crashes-A meta-analysis. *Accident Analysis & Prevention, 41,* 914-923.

Erkuş, U. U. (2017). Risk perception and driving performance comparisons between young male non-professional drivers and taxi drivers. MSc Thesis, Middle East Technical University.

Ernstberger, A., Joeris, A., & Daigl, M. (2015). Decrease of morbidity in road traffic accidents in a high income country- an analysis of 24, 405 accidents in a 21 year period. *Injury, 46,*135-143.

Eusofe, Z., & Evdorides, H. (2017). Assessment of road safety management at institutional level in Malaysia: A case study. *IATSS Research, 41* (4), 172-181.

Evans, L. (1991). Traffic safety and the driver. New York: Van Nostrand Reinhold.

Evans, L. (1996). Safety-Belt Effectiveness: The influence of crash severity and selective recruitment. *Accident Analysis & Prevention, 28(4),* 423-433.

Evans L. (2004). Traffic safety. Bloomfield, Hills, MI: Science Serving Society.

Ewing, R., & Dumbaugh, E. (2009). The built environment and traffic safety: A review of empirical evidence. *Journal of Planning Literature, 23(4*), 347-367.

FAAPA (2019). Nigeria to unveil National Road Safety Strategy 2019-2023. Retrieved from http://www.faapa.info/blog/nigeria-to-unveil-national-road-safety-strategy-2019-2023/

Factor, R., Mahalel, D., & Yair G. (2007).The social accident: A theoretical model and a research agenda for studying the influence of social and cultural characteristics on motor vehicle accidents. *Accident Analysis & Prevention, 39,* 914–921.

Farah, H. (2011) Age and gender differences in overtaking manoeuvres on two-lane rural highways. *Transportation Research Record: Journal of the Transportation Research Board, 2248*, 30-36.

Farouq, M.M., Anwar, F.H., Baba, Z.B., Labbo, M.S., &. Aliyu, D.S. (2017). Road maintenance management in Kano State, Nigeria: Case study of Kano metropolitan. *IOSR Journal of Mechanical and Civil Engineering, 14 (3:3*), 50-62.

Federal Ministry of Works (2013). Compendium report on road infrastructure and related development in Nigeria: An investor's manual. Retrieved from http://www.casafrica.es/casafrica/Newsletter/2017/Compendium-Report_PPP_Nigeria.pdf.

Federal Road safety Corps (2014). Flying vehicles on Nigerian Roads. A publication of the Policy, Research and Statistics Department of the Federal Road Safety Corps, Nigeria. Retrieved from: http://frsc.gov.ng/FLYING%20VEHICLES.pdf.

Federal Road Safety Corps (2015). 2014 FRSC Annual Report. Available at: http://frsc.gov.ng/frsc2014 (Accessed 13 March 2017).

Federal Road safety Corps (2018). 2017 FRSC Annual Report. Retrieved from: https://frsc.gov.ng/wp-content/uploads/2018/09/AnnualReport2017.pdf.

Fernandes, R. F., Hatfield, J., & Job, R.F.S. (2006). Examination of different predictors of different risky driving behaviours in young NSW drivers Sydney, Roads and Traffic Authority of NSW. NSW Injury Risk Management Research Centre.

Field, A. (2005). Reliability analysis. In: Field, A., Ed., Discovering Statistics Using SPSS. 2nd Edition, Sage, London, Chapter 15.

Field, A. (2009). Discovering Statistics Using SPSS: Introducing Statistical Method (3rd Ed.). Thousand Oaks, CA: Sage Publications.

Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention, and Behaviour: An Introduction to Theory and Research. Reading, MA: Addison-Wesley.

Forward, S. E. (2006). The intention to commit driving violations-A qualitative study. *Transportation Research Part F: Traffic Psychology and Behaviour, 9***,** 412-426.

Forward, S., Gustafsson, S., Loukopoulos, P., Nyberg, J., & Sörensen, G. (2009). Utlandsföddas trafiksäkerhet (Traffic safety among immigrants in Sweden). Linköping. Statens väg- och transportforskningsinstitut. Report 640.

Fuller, R. (2000). The task-capability interface model of the driving process. *Recherche-Transports-Securité, 66*, 47-56.

Fuller, R., & Santos, J. A. (2002). A note on advanced transport technology. In R. Fuller & J. A. Santos (Eds.), Human Factors for Highway Engineers (pp. 277-281). Amsterdam, N.L.: Pergamon Press.

Gates, T., & Noyce, D. (2010). Dilemma zone driver behaviour as a function of vehicle type, time of day, and platooning. *Transportation Research Record: Journal of the Transportation Research Board, 2149*, 84-93.

Gehlert, T., Hagemeister, C., & Özkan, T. (2014). Traffic safety climate attitudes of road users in Germany. *Transportation Research Part F: Traffic Psychology and Behaviour, 26*, 326-336.

Ghods, H., Saccomannoa, F., & Guidob, G. (2012). Effect of car/truck differential speed limits on two-lane highways safety operation using microscopic simulation. *Procedia-Social and Behavioural Sciences, 53*, 834- 841.

Ghuzlan, K. A., Al-Khateeb, G. G., & Haddad, M. (2012). Evaluation of 2008 traffic safety policies in Jordan. *Jordan Journal of Civil Engineering, 6***,** 122-134.

Glanz, K., Marcus L. F., & Rimer, B.K. (1997). Theory at a glance: A Guide for Health Promotion Practice. National Institute of Health.

Glendon, A. I. (2007). Driving violations observed: An Australian study. *Ergonomics, 50(8)*, 1159-1182.

Global NCAP, (2017). GlobalNCAP 2016 Annual Report. Available https://issuu.com/globalncap/docs/global-ncap-annual-report-2016 assessed 18 May 2019.

Goodwin, A., Kirley, B. B., Sandt, L., Hall, W., Thomas, L., O'brien, N., & Summerlin, D. (2013). Countermeasures that work: a highway safety countermeasure guide for state highway safety offices (Report No. DOT HS 811 727). Washington, DC: National Highway Traffic Safety Administration.

Goldenbeld, C., Levelt, P. B. M., & Heidstra, J. (2000). Psychological perspectives on changing driver attitude and behaviour. *Recherche - Transports - Sécurité, 67***,** 65-81.

Goldenbeld, C., & van Schagen, I. (2005). The effects of speed enforcement with mobile radar on speed and accidents: An evaluation study on rural roads in the Dutch province Friesland. *Accident Analysis & Prevention, 37(6*), 1135–1144.

Golob, F.T., Recker, W.W., & Alvarez, V.M. (2004). Freeway safety as a function of traffic flow. *Accident Analysis & Prevention, 36 (6),* 933-946.

Gong, H., Chen, C., Bialostozky, E., & Lawson, C.T. (2012). A GPS/GIS method for travel mode detection in New York City. *Computers Environment and Urban System, 36*, 131-139.

Grayson, G.B., Hydén, C., Kraay, J.H., Muhlrad, N., & Oppe, S. (1984). The Malmö study: A calibration of traffic conflict techniques. Report R-84-12. Institute for Road Safety Research SWOV, Leidschendam, The Netherlands.

Green, R.N. (1994). Fatal injuries to restrained passenger car occupants in Canada: crash modes and kinematics of injury. *Accident Analysis & Prevention, 26*, 207-214.

Green, M. (2000). How long does it take to stop? Methodological analysis of driver perception-brake times. *Transportation Human Factors, 2(3),* 195-216.

Gregory, S. W. (1985). Auto traffic in Egypt as a verdant grammar. *Social Psychology Quarterly, 48*, 337–348.

Groeger, J. A. (2006). Youthfulness, inexperience, and sleep loss: the problems young drivers face and those they pose for us. *Injury Prevention, 12 (Supplement 1),* 19-24.

Groeger, J.A., & Clegg, B.A. (2007). Systematic changes in the rate of instruction during driver training. *Applied Cognitive Psychology, 21*, 1229-1244.

GRSP, (2008). Road safety good practice manuals, Geneva Global Road Safety Partnership.

Grzebieta, R. H., Rechnitzer G. & Mcintosh A.S. (2013). Traffic accident investigation analysis and reconstruction In: Ian Freckelton and Hugh Selby (Eds), Expert Evidence (Chapter 140). Thompson Reuters.

Guadagnoli, E., & Velicer, W. F. (1988). Relation to sample size to the stability of component patterns. *Psychological Bulletin, 103 (2)*, 265-275.

Haddon W. A. Jr. (1972). A logical framework for categorizing highway safety phenomena & activity. *Journal of Trauma, 12(3),* 193–207.

Hair, J.F., Tatham, R.L., Anderson, R.E., & Black, W. (1998). Multivariate data analysis. (Fifth Ed.) Prentice-Hall: London.

Hajeeh, M. A. (2012). Traffic accidents in Kuwait: A decision making analysis. *International Journal of Applied Mathematics & Informatics, 6***,** 84-91.

Hale, A. R., Stoop, J., & Hommels, J. (1990). Human error models as predictors of accident scenarios for designers in road transport systems. *Ergonomics, 33(10-11*), 377-1387.

Hao, W., Kamga, C., & Wan, D. (2016). The effect of time of day on drivers' injury severity at highway rail grade crossings in the United States. *Journal of Traffic and Transportation Engineering (English Edition), 3 (1)*, 37-50.

Harré, N., Foster, S., & O'Neill, N. (2005). Self-enhancement, crash-risk optimism and the impact of safety advertisements on young drivers. *British Journal of Psychology, 96*, 215-230.

Hatakka, M., Keskinen, E., Baughan, C., Goldenbeld, C., Gregersen, N.P., Groot, H., Siegrist, S., Willmes-Lenz, G., & Winkelbauer, M. (2003). Basic driver training: New models. Final Report University of Turku, Finland.

Hatcher, L. (2003). Principal Component Analysis. A Step-by-Step Approach to Using the SAS System for Factor Analysis & Structural Equation Modelling. North Carolina, SAS publishers.

Hatfield, J., Fernandes, R., Faunce, G., & Job, R.F.S. (2008). An implicit non-self-report measure of attitudes to speeding: Development and validation. *Accident Analysis & Prevention, 40(2*), 616-627.

Hauer, E. (1971). Accidents, overtaking and speed control. *Accident Analysis & Prevention, 3*, 1-13.

Hauer, E. (2015). The art of regression modelling in road safety. Springer. ISBN 978-3-319-12528-2. http://doi.org/10.1007/978-3-319-12529-9.

Hauer, E., & Gårder, P. (1986). Research into the validity of the traffic conflicts technique. Accident *Analysis & Prevention, 18(6),* 471-481.

Haynes, R., Jones, A., Kennedy, V., Harvey, I., & Jewell, T. (2007). District variations in road curvature in England and Wales and their association with road traffic crashes. *Environment & Planning A, 39 (5)*, 1222-1237.

Hedlund, J. (2015). SHRP 2 naturalistic driving study: the first data analysis studies. *Journal of Safety Research, 54*, 3-4.

Hegeman, G., Hoogendoorn, S., Brookhuis, K. (2005) Observation of overtaking manoeuvres on bi-directional roads. In: A. Jaszkiewicz, M. kaczmarek, J. Zak, & M. Hubiak (Eds), Advanced OR and AI methods in transportation (pp. 505-510). Poznan: Publishing house of Poznana University of Technology.

Hegeman, G. (2008). Assisted overtaking: An assessment of overtaking on two-lane rural roads. TRAIL Thesis Series, (T2008/4).

Helman, S., & Reed, N. (2015). Validation of the driver behaviour questionnaire using behavioural data from an instrumented vehicle and high-fidelity driving simulator. *Accident Analysis & Prevention, 75*, 245-251.

Hess, S. (2004). An analysis of the effects of speed limit enforcement cameras with differentiation by road type and catchment area. *Transportation Research Record: Journal of the Transportation Research Board*, *1865*, 28-34.

Hills, B.L., & Baguley, C.J. (1992). Engineering approaches to accident reduction and prevention. In: The Seventh Road Engineering Association of Asia and Australia (REAAA) Conference, Singapore.

Hoebel, E. A. (1966), Anthropology: Study of man. McGraw-Hill, New York, USA.

Hoeschen, A., Verwey, W., Bekiaris, E., Knoll, C., Widlroither, H., De Waard, D., Uneken, E., Gregersen, N.P. Falkmer, T., & Schelin, H. (2001). TRAINER: Inventory of driver training needs and major gaps in the relevant training procedures (Deliverable No 2.1). Brussels, Belgium: European Commission. Retrieved from http://ec.europa.eu/transport/roadsafety_library/publications/trainer_deliverable_2_1.pdf.

Horrey, W. J., & Simons, D. J. (2007). Examining cognitive interference and adaptive safety behaviours in tactical vehicle control. *Ergonomics, 50(8),* 1340-1350.

Hössinger, R., & Berger, W. J. (2012). Stated response to increased enforcement density and penalty size for speeding and driving unbelted. *Accident Analysis & Prevention, 49,* 501-511.

Hostovsky, C., Wakefield, S., & Hall, F. L. (2004). Freeway users' perceptions of quality of service - Comparison of three groups. *Transportation Research Record: Journal of the Transportation Research Board, 1883,* 150-157.

Howard, E., & Sweatman, P. (2007). Road safety culture development for substantial road trauma reduction: can the experience of the state of Victoria, Australia, be applied to achieve road safety improvement in North America? Improving road safety culture in the United States (pp. 305-327). Washington, DC: AAA Foundation for Traffic Safety.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15(9),* 1277-1288.

Huang, Y. H., Zhang, W., Roetting, M., & Melton, D. (2006). Experiences from dual-country drivers: driving safely in China and the US. *Safety Science, 44,* 785-795.

Hyden, C. (1975). A traffic conflicts technique for risk measuring. Department of Traffic Planning and Engineering, Lund Institute of Technology, Sweden.

Hyden, C. (1987). The development of a method for traffic safety evaluation: the Swedish traffic conflicts technique. Lund Institute of Technology, Lund.

Hyden, C., & Stahl, A. (1979). Measures for the improvement of the safety of unprotected road users, Faculty of Engineering, LTH, Lund University Sweden.

Imo State Board of Internal Revenue, ISBOIR (2018). Number of registered vehicles by type and year (2013-2017). Imo State Board of Internal Revenue, Owerri.

International Transport Forum (2018). Road safety Annual Report 2018. OECD/ITF 2018. https://www.itf-oecd.org/sites/default/files/docs/irtad-road-safety-annual-report-2018_0.pdf. Assessed 10 May 2019.

IRAP, (2016). iRAP, International Road Assessment Program [Online]. Available: http://www.irap.org/en/[Accessed March 2019.

Isler, R.B., Starkey, N.J., & Sheppard, P. (2011). Effects of higher-order driving skill training on young inexperienced drivers' on-road driving performance. *Accident analysis & prevention, 43,* 1818-1827.

ITERATE (2010). IT for Error Remediation And Trapping Emergencies Deliverable 5.1: Results from the analysis and input to the development and validation of the statistical models. The ITERATE consortium.

Iversen, H., & Rundmo, T. (2004). Attitudes towards traffic safety, driving behaviour and accident involvement among the Norwegian public. *Ergonomics, 47(5),* 555 - 572.

James, J.G., & Levenson, R.W. (1993). Emotional suppression: physiology, self-report, and expressive behaviour. *Journal of personality and social psychology, 64(6)*, 970-986.

Jamson, H. (1999). Curve negotiation in the Leeds driving simulator: the role of driver experience. In: Harris, D. (Ed) Engineering in Psychology & Cognitive Ergonomics, 3, 351-358.

James, P., Ito, K., Banay, R. F., Buonocore, J. J., Wood, B., & Arcaya, M. C. (2014). A Health Impact assessment of a proposed bill to decrease speed limits on local roads in Massachusetts (U.S.A.). *International Journal of Environmental Research and Public Health, 11*, 10269-10291.

Jamson, S., Chorlton, K., & Carsten, O. (2012). Could intelligent speed adaptation make overtaking unsafe? *Accident Analysis & Prevention, 48*, 29-36.

Jamson, S., Lai, F., & Jamson, H. (2010). Driving simulators for robust comparisons: a case study evaluating road safety engineering treatments. *Accident analysis & prevention, 42*, 961-971.

Jelenova, I. (2006), Observation of driver expression of aggressive behaviour. *Studia Psychologica, 48 (4),* 293-301.

Jermakian, J. (2011). Crash avoidance potential of four passenger vehicle technologies. *Accident Analysis & Prevention, 43*, 732-740.

Johansson, G., & Rumar, K. (1971). Drivers' brake reaction times. *Human Factors, 13(1),* 23-27.

Jug, M. (2014). Information revolution from data to policy action in low-Income countries: How can innovation help? PARIS21, Partenership in Statistics for Development in the 21st century.

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika, 39(1),* 31-36.

Kaiser, S., & Aigner-Breuss, E. (2017). Effectiveness of road safety campaigns. European Road Safety Decision Support System, developed by the H2020 project Safety Cube. Retrieved from www.roadsafety-DSS.eu on 12/01/2019.

Kaptein, N.A., & Theeuwes, J. (1996). Effects of road design on categorization of 80km/h roads [Effecten van Vormgeving op Categorie-indeling en Verwachtingen ten aanzien van 80 km/h Wegen buiten de Bebouwde Kom] (Report TM-96-C010). Soesterberg, NL: TNO Human Factors Research.

Katrakazas, C. (2017). Education- Hazard perception training, European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved from www.roadsafety-dss.eu on 12/02/2019.

Katrakazas, C., & Talbot, R. (2017). Education – Elderly training, European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved from www.roadsafety-dss.eu on 12/02/2019.

Keall, M.D., Povey, L.J., & Frith, W.J. (2002). Further results from a trial comparing a hidden speed camera programme with visible camera operation. *Accident Analysis & Prevention, 34,* 773-777.

Khan, M.E., Anker, M., Patel, B.C., Barge, S., Sadhwani, H., & Kohle, R. (1991). The use of focus groups in social and behavioural research: some methodological issues. *World Health Statistics Q, 44(3),* 145-149.

Kilpelainen, M., & Summala, H. (2012). Effects of weather and weather forecasts on driver behaviour. *Transport Research Part F: Traffic Psychology and Behaviour, 10 (4*), 288-299.

Kim, Y.S. (2001). Effects of driver, vehicle, and environment characteristics on collision warning system design. Master's degree thesis, Department of Science and Technology, Linkoping University.

Kinnear, N.A.D. (2009). Driving as you feel: a psychological investigation of the novice driver problem-Thesis. Edinburgh: Napier University.

Kolasinski, E. M. (1995). Simulator sickness in virtual environments (Technical Report 1027). Alexandria, VA: U.S. Army Research Institute for the Behavioural and Social Sciences.

Kononov, J., & Allery, B. (2004). Road accident predictions, modelling and diagnostics of accident causalty – a comprehensive methodology. In: Proceedings of the 2nd international congress – Societa Italiana Infrastructure Viarie, University of Firenze.

Koornstra, M., Lynam, D., Nilsson, G., Noordzij, P., Pettersson, H-E, Wegman, F., & Wouters, P. (2002). SUNflower: A comparative study of the development of road safety in Sweden, the United Kingdom, and the Netherlands. SWOV, Leidschendam.

Kosola, S., Salminen, P., & Kallio, P. (2016). Driver's education may reduce annual incidence and severity of moped and scooter accidents. A population-based study. *Injury, 47 (1),* 239-243.

KPMG (2014). Nigeria Country Profile: In KPMG Africa region 2012/2013. Accessed from:nancedocbox.com/Tax_Planning/78212032-Nigeria-country-profile-kpmg-africa-region-2012-2013-kpmgafrica-com.html.

Krippendorff, K. (1980). Content Analysis: An Introduction to its Methodology. Sage Publications, Newbury Park.

Kusano, K., Gorman, T. I., Sherony, R., & Gabler H. C. (2014). Potential occupant injury reduction in the u.s. vehicle fleet for lane departure warning–equipped vehicles in single-vehicle crashes. *Traffic Injury Prevention, 15, Sup1,* S157-S164.

Kweon, Y. J., & K. M. Kockelman (2003). Overall injury risk to different drivers: combining exposure, frequency, and severity models. *Accident Analysis & Prevention, 35 (4),* 441-450.

Laagland, J. (2005). How to model aggressive behaviour in traffic simulation. In: Twente Student Conference on IT, Enschede.

Laapotti, S. (2003). What are young female drivers made of? : Differences in attitudes, exposure, offences and accidents between young female and male drivers. Doctoral thesis, University of Turku.

Lajunen, T., Parker, D., & Summala, H. (2004). The Manchester Driver Behaviour Questionnaire: a cross-cultural study. *Accident Analysis & Prevention, 36(2)*, 231-238.

Lee, J.D., Young, K.L., & Regan, M.A (2009). Defining driver distraction. In: Regan, M., A., Lee, J.D., Young, K.L. (Eds.), Driver Distraction: Theory, Effects, and Mitigation (pp. 31-40). CRC Press, Boca Raton.

Lee, Y.M., Sheppard, E., & Crundall, D. (2015). Cross-cultural effects on the perception and appraisal of approaching motorcycles at junctions. *Transportation research part F: Traffic psychology & Behaviour, 31,* 77-86.

Lenné, M., Salmon, P. M., & Young, K. L. (2011). An exploratory study assessing driver behaviour at highway-rail grade crossings using on-road test vehicles. The 3rd International Conference on Road Safety and Simulation. Indianapolis, USA.

Leviäkangas, P. (1998). Accident risk of foreign drivers - the case of Russian drivers in South-Eastern Finland. *Accident Analysis & Prevention, 30,* 245-254.

Lewis-Evans, B., & Charlton, S. G. (2006). Explicit and implicit processes in behavioural adaptation to road width. *Accident Analysis & Prevention, 38(3),* 610-617.

Lewis, I.M., Watson, B., Tay, R., & White, K.M. (2007). The role of fear appeals in improving driver safety: A review of the effectiveness of fear-arousing (threat) appeals in road safety advertising. *International Journal of Behavioural and Consultation Therapy 3*, 203–222.

Li, J., & van Zuylen H. J. (2014). Road traffic in China. *Procedia-Social and Behavioural Sciences 111*, 107-116.

Li, R., El-Basyouny, K., Kim, A., & Gargoum, S. (2017). Relationship between road safety and mobile photo enforcement performance indicators: a case study of the city of Edmonton. *Journal of Transportation Safety & Security, 9(2),* 195-215.

Lie A., Kullgren A., & Tingvall C (2001) Comparison of Euro NCAP test results with Folksam car model safety ratings, Proceedings of 17th ESV, Netherlands.

Lim, P.C., Sheppard, E., & Crundall, D. (2014). A predictive hazard perception paradigm differentiates driving experience cross-culturally. *Transportation Research Part F: Traffic Psychology and Behaviour, 26*, 210-217.

Liu, B. S. (2006). Association of intersection approach speed with driver characteristics, vehicle type and traffic conditions comparing urban and suburban areas. *Accident Analysis & Prevention, 39 (2),* 216-223.

Lipinge, S.M., & Owusu-Afriyie, P. (2014). Assessment of the effectiveness of road safety programmes in Namibia: Learners' perspective. *Journal of Emerging Trends in Economics and Management Sciences, 5(6),* 532-537.

Lonero, L. P., & Clinton, K. M. (1998). Changing road user behaviour: What works, what doesn't. Toronto, PDE Publications.

Lord, D., & Mannering, F. (2010). The statistical analysis of crash-frequency data: a review and assessment of methodological alternatives. *Transportation Research Part A: Policy & Practice, 44(5),* 291-305.

Lund, I.O., & Rundmo, T. (2009). Cross-cultural comparisons of traffic safety, risk perceptions, attitudes and behaviour. *Safety Science, 47,* 547–553.

Machin, M. A., & Sankey, K. S. (2008), Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour. *Accident Analysis & Prevention, 40 (2),* 541-547.

Mackay, M. (1987). Seat belt legislation in Britain. *Journal of Trauma: Injury, Infection and Critical Care, 27(7)*, 759-762.

Mackie, H.W., Charlton, S.G., Baas, P.H., & Villasenor, P.C. (2013). Road user behaviour changes following a self-explaining roads intervention. *Accident Analysis & Prevention, 50*, 742-750.

Makinen, T., Zaidel, D. M., & Andersson, G. (2003). Traffic enforcement in Europe: effects, measures, needs and future. Final report of the ESCAPE consortium. Brussels: European Commission.

Marsden, G., Kelly, C., & Nellthorp, J. (2009). The likely impact of target setting and performance rewards in local transport. *Transport Policy, 16(2),* 59-67.

Martens, M. H. (2007). The failure to act upon important information: where do things go wrong? Doctoral dissertation, Free University Amsterdam.

Matthews, G., Tsuda, A., Xin, G., & Ozeki, Y. (1999). Individual differences in driver stress vulnerability in a Japanese sample. *Ergonomics, 42, 3*, 387-414.

Matthews, G., & Desmond, P. A. (2001). Stress & driving performance: Implications for design and training. In P.A. Hancock, & P.A. Desmond (Eds.), Stress, Workload, and Fatigue (pp. 211-231). Mahwah, NJ: Lawrence Erlbaum Associates.

Massie, D.L., Campbell, K.L., & Williams, A. F. (1995). Traffic accident involvement rates by driver age and gender. *Accident Analysis & prevention, 27 (1)*, 73-87.

Maycock, G. (1997). Accident liability-the human perspective. In: T. Rothengatter and E. Carbonell Vaya (Eds), Traffic and Transport Psychology. (pp. 65-76). Amsterdam, Pergamon.

Maycock, J., Lockwood, C.R., & Lester, I. E. (1991). The accident liability of car drivers (Rep. No. 315). Crowthorne, England: Transport and Road Research Laboratory.

Mayhew, D. R., Simpson, H. M., & Pak, A. (2003). Changes in collision rates among novice drivers during the first months of driving. *Accident Analysis & Prevention, 35 (5)*, 683-691.

Mayora, J.M.P., & Rubio, R.L. (2003). Relevant variables for crash rate prediction in Spain's two-lane rural roads, Transportation Research Board, 82nd Annual Meeting, Washington, DC.

McCartt, A. T., & Hu, W. (2014). Effects of Red Light Camera Enforcement on Red light Violations in Arlington County, Virginia. *Journal of Safety Research, 48,* 57-62.

McDonald, C. C., Goodwin, A. H., Pradhan, A. K., Romoser, M. R., & Williams, A. F. (2015). A review of hazard anticipation training programs for young drivers. *Journal of Adolescent Health, 57,* S15-S23.

McKenna, F.P., Horswill, M.S., & Alexander, J.L. (2006). Does anticipation training affect drivers' risk taking? *Journal of Experimental Psychology: Applied, 12 (1*), 1-10.

McKenna, F.P. (2010). Education in road safety: Are we getting it right? Report No. 10/113. London: RAC Foundation.

McNeely, C. L., & Gifford, J. L. (2007). Effecting a traffic safety culture: Lessons from cultural change initiatives. Washington, DC: AAA Foundation for Traffic Safety.

Merat, N., Lai, F., & Jamson, S. (2011). The comparative merits of expert observation, subjective and objective data in determining the effects of in-vehicle information systems on driving performance. *Safety Science, 49(2),* 172-177.

Meuleners, L., & Fraser, M. (2015). A validation study of driving errors using a driving simulator. *Transportation Research Part F: Traffic Psychology and Behaviour, 29*, 14–21.

Michie, S., Johnston, M., Francis, J., Hardeman, W., & Eccles, M. (2008). From theory to intervention: mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied Psychology, 57,* 660-680.

Minderhoud, M.M., & Bovy, P.H.L (2001). Extended time-to-collision measures for road traffic assessment. *Accident analysis & prevention, 33(1),* 89-97.

Minichiello, V., Aroni, R., Timewell, E., & Alexander, L. (1990). In-Depth Interviewing: Researching People. Hong Kong: Longman Cheshire

Moharrer, M. (2011). Actual skill vs perceived skill: a new method for assessing overconfidence among drivers. 3rd International Conference in Road Safety and Simulation, September 14-16, 2011. Indianapolis USA.

Monárrez-Espino, J., Hasselberg, M., & Laflamme, L. (2006). First year as a licensed car driver: Gender differences in crash experience. *Safety Science, 44 (2),* 75-85.

Morgan, D.L. (1997). Focus Groups as qualitative research (2nd ed.) Qualitative research method series V16. A SAGE publications Inch, United States of America.

Muhlrad, N. (1993). Traffic conflict techniques & other forms of behavioural analysis: application to safety diagnoses. Proceedings of 6th ICTCT Workshop, Salzburg.

Munk, M.D., Carboneau, D. M., Hardan, M., & Ali, F. M. (2008). Seatbelt use in Qatar in association with severe injuries and death in the prehospital setting. *Prehospital and disaster medicine, 23***,** 547-52.

Musselwhite, C., Avineri, E., Fulcher, E., Goodwin, P., & Susilo, Y. (2010). Understanding public attitudes to road-user safety–literature review: Final report road safety research report no. 112. Department for Transport. London.

National Bureau of Statistics, NBS (2017). National Population Estimates 2016. Available at: http://nigerianstat.gov.ng/ report/0 (Accessed 4 July 2017).

National Institute for Health and Care Excellence (2007). Behaviour change: the principles for effective interventions. NICE public health guidance 6. Available at: https://www.nice.org.uk/guidance/.../behaviour-change-general-approaches-pdf-5545.

National Cooperative Highway Research Program, *NCHRP* (2003). Guidance for implementation of the AASHTO Strategic Highway Safety Plan. NCHRP report 500, Volume 1. Washington, D.C.: Transportation Research Board.

Newnam, S., Watson, B., & Murray, W. (2004). Factors predicting intentions to speed in a work and personal vehicle. *Transportation Research Part F: Traffic Psychology and Behaviour*, 7, 287-300.

Newnam, S., Mamo, W.G., & Tulu, G.S. (2014). Exploring differences in driving behaviour across age and years of education of taxi drivers in Addis Ababa, Ethiopia. *Safety Science, 68*, 1-5.

Nichols, J., Tippetts, S., Fee, J., Eichelberger, A., & Haseltine, P. (2014). The effects of primary enforcement laws and fine levels on seat belt usage in the United States. *Traffic Injury Prevention, 15(6),* 640-644.

Nielsen, J. S. (2011). Use of the internet for willingness-to-pay surveys: A comparison of face-to-face and web-based interviews. *Resource and Energy Economics, 33,* 119-129.

Nilsson, G. (2004). Traffic safety dimensions and the power model to describe the effect of speed on safety. Lund, Sweden: Lund University.

Nisbett, R. E., & Ross, L. (1980). Human inference: Strategies and shortcomings of social judgment, Englewood Cliffs, NJ, Prentice-Hall Inc.

Noland, R.B., & Oh, L. (2004). The effect of infrastructure and demographic change on traffic-related fatalities and crashes: a case study of Illinois county-level data. *Accident Analysis and Prevention, 36,* 525-532.

Nordfjærn, T., & Rundmo, T. (2009). Perceptions of traffic risk in an industrialised and a developing country. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*, 91-98.

Nordfjærn, T., Jorgensen, S., & Rundmo, T.A. (2011). Cross-cultural comparison of road traffic risk perceptions, attitudes towards traffic safety and driver behaviour. *Journal of Risk Research, 14 (6),* 657-684.

Nordfjærn, T., Jørgensen, S., & Rundmo, T. (2012). Cultural and socio-demographic predictors of car accident involvement in Norway, Ghana, Tanzania and Uganda. *Safety Science, 50*, 1862-1872.

Nordfjærn, T., Şimşekoğlu, Ö., & Rundmo, T. (2014). Culture related to road traffic safety: a comparison of eight countries using two conceptualizations of culture. *Accident Analysis & Prevention, 62,* 319-328.

North D.C. (1990). Institutions, Institutional change and economic performance. Cambridge University Press.

Norusis, M. J. (2008). SPSS 16.0 Statistical Procedures Companion Prentice Hall: 409. NTRC (1999).

Novaco, R. W. (2001). Psychology of transportation. *International Encyclopaedia of the Social & Behavioural Sciences,* 15878–15882.

Nunnally, J. C. (1978). Psychometric theory (2nd Ed.). New York: McGraw-Hill.

Nunally J. C., & Bernstein I. H. (1994). Psychometric Theory, 3rd ed. McGraw Hill, New York.

Obinna, C. (2007). "Road traffic crashes kill 0.4m youths every year." Vanguard, April, 24, p. 35.

Odeleye, J. A. (2000). Towards financing and planning road safety audit operations in Nigeria. *IATSS Research, 24(2)*, 85-96.

OECD/ECMT (2006). Speed management. Transport Research Centre, OECD Publishing, Paris. http://www.itf.-oecd.org/sites/default/files/docs/06speed.pdf. Accessed 14 February 2019.

OECD/ITF (2008). Towards Zero: ambitious road safety targets and the safe system approach. Available at https://www.itf-oecd.org/sites/default/files/docs/08targetssummary.pdf

OECD/ITF (2015). “Nigeria”, in Road Safety Annual Report 2015, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/irtad-2015-33-en.

Ogden, K. W. (1996). Safer Roads – A guide to road safety engineering. Department of Civil Engineering. Monash University, Melbourne, Australia.

Ogwude, I.C. (2010). Driver behaviour in Nigeria: Impact of impulsiveness, anger and aggression. 4 FRSC Research Monograph, No 1.

Okigbo N. (2012). Causes of Highway Failures in Nigeria. *International Journal of Engineering Science and Technology, 4(11),* 4695-4703.

Olapoju, M.O. (2016). Culture of distracted driving among intra-city commercial bus drivers in Ile-Ife, South-Western Nigeria. *Transportation Research Part F: Traffic Psychology and Behaviour, 42(3),* 425-432.

Oron-Gilad, T., & Ronen, A. (2007). Road characteristics and driver fatigue: a simulator study. *Traffic Injury Prevention, 8(3),* 281-9.

Osayomi, T. (2013). Regional determinants of road traffic accidents in Nigeria: identifying risk areas in need of intervention. *African Geographical Review, 32(1),* 88-99.

Östlund, J., Nilsson, L., Carsten, O., Merat, N., Jamson, H., Jamson, S., Mouta, S., Carvalhais, J., Santos, J., Anttila, V., Sandberg, H., Luoma, J., de Waard, D., Brookhuis, K., Johansson, E., Engström, J., Victor, T., Harbluk, J., Janssen, W., & Brouwer, R. (2004) Deliverable 2 - HMI and Safety-Related Driver Performance (No. GRD1/2000/25361 S12.319626): Human Machine Interface and the Safety of Traffic in Europe (HASTE) Project.

Özkan, T., & Lajunen, T. (2005). A new addition to DBQ: positive driver behaviours scale. *Transportation research. Part F: Traffic psychology and behaviour, 8,* 355-368.

Ozkan, T. and Lajunen, T. (2015). Traffic Safety Cultures and the Safe Systems Approach Towards a Cultural Change Research and Innovation Agenda for Road Safety. *Technical report.* Deliverable D2.1. A General Traffic (Safety) Culture System (G-TraSaCu-s) Project.

Ozkan, T., Lajunen, T., Chliaoutakies, J., Parker, D., & Summala, H. (2006). Cross cultural differences on driving behaviours: A comparison of six countries. *Transport Research Part F: Traffic Psychology and Behaviour, 9,* 227-242.

Ozkan, T., Lajunen, T., Parker, D., Summer, N., & Summala, H. (2011). Aggressive driving among British, Dutch, Finnish and Turkish drivers. *International Journal of Crashworthiness, 16(3),* 233-238.

Palat, B., & Delhomme, P. (2016). A simulator study of factors influencing drivers' behaviour at traffic lights. *Transport Research Part F: Traffic Psychology and Behaviour*, 37, 107-118.

Pallant, J. (2003). SPSS: Survival manual. Philadelphia: Open University Press, pp. 152–153.

Papakostopoulos, V., Nathanael, D., Portouli, E., & Marmaras, N. (2015). The effects of changes in the traffic scene during overtaking. *Accident Analysis & Prevention, 79,* 126-132.

Parker, D., Reason, J., Manstead, A., & Stradling, S. (1995). Driving errors, driving violations and accident involvement. *Ergonomics, 38(5),* 1036-1048.

Parker, D., Stradling, S. G., & Manstead, A. S. R. (1996). Modifying beliefs and attitudes to exceeding the speed limit: An intervention study based on the theory of planned behaviour. *Journal of Applied Social Psychology, 26***,** 1-19.

Parker, D. (2004). Road safety: What Has Social Psychology to Offer? Traffic & Transport Psycology: Theory and Application. T. Rothengatter & R. D. Huguenin. Amsterdam, Elsevier Ltd.

Peden, M., McGee, K., & Sharma, G. (2002). The injury chart book: a graphical overview of the global burden of injuries. Geneva, World Health Organization, (http://www.who.int/violence_injury_prevention/injury/chartbook/chartb/en/, accessed 20 March 2018).

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A.A., & Mathers, C. (2004). World report on road traffic injury prevention. World Health Organization, Geneva Switzerland.

Peltzer, K., & Renner, W. (2003). Superstition, risk-taking and risk perception of accidents among South African taxi drivers. *Accident Analysis & Prevention, 35,* 619–623.

Persson, A. (2008). Road traffic accidents in Ethiopia: Magnitude, causes and possible interventions. *Advances in Transportation Studies an International Journal, 15*, 5-18.

Panou, M., Bekiaris, E., & Papakostopoulos, V. (2007). Modelling driver behaviour in European Union and international projects. In C. Cacciabue (Ed). Modelling Driver Behaviour in Automotive Environments (pp. 3-25), Italy, Springer.

Phillips, R. O., Ulleberg, P., & Vaa, T. (2011). Meta-analysis of the effect of road safety campaigns on accidents. *Accident Analysis and Prevention, 43(3),* 1204-1218.

Piccinini, G. F. B., Rodrigues, C. M., Leitão, M., & Simões, A. (2014). Driver's behavioural adaptation to Adaptive Cruise Control (ACC): the case of speed and time headway. *Journal of safety research, 49,* 77.e1-84.

Polit, D. F., & Beck, C. T. (2012). Nursing research: Principles and methods. Philadelphia, PA: Lippincott Williams & Wilkins.

Puvanachandra, P., Hoe, C., Özkan, T., & Lajunen, T. (2012) Burden of road traffic injuries in Turkey. *Traffic Injury Prevention*, 13, sup1, 64-75.

Quddus, M.A. Wang, C., & Ison S.G. (2009). Road traffic congestion and crash severity: econometric analysis using ordered response models. *Journal of Transport Engineering, 136 (5),* 424-435.

Quimby, A.R. (1986). Driving errors and individual differences-An in-car observation study. TRRL WP (HSF) 40. Transport Road Research Laboratory, London.

Quimby, A., Downing, C., & Callahan, C. (1991). Road users' attitudes to some road safety and transportation issues. Transport and Road Research Laboratory, Crowthorne, Berkshire, UK (C.R. 227).

Rasmussen, J. (1979). Notes on human error analysis and prediction. In: Apostolakis, G. & Volta, G. (eds.) Synthesis and Analysis Methods for Safety and Reliability Studies (pp. 357-389). New York: Plenum Publishing Corporation.

Rasmussen, J. (1983). Skills, rules, and knowledge, signals, signs, and symbols, and other distinctions in human performance models. Systems, Man and Cybernetics. *IEEE Transactions SMC-13,* 257-266.

Read, G. J. M., Salmon, P. M., Lenne, M., & Grey, E. (2014). Evaluating design hypotheses for rail level crossings: An observational study of pedestrian and cyclist behaviour. Paper presented at the Proceedings of the 5th Advances in Human Factors and Ergonomics Conference, Krakow, Poland.

Reason, J., Manstead, A.S.R., Stradling, S.G., Baxter, J.S., & Campbell K. (1990). Errors and violations on the road: a real distinction? *Ergonomics, 33 (10/11),* 1315-1332.

Regan, M. A., Williamson, A. M., Grzebieta, R., Charlton, J. L., Lenne, M. G., Watson, B. C.,Haworth, N., Rakotonirainy, A., Wolley, J., Anderson, r., Senerrick, T., & Young, K. (2013). The Australian 400-car Naturalistic Driving Study: Innovation in road safety research and policy. In N. Leal (Ed.), *Proceedings of the 2013 Australasian Road Safety Research, Policing and Education Conference* (pp. 1 - 13). Australian Capital Territory: Australasian College of Road Safety.

Retting, R. A., Farmer, C. F., & McCartt, A. T. (2008a). Evaluation of automated speed enforcement in Montgomery County, Maryland. *Traffic Injury Prevention, 9,* 440-5.

Retting, R. A., Kyrychenko, S. Y., & McCartt, A. T. (2008b). Evaluation of automated speed enforcement on loop 101 freeway in Scottsdale, Arizona. *Accident Analysis & Prevention, 40*, 1506-12.

Retting, R. (2011). Running traffic controls. In: BRYAN, E. P. (ed.) Handbook of Traffic Psychology. San Diego: Academic Press.

Reynolds, C. C. O., Harris, M. A., Teschke, K., Cripton, P. A. and Winters, M. (2009). The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. Environment Health, 21; 8 (47)

Rhodes, N., Brown, D. & Edison, A. (2005). Approaches to understanding young driver risk taking. *Journal of Safety Research, 36,* 497-499.

Rice, R. E., & Atkin, C. K. (2002). Communication campaigns: Theory, design, implementation, and evaluation. In J. Bryant & D. Zillmann (Eds.), Media effects: Advances in theory and research (2nd ed., pp. 427-451). Mahwah, NJ: Lawrence Erlbaum Associates.

Rosenstock, I. M. (1974). Historical origins of the Health Belief Model. Health Education Monograph, 2, 1-8.

Royal Society for the Prevention of Accidents, RSPA (2017). Designing evidence based road safety interventions: A practioner's guide

Rubin, R. (1996). Review 'Focus groups: A practical guide for applied research', 2nd edition. In: Krueger, R. A. *Library & Information Science Research, 18 (2),* 191-192.

Rumar, K. (1985). The role of perceptual and cognitive filters in observed behaviour. In: Evans, L. & Schwing, R. (Eds). Human behaviour and traffic safety (pp. 151-170). Springer US.

Ryeng, E. O. (2012). The effect of sanctions and police enforcement on drivers' choice of speed. *Accident Analysis & Prevention, 45***,** 446-454.

Salman, N. & Al-Maita, K. (1995). Safety Evaluation at Three-Leg, Unsignalized Intersections by Traffic Conflict Technique. *Transportation Research Board*, *1485*, 177-185.

Sangowawa A. O., Alagh, B.T., Ekanem, S. E., Ebong, I. P., Faseru, B., Adekunle, B.J., & Uchendu, O.C. (2010). An observational study of seatbelt use among vehicle occupants in Nigeria. *Injury Prevention, 16,* 85-89.

Savolainen, P.T., Mannering, F., Lord, D., & Quddus, M.A. (2011). The statistical analysis of highway crash-injury severities: A review and assessment of methodological alternatives. *Accident Analysis & Prevention, 43,* 1666-1676.

Sawalha, Z., & Sayed, T. (2001). Evaluating safety of urban arterial roadways. *Journal of Transportation Engineering, 127(2),* 151-158.

Schubert, R., Schulze, K., & Wanielik, G. (2010). Situation assessment for automatic lane-change manoeuvres. *IEEE Transactions on Intelligent Transportation Systems, 11(3),* 607-616.

Schwarzer, R. (2008). Modelling health behaviour change: How to predict and modify the adoption and maintenance of health behaviours. *Applied Psychology: An International Review*, 57, 1-29.

Senserrick, T. (2009). Australian graduated driver licensing systems. *Journal of the Australasian College of Road Safety, 20***,** 20-26.

Sétra. (2006). Landscape and road legibility: Some ideas for an approach that brings together road safety and landscape. Begneux Cedex, France: The Technical Department for Transport, Roads, Bridges Engineering & Road Safety (Sétra), Service d'etudes techniques des routes et autoroutes.

Shbeeb, L. (2000). Development of a traffic conflicts technique for different environments. Bulletin 188. Department of Technology and Society, Lund University.

Sheeran, P., Norman, P., & Orbell, S. (1999). Evidence that intentions based on attitudes better predict behaviour than intentions based on subjective norms. *European Journal of Social Psychology, 29,* 403-406.

Shibata, A., & Fukuda, K. (1994). Risk factors of fatality in motor vehicle traffic accidents. *Accident Analysis and Prevention Journal, 26,* 391- 397.

Shinar, D. (1998). Aggressive driving: the contribution of the driver and the situation. *Transport Research. Part F: Traffic Psychology & Behaviour, 1,* 137-160.

Shinar, D., Dewar, R., Summala, H., & Zakowska, L. (2003). Traffic symbol comprehension: a cross cultural study. *Ergonomics, 46,* 1549-1565.

Shinar, D., & Compton, R. (2004). Aggressive driving: an observational study of driver, vehicle, and situational variables. *Accident Analysis & Prevention, 36***,** 429-437.

Shiraev, E., & Levy, D. A. (2010). Cross-cultural psychology: Critical thinking and contemporary applications, Boston, MA, Pearson/Allyn and Bacon.

SHRP2. Strategic Highway Research Program. Available on-line at: 21 http://www.shrp2nds.us, Assessed March 15, 2018.

Şimşekoğlu, O., Nordfjærn, T., & Rundmo, T. (2012). Traffic risk perception, road safety attitudes, and behaviours among road users: a comparison of Turkey and Norway. *Journal of Risk Research, 15(7),* 787-800.

Snyder, L.B. (2001). How effective are mediated health campaigns? In: Rice, R.E., Atkins, C.K. (Eds.), Public Communication Campaigns. Third edition. Sage Publications, CA

Sommer, R., & B. B. Sommer (2002). A practical guide to behavioural research: tools and techniques, Oxford University Press.

Son, J., Park, M., Won, K., Kim, Y., Son, S., McGordon, A., Jennings, P., & Birrell, S. (2016). Comparative study between Korea and UK: relationship between driving style and real-world fuel consumption. *International Journal of Automotive Technology, 17(1),* 175-181.

Soole, D., Watson, B., & Lennon, A. (2009). The impact of police speed enforcement practices on self-reported speeding: An exploration of the effects of visibility and mobility. Australasian Road Safety Research, Policing and Education Conference: Smarter, Safer Directions, 2009 Sydney Convention and Exhibition Centre, Sydney.

Soro, W. L., & Wayoro, D. (2017). A Bayesian analysis of the impact of post-crash care on road mortality in Sub-Saharan African countries. *IATSS Research*, *41*(3), 140-146.

Stanojevic, P., Jovanovic, D., & Lajunen, T. (2013). Influence of traffic enforcement on the attitudes and behaviour of drivers. *Accident Analysis & Prevention, 53,* 29-38.

Stopher, P., & Greaves, S.P. (2007). Household travel surveys: where are we going? *Transportation Research Part A: Policy & Practice, 41,* 367-381.

Stutts, J.C., Feaganes, J.R., Reinfurt, D., Rodgman, E., Hamlett, C., Gish, K., & Staplin, L. (2005). Driver's exposure to distractions in their natural driving environment. *Accident Analysis & Prevention 37 (6),* 1093-1101.

Sullman, M.J.M. (2012). An observational study of driver distraction in England. *Transport Research Part F: Traffic Psychology and Behaviour 15 (3),* 272-278.

Summala, H. (1996). Accident risk and driver behaviour. *Safety Science, 22(1-3),* 103-117.

Sun, D., & Elefteriadou, L. (2011). Information categorization based on driver behaviour for urban lane-changing manoeuvres. *Transportation Research Record: Journal of the Transportation Research Boar, 2249,* 86-94.

Svensson, Å. (1992). Vidareutveckling och validering av den svenska konflikttekniken (in Swedish) Further development and validation of the Swedish Traffic Conflicts Technique. Lund: Department of Traffic Planning and Engineering, Lund University.

Svensson, Å. (1998). A method for analysing the traffic process in a safety perspective. Bulletin 166, Department of Traffic Planning and Engineering, University of Lund.

Svensson, A., & Carsten, O. (2007). Literature review and experience on the application of conflict studies to rural roads. Highways Research Group. Deliverable number 2.

Tabachnick, B. G., & Fidell, L. S. (2001). Using multivariate statistics (4th Ed.). Boston: Allyn and Bacon.

Tabachnick, B. G., & Fidell, L. S. (2007). Using multivariate statistics (5th Ed.). Boston, MA: Allyn and Bacon.

Tarko, A. P. (2009). Modeling drivers' speed selection as a trade-off behaviour. *Accident Analysis & Prevention, 41(3),* 608-616.

Tasca, L. A. (2000) Review of the literature on aggressive driving research. Aggressive Driving Issues Conference. Retrieved from https://www.stopandgo.org/research/aggressive/tasca.pdf.

Taubman - Ben-Ari, O., Mikulincer, M., & Gillath O. (2005). From parents to children – similarity in parents and offspring driving styles. *Transport Research. Part F: Traffic Psychology and Behaviour*, 8, 19-29.

Taubman-Ben-Ari, O., & Yehiel, D. (2012). Driving styles and their associations with personality and motivation. *Accident Analysis & Prevention, 45*, 416-422.

Tay, R. (2005). The effectiveness of enforcement and publicity campaigns on serious crashes involving male drivers: are drink driving and speeding similar? *Accident Analysis & Prevention, 37 (5),* 922-929.

Tay, R., & Watson, B. (2002). Changing drivers' intentions and behaviours using fear-based driver fatigue advertisements. *Health Marketing Quarterly, 19 (4),* 55-68.

Taylor, B., & Rehm, J. (2012).The relationship between alcohol consumption and fatal motor vehicle injury: high risk at low alcohol levels. *Alcoholism: Clinical & Experimental Research, 36,* 1827–34.

Taylor, M. C., Baruya, A., & Kennedy, J. V. (2002). The relationship between speed and accidents on rural single-carriageway roads. TRL report TRL511. Crowthorne, Berkshire: TRL.

Tetali, S., Lakshmi, J.K., Gupta, S., Gururaj, G., Washwaniya, S., & Hyder, A.A. (2013). Qualitative study to explore stakeholder perceptions related to road safety in Hyderabad, India. *Injury, 44 (4),* 17-23.

Theeuwes, J. (1994). Self-explaining roads: An exploratory study (Report TNO-TM 1994 B-18). Soesterberg, The Netherlands: TNO Human Factors Research Institute.

Theeuwes, J., & Godthelp, J. (1992) Self-explaining roads (Report IZF 1992 C-8) Soesterberg, The Netherlands: TNO Human Factors Research Institute.

Theeuwes, J., & Godthelp, H. 1995. Self-explaining roads. *Safety Science, 19(2-3),* 217-225.

Theeuwes, J. (2001). The effects of road design on driving. In P. E. Barjonet (Ed.). Traffic Psychology Today (pp. 241-263). New York: Springer.

Thomas, F., Blomberg, R., Masten, S., Peck, R., Van Dyk, J., & Cosgrove, L. (2017). Evaluation of the Washington Night-time Seat Belt Enforcement Program, NHTSA.

Thompson, B., & Daniel, L. G. (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. *Educational and Psychological Measurement, 56,* 197-208.

Thornton, A., Evans, L., Bunt, K., Simon, A., King, S., & Webster, T. (2011). Climate change and transport choices: segmentation model - a framework for reducing CO2 emissions from personal travel. London, Department for Transport.

TrafficInfraTech. (2011). Improving the effectiveness of lane marking. Retrieved 22 May 2019, from http://www.trafficinfratech.com/trafficmanagement-lanemarking/.

Transportation Research Board (2003). A guide for addressing un signalised intersection collisions. National Cooperative Highway Research Program, vol 5.Transportation Research Board (TRB), Washington, D.C.

Trick, L. M., & Enns, J. T. (2009). A two-dimensional framework for understanding the role of attentional selection in driving. In: Castro, C. (ed.) Human Factors of Visual and Cognitive Performance in Driving (PP. 63-73). Boca Raton, Florida: CRC Press.

Turner, B., & Tziotis, M. (2006). Road safety engineering risk assessment: Recent and future research. Australasian Road Safety Research Policing Education Conference, Surfers Paradise, Australia.

UDRIVE. European Naturalistic Driving Study. Available on-line at: 19 http://www.udrive.eu Assessed March. 15, 2018.

UK Government Department for Transport (2014). Transport statistics Great Britain. https://www.gov.uk/government/statistics/transport-statistics-great-britain-2014 (Accessed March 21, 2019).

UK Government Department for Transport (2018). Reported drinking and driving (RAS51001). https://www.gov.uk/government/ statistical-data-sets/ras51-reported-drinking-and-driving (accessed April 28, 2019).

UK Government Department for Transport (2017). High way Code, road safety and vehicle rules 2017 _ GOV.UK. https://www.gov.uk/browse/driving/highway-code-road-safety (accessed April 28, 2018).

Ukibe, S.N., Nnolum, P.O., Ekezie, J., Okeke, C., Ukibe, N. R., & Mbanugo, J.I. (2011). Epidemiology of road traffic accidents in Owerri, Imo state, South East Nigeria. *Tropical Journal of Medical Research, 15 (2),* 35-38.

Ukoji, V. (2014). Trends and patterns of fatal road accidents in Nigeria (2006-2014). IFRA-Nigeria working papers series. 35. 1-40. Retrieved from: http://www.ifra-nigeria.org/IMG/pdf/fatal-road-accidents-nigeria.pdf

Ulleberg, P. (2002). Influencing subgroups of young drivers and their passengers: Motivational influences of personality traits on risk-taking attitudes and driving behaviour. Institute of Transport Economics, Norwegian Centre for Transport Research.

Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science, 41,* 427–443.

United Nations Economic commission for Europe (2008). Transport Review (1st ed). United Nations, New York and Geneva.

United Nations (2011). Global Plan for the Decade of Action for Road Safety 2011-2020 *is at* www.who.int/entity/roadsafety/decade_of_action/plan/english.pdf.

United Nations Economic Commission for Europe (2019). https://www.unece.org/trans/main/welcwp29.html. Accessed 18 May 2019.

Uzondu, C.C., Jamson, S., & Lai, F. (2018). Exploratory study involving observation of traffic behaviour and conflicts in Nigeria using the traffic conflict Technique. *Safety Science, 110(part a),* 273-284.

Uzondu, C.C., Oyeyemi, B., Lawal, A., & Adenusi, P. (2019). Factors affecting the intent to comply with the use of pedestrian bridges in Lagos state Nigeria. An unpublished report.

Uzondu, C.C., Jamson, S., & Lai, F. (2019). Unsafe behaviours in traffic conflict situations: An observational study in Nigeria. *Journal of Traffic and Transportation Engineering, in press,* available at https://doi.org/10.1016/j.jtte.2018.06.002.

Vaa, T. (1997). Increased police enforcement: Effects on speed. *Accident Analysis & Prevention, 29,* 373-385.

Vaa, T., Assum, T., Ulleberg, P., & Veisten, K. (2004). Effekter av informasjonskampanjer på atferd og trafikkulykker - forutsetninger, evaluering og kostnadseffektivitet. TØI Rapport. 727/2004 Institute of Transport Economics, Oslo

van der Linden, S. (2013). "A response to Dolan". In A. Oliver (Ed.). Behavioural Public Policy (pp. 209-215). Cambridge University Press.

van Elslande, P., & Faucher-Alberton, L. (1997). When expectancies become certainties: A potential adverse effect of experience. In T. Rothengatter & E. Vanya (Eds.). Traffic and Transport Psychology: Theory & Application. Pergamon, Amsterdam.

Van Schagen, I., Commandeur, J. J.F. Goldenbeld, C., & Stipdonk, H. (2016). Monitoring speed before and during a speed publicity campaign. *Accident Analysis and Prevention, 97(12),* 326-334.

Van Winsum, W. (1998). Preferred time headway in car-following and individual differences in perceptual-motor skills. *Perceptual and motor skills, 87(3 Pt 1),* 863-873.

Vasudevan V., Nambisan, S.S., Singh, A. K., & Pearl T. (2009). Effectiveness of media and enforcement campaigns in increasing seat belt usage rates in a state with a secondary seatbelt law. *Traffic Injury Prevention, 10(4),* 330-339.

Vatanavongs, R., & Sonnarong, S. (2014). Impacts of accident severity factors and loss values of crashes on expressways in Thailand. *IATSS Research 37,* 130-136.

Vlakveld, W.P. (2005). The use of simulators in basic driver training. HUMANIST Workshop on the application of new technologies to driver training, Brno, Czech Republic. Retrieved from http://www.esafetysupport.org/download/research_and_development/HUMANISTA 13Use.pdf

Ward, R. L., & R. J. Lancaster (2003). International review of the individual factors contributing to driving behaviour and the implications for work-related road safety. Behavioural Research in Road Safety: Thirteenth Seminar. London, Department of transport.

Ward, N. J., & Ozkan, T. (2014). In consideration of traffic safety culture. *Transport Research Part F: Traffic Psychology and Behaviour, 26, Part B,* 291-292.

Warner, H. W., Ozkan, T., & Lajunen, T. (2009). Cross-cultural differences in drivers' speed choice. *Accident Analysis and Prevention, 41,* 816-819.

Warner, H.W., Ozkan, T., Lajunen, T., & Tzamalouka, G. (2011). Cross-cultural comparison of drivers' tendency to commit different aberrant driving behaviours. *Transport Research Part F: Traffic Psychology and Behaviour 14,* 390-399.

Walter, L., Broughton, J., & Knowles, J. (2011). The effects of increased police enforcement along a route in London. *Accident Analysis & Prevention, 43,* 1219-1227.

Weber, K., Martin, M.M., & Corrigan, M. (2006). Creating persuasive messages advocating organ donation. *Communication Quarterly, 54(1),* 67-87.

Weenig W.H., & Midden, C.J.H. (1997). Mass media information campaigns and Knowledge gap effects. *Journal of Applied Social Psychology, 27,* 945-958.

Wegman, F., & Aarts, L. (eds.) (2006). Advancing sustainable safety: National road safety outlook for 2005-2020. SWOV, Leidschendam.

Wegman, F. (2010). Scientific research on road safety management. *Special Issue Safety Science, 48 (9),* 1081-1224.

Wenzel, T. P., & M. Ross (2005). The effects of vehicle model and driver behaviour on risk. *Accident Analysis & Prevention, 37 (3),* 479-494.

West, R., French, D., Kemp, R., & Elander, J. (1993). Direct observation of driving, self-reports of driver behaviour, and accident involvement. *Ergonomics 36(5),* 557-567.

Wetton, M.A., Horswill, M.S., Hatherly, C., Wood, J.M., Pachana, N.A., & Anstey, K.J. (2010). The development and validation of two complementary measures of drivers' hazard perception ability. *Accident Analysis & Prevention, 42 (4),* 1232-1239.

Weenig, M.W., & Midden, C.J. (1997). Mass-media information campaigns and knowledge-gaps effects. *Journal of Applied Social Psychology, 27 (11),* 945-958.

Wickens, C. D., & Hollands, J. G. (2000). Engineering Psychology and Human Performance. New Jersey: Addison Wesley Pub Co Inc

Wikipedia, the free encyclopaedia (2019) Pit latrine

Wissinger, L. M., Hummer, J. E., & Milazzo, J. S. (2000). Using focus groups to investigate issues of red light running. *Transportation Research Record: Journal of the Transportation Research Board, 1734,* 38-45.

World Bank. (2002). Cities on the move: A World Bank urban transport strategy review. http://documents.worldbank.org/curated/en/928301468762905413/pdf/multi0page.pdf

World Bank. (2012). "Road Safety." Retrieved 17 April, 2018, from http://www.worldbank.org/transport/roads/safety.htm.

World Bank. (2017a). The High Toll of Traffic Injuries: Unacceptable and Preventable. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/29129

World Bank (2017b) https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

World Bank (2018). https://data.worldbank.org/country/nigeria, accessed 23 February 2019

World Health Organisation (2004). The world health report 2004: changing history. www.who.int/whr/2004/en/report04_en.pdf

World Health Organization (2009). Global Status Report on Road Traffic. Time for Action. <http://whqlibdoc.who.int/publications/2009/9789241563840_eng.pdf> (accessed 23.01.19).

World Health Organization. (2010). Data systems: a road safety manual for decision-makers and practitioners, Geneva, Switzerland: World Health Organization/Global Road Safety Partnership/FIA/World Bank.

World Health Organization. (2011). Global plan for the decade of action for road safety, 2011-2020, Version 3. Luxembourg: World Health Organization. Retrieved from: https://www.who.int/roadsafety/decade_of_action/plan/global_plan_decade.pdf

World Health Organization. (2013a). Global status report on road safety 2013 - Supporting a Decade of Action. Luxembourg: World Health Organization. Retrieved from: http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/

World Health Organisation (2013b). Road safety in the WHO African region: The Facts 2013.
www.who.int/violence_injury_prevention/road_safety.../2013/.../factsheet_afro.pdf

World Health Organisation (2015). Global Status Report on Road Safety 2015. Available at: http://who.int/violence_injury_ prevention/road_safety_status/2015/en/ (Accessed 22 April 2017).
WHO (2017). Save LIVES. A road safety technical package. World Health Organization, Geneva, Switzerland.

World Health Organization. (2018). Global status report on road safety 2018. Luxembourg: World Health Organization. Retrieved from: http://www.who.int/violence_injury_prevention/road_safety_status/2018/en/

Yan, X., Radwan, E., & Guo, D. (2007). Effects of major-road vehicle speed and driver age and gender on left-turn gap acceptance. *Accident Analysis & Prevention, 39 (4),* 843-852.

Yannis, G., Golias, J., & Papadimitriou, E. (2007). Accident risk of foreign drivers in various road environments. *Journal of Safety Research, (38)4,* 471-80.

Yannis, G., Papadimitriou, E., & Antoniou, C. (2008). Impact of enforcement on traffic accidents and fatalities: A multivariate multilevel analysis. *Safety Science, 46***,** 738-750.

Zaidel, D. M. (1992). A modelling perspective on the culture of driving. *Accident Analysis & Prevention, 24***,** 585-597.

Zaidel, D. (2002). The impact of enforcement on accidents. Deliverable 3 (Work Package 2) of the ESCAPE project. Finland.

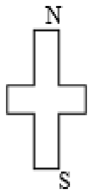
Appendices

Appendix A: Conflict recording sheet

Conflict Recording Sheet

Observer: ________ Date: ___________ Number: __________ Time:__________

City:____



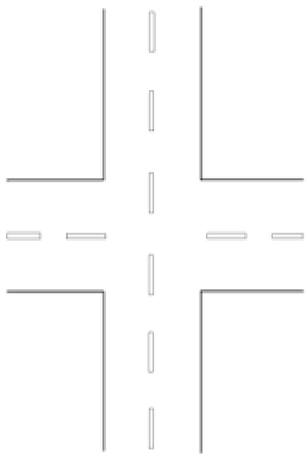
Intersection: ____

Weather: Sunny ☐ Cloudy ☐ Rainy ☐ Drizzle/Shower ☐

Surface: Dry ☐ Wet ☐

Time: From: To:

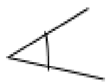
	Road user I	Road user II	Secondary involved
Private car Bicycle Pedestrian Other sex Age	☐ ☐ ☐ ________ M ☐ F ☐ ____ years	☐ ☐ ☐ ________ M ☐ F ☐ ____years	☐ ☐ ☐ M ☐ F ☐ ____years
Speed Distance to collision point Time to Accident	____km/h ____ m ____ secs	____ Km/h ____ m ____ secs	____ Km/h
Avoiding action Braking Swerving Acceleration	 ☐ ☐ ☐	 ☐ ☐ ☐	
Possibility to Swerve	Yes ☐ No ☐	Yes ☐ No ☐	
Other information like Speeding Visual hindrance			
Brief description of causes of event:			



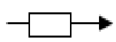
Sketch the position of the road users involved in the Conflict

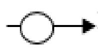
Mark position of observer as 

If video camera is in use, mark position as



Note:  Car, Lorry, Bus…

 Bicycle, Motorcycle

 Pedestrian

Appendix B: Driver Behaviour Questionnaire (DBQ)

Participant id: _________

Dear Participant,

Thank you for volunteering to participate in this survey, which is a part of the driving simulator experiment and being undertaken as part of PhD research in the Institute for Transport Studies, University of Leeds, UK. The purpose of the survey is to investigate drivers' behaviours. The questionnaire is simple and you are not required to give precise answers. If after giving a response, you change your mind, please cross it neatly and circle another one. Your responses will be anonymous and treated in strictest confidence. Your participation is completely voluntary, but should you feel concerned you have the right to stop participating at any time.

PART A: QUESTIONS ABOUT YOU

This section is designed to help us know about your general characteristics.

1. Gender: male ___ female ___
2. Age: prefer not to answer ___ under 19 ___ 19-34 ___ 35-55 ___ 55+ ___
3. How many road crashes you have been involved in the last three years?
crashes_______
4. How long have you been driving? Less than 2 years ___ 3-6 years ___ 6-15 years ___ more than 15 years ___.
5. Where do you have experience of driving? Nigeria_______ UK_______ both _______

PART B: QUESTIONS ABOUT YOUR DRIVING BEHAVIOUR

For each question, you are required to indicate the frequency with which you have performed each type of behaviour by circling the appropriate number.

How often do you:	Never	Hardly ever	Occasi onally	Quite often	freque ntly	Nearly all the time
1. Attempt to drive away from traffic lights in wrong gear?	0	1	2	3	4	5
2. Check your speedometer and discover that you are unknowingly travelling faster than the speed limit?	0	1	2	3	4	5
3. Lock yourself out of your car with the keys still inside?	0	1	2	3	4	5
4. Become impatient with a slow driver in the outer lane and overtake on the inside?	0	1	2	3	4	5
5. Drive as fast along country/village roads at night on low beam as you would on high beam?	**0**	**1**	**2**	**3**	**4**	**5**
6. Attempt to drive away without first having switched on the ignition?	0	1	2	3	4	5
7. Drive especially close to or 'flash' the car in front of you as a signal for that driver to go faster or get out of your way?	0	1	2	3	4	5
8. Forget where you left or parked your car?	0	1	2	3	4	5
9. Distracted or preoccupied, failed to realise on time that the vehicle ahead has slowed and have to slam on the brakes to avoid a collision?	0	1	2	3	4	5
10. Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa?	0	1	2	3	4	5
11. Turn left/right on to a main road into the path of an oncoming vehicle that you hadn't seen, or whose speed you had misjudged?	0	1	2	3	4	5
12. Misjudge the available space where you parked your car and nearly (or actually) hit another vehicle?	0	1	2	3	4	5
13. Realize you have no clear recollection of the road along which you have just been traveling?	0	1	2	3	4	5
14. **Miss your exit on a motorway/highway and have to make a lengthy detour?**	0	1	2	3	4	5

15. Forget which gear you are currently in and have to check with your hand?	0	1	2	3	4	5
16. Stuck behind a slow-moving vehicle on a two-lane highway, you are driven by frustration and try to overtake in risky circumstances?	0	1	2	3	4	5
17. Intending to drive to destination A, you suddenly realize that you are en route to B, because that is your more usual destination?	0	1	2	3	4	5
18. Take a chance and run the red light?	0	1	2	3	4	5
19. Angered by another driver's behaviour, you give chase with the intention of giving him/her a piece of your mind?	0	1	2	3	4	5
20. Try to overtake without first checking your mirror, and then get hooted/horned at by the car behind which has already begun its overtaking manoeuvre?	0	1	2	3	4	5
21. Deliberately disregard the speed limits at any time (morning, afternoon, evening, night)?	0	1	2	3	4	5
22. Forget when your road tax/insurance/vehicle papers expires and discover that you are driving illegally?	0	1	2	3	4	5
23. Forget that your lights are on full beam until 'flashed' by other motorists?	0	1	2	3	4	5
24. On turning left/right, nearly hit a cyclist/tricycle who has come up beside you?	0	1	2	3	4	5
25. In a queue of vehicles turning left/right on to a main road, pay such close attention to the traffic approaching from the right/left that you nearly hit the car in front?	0	1	2	3	4	5
26. Drive even though you realize that you may be over the legal blood-alcohol limit?	0	1	2	3	4	5
27. Have an aversion to a particular class of road user, and indicate your hostility by whatever means you can?	0	1	2	3	4	5
28. Lost in thought or distracted, you fail to notice someone waiting at a zebra crossing, or a pelican crossing light that has just turned red?	0	1	2	3	4	5
29. **Park on a double-yellow line/diagonally striped area and risk a fine?**	0	1	2	3	4	5
30. **Underestimate/Misjudge speed of an oncoming vehicle when overtaking?**	0	1	2	3	4	5
31. Hit something when reversing that you had not previously seen?	0	1	2	3	4	5
32. Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late?	0	1	2	3	4	5
33. Plan your route badly, so that you meet traffic congestion you could have avoided?	0	1	2	3	4	5
34. Overtake a single line of stationary or slow-moving vehicles, only to discover that they were queueing to get through a one lane gap or roadwork lights?	0	1	2	3	4	5
35. Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway?	0	1	2	3	4	5
36. Cut the corner on a left/right-hand turn and have to swerve violently to avoid an oncoming vehicle?	0	1	2	3	4	5
37. Get into the wrong lane when approaching an intersection or roundabout?	0	1	2	3	4	5
38. Fail to read the signs correctly, and exit from a roundabout on the wrong road?	0	1	2	3	4	5
39. Fail to give way when a bus is signalling its intention to pull out?	0	1	2	3	4	5
40. Ignore 'give way' signs, and narrowly avoid colliding with traffic having right of way?	0	1	2	3	4	5
41. Fail to check your mirrors before pulling out, changing lanes, turning etc.?	0	1	2	3	4	5

42. Attempt to overtake a vehicle that you hadn't noticed was signalling its intention to turn right/left?	0	1	2	3	4	5
43. Deliberately drive the wrong way down a deserted one-way street?	0	1	2	3	4	5
44. Disregard red lights when driving late at night along empty roads?	0	1	2	3	4	5
45. Drive with only 'half-an-eye' on the road while looking at a map, changing a CD player or radio channel etc.?	0	1	2	3	4	5
46. Fail to notice pedestrians crossing when turning into a side street from a main road?	0	1	2	3	4	5
47. Get involved in unofficial 'races' with other drivers?	0	1	2	3	4	5
48. 'Race' oncoming vehicles for a one-car gap on a bad, narrow or obstructed road?	0	1	2	3	4	5
49. Brake too hard or quickly on a slippery road and/or steer the wrong way in a skid?	0	1	2	3	4	5
50. Misjudge your crossing interval when turning right/left and narrowly miss colliding?	0	1	2	3	4	5

In Bold: Modified DBQ items

Appendix C: Training manual

Training manual and instructions on how to complete the drive and drive safely (adapted from the Highway Code, Department for Transport, 28 July 2017)

1) **Seatbelts:**

You are required to wear a seat belt in cars, vans and other goods vehicles

2) **Indicator Use:**

Signals warn and inform other road users of your intended actions. You should always give clear signals in plenty of time, having checked it is not misleading to signal at that time. Use them to advise other road users before changing course or direction, stopping or moving off. Cancel them after use

3) **Traffic light signals and traffic signs:**

You are required to obey all traffic light signals and traffic signs giving orders, including temporary signals & signs. Make sure you know, understand and act on all other traffic and information signs and road markings

4) **Braking:**

In normal circumstances. The safest way to brake is to do so early and lightly. Brake more firmly as you begin to stop. Ease the pressure off just before the vehicle comes to rest to avoid a jerky stop.

5) **Speed limits:**

Speed Limits	**Built-up areas***	**Single carriageways**
Type of vehicle	mph (km/h)	mph (km/h)
Cars	**30** (48); **40** (64)	**60** (96)

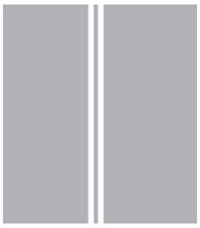
The speed limit is the absolute maximum and does not mean it is safe to drive at that speed irrespective of conditions. Driving at speeds too fast for the road and traffic conditions is dangerous.
Speed limit apples from the signs, you should start slowing down while approaching it.

6) **Stopping Distances:**

Drive at a speed that will allow you to stop well within the distance you can see to be clear. You should leave enough space between you and the vehicle in front so that you can pull up safely if it suddenly slows down or stops. This equates to approximately two car lengths.

7) Line markings:

A broken white line. This marks the centre of the road. When this line lengthens and the gaps shorten, it means that there is a hazard ahead. Do not cross it unless you can see the road is clear and wish to overtake or turn off.



Double white lines, where both lines are solid. This means you should not cross or straddle it.

8) Lane discipline:

If you need to change lane, first use your mirrors and if necessary take a quick sideways glance to make sure you will not force another road user to change course or speed. When it is safe to do so, signal to indicate your intentions to other road users and when clear, move over.

On a two-lane dual road you should stay in the left-hand lane and only use the right-hand lane for overtaking or turning right. After overtaking, move back to the left-hand lane when it is safe to do so.

9) Driving in built-up areas:

Residential streets. You should drive carefully on streets where there are likely to be other road users.

Appendix D: Study Template

Part A: Opening Questions

1. What are the emerging road safety issues in Nigeria?
2. Majority of motorists engage in behaviours that could be considered very unsafe, on a daily basis. Why do you think drivers engage in these behaviours?

Part B: (Activity & Main Questions)

3. The group will be asked to prioritise different road safety measures from a list that will be given to them. They will be required to rate effectiveness and ease of implementation of the measures.

    - If there are policies/ideas that are ranked as effective and easy, why is it that they have not been done?
    - If there are policies and ideas that are ranked as effective and difficult, then what is it that makes them difficult to implement and what would need to be done to overcome that
    - If there are policies which are ranked as ineffective but which you have knowledge that would/should or could be effective then to challenge them as to why these are not seen to be likely to be effective in Nigeria

* A similar point would also apply to any policies where they say it would be effective but where you findings on road culture suggest that this would not in fact be the case without other measures. You could then engage them with a discussion on your work and see if any opinions change or there is a new sort of conversation.

4. How do you collaborate with other ministries e.g. Ministry of Transport (Transport planners, Engineers), FERMA, VIO, Police, NBS, Broader society?
5. Are your research recommendations considered in road safety planning, policy and road construction?

6. In the light of your knowledge and experience, what intervention measures do you think are the most appropriate to improve the level of road safety in the country?

*Is there any other point, recommendation or opinion you would like to share?

Appendix E: Road safety measures

	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
1	Road design: This involves designing and defining the road environment from the onset to encourage safe behaviour	**1**	**2**	**3**	**1**	**2**	**3**
	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
2	Road maintenance: These are usually carried out on existing roads	**1**	**2**	**3**	**1**	**2**	**3**
	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
3	Traffic control: These are put in place to influence or direct road users' behaviour in traffic	**1**	**2**	**3**	**1**	**2**	**3**
	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
4	Vehicle inspection: Safety measures set to make sure vehicles are roadworthy. This also includes regulation and consumer testing.	**1**	**2**	**3**	**1**	**2**	**3**
	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
5	Driver Education and Training: These are formal programmes put in place to prepare new drivers and old drivers to drive safely e.g. comprehensive driver pre-licencing training program and driver improvement program during licence renewal etc.	**1**	**2**	**3**	**1**	**2**	**3**

	Measure	Effectiveness 1 = very ineffective 2= fairly effective 3 very effective			Ease of Implementation 1 = very difficult 2= fairly easy 3 very easy		
6	Public Education and information campaigns: This involves teaching good road behaviour through awareness campaigns	**1**	**2**	**3**	**1**	**2**	**3**
	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
7	Legislation and Enforcement of traffic regulations: These are usually directed towards traffic violations and involves strict application of the laws	**1**	**2**	**3**	**1**	**2**	**3**
	Measure	**Effectiveness** 1 = very ineffective 2= fairly effective 3 very effective			**Ease of Implementation** 1 = very difficult 2= fairly easy 3 very easy		
8	Post-crash care: These aim to reduce severity of injuries sustained in crashes	**1**	**2**	**3**	**1**	**2**	**3**

Appendix F: Result from conflict studies

Conflicts		**Vehicle-vehicle**		**Vehicle-pedestrian**			**Vehicle-tricycle**			**Tricycle-tricycle**			**Tricycle-pedestrian**		
	LOC_			**LOC_**			**LOC_**			**LOC_**			**LOC_**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Total conflicts	80	201	220	22	36	13	63	156	119	5	45	17	-	7	5
Time of day															
Peak	42	110	130	17	20	6	33	87	55	3	29	11	-	4	3
Off peak	38	91	90	5	16	7	30	69	64	2	16	6	-	3	2
Serious	38	138	129	12	25	11	41	104	74	1	27	9		3	3
Peak	14	81	79	9	15	5	23	57	30	1	20	4	-	3	3
Off peak	24	57	50	3	10	6	18	47	44	-	7	5	-	0	-
Slight	42	63	81	10	11	2	22	52	45	4	18	8	-	4	2
Peak	28	29	51	8	5	1	13	30	25	2	9	7	-	1	-
Off peak	14	34	30	2	6	1	9	22	20	2	9	1	-	3	2
Rate/hr (total)															
Peak	4	10.4	12.4	1.6	1.9	.5	3.1	8.3	5.2	.3	2.8	1.0	-	.4	.3
Off peak	3.6	8.7	8.6	.5	1.5	.6	2.9	6.6	6.1	.2	1.5	.6	-	.3	.2
% Frequency															
Peak	44.2	44	63.4	17.9	8	2.9	34.7	34.8	26.9	3.2	11.6	5.4	-	1.6	1.5
Off peak	50.6	46.6	53.2	6.7	8.2	4.1	39.	35.2	37.8	2.7	8.2	3.5	-	1.5	1.2
Conflict type															
Same direction: peak	15	39	11	1	6	-	14	42	10	1	13	4		-	-
Off peak	20	78	13	1	5	-	22	49	8	2	11	1	-	-	-
Opposing direction: peak	-	10	31	-	-	-	-	13	16	-	6	1	-	-	-
Off peak	-	-	12	-	-	-	-	3	9	-	3	1	-	1	-
Crossing: peak	27	62	91	16	13	6	19	31	29	2	11	6	-	4	3
Off peak	18	12	62	4	12	7	8	16	47	-	2	4	-	2	2

Appendix G: Variables applied in the analysis of conflict data

			LOC_1		LOC_2[+]		LOC_3	
Variables	**Description**	**Definition**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Dependent variable								
Conflict severity	condition of observed conflicts	1=serious	92	54.1	297	66.7	236	63.1
		2=slight	78	45.9	148	33.3	138	36.9
Independent variables								
Road user type	different types of road users involved in conflicts	1=vehicle-vehicle	80	47.1	201	45.2	220	58.8
		2=vehicle-pedestrian	22	12.9	36	8.1	13	3.5
		3=vehicle-tricycle	63	37.1	156	35.1	119	31.8
		4=tricycle-tricycle	5	2.9	45	10.1	17	4.5
		5=tricycle-pedestrian	-	-	7	1.6	5	1.3
Direction of traffic	of road users involved in conflicts	1=same direction	76	44.7	244	54.8	48	12.8
		2=opposite	n/a	n/a	35	7.9	67	17.9
		3=crossing	94	55.3	166	37.3	256	69.3
Red light[+]/give way violation	of relevant road user	1=yes	87	51.2	224	50.3	218	58.3
		2=no	83	48.8	221	49.7	156	41.7
Yielding violations	of second road user	1=yes	88	51.8	172	38.7	161	43.0
		2=no	82	48.2	273	61.3	213	57.0
Age(rel. Road user)	age distribution of relevant road user	1=<15	0	0	0	0	0	0
		2=15-24	40	23.5	134	30.1	125	33.4
		3=25-45	72	42.4	169	38.0	139	37.2
		4=46-64	46	27.1	124	27.9	89	23.8
		5=65+	12	7.1	18	4.0	21	5.6
Gender(rel. Road user)	gender of relevant road user	1=male	124	72.9	338	76.2	295	78.9
		2=female	46	27.1	107	24.8	79	21.1
Relevant road user (rel.)	road user who took the evasive action	1=vehicle	156	91.8	357	80.2	341	91.2
		2=pedestrian	4	2.4	6	1.3	-	-
		3=tricycle	10	5.9	82	18.4	33	8.8
Age(sec. Road user)	distribution of age intervals for second road user	1=<15	3	1.8	-	-	-	-
		2=15-24	39	22.9	144	32.4	110	29.4
		3=25-45	63	37.1	160	36.0	148	39.6
		4=46-64	46	27.1	117	26.3	103	27.5
		5=65+	19	11.2	24	5.4	13	3.5
Speed	Whether the relevant road user reduced speed or not	1=yes	94	55.3	246	55.3	198	52.9
		2=no	76	44.7	199	44.7	176	47.1

Evasive action	action taken to prevent a crash	1=braking	65	38.2	155	34.8	124	33.2
		2=swerving	42	24.7	115	25.8	98	26.2
		3=others	63	37.1	175	39.3	152	40.6
Gender(sec. Road user)	gender of second road user	1=male	133	78.2	371	83.4	317	84.8
		2=female	37	21.8	74	16.6	57	15.2
Time of day	period when conflict was observed	1=peak	95	55.9	250	56.2	205	54.8
		2=off peak	75	44.1	195	43.8	169	45.2

[+] red light violation observed at LOC_2; rel.= road user who took the evasive action; sec.= the other road user

Appendix H: Inferential statistics (Chi square results)

	Conflict severity		
	(LOC_1)	**(LOC_2)$^{+}$**	**(LOC_3)**
Road user type			
X^2	6.805	3.171	3.402
p-value	0.078^{o}	0.530^{o}	0.493^{o}
Cramér's V	0.200	0.084	0.095
Direction of traffic			
X^2	2.521	38.812	15.554
p-value	0.112^{o}	0.000*	0.000*
Cramér's V	0.122	0.295	0.204
Red light^{+}/Give way violation			
X^2	1.580	2.925	2.613
p-value	0.209^{o}	0.087^{o}	0.106^{o}
Cramér's V	0.096	0.081	0.084
Yielding violation			
X^2	0.180	0.334	1.466
p-value	0.672^{o}	0.564^{o}	0.226^{o}
Cramér's V	0.033	0.027	0.063
Age(rel. road user)			
X^2	11.924	15.372	5.280
p-value	0.008*	0.002*	0.152^{o}
Cramér's V	0.265	0.186	0.119
Gender(rel. road user)			
X^2	5.705	14.934	4.248
p-value	0.017*	0.000*	0.039*
Cramér's V	0.183	0.183	0.107
Relevant road user			
X^2	0.894	2.148	0.097
p-value	0.639^{o}	0.342^{o}	0.756^{o}
Cramér's V	0.073	0.069	0.016
Age(sec. road user)			
X^2	7.429	8.449	0.975
p-value	0.115^{o}	0.038*	0.807^{o}
Cramér's V	0.209	0.138	0.051
speed			
X^2	15.875	9.442	10.290
p-value	0.000*	0.002*	0.001*
Cramér's V	0.306	0.146	0.166
Evasive action			
X^2	13.784	4.518	2.640

p-value	0.001*	0.104°	0.263°
Cramér's V	0.285	0.101	0.084
Gender(sec. road user)			
X^2	1.233	0.011	0.095
p-value	0.267°	0.916°	0.758°
Cramér's V	0.085	0.005	0.016
Time of day			
X^2	5.279	3.440	3.239
p-value	0.022*	0.064°	0.072°
Cramér's V	0.176	0.088	0.093

°not statistically significant; *significant on a 95% confidence level; + location where red light violation was observed

Appendix I: Participant information sheet

UNIVERSITY OF LEEDS DRIVING SIMULATOR

UNIVERSITY OF LEEDS

Participant Information Sheet
Please read the following information carefully before deciding to partake in this study, as it is important that you understand the purpose of this study and what the experiment will involve. Please do not hesitate to contact Chinebuli Uzondu if you have any questions or concerns.

Background: This study aims to investigate how drivers from different nations drive and to find out what influences their driving behaviour.

Why were you asked to take part? We are looking for 45 Nigerian and UK drivers to participate in the study. Data generated from all 45 participants will be further analysed. For a Nigerian to be involved in this study, he\she must have previously driven in Nigeria.

What will happen if I agree to take part? Taking part in this study will involve one visit to the University of Leeds Driving simulator Laboratory on a pre-arranged convenient date and time for your experiment. You will be asked to read and sign a consent form to show that you understand what is involved in taking part and also read the Participant Information Sheet (this one) before the experiment. Your personal information and data recording will be highly protected for your privacy.

Do I have to take part? No, taking part is entirely voluntary. If you would prefer not to take part, you do not have to give a reason. If you do take part but later change your mind you can withdraw from the study.

What will happen on the day of the experiment? On the pre-arranged date, I will meet you at the entrance of University of Leeds Driving simulator Laboratory (68 Hillary Place, Leeds, West Yorkshire LS2 3AR) and take you to the laboratory, where we will go through your consent form.

During the experiment, you will have to take part in two or three drives- the first representing a typical road in the developing countries with little or no signalisation, and the second and third representing a typical UK road environment with signalisation. The difference between the second and the third drives is that participants will be given a brief training of how to drive in the UK before they do the third drive. Only NG drivers who have never driven in the UK will take part in the third drive. There will be different scenarios in each drive.

The total duration of the experiment will be approximately 90 -120 minutes. This will allow for pre-experimental training, briefing, safety checks and the experiment itself.

In addition, you will be required to complete a questionnaire dealing with information on the background of the drivers (demographic data), the second part will involve the use of the driver behaviour questionnaire (DBQ) and the third part will be about the experiment. For your kind participation in this study you will receive £20-£25 as a token of our appreciation.

What are the Potential risks and disadvantages? We do not expect any significant risks associated with taking part in this study. A small number of participants may feel uncomfortable inside the driving simulator motion, especially while making turns. Participants will be observed from the control room when they are in the task session and if it is observed that they feel uncomfortable in the study, the experiment will be stopped immediately.

What if I have any Concerns? If you have a concern about any aspect of this study you should contact Chinebuli Uzondu, Professor Samantha Jamson and Dr Daryl Hibberd (contact details are provided below), who will do their best to answer your questions.

Who is organising the study? Chinebuli Uzondu is a third year PhD student from the Institute for Transport Studies. Professor Samantha Jamson is a Principal Research Fellow at the Institute for Transport Studies and is the main Supervisor while Dr. Daryl Hibberd who is the co-supervisor is a Research Fellow at the Institute for Transport Studies.

Can you assure me of secure storage and disposal of Study Data? Yes, the University of Leeds adheres to the Data Protection Act 1988. Any information that you give us and any data that we collect from you after your consent will remain anonymous. We will store your paper-based consent forms in locked filing cabinets under the charge of University of Leeds and your electronic responses will be stored on the computer provided by University of Leeds and in the specific data storage drive i.e. N:\drive, which is password protected. All the data files will be encrypted and will not be accessible to anyone other than the lead researcher (i.e. me). The identity of each participant will be coded with numbers and original names will not be mentioned anywhere. Only lead researcher (i.e. me) will have access to the data collected by you.

We will not collect your personal information such as name, date of birth or job title etc. The results of the study will be published in a scientific article but individual's data will not be identifiable. At the end of the research, the merged data will be stored at the University of Leeds data storage. Other researchers may use the data for further analysis in research and teaching, but after going through formal procedures of research ethics under the supervision of Research Ethics & Governance Committee of the University of Leeds, which if satisfied then may allow access to the data.

Who has reviewed this study? This study was approved by the Research Ethics and Governance Committee of the University of Leeds.

Will my identity be disclosed? All information disclosed within the experiment will be kept confidential, except where legal obligations would necessitate disclosure by the researchers to appropriate personnel.

What will happen to the information? All information collected from you during this research will be kept secure and any identifying material, such as names, will be removed in order to ensure anonymity. It is anticipated that the research may, at some point, be published in a journal or report. However, should this happen, your anonymity will be ensured, although it may be necessary to use your words in the presentation of the findings and your permission for this is included in the consent form. You can withdraw your data at any time up till the point of analysis and, if you wish to do so, you will need to provide the number that identifies you, as written on your consent form. However, it must be noted that you can withdraw your data only up to the point of analysis.
Thank you for taking the time to read this information sheet.

If you would like more information or have any questions or concerns about the study please contact:

Chinebuli Uzondu	tsccu@leeds.ac.uk
Professor Samantha Jamson	S.L.Jamson@its.leeds.ac.uk
Dr. Daryl Hibberd	D.L.Hibberd@leeds.ac.uk

Appendix J: Participant consent form

UNIVERSITY OF LEEDS DRIVING SIMULATOR

UNIVERSITY OF LEEDS

Participant Consent Form

Thank you very much for agreeing to take part in this research. The purpose of this form is to make sure that you are happy to take part and that you know what is involved. Signing this form does not commit you to anything you do not wish to do.

If you suffer from any of the following medical conditions, unfortunately we will not be able to use you as a participant. Therefore, please let the experimenter know now if you suffer from:

- Fear of heights
- Epilepsy
- Serious mobility problems affecting the back, knees or hips
- Claustrophobia
- Feelings of disorientation
- Severe motion sickness

Please sign here if you suffer from none of the above ________________________

Have you read and understood the participant information sheet? YES NO

Have you had the opportunity to ask questions and discuss the study? YES NO

Do you agree to have your experiment video recorded? YES NO

If you have asked questions, have you had satisfactory answers? YES NO N/A

I hereby grant permission to use the information I provide as data in the PhD research study on *Cultural differences and effect of roadway environment on drivers' performance.* I allow publishing or presenting of the information provided in any public form. I understand that I have the right to refuse to answer any question or stop participating at any time without any reason. I am aware that the information provided will be kept confidential, and no one else except researcher and her supervisors will have access to the information documented during the experiment. I have also been informed that my identity will be kept anonymous.

I agree to take part in the above research project and will inform the lead researcher should my contact details change.

Name of Participant (please print)	Name of lead researcher (please print)
…………………………………………………………………………	…………………………………………………………………………
Signature…………………………………………………	Signature…………………………………………………
Date (dd/mm/yy)……………………………………	Date (dd/mm/yy)……………………………………

*To be signed and dated in the presence of the participant.

Appendix K: DBQ subscales for NG, NG/UK and UK drivers

Appendix K (i) Three-factor solution of the DBQ items, Cronbach's alpha coefficients and variance of the DBQ subscales for NG.

Variables	**Slips/lapses**	**Violations**	**Errors**
S14 Queuing, nearly hit car in front DBQ25	.847		
S10 On usual route by mistakeDBQ17	.825		
S9 Forget which gear DBQ15	.814		
E2 Turn right into vehicle's path DBQ11	.803		
S12 Forget light on main beam DBQ23	.801		
S4 Forget where car is DBQ8	.742		
S15 Misjudge speed of oncoming vehicle DBQ30	.723		
S7 No recollection of recent road DBQ13	.723		
S13 Turning right, nearly hit cyclist DBQ24	.705		
S2 Locked out of car DBQ3	.665		
S21 Fail to see pedestrians crossing DBQ46		.911	
S18 Manoeuvre without checking mirror DBQ41		.888	
V9 Drink and drive DBQ26		.826	
S19 Try to pass vehicle turning left DBQ42		.779	
V14 Cut corner turning left DBQ36		.722	
V15 Fail to give way to bus DBQ39		.713	
V3 Close follow DBQ7		.679	
S20 Only half-an-eye on the road DBQ45		.670	
V13 Overtake on right on motorway DBQ35		.663	
E7 Get into wrong lane at roundabout DBQ37			.860
E8 Brake to quickly DBQ49			.807
V16 Ignore give-way signs DBQ40			.775
E4 Hit something when reversing DBQ31			.761
E5 Plan route badly DBQ33			.610
Eigenvalues	**9.26**	**5.13**	**3.91**

% variance	31.93	17.68	13.48
Cronbach's alpha (α)	**.92**	**.91**	**.87**

Principal component analysis; Varimax rotation with Kaiser Normalization. Factors extracted based on Eigen value>1. (Factor loadings below. 60 were omitted). V = violations, e=error, L=lapse

Appendix K (ii) Three-factor solution of the DBQ items, Cronbach's alpha coefficients and variance of the DBQ subscales for NG/UK.

Variables	**Violations**	**Slips/lapses**	**Errors**
V6 Angry, give chase DBQ19	.911		
S13 Turning right, nearly hit cyclist DBQ24	.910		
S19 Try to pass vehicle turning left DBQ42	.897		
V5 run the red light DBQ18	.895		
V15 Fail to give way to bus DBQ39	.893		
UV8 Drive without papers DBQ22	.812		
V4 Risky overtaking DBQ16	.806		
S12 Forget light on full beam DBQ23	.800		
V7 disregard speed limits at any time DBQ21	.772		
S15 Misjudge speed of an oncoming vehicle DBQ30	.747		
S20 Only half-an-eye on the road DBQ45	.746		
V10 Have an aversion DBQ27	.715		
V13 Overtake on the inside lane or hard shoulder DBQ35	.699		
S18 Manoeuvre without checking mirror DBQ41		.849	
S6 Intend to switch on wipers, but switch on the lights DBQ10		.829	
S9 Forget which gear DBQ15		.813	
V14 Cut corner turning left DBQ36		.791	
UV11 fail to notice someone waiting at a zebra crossing DBQ20		.727	
S5 Distracted, have to brake hard DBQ9		.704	
S3 Attempt to drive off without switching on the ignition DBQ6		.687	
S7 no clear recollection of the road being travelled on DBQ13			.845
E2 Turn right into vehicle's path DBQ11			.839
E1 Drive as fast on low beam as on high beam DBQ5			.821

E5 Plan route badly DBQ33			.630
V20 Race for a gap DBQ48			.617
Eigenvalues	**12.97**	**3.59**	**3.38**
% variance	**48.02**	**13.28**	**12.51**
Cronbach's alpha (α)	**.97**	**.90**	**.82**

Principal component analysis; Varimax rotation with Kaiser Normalization. Factors extracted based on Eigen value>1. (Factor loadings below. 60 were omitted). V = violations, e=error, L=lapse

Appendix K (iii) Three-factor solution of the DBQ items, Cronbach's alpha coefficients and variance of the DBQ subscales for UK.

Variables	**Violations**	**Errors**	**Slips/lapses**
V16 Ignore give way' signs DBQ40	.832		
V19 unofficial races with other drivers DBQ47	.832		
V6 Angry, give chase DBQ19	.832		
V5 run red light DBQ18	.749		
E6 Overtake queue DBQ34	.747		
V12 Illegal parking DBQ29	.734		
V9 Drink and drive DBQ26	.616		
E5 Plan route badly DBQ33		.776	
S6 Intend to switch on wipers, but switch on lights DBQ10		.775	
E8 Brake too hard or quickly DBQ49		.772	
E9 Misjudge crossing interval when turning right/left DBQ50		.729	
S8 Miss exit on a motorway/highway DBQ14		.633	
V17 Drive wrong way down one-way street DBQ43			.900
V3 Close follow DBQ7			.856
S14 Queuing, nearly hit car in front DBQ25			.790
S3 Try driving off without switching on DBQ6			.764
S20 only half-an-eye on the road DBQ45			.745
S13 turning left/right nearly hit a cyclist/tricycle DBQ24			.724
UV8 Drive without papers DBQ22			.710
S16 Fail to see pedestrian stepping out DBQ32			.677
Eigenvalues	**8.27**	**6.96**	**6.49**
% variance	**16.53**	**13.92**	**12.97**
Cronbach's alpha (α)	**.80**	**.69**	**.90**

Principal component analysis; Varimax rotation with Kaiser Normalization. Factors extracted based on Eigen value>1. (Factor loadings below. 60 were omitted). V = violations, e=error, L=lapse

Appendix L: Table of Means

Mean (SD) of all variables measured in each scenario showing significant differences between cultures, road environment and different intervention conditions.

Scenario	Variable	Culture	Infrastructure		Intervention (NG drivers only)
			Low Infrastructure	High Infrastructure	Training#
Lane changing	Mean speed (mph)	NG	37.76 (6.98)	35.84 (10.72)	32.96 (5.24)
		NG/UK[a]	31.52 (4.28)	31.05(5.67)	NA
		UK	37.07 95.70)	35.57 (3.45)	NA
	SD. speed (m/s)	NG	13.83 (3.57)	13.38 (4.36)	11.25 (3.21)
		NG/UK[b]	9.92 (1.75)	10.50 (1.9)	NA
		UK	12.42 (4.05)	10.62 (2.20)	NA
	Mean acceleration (m/s^2)	NG	.36 (.16)	.36(.19)	.29(.12)
		NG/UK[b]	.25 (.09)	.25(.10)	NA
		UK	.34 (.13)	.28(.06)	NA
	SD acceleration (m/s^2)	NG	.69 (.27)	.73 (.22)	.64 (.30)
		NG/UK	.61 (.21)	.67(.21)	NA
		UK	.60(.14)	.61(.23)	NA
	Time headway (secs)	NG	2.13 (.99	1.81 (1.04)	2.56 (1.43)
		NG/UK	2.7(1.76)	2.46 (1.51)	NA
		UK	3.19(1.51)	3.28(.89)	NA
	TTC (secs)	NG	3.73 (1.44)	3.68 (.866)	4.01 (1.67)
		NG/UK	4.27 (1.36)	4.61 (2.36)	NA
		UK	4.37(1.14)	4.80(.59)	NA
	Distance tailway (m)	NG	22.20 (13.74)	31.08 (24.75)	35.30 (25.54)
		NG/UK	25.89 (16.63)	31.19 (24.58)	NA
		UK	39.08 (6.80)	35.05(5.66)	NA
	Indicator use (% count)	NG	81%	79.5	88
		NG/UK	87	82.0	NA
		UK	93	90	NA
Amber dilemma	Crossed at amber (count)	NG	NA	9	8
		NG/UK	NA	10	NA
		UK	NA	7	NA
	Red light violation (count)	NG	NA	1	1
		NG/UK	NA	1	NA
		UK	NA	0	NA
	Spot speed at TTC = 2.5 (mph)	NG	NA	29.65 (16.45)	**22.08(11.91)[3]**
		NG/UK	NA	24.75(10.32)	NA
		UK	NA	26.34(15.14)	NA
Acceleration (deceleration to red light)	Mean deceleration (m/s^2)	NG	NA	-.10 (.06)	.09(.05)
		NG/UK	NA	.01(.35)	NA
		UK	NA	-.09(.04)	NA
	SD. deceleration (m/s^2)	NG	NA	.96(.26)	**.80(.24)[3]**
		NG/UK	NA	.75(.27)	NA
		UK[b]	NA	.63(.22)	NA
	Max. brake pressure (N)	NG	NA	120.66(46.19)	117.6(73.84)
		NG/UK	NA	107.29(89.21)	NA
		UK	NA	104.62(63.79)	NA
		NG[a]	NA	14.11 (19.85)	**3.65(10.06)[3]**

Acceleration (anticipatory behaviour)	Distance covered in 45secs (m)	NG/UK	NA	6.67 (14.72)	NA
		UK	NA	4.17 (14.98)	NA
Acceleration (away from red light)	Mean acceleration (m/s²)	**NG[a]**	NA	.35 (.19)	**.19(.20)[3]**
		NG/UK	NA	.16(.15)	NA
		UK	NA	.18(.06)	NA
	SD. acceleration (m/s²)	NG	NA	.43 (.21)	.35(.12)
		NG/UK	NA	.37(.10)	NA
		UK	NA	.30(.10)	NA
	Time to accelerate to speed limit (secs)	**NG[a]**	NA	12.41(10.65)	16.37(9.8)
		NG/UK	NA	22.97 (8.55)	NA
		UK	NA	26.13 (3.79)	NA
	Max. accelerator pedal angle (⁰)	NG	NA	22.13(6.80)	**18.40(6.05)[3]**
		NG/UK	NA	18.59(4.77)	NA
		UK	NA	17.32(8.86)	NA
Speed choice	Mean speed (mph)	**NG[a]30**	44.51(8.84)	43.62(10.9)	**35.40(5.96)[2]**
		60	55.19(11.37)	52.47(11.13)	52.89(8.44)
		NG/UK 30	34.65(4.76)	32.51(5.51)	NA
		60	48.62(9.11)	50.42(8.32)	NA
		UK 30	35.50(6.17)	32.78(3.68)	NA
		60	53.80(9.94)	56.58(4.11)	NA
	SD. Speed (m/s)	NG 30	8.90(3.72)	4.19(1.43)	4.06(1.43)
		60	6.69(6.42)	7.41(2.82)	9.58(6.60)
		NG/UK 30	7.15(2.88)	3.18(1.52)	NA
		60	4.57(2.07)	7.95(2.83)	NA
		UK 30	6.02(3.86)	2.49(.86)	NA
		60	4.96(2.76)	8.13(1.79)	NA
	Speed limit exceedance (% of time)	NG 30	91.40(9.47)	88.56(28.31)	74.21(28.65)
		60	37.80(36.73)	26.46(38.05)	29.15(30.91)
		NG/UK[b]30	79.64(16.63)	60.45(29.90)	NA
		60	16.72(28.22)	25.67(32.89)	NA
		UK 30	84.35(16.65)	75.92(20.90)	NA
		60	35.58(37.11)	35.68(32.40)	NA
	Spot speed (mph)	NG 30	40.77(10.51)	43.38(10.65)	35.28(6.08)
		60	56.09(10.71)	53.81(10.30)	57.97(13.98)
		NG/UK[b] 30	28.86(9.91)	31.96(5.64)	NA
		60	49.16(9.57)	53.16(9.04)	NA
		UK 30	32.98(7.91)	32.13(3.82)	NA
		60	54.85(10.45)	58.50(5.45)	NA
Green lights	Mean speed (mph)	**NG[a]**	NA	39.88(10.12)	**33.09(4.30)[3]**
		NG/UK	NA	31.58(3.48)	NA
		UK	NA	33.34(5.41)	NA
	Mean deceleration (m/s²)	NG	NA	-.01(.20)	.01(.08)
		NG/UK	NA	.05(.07)	NA
		UK[b]	NA	.04(.04)	NA
	SD. deceleration (m/s²)	NG	NA	.50(.35)	.35(.16)
		NG/UK	NA	.31(.10)	NA
		UK	NA	.28(.11)	NA
	Max deceleration (m/s²)	NG	NA	.98(.48)	.75(.36)
		NG/UK	NA	.81(.39)	NA
		UK	NA	.72(.38)	NA
		NG	NA	33.45(10.50)	27.57(5.04)

	Minimum speed (mph)	NG/UK	NA	27.34(4.18)	NA
		UK	NA	29.34(5.52)	NA
Car cutting 1	Mean speed (mph)	NG	29.97(18.00)	24.16(18.77)	17.22 (10.56)
		NG/UK	24.71(11.13)	20.07(11.28)	NA
		UK	26.16(14.24)	22.90(12.72)	NA
	SD. speed (m/s)	NG	2.29(1.76)	2.60(1.69)	3.55(1.29)
		NG/UK	2.05(1.30)	2.83(1.46)	NA
		UK	2.50(1.88)	3.23(1.99)	NA
	Mean deceleration (m/s^2)	NG	.15(.44)	.16(.34)	.34(.20)
		NG/UK	.26(.21)	.20(.28)	NA
		UK	.29(.21)	.34(.22)	NA
	SD. deceleration (m/s^2)	NG	.81(.78)	1.18(.71)	1.27(.53)
		NG/UK	.68(.57)	1.14 (.85)	NA
		UK	.72(.51)	.82(.46)	NA
	Max. brake pressure (N)	NG	64.10(86.87)	68.12(53.05)	76.66(54.27)
		NG/UK	31.61(45.66)	67.28(61.20)	NA
		UK	41.67(58.26)	39.02(40.20)	NA
Crossing car	Spot speed at TTj = 3secs (mph)	**NG**[a]	52.00(7.37)	47.25(11.27)	NA
		NG/UK	37.42(8.92)	41.44(5.38)	NA
		UK	40.16(11.79)	37.71(4.21)	NA
	TTC (secs)	NG	1.41 (1.17)	1.38(1.08)	**2.33(.84)**[1]
		NG/UK[b]	2.23(1.70)	2.10(2.04)	NA
		UK	1.56(.708)	1.72(.43)	NA
	BRT (secs)	**NG**[a]	3.01(.78)	2.93(.28)	NA
		NG/UK	2.56(.22)	2.62(.32)	NA
		UK	2.53(.37)	2.58(.31)	NA
Car cutting 2	Mean speed (mph)	NG	35.19(11.10)	35.67(11.00)	33.48(9.18)
		NG/UK	32.09(10.10)	30.59(6.58)	NA
		UK	33.59(8.82)	35.44(9.24)	NA
	SD. speed (m/s)	NG	1.73(1.36)	1.43(.70)	1.48(.96)
		NG/UK	1.57(.78)	1.53(.74)	NA
		UK	1.42(.79)	1.27(.69)	NA
	Mean deceleration (m/s^2)	NG	.48(.43)	.55(.35)	.38(.42)
		NG/UK	.46(.47)	.33(.41)	NA
		UK	.07(.40)	.29(.35)	NA
	SD. deceleration (m/s^2)	NG	.71(.57)	.50(.39)	.67(.66)
		NG/UK	.67(.66)	.74(.54)	NA
		UK	.98(.78)	.70(.62)	NA
	Max. brake pressure (N)	NG	21.88(38.55	16.09(28.09)	33.38(49.65)
		NG/UK	21.53(41.41)	24.80(36.03)	NA
		UK	45.42(53.35)	23.52(37.85)	NA
Overtaking	Attempts (count) [Easy]	NG	NA	NA	NA
		NG/UK	NA	NA	NA
		UK	NA	NA	NA
	[Difficult]	NG	16	19	15
		NG/UK	12	11	NA
		UK	14	14	NA
	Successful overtaking (%) [Easy]	NG	87.5	93.75	93.75
		NG/UK	93.75	100	NA
		UK	87.5	100	NA
	[Difficult]	NG	93.75	87.5	93.75
		NG/UK	62.5	68.75	NA
		UK[b]	81.25	87.5	NA

	TH with slow leader (secs) [Easy]	NG	.68(.41	.65(.52)	1.07(1.17
		NG/UK	.56(.19	.64(.33)	NA
		UK	.82(.45	.71(.28)	NA
	[Difficult]	NG	.47(0.31)	.39(.36)	**.66(.24)**[3]
		NG/UK	.51(.21)	.69(.38)	NA
		UK	.71(.23)	.76(.24)	NA
	overtaking duration (secs) [Easy]	NG	4.84(1.85	5.25(1.25)	5.82(1.1)
		NG/UK	6.28(1.65	6.38(1.33)	NA
		UK	6.08(1.42	5.99(1.59)	NA
	[Difficult]	NG	3.61(1.14	4.70(1.61)	4.40(.75)
		NG/UK	4.42(2.13	4.40(1.30)	NA
		UK	4.92(1.07	4.88(1.06)	NA
	Max speed (mph) [Easy]	NG	48.95(6.49	49.03(7.18)	51.63(2.41)
		NG/UK	49.38 (7.10)	51.98(4.29)	NA
		UK[b]	53.61(4.96	54.09(5.34)	NA
	[Difficult]	NG	47.94(5.92	49.13(5.20)	51.21(7.50)
		NG/UK	52.14(6.86	49.94(6.31)	NA
		UK[b]	52.58(5.14	56.40(4.60)	NA
	TH with oncoming vehicle (secs) [Easy]	NG	NA	NA	NA
		NG/UK	NA	NA	NA
		UK	NA	NA	NA
	[Difficult]	NG	11.25(3.5)	8.68(2.91)	**8.00(2.22)**[2]
		NG/UK	11.59(3.1)	8.89(3.81)	NA
		UK	8.37(3.61	7.10(2.65)	NA
	Distance tailway (m) [Easy]	NG	20.52 (13.02)	21.45 (11.92)	23.62(12.11)
		NG/UK	25.04 (10.87)	30.42 (8.47)	NA
		UK[b]	35.10 (12.49)	32.36 (10.81)	NA
	[Difficult]	NG	15.13 (9.94)	13.94 (9.81)	17.81 (7.15)
		NG/UK	20.14(6.20)	17.83 (7.365)	NA
		UK[b]	27.44 (10.62)	23.53 (7.04)	NA
	Indicator use (counts) [Easy]	NG	75	81.3	90.5
		NG/UK	93.5	100	
		UK	81.3	97.5	
	[Difficult]	NG	68.8	81.3	86.5
		NG/UK	68.8	87.5	
		UK	75.0	87.5	
Compliance with road marking	Road marking violation (count)	**NG**[a]	8	11	5
		NG/UK	4	5	NA
		UK	1	1	NA
	Mean speed (mph)	NG	51.65(10.43)	49.98(8.99)	50.03(9.03)
		NG/UK	47.52(8.35)	48.00(5.21)	NA
		UK	45.76(6.66)	47.46(4.05)	NA
	SD. speed (m/s)	NG	6.55(4.48)	7.42(4.55)	6.61(4.55)
		NG/UK	5.26(3.04)	5.98(2.52)	NA
		UK[b]	3.66(1.41)	4.58(1.56)	NA
	Mean acceleration (m/s^2)	NG	.03(.09)	.02(.06)	.02(.05)
		NG/UK	.02(.11)	-.001(.03)	NA
		UK	-.01(.02)	-.02(.01)	NA
	SD acceleration (m/s^2)	NG	.47(.23)	.61(.38)	.52(.33)
		NG/UK	.42(.26)	.47(.26)	NA
		UK	.26(.13)	.29(.15)	NA

All the numbers are presented as Mean (SD); **(In bold)** significantly different at 0.05%.

[a]significantly different from other two cultures; [b]significantly different from NG; [C]significantly different from NG/UK; [d]significantly different from UK.

[#] Training (NG drivers only): [1]significantly different from other two conditions; [2]significantly different from low infrastructure; [3]significantly different from high infrastructure; [4]significantly different from training.

Appendix M: Invitation Letter

Institute for Transport Studies

36-40 University Road
University of Leeds
Leeds LS2 9JT

T +44 (0) 113 343 6606
F +44 (0) 113 343 5334
E S.L.Jamson@its.leeds.ac.uk
W www.its.leeds.ac.uk

UNIVERSITY OF LEEDS

Corps Marshal
Federal Road Safety Corps,
3 Maputo Street,
Wuse, Zone 3, Abuja
Federal Capital Territory,
Nigeria
August 30, 2018

Dear Dr Oyeyemi,

Re: Request for a Meeting with the Federal Road Safety Corps

We have followed the activities of the Federal Road Safety Corps **(**FRSC) and seen your dedication in providing a safe motoring environment in Nigeria. After discussion with some of your officials at the 97th annual general meeting of the Transportation Research Board (TRB) in Washington DC last January, we were even more convinced that your input will be needed in our ongoing research. Therefore, we would greatly appreciate an opportunity to visit you and invite you (with 6-8 other officials) to participate in an interview-based research study. A brief description of our ongoing research and an outline of the proposed interview study is provided below.

Completed Research
For the last three years, we have been conducting research on road safety in Nigeria at the Institute for Transport Studies (ITS), University of Leeds. The Institute is UK's largest single academic group providing transport courses and training and a leading international centre for transport research. Our research uses a problem-oriented approach with the intention to recommend research-based solutions to road safety problems in Nigeria while considering cultural and environmental factors that provoke different driving styles and behaviours. To achieve these objectives, we have adopted different quantitative approaches including on-road observations in Nigeria, questionnaires and a driving simulator experiment using Nigerian participants. In the initial exploratory stage, we carried out an on-road observation of road users' behaviour using the Traffic Conflict Technique (TCT) in the eastern part of Nigeria (Imo state). This study has now been concluded, and the results presented at four international conferences and accepted for publication in two leading peer-reviewed transportation journals - Safety Science and the Journal of Traffic and Transportation Research.

Based on the results of that study, we designed and carried out a driving simulator experiment comparing the driving style and behaviour of Nigerians to that of other drivers under different conditions and scenarios. Participants also completed different questionnaires so that their self-reported behaviour could be compared to their actual behaviour in the driving simulator.
Furthermore, we carried out an additional experiment with only the Nigerian group whereby we evaluated the effect of some simple safety training on their driving behaviour. The data have now been analysed and we are in the process of writing some further journal publications.

Our research represents an innovative approach to defining the key safety-critical behaviours which are prevalent in Nigeria as well as starting to understand how features of the road environment and/or training could be used to improve the road safety record in Nigeria. We wish now to move onto the next stage of our research, in order to ensure that any recommendations we make are well-grounded and policy-relevant.

The next stage

We have decided to approach the FRSC as the lead safety agency in Nigeria, with a vision to provide efficient and reliable transportation, thereby creating a safe motoring environment in Nigeria. We would like to present the results of our 3-year study to the agency and obtain your expert feedback on some policy recommendations. Your experience as a lead safety agency in Nigeria can offer insight to some of the questions raised during the studies and the problems associated with the traffic and transport system as well as the current driving practices in Nigeria that mediate risky situations.

Your participation and involvement in this study is very important in ensuring that the road safety profile of Nigeria is better understood and presented properly.

Your involvement

At the beginning of the meeting, those present would need to complete a consent form to indicate their consent to participate in the study and allow us to record and transcribe their responses. The meeting will take 60-90mins and would follow a semi-structured format of open-ended questions. We intend to visit any day between November 19 – 30, 2018 and would hope to interview 6-8 participants.

The interview template is prepared within the framework of road traffic behaviour and includes questions regarding the road safety issues in Nigeria, influential factors contributing to crash causation, best solutions or tools to raise the safety profile and driver education, training and tests. During the interview, we will take some notes and will also record it on audiotape for transcription and coding at a later date. The study outcome will form a part of a PhD thesis and will be published in academic journals. Your participation is completely voluntary, but should you feel concerned you have the right to stop participating at any time. Any parts of the interviews that you want removed will be deleted.

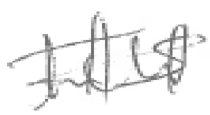
It is hoped that you will agree and enjoy taking part in the study. Should you have any questions or concerns about the study or procedure, please feel free to contact us.

Thank you for your assistance and we look forward to hearing from and meeting you.

Yours sincerely,

Prof. Samantha Jamson
Supervisor/Deputy Director

Chinebuli Uzondu
Postgraduate Researcher



Appendix N: Consent form

Institute for Transport Studies
6-40 University Road
University of Leeds
Leeds LS2 9JT

T +44 (0) 7459539262
E tsccu@leeds.ac.uk
W www.its.leeds.ac.uk

UNIVERSITY OF LEEDS

Consent to take part in a meeting on "Road safety and driver behaviour in Nigeria".	Add your initials next to the statement if you agree
I confirm that I have read and understand the information sheet dated November 1, 2018 explaining the above research project and I have had the opportunity to ask questions about the project.	
I understand that my participation is voluntary and that I am free to withdraw at any time before or during the workshop without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. Lead Researcher: Chinebuli Uzondu Phone Number:+447459539262	
I give permission for members of the research team to have access to my anonymised responses of both written and recorded form. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.	
I agree that responses be audio recorded for transcription and coding at a later date and for the data collected from me to be stored and made available for further research conducted under the auspices of an institutional ethics committee. Data will be archived at the University of Leeds research data repository.	
I understand that my words may be used anonymously in publications, reports, web pages, and other research outputs.	
I agree not to disclose the identity of other participants in this workshop.	
I understand that data collected during the study may be looked at by auditors from the University of Leeds.	

I agree to take part in the above research project and will inform the lead researcher should my contact details change during the project and, if necessary, afterwards.	

Name of participant	
Participant's signature	
Date	
Name of lead researcher or person taking consent	Chinebuli Uzondu
Signature	
Date*	21 November 2018.

*To be signed and dated in the presence of the participant.

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/ pre-written script/ information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.