ASSESSMENT OF VISUAL FUNCTION AMONGST MOTOR VEHICLE DRIVERS IN MASERU, LESOTHO

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DECLARATION

I, Mrs Zubeta Moledi, declare that:

The research reported in this thesis, except where otherwise indicated, and is my original work.

This dissertation has not been submitted for any degree or examination at any other university.

This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Signed____________________ Date____________

DEDICATION

The dissertation is dedicated to my Lord and Saviour, Jesus Christ, for all the strength when I felt like giving up. Indeed, I can do all things through Christ who gives me strength.

My family:
My husband (Mr Thuso Moledi) and my children (Tumelo, Mokhethoa and Hlalefo Moledi). Thank you for your constant support and motivation throughout this journey. *Ke ya leboha Bataung ba batle*.

Victims of road traffic accidents in Lesotho: many families have lost lives and children are left with no parents due to road accidents. I pray to God that through the impact of this study, we will combat this tragedy.

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LIST OF ACRONYMS

AMD	AGE-RELATED MACULAR DEGENERATION
AU	AFRICAN UNION
BREC	BIOMEDICAL RESEARCH ETHICS COMMITTEE
BVF	BINOCULAR VISUAL FIELD
CS	CONTRAST SENSITIVITY
CV	COLOUR VISION
CVD	COLOUR VISION DEFECTS
DR	DIABETIC RETINOPATHY
EU	EUROPEAN UNION
FRSC	NIGERIAN FEDERAL ROAD SAFETY COMMISSION
GNP	GROSS NATIONAL PRODUCT
HDI	HUMAN DEVELOPMENT INDEX
HFD	HOMONYMOUS FIELD DEFECTS
IQR	INTER-QUARTILE RANGE
MVC	MOTOR VEHICLE COLLISION
NPDR	NON-PROLIFERATIVE DIABETIC RETINOPATHY
PDR	PROLIFERATIVE DIABETIC RETINOPATHY
RESC	REFRACTIVE ERROR STUDY IN CHILDREN
RGNS	ROUTE GUIDANCE AND NAVIGATION SYSTEM
SADC	SOUTHERN AFRICAN DEVELOPMENT COMMUNITY
RTA	ROAD TRAFFIC ACCIDENTS
UK	UNITED KINGDOM
UKZN	UNIVERSITY OF KWAZULU-NATAL

UN	UNITED NATIONS
USA	UNITED STATES OF AMERICA
VA	VISUAL ACUITY
VF	VISUAL FIELD
VFD	VISUAL FIELD DEFECTS
WHO	WORLD HEALTH ORGANIZATION

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ABSTRACT

Background: Driving is a primary mode of travel in many countries. It relies primarily on the function of vision to navigate roads and traffic safely. Ensuring good vision for motor vehicle drivers is therefore important to promote safety for all road users. Lesotho is a developing country, with road transportation central to the movement of people and goods within, and across the borders of the country. The absence of clear minimal requirements for visual function among holders of motor vehicle licences in Lesotho motivated this study.

Aim: To assess the visual function of motor vehicle drivers in Maseru, Lesotho.

Methods: A descriptive, mixed methods cross-sectional study employing systematic random sampling was conducted at the Traffic Department in Maseru, Lesotho. Active licensed drivers, both males and females, from 22–76 years of age participated in the study. Data was collected by means of key informant interviews, structured questionnaires and a comprehensive vision examination of all participants. Quantitative data was analysed using Strata version 14 software, while qualitative data was analysed descriptively.

Results: The study included 460 licensed drivers with an overall mean age of 42.9 years, of which 64% (n=294) were men. One in five participants had not had an eye examination before obtaining their driving licence. Most participants (70.87%) had normal vision (6/9 or better) in the better-seeing eye, while 29.13% had visual acuity worse than 6/9 in the better-seeing eye. Among those with sub-normal vision, 29% had visual acuity ranging between 6/18 and 6/48 in the better-seeing eye. More than one third (39%) of participants had some form of refractive error, with myopia showing the highest distribution (46.46%), followed by astigmatism (32.96%) and hyperopia (24.59%). Of those with hyperopia, the majority (98%) were classified as having mild hyperopia (+0.50DS up to +2.00DS). Although myopia had the highest distribution, most cases were mild to moderate myopia (-0.50DS up to -5.75DS). The majority of participants (97.61%) passed the colour vision test, 53.70% achieved contrast sensitivity of up to 6/12 in the better eye and 99.6% achieved a measurement of 100 degrees for visual field test screening.

Most participants did not wear spectacles when driving, with 37% of these having previously been advised to wear them based on identified need. Almost half (44%) of the participants reported to have been involved in road traffic accidents.

Discussion: While most participants in this study presented with good vision for driving, it is concerning, that almost one in three (29%) had mild to moderate visual impairment and 39% had refractive error, yet they continued to drive without any form of refractive correction. Also, almost half of the participants (44%) had been involved in road traffic accidents, with almost one in five (19%) who had refractive error. It is possible that refractive error and visual impairment could have contributed to their involvement in road traffic accidents. The visual function findings in this study suggest that the Traffic Department in Lesotho should have guidelines on the minimum visual requirements for driving, as well as routine screening procedures.

Conclusion: A significant proportion of the motor vehicle drivers in Lesotho have some form of compromised visual function, with many not undergoing an eye examination before obtaining a driver's licence. If drivers are advised to have their eyes examined regularly, many visual function anomalies could be detected early and their vision corrected accordingly. The absence of effective screening methods for drivers in Lesotho could possibly be a contributor to the incidence of road traffic accidents in the country with the resultant negative socio-economic impacts.

Keywords: Driving licence, visual function, driving regulations, road traffic accidents, vision standards.

Operational Terms:

- **Driver:** Lesotho citizen or permanent resident who drives (operates) a motor vehicle on Lesotho's roads.
- **Motor vehicle:** Any motorised vehicle, such as a motorcycle, car, truck, or bus used on a public road in Lesotho.
- **Visual assessment:** Evaluating the basic visual function of drivers in Lesotho, using LogMar VA chart for visual acuity, Ishihara 24 plate test for colour vision, LEA Low Contrast chart for contrast sensitivity, Vision Disk for visual field, PlenOptika hand-held auto refractor for refractive error and Keeler ophthalmoscope for pathology screening.
- **Driver's licence:** An official document permitting a specific individual to operate a motorised vehicle, such as a motorcycle, car, truck, or bus on public roads in Lesotho.

CHAPTER 1: INTRODUCTION

1.1 CHAPTER OUTLINE

The aim of this chapter is to orientate the reader to this study, with emphasis on the visual function of motor vehicle drivers. The chapter addresses the following key aspects: definition of key terms, importance of vision in driving, regulations of visual requirements for driving and the history of vision and driving in Lesotho.

1.2 BACKGROUND

Most people in the world, in both developed and developing countries, rely mostly on driving to move from one place to another, for various private or commercial reasons. Operating a vehicle relies mostly on the function of vision to navigate the roads and traffic safely. Among the human factors that contribute to safe driving, visual skills of a driver are considered important (Burg, 1971; Austroads, 2017). It is estimated that about 95% of sensory information needed for driving is visual (Taylor, 1987; Bener, *et al.*, 2004). Research has shown that drivers with good vision have an advantage compared to those with poor vision and may have less chance of being involved in a road traffic accident (RTA) (Boadi-Kusi, *et al.*, 2016; Owsley & McGwin, 1999). Drivers with poor vision may not be able to identify other vehicles or potentially dangerous situations on the road. It is therefore important to ensure that all drivers should possess good vision for driving.

In developing countries, commercial vehicles are a major source of transport (Bener *et al.*, 2004). Many people rely on public transport such as buses and taxis to commute between various destinations for work-related purposes or for leisure. Other commercial drivers, such as truck drivers, transport goods across and outside the country. These commercial drivers form an important part of the transport industry as commercial driving contributes to the country's economic development (Ovenseri-Ogomo & Adofo 2011). It is therefore important that all drivers have good vision, especially in the case of long-distance public transport and heavy-duty truck drivers who drive for long stretches of time and are responsible for the safety of others, such as passengers and fellow road users.

Drivers with ocular diseases may also drive less competently than those without ocular diseases (Owsley, *et al.*, 2001; Wood, *et al.*, 2016), since ocular diseases such as cataracts (Owsley *et* *al.*, 2001) and glaucoma (Wood *et al.*, 2016) may have a direct impact on visual impairment of drivers. As the ability to see clearly is a very important part of safe driving (Owsley & McGwin, 2010; Taylor, 1987), it is important to ensure good visual function for all motor vehicle drivers. Furthermore, when drivers are responsible for the lives of multiple people on the road, as in the case of drivers of public transport vehicles, it becomes an even more important public health concern.

1.3 DEFINITION OF KEY TERMS

1.3.1 Visual function: It is described as how well the eye and visual system function (Colenbrander, 2005). It includes aspects such visual acuity (VA), contrast sensitivity (CS), visual field (VF), and colour vision (CV). Visual function may be affected, among others, by factors such as ocular pathology, refractive error and visual impairment. Tests that are important for visual function assessment are the following:

1. **Visual acuity (VA):** The measure of the ability to discriminate two stimuli separated in space (Kniestedt & Stamper, 2003). Assessment of VA can be done using charts such as the Snellen Acuity chart and LogMar VA chart.
2. **Contrast sensitivity (CS):** This is the ability to detect subtle differences in shading and patterns (Guccione, Wong & Avers, 2012). It is important in detecting objects without clear outlines and discriminating them from their background. This function assists the driver when driving at night, and in rainy or foggy weather conditions.
3. **Visual field (VF):** This describes how wide of an area the eye can see when focusing on a central point (Murdoch *et al.*, 1997). Different tests can be used to assess VF including automated perimetry and the confrontation test. The VF function is important in driving as it allows the driver to see oncoming vehicles and those on the sides before overtaking.
4. **Colour vision (CV):** This refers to the ability to discriminate the wavelength composition of the light, independent of its intensity (Blakeslee & McCourt, 2011). Colour vision is important in driving, as it assists drivers to see road signs and road markings, traffic lights, pedestrians crossing the road, as well as other vehicles on the road.

5. **Refractive error:** This is a condition that occurs when the eye cannot clearly focus the images from the outside world, resulting in blurred vision (World Health Organization, 2013). Refractive error cannot be prevented but can be diagnosed through proper eye examination. Refractive error is corrected by the use of spectacles, contact lenses or refractive surgery. The most common types of refractive error, which have been assessed in this study, are listed below:

    i. ***Myopia:*** Also known as near-sightedness, this is difficulty in seeing distant objects clearly.
    ii. ***Hyperopia:*** Also known as far-sightedness, this is difficulty in seeing near objects clearly.
    iii. ***Astigmatism:*** This is the distorted vision resulting from an irregularly curved ocular surface.

6. **Ocular pathology:** This is the nature of diseases of the eye and its surrounding structures, their effect on ocular tissues and on ocular functions (Millodot, 2019). The most common ocular pathology that could impede vision for driving are cataracts, glaucoma, diabetic retinopathy, macular degeneration, and corneal opacity.

1.3.2 Binocularity: Binocularity is the ability of the brain to fuse two independent images from each eye so that the person can see one image (Millodot, 2019). Factors such as ocular trauma, tumours and severe visual impairment may reduce binocularity. This may place stress on the visual system leading to discomfort such as double vision, fatigue, difficulty concentrating on certain tasks that require concentration, such as driving and poor performance on the task being undertaken.

1.3.3 Driving: Driving is defined as the ability to operate and control the direction and speed of a moving vehicle (Collins Online Dictionary, 2016). It is a complex multitasking activity which requires various personal and visual skills to be executed efficiently. Personal skills are knowledge of operating a vehicle, of traffic signs and of traffic rules. Visual skills include the possession of good vision that enables the driver to see well and drive safely.

1.3.4 Motor vehicle driver: This is a person who operates a vehicle (Collins Online Dictionary, 2016).

1.4 IMPORTANCE OF VISION IN DRIVING

Driving forms part activities of daily living in many countries, and is linked to quality of life (Owsley & McGwin, 1999). Drivers with reduced VA and VF could pose a safety risk on the road if they have difficulty detecting possible dangerous situations whilst driving (Desapriya *et al.*, 2014). Poor VA and a reduced VF may subsequently impact the quality of people's lives. This has been emphasized by the National Transport Commission in Australia when formulating medical standards and guidelines for issuing licences to drivers (Austroads, 2017). It has also been documented that vision forms part of about 95% of the sensory requirements for driving (Taylor, 1987; Bener *et al.*, 2004). It is therefore crucial that drivers possess good vision.

Good vision is imperative for safe driving (Wales, 2017; Huvarinen, Svatkova & Oleshchenko, 2017; Owsley & McGwin, 2010). Drivers with ocular diseases, which often result in poor vision, may also drive less ably than those without ocular disease (Owsley *et al.*, 2001; Wood *et al.*, 2016). Ocular diseases such as cataracts (Owsley *et al.*, 2001) and glaucoma (Wood *et al.*, 2016), both prevalent in Africa, have a direct impact on the visual function of drivers. Possessing good vision is therefore a critical aspect for safe driving (Owsley & McGwin, 2010; Taylor, 1987).

1.5 ROAD TRAFFIC ACCIDENTS AS A PUBLIC HEALTH CONCERN

Road traffic accidents (RTAs) are the 9th leading cause of death globally (Wales, 2017) and the leading cause of death for children and young adults aged 15–29 years (World Health Organization, 2018). It is estimated that about 1.25 million people are killed on the world's roads annually, with 50 million people incurring non-fatal RTA-related injuries (Wales, 2017). This presents a significant global health challenge. Road safety and road fatalities should therefore be recognised as a major international public health issue, yet it rarely receives the attention it needs.

Interventions to reduce the occurrence of RTAs have included maintenance of road infrastructure, law enforcement against alcohol consumption while driving, reduction in speed limits and the use of safety belts when driving (Wales, 2017). Additionally, ensuring that new and used vehicles meet high quality safety standards such as those recommended by the United Nations' (UN) regulations, is also deemed important (World Health Organization, 2018). While such interventions are necessary, ensuring good vision for motor vehicle drivers, is also an important factor in safe driving, yet receives much less attention (Wales, 2017).

The high number of RTAs which occur globally on an annual basis constitute a major public health and development concern (World Health Organization, 2008). If countries do not work on road safety strategies, injuries due to RTAs will probably increase. In 2010 the International Road Federation set a 2020 goal to reduce RTAs in European Union (EU) countries by 50%, with a further target of close to 0% by 2050 (Huvarinen *et al.*, 2017). Efforts aimed at reaching these goals included safe road designs, as well as training of engineers and road builders on how to use new technologies. The World Health Organization (WHO) and the World Bank also formed a joint venture to fight this public health concern, with the World Bank encouraging its borrowers to include road safety components within highway and urban transport projects (Jindal & Mukherji, 2005) to reduce the economic impact of RTAs on the countries' economies.

1.6 REGULATION OF VISUAL REQUIREMENTS FOR DRIVING

Research in the field of vision and driving emerged in the early 1970s by Burg (1971) who evaluated a large population of drivers in California, in the United States of America (USA) on vision, reaction time and decision making as it relates to driving functions (Burg, 1971). The study assessed 17 769 people aged 16–92 years and concluded that VA declines progressively with both the increasing speed of target movement and with advancing age. The study highlighted VA, CS, VF and CV as the most important visual functions which are related to driving abilities. This work served as the basis for establishing requirements for driving licences in California.

Although good vision is a logical requirement for safe driving, vision standards are not the same throughout Europe and in some cases do not meet minimum requirements as outlined by the European Union Driving (Austroads, 2017). There are also variations in visual requirements for driving both in developed and developing countries across the globe. In Australia requirements include VA of 6/9 in the better-seeing eye and a VF of 120^0 (Austroads, 2017). In the United Kingdom (UK) VA should be 6/12, with a VF of 160^0 in the best eye for driving (Government of United Kingdom, 1988). Section 92 of the UK's Road Traffic Act of

1998, states that a licence will not be given in this event: *"The inability to read in good light (with the aid of corrective lenses if necessary) a registration mark fixed to a motor vehicle and containing letters and figures 79.4 mm high at a distance of 25 yards."* However, unlike Australia, the UK makes no distinction between the better or worse eye. In the USA, legislation also varies from state to state. For instance, in Alabama VA should be at least 6/12 and VF should be at least 110°, while in Indiana VA is required to be at least 6/12, but a minimum VF of 70° is required for one eye and 120° for both eyes.

African countries, similarly, do not have common visual standards. The Nigerian Federal Road Safety Commission (FRSC) has stipulated VA requirement for driving as 6/9 in the best eye and 6/24 in the other eye, and a horizontal VF of 140^0 or more (Nigerian Federal Road Safety Commission, 1988; Chidi-Egboka, Akeem Bolarinwa & Olugbenga Awoyemi, 2015). In South Africa, according to Regulation 102 of the National Traffic Act 93 of 1996 (Republic of South Africa, 1996), a driver may be issued with a driver's licence if, according to the Snellen rating his VA is 6/12 for each eye, with or without refractive correction. Where one eye of the driver is blind, a minimum VA for the other eye should be 6/9. A minimum VF of 70^0 temporal, with or without refractive correction, is required in each eye. If the minimum VF in one eye is less than 70^0 temporal, or one eye is blind, the minimum total horizontal VF should be 115^0 (Republic of South Africa, 1996; Adams, 2011). In contrast, Lesotho has no defined visual standards or regulations for vision for driving.

1.7 BACKGROUND TO LESOTHO AS A DEVELOPING COUNTRY

Lesotho, officially known as the Kingdom of Lesotho, is an enclave country within the border of South Africa. It covers about 30 000km^2 area, with population of over 2 million people. The country is divided into ten districts, as shown in Figure 1 (World Atlas, 2011) of which the largest is the capital, Maseru District. The country was formerly ruled under the British Colony, but declared independence from the UK on 4th October 1966. The country is a member of the UN, the African Union (AU), the Commonwealth of Nations, and the Southern African Development Community (SADC). The main languages spoken in Lesotho are English and Sesotho. The Government of Lesotho is a constitutional monarchy, where the Prime Minister is the head of the government and has executive authority. Lesotho is among the countries with the highest literacy rate in Africa (CIA, 2011). According to recent studies, about 85% of women and 68% of men over the age of 15 years in Lesotho are literate (CIA, 2011). The economy of Lesotho is dependent mainly on agriculture, livestock, manufacturing and mining. The formal sector employment consists of female workers in the apparel sector, male migrants in mines in South Africa and employment in the Government of Lesotho. The main form of transport in Lesotho is through public and private vehicles that make use of a road network. There is one railway station which is used for importing and exporting goods, and one airport; both are situated in Maseru.

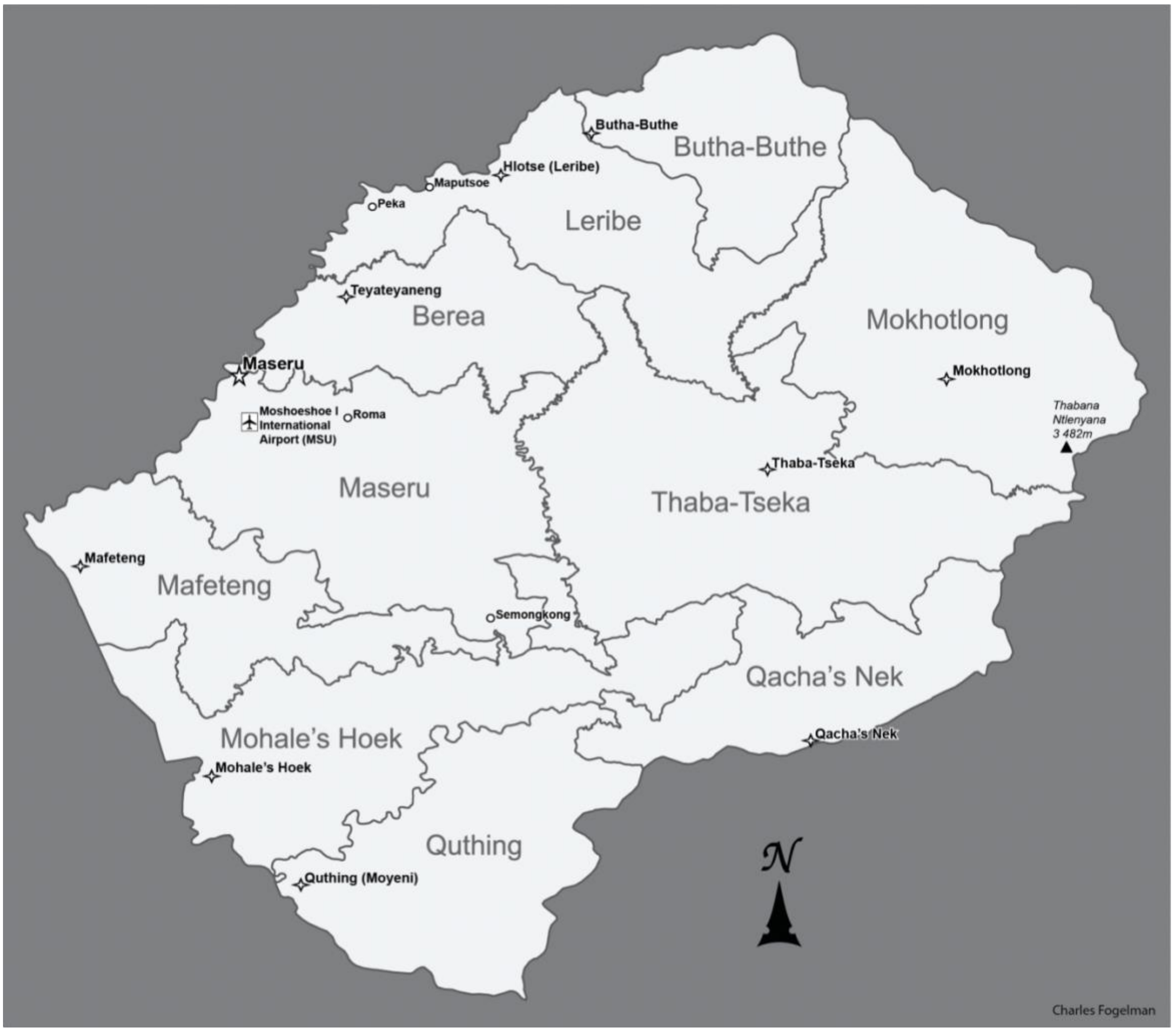

Figure 1: Map of Lesotho showing 10 districts (World Atlas, 2011)

In Lesotho, approximately 70 000 drivers' licences are issued by the National Transport Authority every year (Traffic Department of Lesotho, 2016), allowing drivers the legal right to drive within the country, as well as across its borders shared with South Africa. Anecdotal evidence is that hundreds of Lesotho drivers across the country's borders into South Africa on a daily basis for economic or other reasons. Figure 2 shows a map of Lesotho and the various border posts between Lesotho and South Africa (World Atlas, 2011), as shown by red flags.

Figure 2: Map of Lesotho showing border crossings (World Atlas, 2011)

Each year the Traffic Department of Lesotho issues about 36 885 new licences and 32 351 licence renewals (Traffic Department of Lesotho, 2016). Driver's licences in Lesotho require renewal every five years.

Lesotho's Human Development Index (HDI) value for 2018 was 0.52. This puts the country in the low human development category at 159th out of 189 countries and territories. However, there has been an increase of HDI from 2010 to 2016 with values of 0.43 to 0.52 respectively. Lesotho is therefore considered a developing country (United Nations Development Programme, 2019). In developing countries, commercial drivers form an important part of the transport industry as the majority of citizens commute daily to their different destinations by means of public transport; mainly rail and road transportation. The use of motor vehicles, both for public and private use, also forms an important part of the socio-economic development in low- and middle-income countries. As vision is the most important source of information during driving, it is a critical health concern that drivers should possess good vison for driving.

It is therefore very important to ensure the safety of all road users by implementing appropriate visual guidelines for drivers.

1.8 HEALTH AND EYE CARE IN LESOTHO

The organization of health care services in Lesotho is done at three levels: (a) primary, (b) secondary and (c) tertiary. There are 372 health facilities in Lesotho consisting of one referral hospital, two specialised hospitals, 18 district hospitals, three filter clinics, 188 health centres, 48 private surgeries, 66 nurse clinics and 46 pharmacies (World Bank Group, 2017). Health centres are the first point of care and these are aimed at reducing the patient load at district and referral hospitals. Optometry services, primarily concerned with managing visual function anomalies, are mainly offered at private practices. There are less than 20 registered Optometrists in the country, who mainly work in private practices. Most of these Optometrists are based in Maseru. Most of the patients who need specialized or ophthalmological services such as glaucoma management, cataract surgery or minor operations, are referred to Tsepong Hospital, which is a referral hospital. However, some patients prefer to travel to Bloemfontein in South Africa, which is about 143km from Maseru (World Atlas, 2011), in order to avoid the waiting period at the referral hospital in Lesotho. On average, patients wait for about one year to be seen in Lesotho, whereas in Bloemfontein they wait less than six months to be seen in a government hospital, and approximately 1 week in a private hospital.

1.9 VISUAL REQUIREMENTS FOR DRIVING IN LESOTHO

While many countries require potential drivers to meet certain minimum visual function requirements before the issuance of a driving license or permit, Lesotho has not yet implemented such regulations. Currently in Lesotho there is no policy nor standardized protocols in place to assess the visual function of motor vehicle drivers on the first issuance of drivers' licenses, nor on renewal. In The Traffic Act 8 of 1981 (Government of Lesotho, 1981), among other stipulated requirements for obtaining a drivers' license, is the ability to drive and have knowledge of road signs. However, "eyesight" is the only visual requirement to obtain a driver's licence (Appendix 1). There are no clearly documented guidelines on what the status of drivers' eyesight should be. The regulatory body of Lesotho country usually issues different categories of driver's licences for different categories of vehicles.

Furthermore, since Lesotho drivers frequently cross the South African borders for economic or other reasons, it would stand to reason that the traffic regulations in general, as well as those related to vision standards for drivers on South African roads, should apply to all drivers and users of South Africa's public roads and not only South African licence holders. Therefore, visual requirements of these drivers need to be known, and should be comparative to the South African visual standards.

This study was conducted to assess the visual function of drivers in Lesotho, and to comment on the findings in relation to regional requirements for driving. The results of the study could assist the Department of Traffic in Lesotho to develop guidelines for minimum requirements for driving.

1.10 PROBLEM STATEMENT

Motor vehicles drivers in Lesotho do not undergo any standardized vision testing prior to issuance of driving licences. There is therefore the risk that people with poor vision may be issued with driving licences and pose a safety hazard on the road. Many people travel to other countries in the region mostly for commercial reasons. While countries such as South Africa, which neighbours Lesotho, have clear visual guidelines for issuing of licences to drivers, there are no standard guidelines in place in Lesotho against which the Traffic Department can measure visual function. To the best of the researcher's knowledge, no research has previously been conducted in Lesotho to determine the visual function of motor vehicle drivers. This study could contribute towards providing evidence for policy makers in Lesotho.

1.11 PURPOSE OF THE STUDY

The main purpose of the study was to assess the visual function of motor vehicle drivers in Maseru, Lesotho in order to highlight the importance of good vision for driving.

1.12 RESEARCH QUESTION

What is the visual function of motor vehicle drivers in Maseru, Lesotho?

1.13 AIM AND OBJECTIVES

1.13.1 AIM

The aim of the study was to assess the visual function of active motor vehicle drivers in Lesotho.

1.13.2 OBJECTIVES

1. To investigate the current visual assessment processes and procedures for drivers in Lesotho by means of a desk review and key informant interviews.
2. To establish a profile of motor vehicle drivers in Lesotho, their associated ocular history and vision-related experience while driving, by means of a questionnaire.
3. To determine the visual function of motor vehicle drivers in Lesotho by means of a clinical assessment tool.

Table 1: Outline of objectives

OBJECTIVE	TOOL
1	• Desktop review • Key informant interviews
2	• Structured questionnaire, adapted from Boadi-Kusi et al. (2016)
3	• Clinical assessment of participants for visual acuity, color vision, contrast sensitivity, visual fields, refractive error and screening for pathology.

1.14 DISSERTATION OVERVIEW

This dissertation has been divided into five chapters, as follows:

Chapter 1: Introduction

This chapter discusses the definition of visual function, driving and motor vehicle drivers as concepts, the importance of vision for driving, RTAs as public health concern, regulations of visual requirements for driving, the background to Lesotho as a developing country, the health care system in Lesotho as well as visual requirements for driving in Lesotho.

Chapter 2: Literature Review

This chapter discusses studies done on visual function of motor vehicle drivers globally and in Africa as well as evidence relating to the impact of RTAs on countries' economies. The central focus is on visual acuity, contrast sensitivity, color vision, visual field, refractive error and ocular pathology. The chapter also discusses the current state the Traffic Department of Lesotho, in relation to developments on vision and driving.

Chapter 3: Research methodology

In this chapter, the theoretical description of the research design will be outlined. A brief description of qualitative, quantitative and mixed methods research designs will be discussed. The data collection methods, study setting, and sampling methods employed in this study will also be discussed.

Chapter 4: Results (Manuscript)

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This chapter presents results for objective 1 of the research which was as follows:

1. To investigate the current visual assessment processes and procedures for drivers in Lesotho by means of a desk review and a key informant interview.

The chapter also presents the results for quantitative analysis of objectives 2 and 3 respectively, which were as follows:

2. To establish a profile of motor vehicle drivers in Lesotho, their associated ocular history and vision-related experience while driving by means of a questionnaire.
3. To determine the visual function of motor vehicle drivers in Lesotho by means of a clinical assessment tool.

Chapter 5: Synthesis, conclusion, strengths, limitations and recommendations

This chapter concludes with main findings of the study, study limitations and recommendations. The chapter highlights recommendations from the study on the minimum guidelines that motor vehicle drivers in Lesotho should meet in order to qualify for issuance of a driving licence by the Department of Traffic in Lesotho.

1.15 CONCLUSION

Lesotho is a developing country with limitations in most of its operating systems, including the health care system, especially eye health care and related policy development. Current road traffic policies do not include standards for the minimum visual function of motor vehicle drivers in order to be eligible for a driver's licence. It is believed that drivers with visual impairment pose hazards to other road users and that the poor vision of some drivers might be contributing to the number of RTAs in the country. It was therefore deemed necessary to conduct this study.

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CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the review of literature is presented on the origin of research on vision and driving. The central focus is on visual acuity (VA), contrast sensitivity (CS), colour vision (CV), visual field (VF), refractive error (RE) and ocular pathology as they relate to vision and driving. The chapter also covers the effects of binocular and monocular vision on driving, road traffic accidents (RTAs) as a result of visual impairment, and its subsequent economic impact on a country's economy. It also presents the current situation in Lesotho as far as vision and driving is concerned.

2.2 DRIVING AND VISION

Travelling by road is by far the most preferred mode of transport in many countries. Vision is the important part of driving as it allows the drivers to be able to see traffic signs, pedestrians as well as other drivers and vehicles in order to navigate safely on the road. Research in the field of vision and driving first emerged in the early 1920s by the Transaction of the Section on Ophthalmology of the American Medical Association's 76th Annual Session in Atlantic City (Behrens, *et al.,* 1925). The Committee on Visual Standards of the Journal of Ophthalmology of the American Medical Association recommended VA for driving to be 20/50 in one eye and 20/100 in the other eye. Drivers with VA worse than 20/100 would be given a special permit to drive. In 1937, the Journal of the American Medical Association revised the standards set in 1925, having declared them as impracticable (Black, Gradle & Snell, 1937) and recommended the vision standards for driving to be modified. The new recommended VA was 20/40 or better in one eye, with or without spectacle and 20/100 in the fellow eye. Visual field was recommended to be 45 degrees in both eyes and the driver was required to be able to distinguish between red, green and yellow (Johnson & Wilkinson, 2010).

The 1937 report was followed by Burg in the early 1970s, (Burg, 1971), who evaluated a large population of drivers in California on vision, reaction time and decision making as it relates to driving functions (Burg, 1971). The study assessed more than 17 000 subjects aged 16–92 years and concluded that VA declines progressively with both increasing speed of target movement and advancing age. The study highlighted VA, CS, VF and CV as the most important visual functions which are related to driving abilities. This work served as the basis for establishing visual requirements for driving licences in California. Despite these developments on research in vision and driving, there are still significant differences in visual standards and requirements for driving in many countries throughout the world.

Several research studies have been conducted to emphasize the importance of visual function among motor vehicle drivers. Most research studies indicate that VA, VF, CS and CV are associated with driving capabilities and performance (Burg, 1971; Dairo *et al.*, 2019; Boadi-Kusi *et al.,* 2016). In a review of scientific research which investigated vision performance amongst commercial drivers, the U.S. Department of Transportation Federal Highway Administration deemed it necessary to include VA and VF in the standard requirements for licensing drivers (Australian Department of Transport, 2016). In this study, 200 participants who already had driving licences were tested for VA, CV and VF, among other tests. Approximately 11% performed poorly for VA, 17% for CV and 12% had restricted horizontal VFs. This emphasized that it is important for regular screening of drivers' vision when issuing them with licences, whether it is the first issue or a renewal.

In a cross-sectional study in Nigeria (Adekoya, Owoeye & Adepoju, 2009), 399 drivers were tested to determine the prevalence of visual impairment among commercial drivers. The prevalence of drivers with inadequate VA was found to be 11.5%, abnormal CV was 4.3% and VF loss was 5.5%. The study concluded that a significant number of drivers were driving with vision that is below what is expected by the Nigerian Federal Road Safety Commission, and that there is a need for regular eye screening of drivers to ensure that they have adequate vision for driving. Also, in a survey on VA among 340 intra-city commercial vehicle drivers in Nigeria, about 15% of drivers had VA worse than 6/9 and 5% had visual impairment (VA <3/60) although they were valid drivers' licence holders (Dairo, Ugochukwu & Nwakpa, 2019). The study also found that drivers over the age of 40 years showed more visual impairment as compared to younger drivers. Most of the participants reported not being aware of the gradual reduction in their vision. Thus, regular visual screening for drivers is important to detect any reduction in drivers' vision and to enable early correction.

2.3 TESTS OF VISUAL FUNCTION FOR DRIVING

2.3.1 VISUAL ACUITY (VA)

In most countries, VA is the primary visual function assessed to measure fitness to drive. Visual acuity is the ability of the eye to resolve detail (Dictionary of Optometry and Vision Science, 2018). It assists drivers to be able to see objects such as traffic signs, road hazards and road markings clearly while driving, both at night and during the day. Various tests such as the Snellen VA chart and the LogMar VA chart are used to assess VA. VA is important as it is believed that drivers with visual impairment pose a hazard on the road and are at risk of being involved in RTAs.

A descriptive, cross-sectional study was conducted to determine the prevalence of visual impairment among 340 commercial drivers in Ibadan, Nigeria (Dairo *et al.*, 2019). In this study, about 15% of drivers had VA below 6/9 and 5% had visual impairment (VA <3/60). In another study to assess VA of commercial drivers in Ogun State, Nigeria (Onabolu *et al.*, 2012), out of 524 drivers, 12% were not eligible to drive because their VA was lower than 6/12, which is required for issuance of a driving licence. Both these studies show that there is a need to improve on testing for visual function in motor vehicle drivers when issuing them with licenses. Where only VA is tested, it is important to conduct the test properly to ensure accurate results.

2.3.2 CONTRAST SENSITIVITY

Contrast sensitivity (CS) is not routinely included as a requirement for obtaining a driver's licence in many countries, although it is equally important for safe driving as many of the other aspects of visual function (Swan, *et al.*, 2019). It assists drivers in the detection of low contrast objects under low visibility conditions such as rain, fog, snow and during night driving. Some research studies have shown that contrast sensitivity plays a major role in drivers' vision. In a study conducted to assess the addition of CS to VA when testing fitness to drive (Spreng, *et al.*, 2018), it was found that CS loss was common among older drivers and that daytime evaluation of driving performance was limited in its ability to correctly identify difficulties related to CS loss. Cataracts are a major cause of decrease in CS. If drivers were screened for CS and referred for cataract surgery, that could help restore the safe mobility of drivers. Night driving requires mesopic vision because there is some light involved, such as that from streetlights and headlights from oncoming traffic. Mesopic vision decreases and glare sensitivity increases in old age, even in the absence of ocular pathology (Gruber, *et al.,* 2013). Gruber et al. (2013) recommended that it is important to screen drivers, especially older ones, for CS when issuing them with a driver's license. In a one study, drivers with a crash history were found to be six times more likely to have reduced CS levels when compared to those with no history of crash involvement (Owsley *et al.,* 2002). In another study, drivers showed improved driving performance following cataract surgery (Wood & Carberry, 2006). It was also noted that there was improved CS function following cataract surgery. Based on this evidence, it should be noted that CS is an important visual function for driving and CS testing should be considered for inclusion in the battery of tests used in the visual assessment of drivers.

2.3.3 VISUAL FIELDS

It is estimated that VF defects affect 20% to 50% of people with stroke (Pollock *et al.,* 2019) and about 37% of people with glaucoma (Ramrattan *et al.,* 2001) with both conditions being more prevalent in older people. Visual field defects affect a person's ability to function in daily activities of life such as reading, social interaction, walking and driving. The most common type of VF defect is a homonymous field defect (HFD) (Bowers, 2016). HFDs affect the same side of the visual field, either right or left. The causes of HFDs are stroke, brain injury, brain tumours or brain surgery (Zhang, *et al.,* 2006). In a survey conducted in Australia in early 2000, it was found that HFDs affect almost 1% of people over 49 years of age (Gilhotra, *et al.*, 2002). Because driving is the primary form of transport in many countries, people who have had a stroke and were licensed to drive before, usually return to driving as a form of rehabilitation (Fleming, *et al.,* 2014). However, people with HFDs usually have relatively good vision in the unaffected eye. Their main challenge when driving is the ability to steer and to change lanes, which may affect the detection of hazards and the ability to respond in a timely manner on the affected side of the VF (Bowers, 2016). Drivers with VF losses are denied licences in countries such as Australia (Silveira, *et al.,* 2007), United Kingdom (UK) (Driver and Vehicle Licensing Agency, 2011), United States of America (USA) (Peli, 2002) and Canada (Yazdan-Ashoori, 2010) due to a failure to meet the horizontal VF requirements. Visual field requirements in these countries ranges between ≥110° and ≥120°.

In a study to evaluate how central visual field loss can affect vehicle control in a driving simulator (Bronstad, *et al.,* 2013), participants with central visual field loss showed higher steering wheel reversal rates, meaning that the steering wheel task was more demanding for them. To compensate for their vision impairment, they had to allocate more time to the steering efforts in order to maintain their lane position, which in turn could affect their concentration on other driving tasks and hence impact negatively on their driving behaviour.

A cross-sectional study was done to investigate the association between VF defects and quality of life in the population in the USA (Qiu, *et al.*, 2014) and 10%, 7%, and 2% showed mild, moderate, and severe visual field defects, respectively. The subjects with severe VF field loss had difficulties with daily vision-related activities such driving and reported worrying about their vision. The study further suggested that routine visual screening and therapy may be important for drivers to prevent further progression of VF loss. With regular and thorough assessment, drivers with VF loss could be identified and road safety could be maintained.

2.3.4 COLOUR VISION

Colour vision plays an important role in road safety as it allows drivers to be able to recognise traffic lights, road markings and signals from other vehicles (Chakrabarty, *et al.*, 2013). Some studies have indicated that there is a relationship between colour vision defect (CVD) and involvement in RTAs while other studies have argued that there is no relationship between the two variables. For instance, in a study conducted in Ghana to determine the visual function of motor vehicle drivers (Boadi-Kusi *et al.*, 2016), about 7% of the participants had CVD and were more likely to report involvement in RTAs. However, other studies conducted in Nigeria among commercial drivers to determine the visual function of drivers and its relationship to RTAs (Oladehinde, *et al.*, 2007; Pepple & Adio, 2014) concluded that there was no association between CVD and involvement in RTAs.

Many people now use In-Car Route Guidance and Navigation Systems (RGNS) when following a certain route. Reading a map while driving may limit the attention of the driver and compromise road safety (Tsimhoni & Green, 2001). This can be even more hazardous for drivers with CVD as most of the maps in RGNS include different colours (Oliveira, *et al.*, 2018). Also, drivers with red colour deficiency may have difficulty seeing red traffic lights as well as rear braking lights when driving and should therefore pay more attention while operating a vehicle (Austroads, 2017. Although evidence shows that CV is important for driving (Adekoya *et al.*, 2009; Burg, 1971), it is not included in the requirements for driving in many countries. However, in the USA a driver is required to distinguish traffic signals and devices with red, green and amber in order to obtain a commercial driver's licence (Johnson & Wilkinson, 2010).

2.3.5 REFRACTIVE ERROR

Refractive error is one of the causes of visual impairment that could be reversed with proper assessment and management. Uncorrected refractive error among motor vehicle drivers may compromise road safety since drivers may not be able to detect all road hazards such as reading road signage, recognising traffic lights, noticing signals from other vehicles, and night driving as well as driving under difficult weather conditions such fog, snow or rain. Many studies that have evaluated visual function of motor vehicle drivers discovered that some drivers have uncorrected refractive error, which in some cases may be associated with involvement in RTAs. Biza, et al., (2013) found that approximately 8% of drivers in a study that was conducted in Ethiopia to determine the impact of visual impairment among vehicle drivers had uncorrected refractive error and none of them had appropriate refractive correction. Also, Ovenseri-Ogomo and Adofo (2011) found that the prevalence of refractive error in their study was about 32% and refractive error was the most common cause of visual impairment among the drivers examined. Boadi-Kusi et al. (2016) found that about 60% of the participants enrolled in a study to determine visual function of motor vehicle drivers in Ghana, had some form of refractive condition, the most common being hyperopia. There was no statistical association between refractive error and RTAs. However, corrected refractive error seemed to improve road safety (Cox, *et al.,* 2015). It is therefore important that regular visual screening among drivers is encouraged in order to detect any refractive errors that could impede vision for driving.

2.3.6 AGE-RELATED OCULAR DISEASES

The number of drivers with visual impairment may increase as the driving population ages, due to age-related ocular diseases (Wood, *et al.*, 2016). The most common ocular diseases among the older people are cataracts, glaucoma, diabetic retinopathy (DR) and age-related macular degeneration (AMD).

Cataracts

Cataracts are among the leading causes of reversible visual impairment among the older population (Thulasiraj *et al.*, 2003). Although cataract surgery is the most common eye surgery conducted globally, many people live with cataracts for a long time, and continue to drive irrespective of whether their vision is negatively affected (Owsley & McGwin, 1999). Drivers with cataracts have reported driving difficulties especially at night and in conditions such as rain, fog and snow (Owsley & McGwin, 1999). In a cross-sectional study to describe driver self-regulation practices among older bilateral cataract patients (Fraser, *et al.*, 2013), it was found that about 48% of drivers self-regulate their driving to avoid challenging situations such as driving at night, on the freeway, in the rain and parallel parking. Manda, et al., (2019) investigated the impact of headlight glare on pedestrian detection with unilateral cataract by simulating a cataract with frosted lenses. Their study found that participants with normal vision detected more pedestrians (57%) than those with a simulated cataract (30%). They also found that a simulated cataract decreased VA by two lines (0.2 LogMar) and CS by about 0.78 log units. The study concluded that cataracts had a significant impact on the drivers' vision.

Drivers with cataracts have increased chances of being involved in RTAs than those without cataract (Owsley & McGwin, 1999; Owsley, *et al.*, 2001), and those involved in RTA are more likely to have poor CS function (Owsley *et al.*, 2001). Cataract surgery has however been shown to improve driving performance by almost 88% (Desapriya *et al.*, 2014) especially with tasks such as driving in the rain and at night (Fraser *et al.*, 2013). Owsley et al. (2002) has shown that there was a 50% reduction in RTA among drivers who had undergone cataract surgery when compared with those who did not have this surgery. With this evidence, it can be concluded that if drivers have cataract surgery as soon as it is needed, earlier rather than later, this could improve road safety.

Glaucoma

Glaucoma is a leading cause of visual field loss in adults (Ramrattan *et al.*, 2001). It affects almost 60 million people globally (Quigley & Broman, 2006; Tham *et al.*, 2014). Drivers with glaucoma have reported driving difficulties such as glare sensitivity, driving at night and lane changing on the affected side (Freeman, *et al.*, 2008; Béchetoille *et al.*, 2008; Janz *et al.*, 2009). For this reason, many drivers with glaucoma have ceased to drive (Ramulu, 2009) due to fear of being involved in RTAs. Drivers with mild to moderate VF loss exhibit impairment in driving, especially where lane repositioning and approaching traffic lights are involved (Wood *et al.*, 2016). Wood et al. (2016) investigated the types of driving errors and problematic driving situations among 75 drivers with glaucoma. They found that the drivers with even mild to moderate VF loss exhibited impaired driving performance and may drive less efficiently than those without glaucoma.

Several studies have been conducted to evaluate the relationship between glaucoma and motor vehicle collisions (MVCs). For example, McGwin et al. (2005) evaluated visual field dysfunction (VFD) and the risk of MVC among the drivers with glaucoma, and found that participants with moderate or severe VFD were at significantly higher risk of MVC, when compared with those with no defects. Furthermore, McGwin, et al., (2015) evaluated binocular visual field (BVF) impairment in 438 drivers with glaucoma and the risk of MVC. Drivers with severe BVF loss showed a higher rate of at-fault MVC when compared with those with less impaired or unimpaired binocular VF. In a small-scale study of 48 participants with glaucoma to evaluate the risk of falls and MVC in patients with glaucoma (Haymes, *et al.*, 2007), participants with glaucoma were approximately three times more at risk to have fallen and six times more at risk of being involved in MVC in the past five years. In another observational study that was done to compare the risk of MVC involvement among drivers with and without glaucoma (McGwin *et al.*, 2004), it was discovered that drivers with glaucoma were at higher risk of being involved in MVC than those without, and showed higher levels of avoidance to drive at night, in the fog, in the rain, on the highway and during rush hour. Therefore, early detection of glaucoma among motor vehicle drivers is important, not only to minimise the extent of VF loss, but also to improve their driving behaviour and lesson their chances of MVC involvement.

Diabetic Retinopathy

Diabetic retinopathy (DR) is a group of characteristic lesions found on the retina of a person who has had diabetic mellitus for many years (World Health Organization, 2019). It is a significant cause of visual impairment among older adults in developed countries (Zhang *et al.*, 2010). Diabetic retinopathy is classified in two types: proliferative and non-proliferative (Frank, 2004). Non-proliferative DR (NPDR) is often found in individuals who have had diabetes mellitus for over twenty years (Frank, 2004) and it is characterised by microaneurysms and intraretinal haemorrhages, which could progress to the presence of cotton wool spots and advanced retinal vascular damage (Frank, 2004). Proliferative DR (PDR) is often characterised by the increased proliferation of retinal blood vessels and possible retinal detachment (Frank, 2004). PDR may also cause macular oedema, leading to significant reduction of VA, and defects in both central and peripheral VF (World Health Organization, 2019). The visual impairment in DR is thought to be caused by central foveal thickening and plasma leakage (Antonetti, Klein & Gardner, 2012). Types of treatment for DR include photocoagulation, which could have an undesirable impact on visual function such as VF loss, visual impairment, glare sensitivity, reduced CS and impaired CV (Frank, 2004). Research done to investigate the impact of DR on driving performance in a driving simulator study found that among 25 drivers with DR, with and without history of laser treatment (Szlyk *et al.*, 2004), retinal thickening and scarring had a negative impact on driving performance as these drivers showed an increased risk of simulator crashes. Similarly, a study that investigated the relationship between DR and MVC in older drivers with DR showed an increased risk of crash involvement when compared to the control group (Akpek & Smith, 2013). Sagberg (2006) investigated crash involvement risk associated with diagnosed medical conditions among 4 448 drivers of all ages who were involved in MVC. The study found that there was an association of MVC with DR. With the evidence that DR causes impairment in visual function, it is important that drivers should be encouraged to control their blood glucose levels in order to avoid PDR, which could negatively affect their vision.

Age-related macular degeneration

Age-related macular degeneration (AMD) is a leading cause of irreversible visual impairment globally (Weih, *et al.*, 2000; World Health Organization, 2019) and among people over the age of 70 years (Kawasaki *et al.*, 2010; World Health Organization, 2019). AMD causes loss of central VF due to insufficiency of blood circulation to the macula (World Health Organization, 2019). There are three stages of AMD according to severity, namely: early, intermediate and advanced AMD (McGwin *et al.*, 2013). The central vision loss in AMD has a negative impact on driving performance, whereby drivers self-regulate their driving and avoid challenging tasks such as night driving, driving during rush hour and in unfamiliar environments (Sengupta *et al.*, 2014). In a study to explore differences in driving performance in adults with AMD and age-matched control (Wood, *et al.*, 2018), drivers with early and intermediate AMD showed impairment in their driving performance, especially during complex driving situations. In simulation studies to determine if central binocular scotomas could affect detection of hazards among older drivers (Bronstad *et al.*, 2013; Bronstad, *et al.*, 2015), it was reported that the drivers performed poorly when detecting pedestrians, even if they appeared on the less affected VF side when compared to the control group. Although drivers with AMD exhibit challenges and poor driving performance, studies indicate that they show less MVC involvement (Szlyk *et al.*, 1995; McGwin *et al.*, 2013). This may be because the drivers are more careful when driving, self-regulate their driving or they cease to drive.

2.3.7 BINOCULAR VISION

Drivers with binocular vision have an advantage of better quality of vision over those with monocular vision (Westlake, 2001) because their peripheral vision is wider. This is because the process of probability summation occurs when the images from the two eyes fuse and the photoreceptors in both eyes are stimulated simultaneously at the corresponding retinal points (Westlake, 2001). Thus, visual tasks such as driving are performed better with both eyes open than in monocular vision (Simmon & Kingdom, 1998).

Binocular VF in a normal individual is estimated at 140°, which could be assumed to be 70° from each eye. This could mean that drivers with monocular vision could have a limited VF of 70° or less when compared with those with binocular vision (Westlake, 2001). In a study by McKnight, Shinar, and Hilburn (1991) that compared 40 monocular and 40 binocular truck drivers, monocular drivers had limitations in visual measures such as VA under low illumination, glare, CS and binocular depth perception. However, there were no differences found between both groups, in driving measures such as visual search, lane keeping, clearance judgement, gap judgement and hazard detection.

In contrast to the above, a simulation study to explore the implications of monocular vision for racing car drivers in terms of crash and reaction time, conducted among 75 racing car drivers by Adrian et al. (2019), showed different results. The study found that drivers, under monocular conditions were 2.1 times more likely to collide with target vehicles when compared with binocular conditions. Also, there was an increase in the reaction time from 64ms to 126ms among drivers under monocular conditions (Adrian *et al.*, 2019). The study concluded that monocularity had a significant impact on driving performance during car racing.

Monocular drivers lack stereopsis. Stereopsis is defined as the ability to perceive depth with different viewpoints between two eyes (Chopin, *et al.*, 2019). The absence of stereopsis is called stereo-blindness and could be associated with poor distance judgement (Chopin *et al.*, 2019). Stereopsis could be impaired or absent in patients with strabismus, amblyopia (Levi, Knill and Bavelier, 2015), AMD (Verghese & Ghahghaei, 2020) and enucleated patients (Westlake, 2001). Inability to judge speed may put a driver at risk of MCV involvement (Poulter & Wann, 2013). Therefore, drivers with stereo-blindness could pose a hazard to other road users.

2.4 ROAD TRAFFIC ACCIDENTS AS A PUBLIC HEALTH PROBLEM

Road traffic accidents (RTA) constitute a major public health problem globally, which claims about 1.25 million lives each year (World Health Organization, 2018), and leaves over 50 million people injured (Wales, 2017). According to the World Health Organization (2018), RTAs are responsible for 25% of all deaths globally. However, road safety awareness receives very little attention.

Driving is the preferred mode of travel worldwide (Hu & Reuscher, 2004) and RTAs are an undesirable result of driving. The causes of RTAs could be mechanical, human or environmental. Mechanical causes could include machinery failure, while human causes could be poor driving behaviours, poor driving skills, drunken driving or visual dysfunction (Verma *et al.*, 2016). Visual skills have been found to be among the most important physical abilities that assist motor vehicle drivers to drive safely (Verma *et al.*, 2016). It is important to assess the visual abilities of a driver in order to determine if they could be linked to causes of RTAs. To assess driver fitness to drive, VA, CS and VF have been identified as the important visual functions (Matas, Nettelbeck, & Burns, 2014; Burg, 1971).

Several research studies have been conducted to show an association of visual dysfunction and crash involvement. Friedman et al. (2013) found visual impairment to be a major contributing factor to MVC involvement among drivers over the age of 70 years. Also, drivers with poor binocular VA were found to be at higher risk of accidents when compared to those with normal VA (Hofstetter, 1976; Maag, *et al.*, 1997). Biza et al., 2013) also found binocular visual impairment to be strongly associated with involvement in RTAs. Protanopia is defined as red colour blindness, which occurs as a result of the complete absence of red retinal photoreceptors (Khalaj, Barikani & Mohammadi, 2014). Studies have also shown that CV defects and poor glare recovery have an association with involvement with RTAs (Desapriya *et al.*, 2014; Javitt, 2002). Another study that assessed visual function of commercial vehicle drivers found that protans were at an increased risk of being involved in RTAs (Boadi-Kusi *et al.*, 2016). Furthermore, Cole (2002) has concluded that protanopia has a great influence on the risk of an RTA occurring, irrespective of the severity of the condition.

Contrast sensitivity function has also been found to have an association with RTAs (Owsley *et al*., 2001) especially in drivers with cataracts, with driving performance improving following cataract surgery (Wood & Carberry, 2006). It has also been found that ocular pathology such as glaucoma (Haymes *et al.*, 2007; McGwin *et al.*, 2004), AMD (Bronstad *et al.*, 2013; Bronstad *et al.*, 2015; Szlyk *et al.*, 1995; McGwin *et al.*, 2013) and DR (Szlyk *et al.*, 2004; Akpek & Smith, 2013) have an association with RTA involvement. Most drivers with these conditions tend to avoid driving in certain situations to prevent being involved in RTAs and some self-regulate their driving (Fraser *et al.*, 2013).

Road traffic accidents may affect countries' economies negatively. The cost of RTA-related injuries is estimated at 1% of gross domestic product (GDP) in poor countries, 1.5% in middle income countries and 2% in developed countries (Jacobs, Thomas & Astrop 2000). The direct economic impact of RTA globally is estimated at US$ 518 billion (Jacobs *et al.*, 2000). In European Union (EU) countries, the annual estimated cost of RTAs is US$ 207 billion (Hakamies-Blomqvist, 2003), in the United States of America it is US$ 230 billion (Blincoe *et al.*, 2002) while in low-income countries it is US$ 65 billion (Jacobs *et al.*, 2000).

In a study conducted by Cubí-Mollá, *et al.*, (2015) in Spain, it was found that the estimated loss of labour productivity caused by fatal traffic injuries between 2002 and 2012 in Spain amounted to €9 521 million. A retrospective study conducted in Argentina investigating patients who received care at Carlos G. Durand Hospital from January 2013 to December of 2015, showed the medical and economic impact of RTAs (Besse *et al.*, 2018). Of a total of 4 368 incoming patients due to traffic accidents, 67% were the result of motorcycle crashes; 18% of them required hospitalization, with hospital stay varying between 5 and 150 days. The study revealed that the total cost of care was almost US$ 17 million, and in 2014 it was estimated at US$17 936 per patient. It has been reported that over 3 000 Kenyans aged between 15 and 44 die every year on the Kenyan national roads due to RTAs, the cost of which amounted to over US$ 50 million. In South Africa the associated consequences of RTAs are reported to have a significant impact on the country's economy (Labuschagne, *et al.*, 2017). This impact is measured based on human lives lost, 'pain, grief and suffering', as well as an increasing cost to the economy. The total cost for the period 2004 – 2015 was estimated at over ZAR142 billion.

Currently in Lesotho there is no available data that pertains to studies done on the visual function of motor vehicle drivers. The reported causes of RTA are drunken driving, poor driving behaviour, pedestrian and animal related accidents and vehicle machinery failure. There are no recorded vison related causes of RTA. According to the Department of Road Safety (2017), the number of road accidents in 2017 was estimated at over 4 000, causing almost 350 fatalities in the whole country, with the Maseru District being the highest (43%). This included 2 100 injuries to people, and almost 7 000 damaged cars. However, the effects and impact of RTAs on the country's economy are unknown.

2.5 CONCLUSION

Visual function is an important component for driving safety. Evidence has shown that VA, CS, VC and VF are important for driving and have been shown to assist drivers with good driving capabilities; they should therefore be included in the assessment of driver fitness. Many studies have recommended that the countries should include assessments of these visual functions in their procedures for issuing a driver's licence. Refractive error, visual dysfunction and ocular pathology have also been shown to have an association with RTAs. It is thus important to encourage motor vehicle drivers to have regular eye examinations to detect visual problems as early as possible and manage them accordingly, so as to promote road safety for all road users.

Research in the field of vision and driving dominates in developed countries. There is limited data available in developing countries such as in Africa due to poor socio-economic status. There is therefore a need for more research to be done in such countries.
In Lesotho there is no data available that involves vision and driving and there are no formalised procedures that the Traffic Department follows in issuing a driver's licence for new and prospective drivers. It was therefore important to conduct this study so as to make recommendations to the Department of Road Safety.

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CHAPTER 3: RESEARCH METHODOLOGY

This chapter will outline the theoretical description of research design and brief description of qualitative, quantitative and mixed methods research designs. Data collection methods, study setting and sampling methods employed in this study will be discussed.

3.1 TYPES OF RESEARCH DESIGNS

3.1.1 QUALITATIVE RESEARCH DESIGN

Qualitative research design is described as scientific inquiry which seeks to build a holistic and largely narrative description to inform the researcher's understanding of a social or cultural phenomenon (Astalin, 2013). It involves combination methods which include observations, interviews and document reviews.

3.1.2 QUANTITATIVE RESEARCH DESIGN

Quantitative research involves measuring variables, and testing relationships between variables in order to reveal patterns, correlations or causal relationships (Leavy, 2017). Quantitative data uses statistical, mathematical and computational techniques (Brink, Van der Walt & van Rensburg, 2018). It is mainly used in surveys, experimental and correlational research studies, where statistical, mathematical and computational techniques are used (Brink *et al.*, 2018).

3.1.3 MIXED METHODS RESEARCH DESIGN

This is where the researcher combines elements of both qualitative and quantitative approaches within a single research project for the broader purposes of achieving a deeper understanding of the phenomenon of interest (Schoonenboom & Johnson, 2017). The ultimate goal is to achieve heightened knowledge on the subject and to strengthen validity (Abrams, 2009).

An advantage of the mixed methods research design is the development of a more comprehensive understanding of a particular situation that neither qualitative nor quantitative research could provide on their own. It is thus most appropriate for use when the purpose of research is to describe, explain or evaluate a certain concept (Leavy, 2017).

3.2 RESEARCH DESIGN

This study employed a descriptive, mixed methods cross-sectional research design. Qualitative methods were employed to address objective 1 using desk review and key informant interview methodologies where snowball sampling was employed. Quantitative methods were employed to address objectives 2 and 3 with questionnaires used to address objective 2, while clinical assessments were conducted to address objective 3. The aim and objectives of the study are outlined as follows:

AIM

The aim of the study was to assess the visual function of active motor vehicle drivers in Lesotho.

OBJECTIVES

1. To investigate the current visual assessment processes and procedures for drivers in Lesotho by means of desk review and key informant interviews.
2. To establish a profile of motor vehicle drivers in Lesotho, their associated ocular history and vision-related experience while driving by means of a questionnaire.
3. To determine the visual function of motor vehicle drivers in Lesotho by means of a clinical assessment tool.

3.2.1 DATA COLLECTION METHODS

The steps taken for data collection are summarised in Figure 3 below:

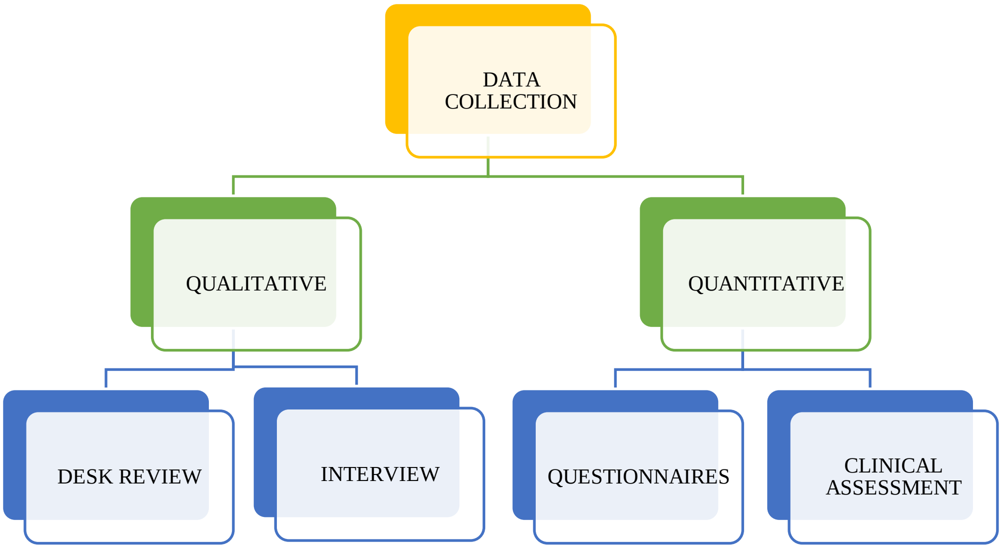

Figure 3: Summary of data collection methods

3.2.1.1 QUALITATIVE METHODS

Objective 1 sought to investigate the current visual assessment processes and procedures for drivers in Lesotho. This was carried out by desk review and key informant interviews as follows.

DESK REVIEW:

A search was conducted on the internet for any documents or information pertaining to Lesotho's Road Traffic legislation or regulations. The only document found was The Traffic Act 8 of 1981 (Government of Lesotho, 1981). The purpose of reviewing this document was to understand the country's legislation with regard to visual requirements for driving. An excerpt of this is presented in Appendix 1.

KEY INFORMANT INTERVIEWS:

The Traffic Commissioner of Lesotho was interviewed in February 2019 in order to obtain clarity regarding the contents of the Traffic Act 8 of 1981 and related protocols with regards to procedures and requirements for issuance of driving licences in Lesotho. An interview guide was used to address key areas of interest (Appendix 2). Snowball sampling technique was employed to obtain information from other key informants, which included the Director of Road Safety Department and other officials working at the Traffic Department of Lesotho.

3.2.1.2 QUANTITATIVE METHODS

QUESTIONNAIRES:

The data collection tool used by Boadi-Kusi et al. (2016) in a similar study in Ghana was utilized in this study (Appendix 3) to assess the biographical data of the participants and their knowledge on the importance of good vision and driving. Questionnaires were translated into Sesotho, which is the local language of Lesotho. Participants were assisted by members of the research team in the completion of the questionnaires. This addressed objective 2 of the research which was to establish a profile of motor vehicle drivers in Lesotho, their associated ocular history and vision-related experience while driving by means of a questionnaire.

CLINICAL ASSESSMENT:

To address objective 3, which was to determine the visual function of motor vehicle drivers in Lesotho by means of a clinical assessment tool, the participants underwent a visual function assessment after completion of the questionnaire. Clinical assessment was conducted only by the researcher to maintain standardization. Tests conducted included:

Visual acuity (VA): This is a measure of the spatial resolution of the visual processing system. A LogMar VA chart (Figure 4) was used to measure VA, as it is the most reliable chart used in most research studies. The test was done with spectacle correction for the participants who already wore spectacles. The participant was asked to sit 6m from the chart, with their right eye covered and to read out loud the letters on the chart seen with the uncovered left eye. This testing procedure was repeated for the right eye. The test was done under room illumination. Only distance VA was tested as it was deemed important for driving.

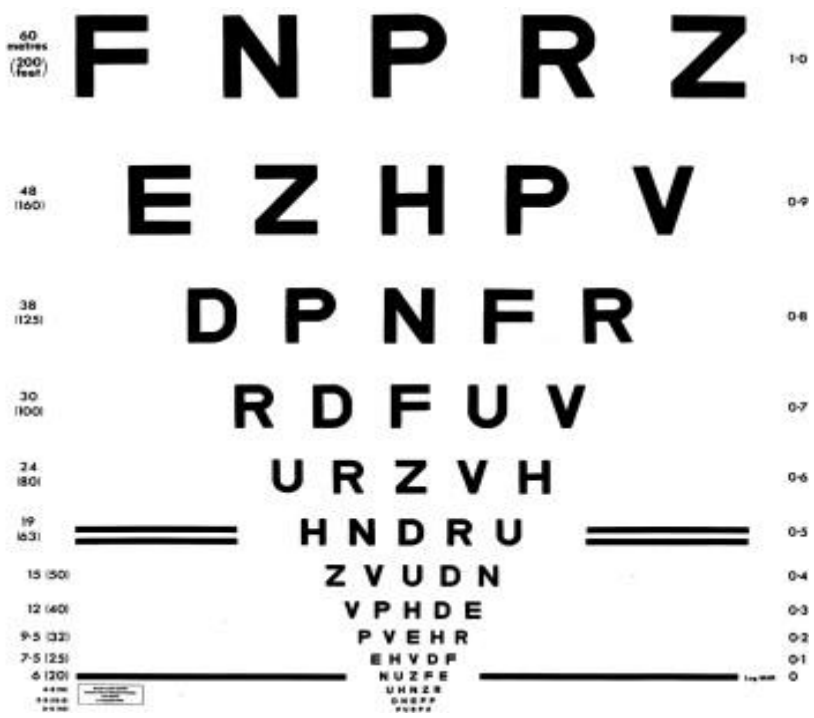

Figure 4: LogMar VA chart (Bailey & Lovie-Kitchin, 2013)

Contrast sensitivity (CS): This is the ability to detect objects and discriminate them from their background. This function is important in driving in foggy and rainy conditions as well as at night. The test chart used to assess CS was LEA symbols low contrast chart (Figure 5). Participants who already wore spectacles were tested with them on. The chart was placed 6m away from where the driver was seated. He/she was asked to cover the right eye and read what was seen by the uncovered left eye; the procedure was then repeated with the right eye. The test was done under room illumination.

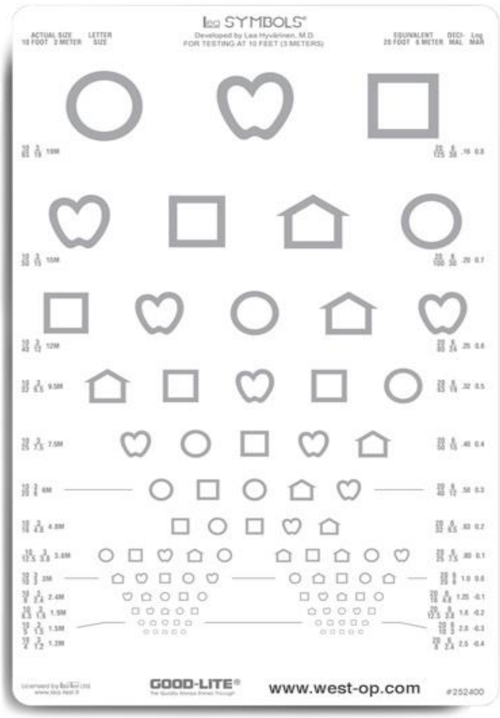

Figure 5: LEA Symbols low contrast chart (Lea Contrast Sensitivity Test, 1988)

Colour vision (CV): This is the ability to discriminate wavelength of the light independent of its intensity (Blakeslee & McCourt, 2011). This test is important in driving as it allows the driver to see objects such as cars and people, road markings and traffic lights. In this study the test that was used for colour vision testing was Ishihara 24 colour vision plates (Figure 6) as this is easy to use and it is the standard test used routinely in the optometry clinics. The test was conducted under room illumination with spectacles on for those who already wore them. The chart was held at about 60cm from the driver's eyes and the driver was asked to identify the numbers seen on the plates.

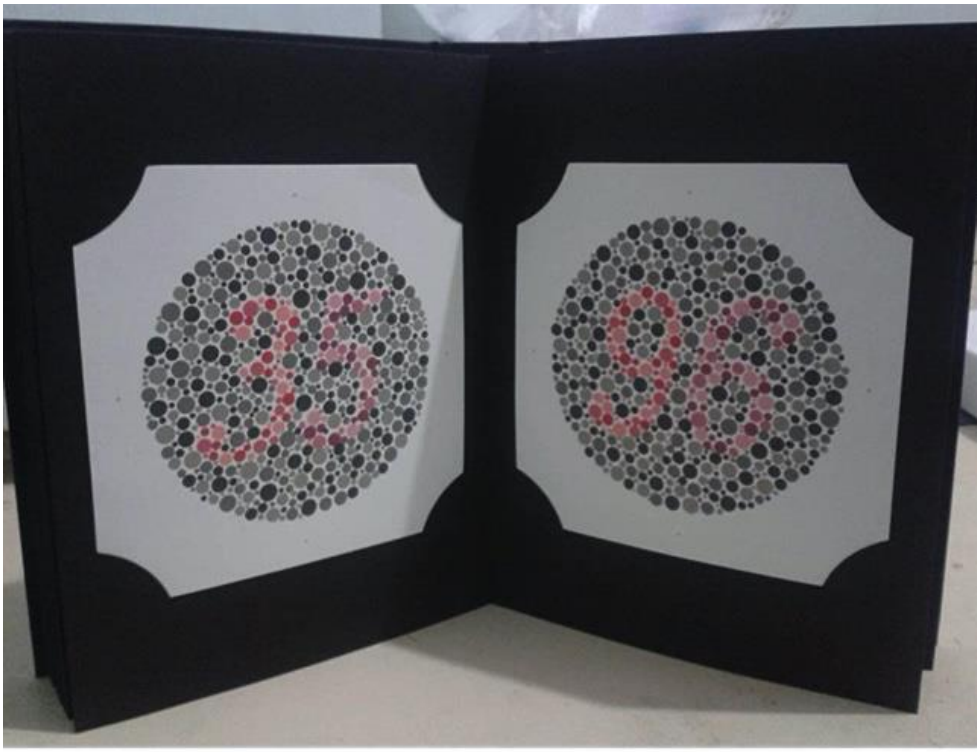

Figure 6: Ishihara 24 plate (Ishihara, 1987)
Source: Photograph by the researcher

Visual field (VF): This is an assessment of the peripheral vision of a person while focusing on a central point. The test was conducted using a Vision Disk (Figure 7), which is a type of arc perimeter used for determining visual field. In a room with lights on, the participant was asked to sit on the chair and hold the disc, placing the arc part of the disc just above his/her nose. A colourful target was placed on the centre of the disc on which the driver had to fixate. A different target was moved from the centre temporally until the point at which the participant could not see it. The test was performed for both right and left sides.

Figure 7: Vision Disk
Source: Photograph by the researcher

Refractive error: This results when the eye cannot clearly focus the images on the retina from the external stimuli, resulting in blurred vision (World Health Organization, 2013). It was assessed using PlenOptika handheld auto refractor (Figure 8) because this instrument is widely used in screening for refractive error in adults and children (Durr *et al.*, 2019). The test is quick and easy to use. The test was done while the participant was seated on a chair, focusing on a target on the wall. The target chosen was a letter on the VA chart. To ensure that the results were valid, the measurement was taken in the same eye three times and average was taken. Refractive error was measured objectively and no subjective refraction was conducted due to time constraints.

Figure 8: PlenOptika Hand-held autorefractor
Source: Photograph by the researcher

Ocular pathology: This is the presence of disease in the eye, the ocular structures or the surrounding tissues. In this study, drivers were screened for any possible ocular pathology which could impair their vision when driving. A Keeler ophthalmoscope (Figure 9) was used for pathology screening. The test was done in a darkened room and was conducted by the researcher.

Figure 9: Keeler Ophthalmoscope
Source: Photograph by the researcher

WORKFLOW PLAN:

Participants started at the information centre where the purpose of the study was described. Participants then signed the consent forms and were assisted to answer the questionnaires. The next station was where the visual assessment was done. The last station was the advice centre, where participants with visual anomalies were referred to either the optometrist, ophthalmologist or hospital. The workflow plan is summarised in Figure 10 below.

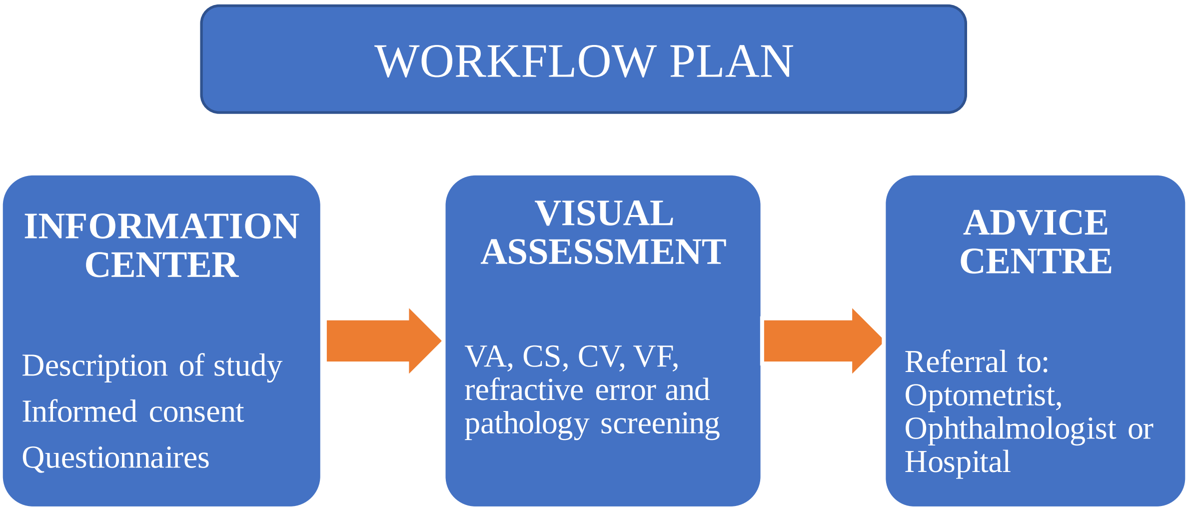

Figure 10: Workflow plan

Visual function results were recorded on a clinical record sheet (Appendix 4) designed by the researcher. Those participants who were found to have vision anomalies such as refractive error and pathology, were referred to the nearest optometrist or ophthalmologist for a more comprehensive eye examination (Appendix 5).

3.3 STUDY SETTING

The study was conducted at the Traffic Department in Maseru, which is the main licensing centre where all drivers in the country must apply for issuance or renewal of driving licences.

Data was collected during normal operational hours which are Monday to Friday from 08h00 to 16h00, from 24-05-2019 to 07-08-2019. A designated room was provided at the Traffic Department in Maseru where each participant was examined individually, allowing for privacy and confidentiality.

3.4 PARTICIPANT SELECTION

The study population consisted of all active motor vehicle drivers in Lesotho.

3.4.1 SAMPLING STRATEGY

A systematic sampling technique was employed to select participants who met the inclusion criteria. Every third subject who presented at the Traffic Department to renew their driver's licence during the period of the study was selected. A systematic sampling technique was used as it supports representivity of the population. For qualitative data (objective 1b), snowball sampling method was employed to obtain information from The Traffic Commissioner of Lesotho as well as the other people who work and different sectors within the Traffic Department.

3.4.2 INCLUSION CRITERIA

1. Adults aged 18–80 years.
2. Active drivers with an existing driving licence.
3. Consent to participate in the study.

3.4.3 EXCLUSION CRITERIA

1. Participants under 18 and over 80 years.
2. Those without driving licences.
3. Refusal to participate in the study.

3.5 SAMPLE SIZE CALCULATION

Sample size was determined using the single population proportion formula. The desired sample size was obtained using the following formula:

$$n = \frac{z^2 * p * (1-p) * D}{d^2}$$

Where:

z is the value of z statistic at 95% confidence level = 1.96

p is the proportion of people who will be evaluated = 0.5

n is the desired sample size

d is the margin of error = 0.05

80% power of test

The calculated sample size was 384 participants and after adding 20% for missing information and attrition, the final sample size was then 460 participants.

3.6 DATA MANAGEMENT

A coding system was used where each questionnaire and record sheet were assigned a unique identification number. The code for the questionnaire and the record which belonged to the same participant were matched. This helped to maintain anonymity of the subjects and allowed for smooth data analysis.

3.6.1 DATA CAPTURING

All questionnaire and clinical assessment data were captured in an Excel spreadsheet by the researcher; a double capturing technique was used to minimize error. The data were cleaned to check for errors and no imputation was done since no missing information was found. The data from the interviews' audio recordings were translated at the same time and was coded and categorized.

3.6.2 DATA ANALYSIS

Quantitative data was analysed using Strata version 14. Descriptive statistics were used to describe measures of central tendency such as mean, median and mode. Graphs and tables were used to display descriptive data. Inferential statistics were used to analyse the different variables. In order to determine the association between variables, correlation coefficient was used. To test the strength of association between two categorical variables, Chi-squared test was used. Results were presented at 95% significance level for all inferential statistics.

Qualitative data was analysed using the method of content analysis. The transcribed interview content was read and re-read. Then the impressions arising from the re-readings were coded and categorised into themes.

3.7 VALIDITY AND RELIABILITY

3.7.1 VALIDITY

The questionnaire used was adopted from Boadi-Kusi et al. (2016) because it was used in a similar study in Ghana in 2016. The visual assessment test tools are widely used and recommended in most clinical settings and research studies.

3.7.2 RELIABILITY

A pilot study was conducted among 10 participants at the researcher's private practice to establish reliability of the questionnaire and visual assessment tools for objective 2 and 3. Its purpose was to assess if the questionnaire and visual assessment tools tested what they were intended to test. A brief introduction about the purpose of the study was done verbally. Participants were asked to sign consent forms before participating in the pilot study. Time taken to complete the questionnaire and undergo eye examination was approximately 20 minutes per participant. Questionnaires and visual assessment record sheets were coded. The results of the pilot study were not included in the overall results of the study. After 4 weeks the 10 participants were retested to see if they obtained the similar results. Only minor changes were made to the final questionnaire.

3.8 LEGAL AND ETHICAL CONSIDERATIONS

Before the data collection could commence, ethical clearance was obtained from the Biomedical Research and Ethics Committee (BREC) at the University of KwaZulu-Natal (UKZN) (Ref:BE023/19) as well as the Ministry of Health Research and Ethics Committee, Lesotho (Ref: ID164-2018). Gate keeper permission was also obtained from the Traffic Commissioner of Lesotho. Participants issued with an information document which contained all the important details about the study such as procedures involved, assurance of confidentiality, their voluntary participation as well as their ability to withdraw from the study at any time without incurring any penalties. Each subject was given a consent form to sign after being given this. Each participant was then assigned an identification code to maintain anonymity. All the questionnaires, information sheets and consent forms were also available in the local language (Sesotho) to ensure that the participants fully understood all the information and aspects involved in this study. Data was captured electronically and was stored in an encrypted folder. Data will be securely stored for a period of five years and will only be accessed by the main researcher.

3.9 SIGNIFICANCE OF THE STUDY

In other African countries such as Ghana (Boadi-Kusi *et al.*, 2016) and Nigeria (Chidi-Egboka, Akeem Bolarinwa & Olugbenga Awoyemi, 2015), studies have been conducted to determine the visual functions of motor vehicle drivers. These studies have assisted traffic authorities to establish guidelines that drivers should meet before being issued with a driving licence. The results of this study will likely similarly assist the Department of Traffic in Lesotho to develop guidelines for minimum requirements for driving.

To the researcher's knowledge, no such study has previously been conducted in Lesotho. Given the absence of specific visual requirements for driving in Lesotho, it is therefore important to investigate the visual function of current drivers in an effort to guide the Ministry of Transport and promote safety on Lesotho's roads.

3.10 CONCLUSION

This chapter outlined a brief description of qualitative, quantitative and mixed methods research designs. The data collection methods, study setting and sampling methods and data analysis employed in this study were also discussed.

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CHAPTER 4: RESULTS

This chapter answered the main research question which is: What is the visual function of motor vehicle drivers in Maseru, Lesotho?

This chapter is presented in the form of a manuscript and reported on the assessment of visual function of active licenced motor vehicle drivers in Maseru, Lesotho by addressing objectives 2 and 3 of the research study.

AN ASSESSMENT OF VISUAL FUNCTION AMONGST MOTOR VEHICLE DRIVERS IN MASERU, LESOTHO

ABSTRACT

Background: Driving is a primary mode of travel in many countries. It relies principally on the function of vision to navigate roads and traffic safely. Ensuring good vision for motor vehicle drivers is therefore important to promote safety for all road users. Lesotho is a developing country, with road transportation central to the movement of people and goods within, and across the borders of the country. The absence of clear requirements for visual function among drivers issued with motor vehicle licences in Lesotho, motivated this study.

Aim: To assess the visual function of motor vehicle drivers in Maseru, Lesotho.

Methods: A descriptive, mixed methods cross-sectional study, employing systematic random sampling was conducted at the Traffic Department in Maseru, Lesotho. Active licensed drivers, both males and females, aged 22–76 years participated in the study. Data was collected by means of key informant interviews, structured questionnaires and a comprehensive vision examination of all participants. Quantitative data was analysed using Strata version 14, while qualitative data was analysed descriptively.

Results: The study included 460 licensed drivers with an overall mean age of 42.9 years, of which 64% (n=294) were men. One in five participants had not had an eye examination before obtaining their driving licence. Most participants (70.87%) had normal vision (6/9 or better) in the better-seeing eye, while 29.13% had visual acuity worse than 6/9 in the better-seeing eye. Among those with sub-normal vision, 29% had visual acuity ranging between 6/18 and 6/48 in the better-seeing eye. More than one third (39%) of participants had some form of refractive error, with myopia showing the highest distribution (46.46%), followed by astigmatism (32.96%) and hyperopia (24.59%). Of those with hyperopia, the majority (98%) were classified as having mild hyperopia (+0.50DS up to +2.00DS). Although myopia had the highest distribution, most cases were mild to moderate myopia (-0.50DS up to -5.75DS). The majority of participants (97.61%) passed the colour vision test, 53.70% achieved contrast sensitivity of up to 6/12 in the better eye and 99.6% achieved a measurement of 100 degrees for visual field test screening.

Most participants did not wear spectacles when driving, with 37% of these having previously been advised to wear them based on identified need. Almost half (44%) of the participants reported to have been involved in road traffic accidents.

Discussion: While most participants in this study presented with good vision for driving, it is concerning, that almost one in three (29%) had mild to moderate visual impairment and 39% had refractive error, yet they continued to drive without any form of refractive correction. Also, almost half of the participants (44%) had been involved in road traffic accidents, with almost one in five (19%) who had refractive error. It is possible that refractive error and visual impairment could have contributed to their involvement in road traffic accidents. The visual function findings in this study suggest that the Traffic Department in Lesotho should have guidelines on the minimum visual requirements for driving, as well as routine screening procedures.

Conclusion: A significant proportion of motor vehicle drivers in Lesotho had some form of compromised visual function, with many not having had an eye examination before obtaining a driver's licence. If drivers are advised to have their eyes examined regularly, many visual function anomalies could be detected early and their vision corrected accordingly. The absence of effective screening methods for drivers in Lesotho could be a contributor to the incidence of road traffic accidents in the country with the resultant negative socio-economic impacts.

Keywords: Driving licence, visual function, driving regulations, road traffic accidents, vision standards.

4.1 INTRODUCTION

Among the human factors that contribute to safe driving, visual skills of a driver are considered important (Burg, 1971; Austroads, 2017). It is estimated that about 95% of sensory information needed for driving is visual (Taylor, 1987; Bener, *et al.*, 2004). Research has shown that drivers with good vision have an advantage as compared to those with poor vision and may have reduced chances of being involved in road traffic accidents (RTAs) (Boadi-Kusi *et al.*, 2016; Owsley & McGwin, 1999).

Road traffic accidents are the leading cause of death among children and young adults between the ages of 15 and 29 years (Wales, 2017; World Health Organization, 2018). Every year about 1.25 million people are killed and injured due to road traffic accidents, leaving families and communities to deal with the numerous negative effects (World Health Organization, 2008). Efforts to address road safety include factors such as traffic law enforcement, improvement of road infrastructure and ensuring that road vehicles on national roads are roadworthy (Wales, 2017). While good vision is important for safe driving, it receives very little attention and enforcement.

Most developed countries such as the United Kingdom, Australia and the United States of America, require anyone who intends driving on public roads to meet certain minimum visual function requirements before issuance of a driving licence or permit. Similarly, South Africa which enclaves Lesotho, also has stipulated minimum visual functions that motor vehicle drivers should meet in order to be issued with a driver's licence (Adams, 2011). Currently, in Lesotho there is no standardised tool in place to assess the visual function of motor vehicle drivers before they are issued with a driving licence. The Traffic Department issues about 35 000 licence renewals and 37 000 new licences each year (Traffic Department of Lesotho, 2016). Between 2012 and 2013, the number of road traffic accidents in Lesotho increased from 2 473 to 5 538 and were recorded as 4 169 in 2017. Fatalities from these accidents were 15.7% in 2013 and 16.4% in 2017 (Lesotho Department of Road Safety, 2017). The highest percentage of fatalities (42.5%) from RTAs in Lesotho was observed in Maseru District (Lesotho Department of Road Safety, 2017). When reporting the causes of accidents, the Department of Road Safety focused only on reckless driving, driving under the influence of alcohol and 'machinery failure'. Factors relating to visual impairment have not been included in these reports.

There are many studies which have been conducted on visual function for driving (Boadi-Kusi *et al.*, 2016; Chakrabarty, *et al.,* 2013; Burg, 1971; Chidi-Egboka, Bolarinwa & Awoyemi, 2015) which have recommended that visual acuity, contrast sensitivity, visual field and colour vision are important functions for driving and should therefore be assessed before issuing drivers with drivers' licences. Therefore, this study was conducted to assess the visual function of drivers in Maseru, Lesotho, in order to identify the percentage of drivers who have sub-optimal visual function for driving. The objectives of the study were to investigate existing visual assessment procedures for drivers in Lesotho, to establish a profile of motor vehicle drivers in Lesotho, as well as to assess their visual function.

4.2 METHODS

This descriptive, mixed methods cross-sectional study was conducted at the Traffic Department in Maseru, which is the main licensing centre in Lesotho. Ethical approval was obtained from University of KwaZulu Natal (UKZN) Biomedical Research Ethics Committee (BE023/19) and from Lesotho's Ministry of Health Research and Ethics Committee (ID164-2018). Individual consent was obtained from participants after a thorough verbal explanation on the procedures that were involved in the study. Qualitative methods were employed to gain an understanding of existing visual assessment procedures for drivers in Lesotho. This included interviewing the Traffic Commissioner of Lesotho as a primary key informant. Further information was obtained at the request of the Traffic Commissioner of Lesotho from the Director of Road Safety in Lesotho, as well as the officials working in the different divisions within the Traffic Department (Figure 12). Snowball sampling was employed in the series of interviews listed above. The Traffic Commissioner of Lesotho was interviewed (Appendix 2: interview guide) regarding the Lesotho Traffic Act 8 of 1981, and the Director of Road Safety in Lesotho provided information about the local campaigns to enhance road safety, with particular emphasis on good vision for driving. Traffic Department officials outlined the steps followed in order to issue drivers' licences to prospective drivers.

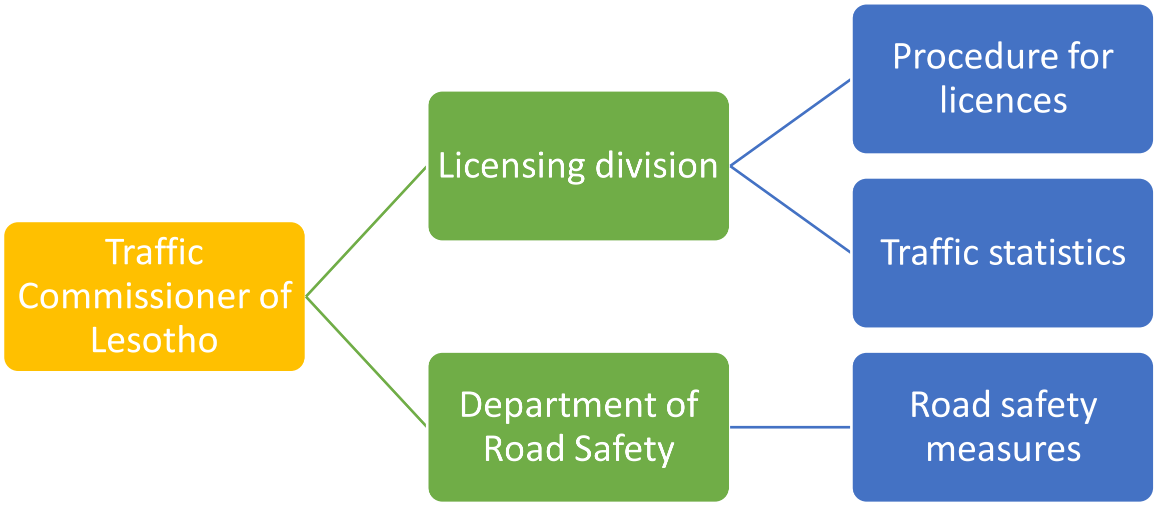

Figure 11: Qualitative data collection approach

To understand the profile of motor vehicle drivers in Lesotho, structured questionnaires were administered to participants who were all licensed drivers presenting to the Traffic Department in Maseru. The questionnaires were designed to elicit demographic data, the history of participants' health assessments and their knowledge of the importance of good vision for driving. Visual function assessments were then performed on all participants by the researcher, to address the final objective (Table 2) of the study.

Table 2: Visual function tests and tools used

VISUAL FUNCTION TEST	ASSESSMENT TOOL
Visual acuity (VA)	LogMar VA chart
Contrast sensitivity (CS)	LEA Symbols Low contrast chart
Color vision (CV)	Ishihara 24 plate
Visual field (VF)	Vision Disk
Refractive error (RE)	PlenOptika handheld auto refractor
Pathology screening	Keeler Ophthalmoscope

A total of 460 participants were selected to participate in the study, following a systematic sampling technique, with every 3rd. driver presenting at the Traffic Department between May 2019 and August 2019 being selected. After informed consent, driver profile data was collected using the structured questionnaire, with participants finally undergoing a visual function assessment. For the purposes of this study, the refractive error definition was adapted from Refractive Error Study in Children (RESC) studies (Wu *et al.*, 2013; Mckean-Cowdin *et al.*, 2013; Tarczy-Hornoch *et al.*, 2013), where refractive error which ranged from 0.00 to +/- 0.25 was regarded as normal vision (emmetropia).

Myopia was classified as follows:

1. Low to medium: -0.50DS up to -5.75DS
2. High: ≥ -6.00 DS

Hyperopia was classified as follows:

1. Low: +0.50DS up to +2.00DS
2. Medium to high : ≥+2.25DS

Astigmatism was reported ≥-0.75DC where axis was in any meridian.

VA was measured using LogMar VA chart and was classified as follows (World Health Organization, 2017):

1. Normal vision: 6/6 up to 6/9
2. Mild visual impairment: 6/12 up to 6/15
3. Moderate visual impairment: 6/18 up to 6/48
4. Severe visual impairment: ≤6/60.

The Ishihara 24 plate colour vision test was used to assess CV. As shown in Table 3, if 10 plates or more were correctly read, this was considered as a PASS (Ishihara, 1987). If less than seven plates were correctly read, this was considered as a FAIL.

Visual field was assessed using the Vision Disk. The temporal VF was assessed, as it was considered to be most relevant for driving. A PASS was considered when a participant achieved 100 degrees (Austroads, 2017). and more (full field) and a FAIL was less than 100 degrees.

For CS, the LEA Symbols low contrast chart was used and a PASS was regarded as being able to read up to 6/12 while a FAIL (Lea Contrast Sensitivity Test, 1988) was reported if the result was ≤6/15.

Table 3: Pass/Fail criteria for visual function tests

TEST	TOOL	PASS CRITERIA	FAIL CRITERIA
Contrast sensitivity	LEA symbols	Up to 6/12	Less than or equal to 6/15
Color vision	Ishihara 24 plate	10 plates and more	7 plates and less
Visual field	Vision Disk	100° and more	Less than 100° for both eyes

After clinical assessment, examination findings were recorded on the clinical record sheet designed by the researcher (Appendix 4). Quantitative data was captured in Microsoft Excel, using a double capturing technique to minimize error and was analysed using Strata version 14. Qualitative data was presented descriptively.

4.3 RESULTS

4.3.1 QUALITATIVE RESULTS

DESK REVIEWS

A review of the contents of Lesotho's Traffic Act 8 of 1981, which was retrieved online, showed that the only information it included about vision and driving was a single reference to "eyesight". Among other requirements for obtaining a driver's license, such as knowledge of traffic signs and knowing how to drive, is the requirement to possess "eyesight". The researcher then interviewed the Traffic Commissioner of Lesotho for more detailed information.

INTERVIEWS

The researcher identified the primary key informant as the Traffic Commissioner, whose input was sought on the visual requirements for driving. The Traffic Commissioner pointed out that there are no detailed visual standards in the Traffic Act that guide the Traffic Department on visual requirements for drivers to obtain a licence. Further questions related to: the procedure followed to obtain a driver's license, the number of licences issued per year as well as the visual requirements for driving and road safety, then directed the researcher to the Licensing Division within the Traffic Department and Department of Road Safety respectively (Figure 12) on the advice of the Traffic Commissioner. Those who worked at the licensing station of Traffic Department were interviewed about the standard procedure followed to process licenses to new applicants, as well as those who apply to renew their licences. Appendix 6 summarizes the procedure followed to obtain the driver's licence in the form of a flowchart provided by the Traffic Department. (presented as received).

The Director of Road Safety provided information on the efforts taken to improve road safety in Lesotho, with particular attention to vision and driving. She noted that such efforts mainly involve law enforcement, road infrastructure and road safety campaigns (Figure 13); however, they do not include visual assessment of drivers.

Figure 12: Efforts to promote road safety in Lesotho

4.3.2 QUANTITATIVE RESULTS

4.3.2.1 QUESTIONNAIRE

DEMOGRAPHICS OF PARTICIPANTS

The study included 460 licensed drivers, of whom 64% were male and the remaining 36% were female. The overall mean age was 42.90 years, with most participants (66%) being 36 – 39 years of age. The median age was 40 years within inter-quartile range (IQR) of 25 – 50 years.

Table 4: Demographic characteristics

CATEGORY	N	%
Gender		
Male	294	63.91
Female	166	36.09
Age groups		
Youth (18 – 35 years)	116	25.22
Adults (36 – 59 years)	303	65.87
Aged (≥ 60 years)	41	8.91

DRIVER HEALTH ASSESSMENT

Almost all participants (90%) reported having previously undergone an eye examination as part of their general personal health assessments, which was not a recommendation or requirement for obtaining a driver's licence. The participants had voluntarily consulted an eye practitioner of their own accord. On the other hand, a significant percentage of study participants (76.95%) also reported that they were recommended to have their general health assessed when they had their first licence issued. This health assessment included an eye examination. However, this 'eye examination' was mainly a VA assessment. Medical doctors from both government hospitals and private practices were the most common practitioners who reportedly conducted these VA assessments. However, some of the participants (12.05%) were unsure of the occupation of the person who had assessed their vision.

FACTORS RELATED TO SAFE DRIVING

Factors which are related to safe driving, as identified by Boadi-Kusi et al. (2016) were also investigated in this study. These factors included knowledge of traffic lights, difficulty driving at night, judging distance while driving, difficulty driving in foggy and rainy conditions and involvement in RTAs.

Knowledge of traffic lights was classified into (a) knowledge of the basic colours of traffic lights (red, orange and green), and (b) the ability to identify the colours of traffic lights. The majority of participants (98.26 %) reported that they knew the basic colours of traffic lights. However, twelve participants (2.61 %) did not know the basic traffic light colours when asked to identify them, suggesting colours such as blue, black and white instead.

More than half of participants (57%) reported difficulty driving at night. On a Likert scale of 1 (poor) to 5 (excellent), all participants were asked to self-report their ability to judge distances between their car and the car in front of them when driving. A small percentage (4.13%) reported some level of difficulty judging distance while driving. When asked whether participants experienced any difficulty driving in foggy or rainy conditions, the majority (67.61%) reported no difficulty, while 5.43% of participants reported some level of difficulty when driving in foggy conditions. Two out of three participants (66.95%) similarly reported no difficulty when driving in rainy conditions. Only 4.35% reported difficulty when driving in rainy conditions. Almost half of the study sample (43.70%) reported to have previously been involved in RTAs while driving. Overall, the majority of participants (77.83%) felt that they had good vision for driving, with 11.30% reportedly indicating that they felt that they did not have good vision for driving.

4.3.2.2 CLINICAL ASSESSMENT OF VISUAL FUNCTION

VISUAL ACUITY

The majority of participants (70.87%) had normal vision of 6/9 or better in the eye with the best vision (Figure 13), while 134 participants (29.13%) had some degree of visual impairment, with VA worse than 6/9 in the eye with best vision. Among those with sub-normal VA, 0.75% were found to have severe visual impairment.

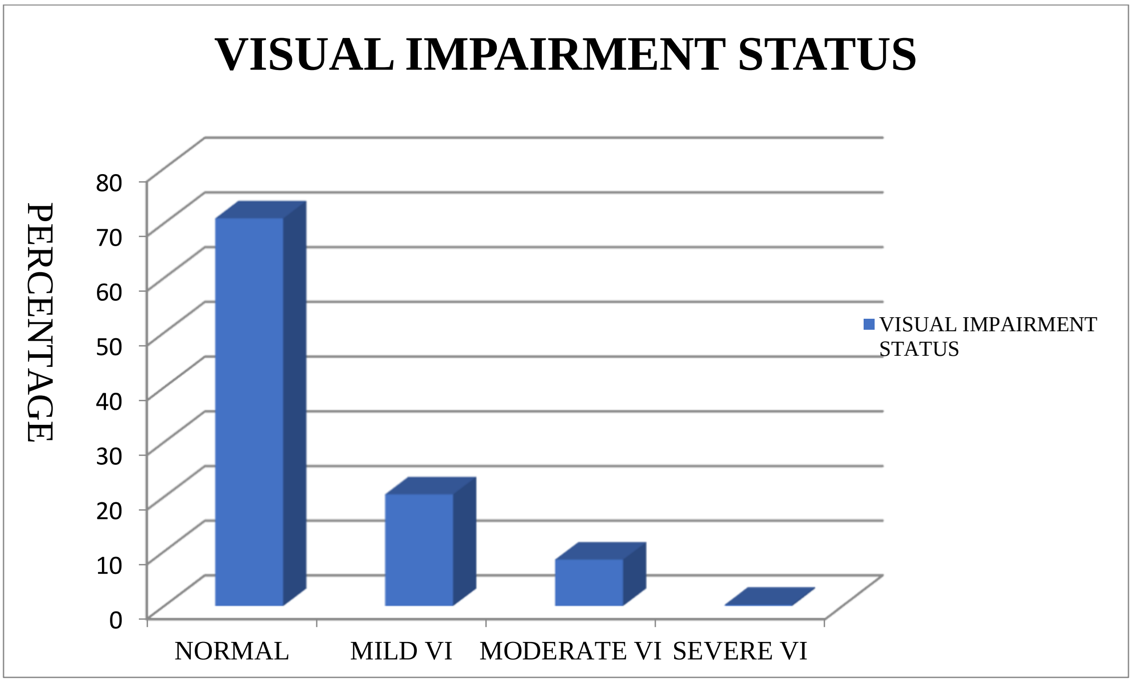

Figure 13: Distribution of visual impairment

REFRACTIVE ERROR

More than one third of participants (38.91%) had some form of refractive error (Figure 14) with the remaining being emmetropic. Out of 179 of the participants with refractive error, the majority had myopia (42.46%), followed by astigmatism (32.96%) and hyperopia (24.57%). Although myopia had the highest distribution, it was mainly low to medium myopia (-0.50DS up to -5.75DS). No participant had high myopia (above -6.00DS). Of those who were hyperopic, almost 98% were classified as low hyperopia (+0.50DS up to +2.00DS) and only 1 as moderate to high hyperopia (≤ +2.25DS).

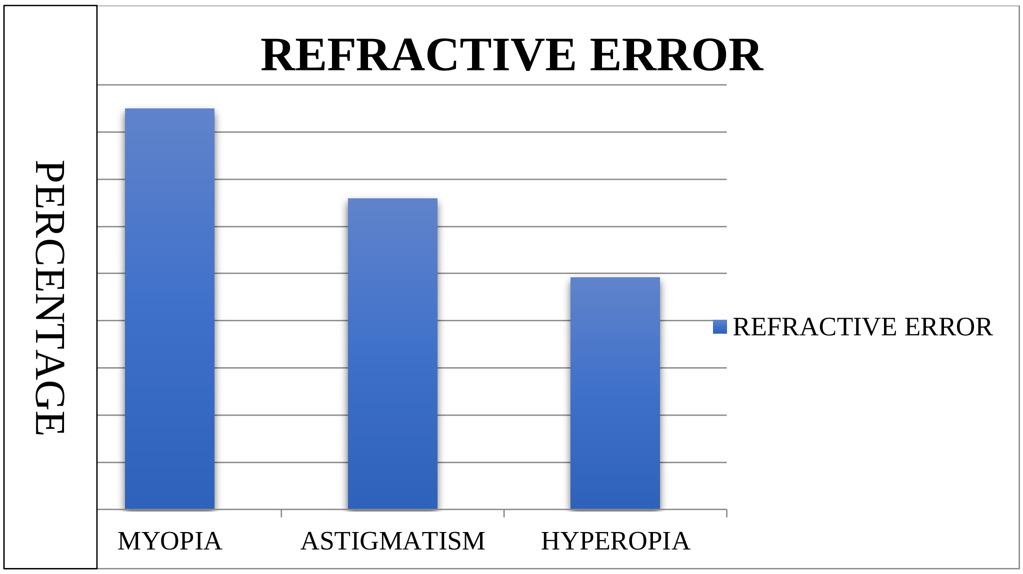

Figure 14: Distribution of refractive error

HISTORY OF SPECTACLE WEAR

More than half of participants (53.26%) reported that they did not wear spectacles when driving or in general (Table 5). Among those who did not wear spectacles, about 37% reported having been previously recommended to wear spectacles.

Table 5: History of wearing spectacles

	N	**%**
Wearing spectacles		
No	245	53.26
Yes	215	46.74
Recommended to wear spectacles		
No	154	62.86
Yes	91	37.14

Relationship between refractive error and wearing spectacles:

Distribution of spectacle wear was assessed against refractive error (Table 6), categorising it into myopia, hyperopia, emmetropia and astigmatism.

Table 6: Proportion of drivers with refractive error who wore spectacles

Refractive error	No (%)	Yes (%)
Myopia	50	50
Hyperopia	36.4	63.6
Astigmatism	40.7	59.3

The relationship on wearing spectacles and refractive error was statistically significant ($P < 0.05$) because most participants who had refractive error wore spectacles.

COLOUR VISION

The colour vision (CV) test was done using Ishihara Colour vision plates. The majority of participants (97.61%) as shown in figure 15, passed the test, with eleven participants (2.39%) failing the test. Of these, eight (72.73%) were males.

CONTRAST SENSITIVITY

Contrast sensitivity (CS) was measured with LEA Symbols low contrast chart. The test was done monocularly with spectacle correction, for the participants who habitually wore spectacles. CS function of 6/6 up to 6/12 was regarded as normal in this study. Majority of the participants (53.70%) passed this test (figure 15), as they achieved CS of up to 6/12 in the eye with the best vision. Out of this, 37.65% reported wearing spectacles while driving. Among the participants who failed CS, about 57% reported that they wore spectacles while driving.

VISUAL FIELD

Visual field (VF) was tested using a Vision Disk. Almost all participants (99.6%) as shown in figure 15 achieved a measurement of 100 degrees (both eyes), with only two participants failing the test.

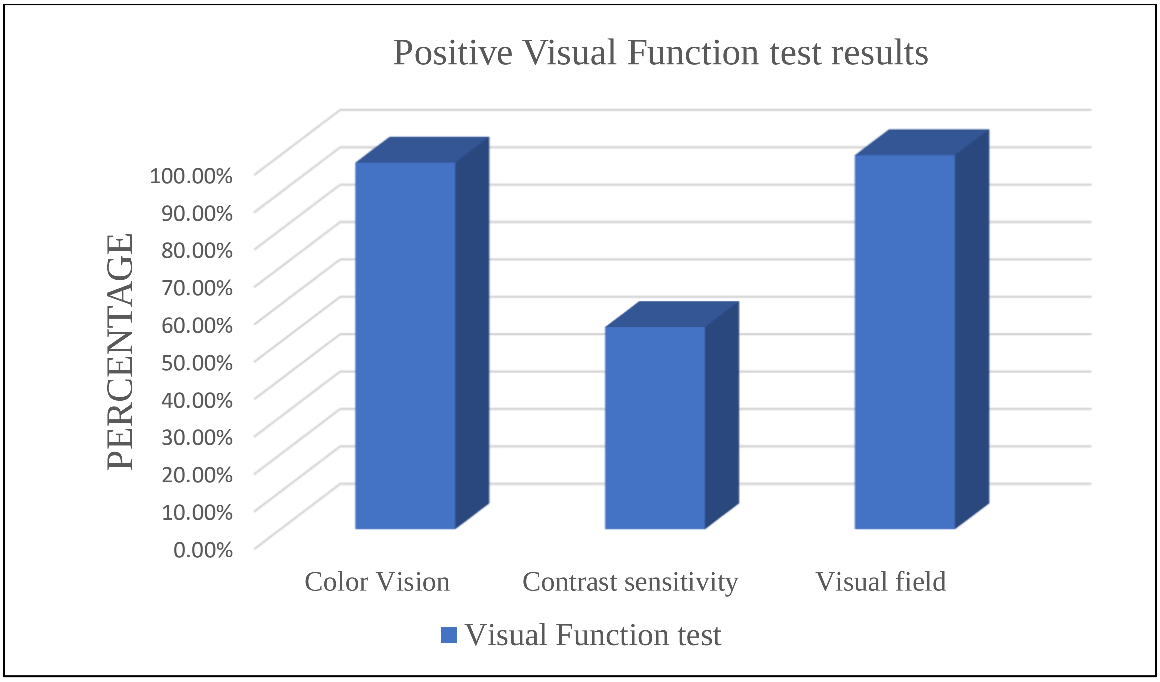

Figure 15 Positive visual function test results

OCULAR PATHOLOGY

Screening for the presence of ocular pathology was conducted using a direct ophthalmoscope. Figure 15 below shows that most of the participants (91.09%) had normal ocular health findings, with cataracts being the most common identified pathology, found in 22 participants (4.78%). One participant was found to have a lesion suspicious of squamous cell carcinoma of the conjunctiva, which was later confirmed through a laboratory report.

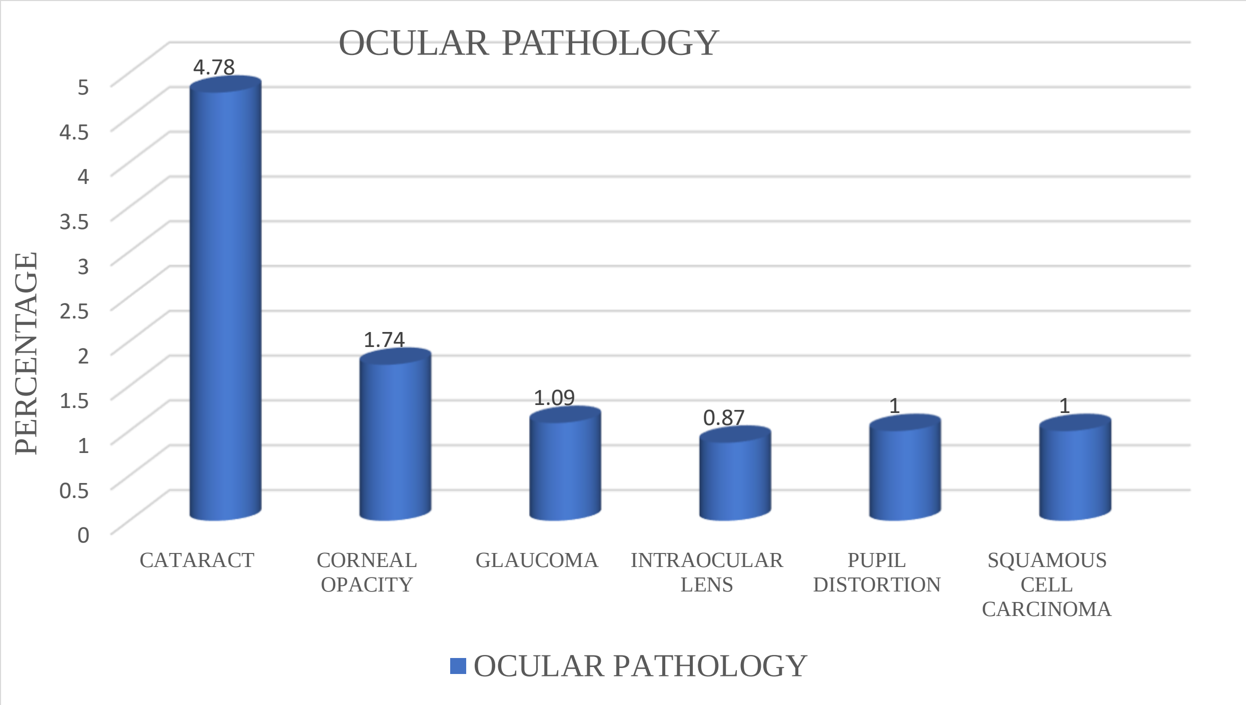

Figure 16: Ocular pathology findings

4.4 DISCUSSION

The aim of the study was to assess the visual function of motor vehicle drivers in Maseru, Lesotho. Most of the drivers in this study reported having some form of vision assessment (self-reported) prior to the initial issuance of their driving licence. However, this assessment consisted primarily of a VA measurement and did not include other important aspects such as CS, VF, CV and RE. The VA assessments were also not standardised, with different health personnel conducting this test in different ways.

Although most participants felt they had good vision for driving, it is interesting to note that about 11% acknowledged that they did not have good vision for driving. This shows that there is a need to educate the general public on the importance of good vision for driving. It was also noted that even though participants were aware of their compromised visual status, they continued to drive, possibly because of the lack of laws in Lesotho that prohibit drivers with poor vision from driving, and lack of awareness of good vision and driving and how this can be addressed.

Of concern is that almost one third (29.13%) of participants had mild to moderate visual impairment, yet did not use spectacles. The reasons behind participants not wearing spectacles were not investigated in this study, but this finding suggests that further interventions are needed to educate the general public about the importance of wearing corrective visual devices, especially when driving. Furthermore, one in five of those drivers who did not wear spectacles reported having been involved in RTAs. This could likely be due to reduced visual function, especially poor VA, which is usually the main reason for poor vision and recommended spectacle use in clinical practice.

Most participants displayed visual acuity of 6/9 in the better-seeing eye, which is the minimum requirement for driving in most countries. However, the finding that almost one third had VA worse than 6/9 and one person had VA worse than 6/60 in their eye with the best vision, is concerning. Furthermore, most drivers were not wearing any form of visual correction despite their visual impairments. These findings are similar to those reported in Nigeria (Boyce, 2008; Okafor *et al.*, 2015). Participants with poor VA would likely have difficulty driving as they may experience challenges detecting potential hazards, as emphasized by other authors (Owsley, *et al.*, 2001). Drivers with reduced VA could also have challenges in performing tasks such as reading road signs during both day and night time driving, and their ability to judge distances while driving could also be affected by the reduced VA (McKnight, Shinar & Hilburn, 1991). While the relationship between VA and RTAs was not statistically significant in this study ($p>0.26$), it was almost similar to that reported by Pepple and Adio (2014). This does not take away from the importance of implementing comprehensive visual assessments of drivers in Lesotho as it would promote safety on the roads. Furthermore, while the results may not be statistically significant, there is a clinically significant association between VA and visual function.

The prevalence of refractive error amongst drivers in this study (38.91%) was found to be quite similar to that in Ghana (Boadi-Kusi *et al.*, 2016). Drivers with refractive error (astigmatism, myopia or hyperopia) are more likely to be involved in RTAs as compared to those without refractive error (Biza, et al., 2013; Ovenseri-Ogomo & Adofo, 2011). Over 40% of participants with refractive error reported that they do not wear spectacles. There was a statistically significant association between wearing spectacles and refractive error ($P < 0.05$) as most participants who had refractive error wore spectacles. Uncorrected refractive error could also contribute to difficulty driving at night, blurred vision, difficulty judging distance while driving and some level of impairment when driving in conditions such as rain and fog (Owsley & McGwin, 1999). This could imply that even if their vision is assessed and spectacle correction recommended, they may not actually wear the corrective devices, resulting in compromised vision when driving. It is therefore recommended that the importance of having good vision when driving, with or without visual correction should be emphasized in any road safety campaigns in Lesotho.

Of the eleven participants who failed the colour vision test, majority (72.73%) being males, in keeping with literature that males are more prone for color vision defects, four reported being involved in RTAs. Other authors (Freeman, *et al.*, 2006; Emerole & Nneli, 2013) confirmed that colour vision defects may compromise safe driving due to difficulty in identifying road signs and seeing traffic lights. In this study, the prevalence of colour vision defects was found to be lower than in studies done by Pepple and Adio (2014) and Emerole and Nneli (2013) in Nigeria, who also used the Ishihara colour vision plates. However, even though colour vision is important in driving, it is not included among the visual function tests for drivers in many countries. It is therefore recommended that CV should be included among visual function tests for drivers.

Similarly, although CS function is not included in drivers' vision testing in many countries, it has been found to be associated with history of MVC involvement (Hennessy, 1995), therefore it was a visual function test of interest in this research. In California, participants who failed the CS test were also more likely to be involved in RTAs, than those who passed the test (Hennessy & Janke, 2005). It is concerning that in this study, more than half of participants (57%) who failed CS reported that they wore spectacles while driving. This implies that it is important to include CS as one of the visual function tests for drivers.

Almost all the participants (99.6%) achieved a measurement of 100 degrees in the eye with better vision, which is the minimum requirement for driving in most countries, however two did not, suggesting that routine screening may be necessary. Most research that assessed the relationship of VF defects and involvement in RTAs has been done on drivers with glaucoma and the tests used were more comprehensive rather than those used in screening processes. Sanuki et al. (2015) found that drivers with advanced glaucoma had a higher chance of being involved in RTAs than drivers with normal vision. Wood et al. (2016) also found that drivers with glaucoma were significantly less safe on the road and made more errors while driving. Although the current study found that less than 1% of participants had reduced temporal VF, it is important that VF assessments should be done among drivers in Lesotho as there may be drivers with advanced glaucoma on the road. Visual field defects could also affect driving abilities and put the lives of other road users in danger.

Almost half of the participants in this study reported to have been involved in an RTA while driving. Among other factors, this could be due to the visual impairment identified among drivers**,** even though at some point some of the participants felt they had good vision for driving. These findings are slightly higher than findings of other studies done in Nigeria (Pepple & Adio, 2014) and Ghana (Boadi-Kusi *et al.*, 2016) This could possibly be because of the climatic differences in the three countries since the participants in Lesotho reported to have been involved in RTA in foggy or rainy conditions. It has also been shown that 13.92% of participants who reported a history of RTA had reduced VA and 18.7% had some form of refractive error. These results are similar to studies conducted in India (Verma & Bharadwaj, 2015) who found refractive error to be just above 18% in the sample they used in their study. Similarly, other studies also found a relationship between the incidence of RTAs and reduced VA (Rubin *et al.*, 2007; Lyman, McGwin & Sims, 2001). This indicates that visual impairment poses a road safety hazard among motor vehicle drivers. It is therefore important to ensure that all the drivers should possess good vision.

While most participants in this study did not have identifiable ocular pathology that could impair their vision for driving, cataracts, which were found in about 5% of the participants, has a significant impact on one's quality of vision and their ability to see clearly while driving. Cataracts were also found to be the most common cause of poor vision in Nigeria, with glaucoma the second (Anstey *et al.*, 2016). Cataracts are an unnecessary, preventable cause of visual impairment in Africa, of which Lesotho is part. In this study the prevalence levels of both cataracts and glaucoma were lower than that of Pepple and Adio, (2014), which were 14% and 11.5% respectively. There could, however, be more drivers in Lesotho with undetected ocular pathology. As previously stated, one participant was found to have a lesion suspicious of squamous cell carcinoma of the conjunctiva, which was later confirmed through a laboratory report. Therefore, if the vision of drivers is assessed regularly by the appropriate personnel, such serious medical conditions could be detected and treated early.

4.5 CONCLUSION

While most drivers in Lesotho can be considered as having good visual function in line with minimum requirements for driving in other countries, it is still important for drivers' vision to be assessed prior to issuance or renewal of licenses in Lesotho because, if implemented, visual function problems in drivers can be identified early which will reduce the safety risk to road users and improve eye health. Most countries do not include good CS and CV as visual requirements for drivers, although evidence has been shown that they are equally as important as the need for good VA and VF. The results of this study suggest that it may be important to include these tests in drivers' vision screening processes.

It is therefore recommended that the Lesotho government consider introducing specific visual assessment standards for drivers, in order to ensure adequate visual status of drivers. This will minimize risks on the road related to compromised visual function, which could also potentially reduce RTAs in the country and related economic impact. Furthermore, eye health promotion activities are needed in the country so that the general population understands the importance of good vision when driving, as well as wearing corrective spectacles if necessary, both for their personal benefit and for the safety of road users.

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CHAPTER 5: SYNTHESIS, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The main aim of the study was to assess the visual function of motor vehicle drivers in Maseru, Lesotho. The overall goal of the study was to make recommendations to the Traffic Department of Lesotho on the importance of establishing specific minimum visual requirements for motor vehicle drivers before issuance of driving licenses. In order to answer the research question, data was collected by reviewing relevant documents and interviewing key informants within the Traffic Department on the current state of Lesotho with regards to procedures and regulations that pertain to vision and driving, procedures followed for obtaining a driver's licence, the measures to promote road safety in Lesotho as well as how visual function is included in the current policies. Data was also collected by structured self-administered questionnaire (Appendix 3), which assessed the basic demographics of participants, as well as drivers' perceptions of the importance of having good vision. Visual function data was collected by performing a comprehensive visual examination of all motor vehicle drivers participating in the study. This last chapter synthesizes all evidence from this study, with recommendations that may assist the local stakeholders in formulating policies that enhance drivers' vision in Lesotho.

5.2 CONCLUSIONS RELATED TO EACH OBJECTIVE

Objective 1

The purpose of objective 1 was to explore and describe the current visual assessment procedures for drivers wanting to obtain drivers' licences in Lesotho. Data was collected by means of desktop review and key informant interviews.

In the Traffic Act (No 8. of 1981) , "eyesight" is the only visual reference to obtaining a driver's licence. However, there are no clear guidelines on what the required standards for vision or eyesight should be or what the visual assessment of drivers should entail before issuance of new licences or licence renewals. The Lesotho Transport Department issues more than 70 000 licences each year and as such, it is important to ensure that all these drivers meet acceptable standards for driving to minimize the risk of road traffic accidents (RTAs) and improve driver competency and safety on the roads. Furthermore, the Road Safety Department which oversees aspects of road safety such as law enforcement on drunken driving and wearing of safety belts, should also be sensitized to the importance of the visual capabilities of drivers in promoting road safety. In the absence of laws, policies and guidelines for vision and driving in Lesotho, it is difficult for authorities to enforce good vision as an aspect of Road Safety in the country.

Objective 2

To establish a profile of motor vehicle drivers in Lesotho, their associated ocular history and vision-related experience while driving, by means of a questionnaire.

Most of the participants in this study had some form of visual assessment before issuance of their first driver's license, which was not comprehensive. This screening was mainly a visual acuity (VA) assessment. However, there was no standardisation of this because in most cases, the VA tests were performed by health personnel who were not trained in eye care health. Although most of the participants reported that they had good vision for driving, it is concerning that one out of ten participants agreed that they did not have good vision for driving but they continue to drive. This maybe because there are no laws that prevent them from doing so. This puts all road users at risk, especially if the drivers with poor vision are commercial drivers responsible for multiple passengers or heavy-duty truck drivers who have the potential to cause greater harm than light motor vehicle in the event of possible occurrence of road traffic accidents. Even though recommendations had been made to some of the participants to wear spectacles, they did not wear them for various reasons. This implies that there is a need for public education in Lesotho on the importance of correction of refractive error by use of spectacles, to improve quality of life.

Objective 3

The purpose of objective 3 was to determine the visual function of motor vehicle drivers in Lesotho by means of a clinical assessment tool.

Most of the drivers in this study passed the core visual function tests required for driving as stipulated in other countries, i.e. VA and VF. This implies that while there are no standardized guidelines in place for drivers' visual function assessment in Lesotho; most of the driving population is still considered relatively safe on the road in terms of their visual function capabilities. However, the finding that almost half of study participants had previously been involved in RTAs is very concerning and may be fuelled by factors not related to visual function such as the quality of the roads, signage and driver behaviour. However, all efforts should be made to minimize RTAs as these potentially pose a significant economic risk to the country due to the economic effects of premature death, injury or disability and insurance claims, among others, which result from motor vehicle collisions. Therefore, removing visual impairment as a contributing factor, in addition to addressing other potential causes is important, as the cost of vehicle repairs and medical costs due to road traffic accidents are generally high.

Awareness of visual function needs and the importance of good eyesight for driving was generally found to be low among road users. With some of the drivers having some degree of uncorrected refractive error, this suggests a need for more advocacy work in relation to the importance of refractive services and vision correction for overall wellbeing and improved quality of life. This finding may be due to a lack of properly coordinated and integrated eye health services in Lesotho. This gap therefore needs to be addressed.

The only visual measurement done for drivers in Lesotho is VA, but it is not standardized as it is done by personnel such as general nurses or medical doctors. It is therefore recommended that the visual function assessment should only be done by trained eye care personnel such as optometrists, who will then refer any cases of severe visual anomalies and ocular pathology to ophthalmologists. It is also concerning that there are no standardised visual requirements for driving globally, and it is unclear what informs country-specific standards. Each country or state sets its own visual standards where in some countries, refractive correction is encouraged, while in others it is not expressly stipulated. Furthermore, colour vision (CV) and contrast sensitivity (CS) are not included in visual standards for driving in many countries, although research has shown that they are as important for driving as VA and VF. It is therefore clear that there are still many discrepancies across the globe with regards to visual standards for driving. As such, it is important that policymakers both regionally and internationally evaluate the current policies regarding visual standards for driving and possibly agree to standardised visual requirements for driving.

5.3 CONCLUDING REMARKS

Good vision is very important for driving. Since RTAs are a significant public health challenge, it is imperative that appropriate visual standards be developed in all countries, particularly in developing countries, including Lesotho, so that compromised visual function is not a contributing factor. This study provides useful information which will assist in policymaking for establishing standards for vision and driving in Lesotho.

5.4 STRENGTHS OF THE STUDY

1. The study included a representative sample of the population of the drivers in Maseru, Lesotho.
2. Findings in this study serve as a baseline for the visual function of drivers in Lesotho and could advise policy makers of Lesotho on developing appropriate processes for visual function assessment as part of the process of issuing driving licences.
3. The results of this study will create awareness on the importance of having good vision for driving.

5.5 LIMITATIONS OF THE STUDY

1. **Ill perceptions:** Since this was the first study conducted in Lesotho, some subjects declined to participate due to fear that failing the visual function tests would result in their licences being refused or revoked.
2. **Access to official data:** Related data from the Traffic Department, Road Safety and Statistics Department was not recent or in some cases, reliable.
3. **Political bureaucracy:** The study was conducted at a time when Lesotho was experiencing some political instability. It was therefore very challenging to obtain data on time.
4. **Time:** The data collection process took longer than planned to because some of the subjects withdrew from the study, which took longer to get the required sample size.

5.6 RECOMMENDATIONS

Based on the findings of this study, it is evident that many drivers on Lesotho's roads have uncorrected visual impairment. Visual impairment amongst motor vehicle drivers in Maseru, Lesotho could have a direct impact on RTAs. It is therefore recommended that:

1. The Traffic Department should formulate guidelines on minimum requirements for driving.
2. The assessment of visual function of motor vehicle drivers should be done before obtaining the first driving licence as well as during renewal of the licence.
3. The Traffic Department should develop a Drivers' visual assessment tool similar to the one used in South Africa (Appendix 7).
4. The Department of Road Safety should include visual impairments as an indicator among the causes of the RTAs in Lesotho and they should involve eye health awareness when implementing road safety campaigns, in partnership with the Ministry of Health.
5. Optometrists in Lesotho should more actively promote the importance of good vision and spectacle correction for improved quality of life.

5.7 DISSEMINATION AND IMPLEMENTATION OF FINDINGS

1. Results of the study will be sent to The Traffic Department and the Department of Road Safety in the hopes that the policy makers may incorporate the findings of the study into the relevant policies.
2. The results of the study will be published in accredited scientific journals.
3. The research will be presented at conferences and seminars both in Lesotho and in other countries, especially to the Optometry community. This may improve awareness of the situation in Lesotho and may encourage further related research.